Monitoring and evaluation of household energy use: insights from EVALOC

A shared learning resource from the EVALOC project

EVALOC
EVALUATING LOW CARBON COMMUNITIES

May 2014

Written by: Laura Barnfield and Rajat Gupta

Low Carbon Building Group, Oxford Institute for Sustainable Development, Oxford Brookes University, Gipsy Lane, Oxford OX3 0BP

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EVALOC is one of seven projects funded by the Economic and Social Research Council (ESRC) and Engineering and Physical Sciences Research Council (EPSRC) Energy and Communities stream of the Research Council UK (RCUK) Energy Programme (Grant reference: RES-628-25-001). EVALOC project brings together researchers from Oxford Brookes University and University of Oxford with six Department of Energy and Climate Change (DECC) funded low carbon communities.

This report should be referenced as:

Laura Barnfield and Rajat Gupta (2014). *Monitoring and evaluation of household energy use: insights from EVALOC,* Oxford Brookes University, Oxford

For more information on EVALOC project, please visit: **www.evaloc.org.uk** or contact Professor Rajat Gupta, rgupta@brookes.ac.uk

Published by:

Low Carbon Building Group, Oxford Institute for Sustainable Development, Oxford Brookes University
Environmental Change Institute, University of Oxford

Images front cover (from top to bottom, left to right): *EVALOC team* | **Back cover** (from left to right): *EVALOC team*

Executive summary

This document has been produced for those concerned with monitoring and evaluating community-led low carbon/energy improvements of existing dwellings (technical, physical and behavioural interventions).

It outlines the survey activities and processes that were undertaken as part of the monitoring and evaluation (M&E) of household energy use within the EVALOC project. It is a reflective document, highlighting the practicalities and limitations of the different survey tools and methodological approaches used as well as providing key learning for the future.

It provides an overview of the EVALOC project, and the context in which the household M&E is situated. Furthermore, a review of the household recruitment strategy is undertaken with an analysis of the different techniques used, and the limitations created through the practicalities of recruitment.

The overall strategy of the EVALOC household M&E is set out, including the data collection framework, survey instruments and techniques used, data management and analysis frameworks. The sections that follow set out the methodology for each survey instrument used, as well as reflections not only on the actual process, but also the outcomes. Many of these outcomes provide unexpected learning, not only in terms of the project itself but also potentially wider community and policy impacts.

This report should be read in conjunction to the EVALOC 'simple guide to household energy use M&E' (available online). This provides practical guidance for community groups, local authorities and practitioners in the field is given on how to conduct M&E of household energy use and behaviours, based on different levels of resources available; cost, people, time and skills.

Acknowledgements

Thanks to the EVALOC researchers, past and present, for their invaluable help with survey design, data collection and processing particularly Priyanka Arora, Ruchi Parakh, Marina Topouzi, Nina Sharp, Jo Hamilton and Ruth Mayne. We also gratefully thank the EVALOC participants for allowing us to survey their homes, and the community groups for their instrumental help with recruitment and continuing involvement in the EVALOC project.

Summary of findings

Recruitment of households

- Of the 95 households originally recruited, first round interviews were held with 88, and second round interviews (two years later) were held with 58.

Grouping and sampling

- Whilst the original grouping of the households was instigated in order to provide 'pure' samples, in reality it was not possible in a vast majority for a number of reasons:
    - Most community initiatives included both technical and behavioural interventions.
    - Nearly all dwellings (across all three groups) have had 'standard' physical retrofit measures such as double glazing, cavity wall insulation and loft insulation.
    - Households often did not know they had certain interventions, and this was only uncovered by the researcher during the household survey.
    - There was sometimes disparity between the information given at the initial grouping stage, and that given during more in-depth study. For example, some Group C households stated that they did not have an energy display monitor during the initial grouping stage and/or did not recognise that was what it was but when questioned about it during the semi-structured interview were found to have one.

Recruitment Approaches

- Whilst approaches such as community events and community groups (other than the LCCs themselves) do not appear to be very successful, they cannot be ruled out for other research projects. Much of this depends on the preparation time given prior to visiting the communities, and timing visits to coincide with popular community events such as fetes and school activities (plays etc). This was unfortunately not always possible due to time constraints on this project but should increase the success rate of such approaches. ***Good preparation particularly into the local context can enable a local recruitment strategy to be created based on the local resources and potential recruiting areas.***
- Different levels of success were achieved in different communities; there was one community in which recruitment was particularly unsuccessful. This was potentially for several reasons; the LCC organisation was in a period of change, with all three of the original contacts for the EVALOC project leaving; and the area had a high level of private rented houses with a short turn-over. It was also found that there were certain cultural and language barriers and whilst some were overcome with the use of researchers who spoke the language as well as the recruitment of a respected and trusted member of the community who helped introduce the researchers to further participants, numbers of Groups B and Cs are lacking, and ultimately will have an impact on the evaluation and analysis of this community. ***Cultural and language differences between potential participants and researchers should be addressed to increase likelihood of involvement in study (translate information packs; use researchers who can speak the language).***
- Other communities were also difficult to recruit in despite large lists of potential recruits from the LCC organisation. It was felt in such communities that a level of research 'saturation' had been reached that meant potential participants simply had had enough of research participation (in other academic & LCC research projects), and the time it would involve.
- The most successful recruitment approaches were through community contacts, often previously recruited households providing names of friends and family in the area. In the case of the LCC organisation being unable to provide time and resources to recruitment for the study, this appears to be the best approach but is often down to good fortune in meeting the right individuals within a community. Whilst this is an interesting learning for the project in terms of social networking within the communities, the researchers should also be aware that this approach could lead to a certain bias in the project, with only a certain closed section of the community being researched. ***Contact and involvement with a trusted community member will greatly increase the likelihood of successful recruitment.***
- Leaving information packs in community buildings/with people within the community is generally not successful – the researcher must be pro-active in contacting recruits. ***Face-to-face recruitment builds up trust with potential participant and allows greater first assessment and understanding of the project to be provided.***

Resources

- ***It was important to be realistic and pragmatic about available resources***, particularly in terms of personnel and time; the location of the communities proved challenging for the EVALOC researchers; due to the extensive travel times it was necessary to group activities together, thus recruitment was often dictated by other activities such as other interviews and/or attendance of community events or meetings.

- ***The preparation time for recruitment activities should not be underestimated*** due to the variety of persons and groups that needed to be found, contacted and subsequently a visit coordinated and arranged. Administrative tasks also took up a large amount of time; with recruitment leaflets and information packs requiring designing, printing, sorting before distribution.

Incentives

- ***Financial incentives were welcomed, but were often not the primary reason for the participants involvement***; altruistic benefits such as helping the community and the provision of knowledge/expertise in the area of energy saving also play a large role in positive participation.

- Cash incentives were accepted, and often preferred; comments from householders were often negative towards vouchers.

- Split total cash incentives across the length of the study were used to increase likelihood of sustained participation, but as previously mentioned, most EVALOC case study households were not involved in the study for financial gain.

Ethics and Consent

- ***When gaining consent, it was important to be open about the amount of involvement required, and for updates to be given, even if this changed due to unforeseen circumstances.*** Therefore, it was important to have a description of the project, its length and what it would involve to participate to ensure the potential participants were fully aware of what it is and what level of involvement is required from them, but also to ensure the researchers in the field are thoroughly briefed, and run through the project description etc. and provide the participants time to ask questions.

Monitoring and evaluation framework

- The monitoring and evaluation (M&E) framework used within the EVALOC project provided a robust approach to the research activities. However, a significant issue within EVALOC was the establishment of a baseline. Whilst it may not always be possible to gather data on this prior to the M&E study taking place, often it is possible to retrospectively gather this information. However, this does have limitations as it is most likely to be based upon estimations and/or self-reporting, which can result in less rigorous and objective findings. It is also critical to ensure that the M&E methods and approaches enable 'unanticipated' impacts to be uncovered, for example in relation to potential changes in environmental conditions in the home due to improved fabric and air tightness, which may have a subsequent knock-on effect on occupant health, behaviours and comfort levels.

- The multi-disciplinary approach adopted by EVALOC combined both building and social science data collection techniques enabled all aspects of household energy use to be covered in-depth. This is critical due to the complex and socio-technical nature of energy use. Data collected was both quantitative ('hard' data) and qualitative ('soft' data). Whilst quantitative (numeric) data provides detailed information on actual energy use, behaviours/interaction as well as performance of the built environment, the qualitative (narrative and images) allows further probing into the reasons, understanding and motivations behind household energy use and behaviours. ***The EVALOC project sought to integrate both types of data using a mixed methods approach as this enables data to gathered and cross-tabulated and provide invaluable and rich insights into the relevant fields of study.***

- A case study approach was felt the most appropriate as it enables to researchers to be close to real-life situations, access a great wealth of details and receive direct feedback from the households (and communities) under study. Whilst this not only provides concrete experiences, it also creates an active learning process.

Monitoring and evaluation methods

- The possible survey methodologies and tools used to gather baseline, output, outcome and impact data relating to household energy use-related indicators vary widely. However, by using a variety of survey instruments and techniques,

the data can be triangulated; minimising bias and enhancing the accuracy of the findings.

- Some of the survey tools used, feed into more than one area of study, such as a photographic survey can also be used to capture evidence relating to user interactions within the home as well as provide information on the physical and household characteristics; and a semi-structured interview can provide data on physical and household characteristics as well as occupant behaviours, energy use and perceptions. By drawing from different survey techniques and tools, both qualitative and quantitative data can be gathered and analysed, creating a robust and verifiable dataset.

- Not all survey methods need to be used in every case study; and generally the selection of methods is dependent on:

    - The level of detail required within the case studies;

    - The level of involvement needed and/or desired by the participant;

    - The timeframe of the study;

    - The time, human and skills resources available;

    - The amount of funding available.

- Within the EVALOC study, a graduated approach was adopted; enabling participation to happen at varying degrees. *A short guide to undertaking M&E of household energy use and behaviours, based on the learnings from EVALOC is available on the website, and provides detail on different levels of approach, and suitable methods to include based on the selection methods above.*

Data management and analysis

- The quantity of data collected during the M&E of household energy use activities can be huge, and in a variety of formats. This raised challenges within EVALOC in terms of both data management and analysis, which are both critical aspects of M&E; without good management, the data cannot be analysed to its full potential and the information collected will not be disseminated and used to inform future work and add to the body of evidence relating to household energy use. It is therefore extremely useful to have protocols in place prior to fieldwork being undertaken, and not to collect unnecessary data.

- The data gathered during the monitoring and evaluation of household energy use is both qualitative and quantitative, thus requiring various management and analysis methods.

Outputs and dissemination

- It is important for data collected and analysed to be disseminated in a variety of formats in order to ensure key stakeholders benefit from the research; such outputs from EVALOC included short summary briefings and resource booklets as well as newsletters, case studies (varying in length), more detailed technical reports as well as academic papers.

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Chapter 1
Introduction

1.1 Context

At present, the UK is committed to carbon reduction targets of 80% by 2050, relative to 1990 levels. With energy consumption in the domestic sector accounting for 26% of the UK's total final consumption[1], reducing household energy use is key to meeting such targets. Yet it is not that simple; the problem of reducing energy use in homes is complex and reliant on many elements; the building itself (fabric measures, low carbon technologies) as well as the occupants and their behaviours and habits. Recent research[2] into the impacts of behaviours on energy consumption has stated that through simple changes to habitual behaviours such as switching off unnecessary lights and turning thermostats down by 1°C could reduce emissions by 4.5MtCO_2 (equivalent to just over 3% of the total CO_2 emissions from residential buildings in 2010).

The importance of community energy action is becoming clear; the 'quiet revolution' is being recognised as a way to catalyse collective change in individual household energy use. Perfectly placed to deal with contextual factors, geographically, socially and economically, communities (of place or interest) can act as agents of change; as trusted members within the community they can encourage localised trials and increased awareness of household energy matters.

The Government is recognising the importance of community energy action in helping to achieve its targets; in both policy (Community Energy Strategy, Green Deal and the Heat Strategy) and recent funding schemes such as the Renewable Heat Premium Payment (RHPP) but there are still many challenges and there is uncertainty as to the shape, nature and scale of the role community energy action projects can take to successfully navigate the difficult path between individual, local needs and Government, national requirements.

Part of the uncertainty relates to the lack of empirical evidence particularly in terms of measured energy (carbon) reduction and the added value benefits of community-led energy projects[3]. Whilst informal learning and improving is undertaken by many community groups, the evidence provided is often reliant on self-reporting and the approaches taken are inconsistent; reducing the comparability and credibility of the data gathered.

1.2 Purpose of Monitoring and Evaluating Household Energy Use

Monitoring and evaluating household energy use is vital for providing such empirical evidence on the effectiveness and impacts of community-led household energy improvements, within individual homes and community-wide. M&E can help:

- Define and demonstrate the outcomes and impacts on individuals and wider community of home energy improvements.
- Provide learning to help inform and improve future improvements and activities.
- Create opportunities to share evidence on what has been achieved; the benefits, barriers and limitations to a wide audience including individuals, other community groups and government.
- Increase evidence base on effectiveness of low carbon/energy improvements in terms of energy use, carbon reductions as well as unintended consequences.

More comparable and conclusive evidence can be gathered by using robust and consistent methods of M&E, and this document seeks to outline such methods within three approaches to take into account the varying levels of resources required (funding, costs, skills and people).

The methods and approaches described are based on those already established in both building and social science research; with the majority of tools and techniques being used within the EVALOC project. The overall aim of the document is to provide guidance on M&E methods and approaches to help enhance the impact of community groups on government policy as well as ensure an increase in the body of robust and comparative evidence relating to the effectiveness and impacts of community-led energy improvements, in relation to

[1] http://www.decc.gov.uk/assets/decc/11/stats/publications/energy-consumption/2324-overall-energy-consumption-in-the-uk-since-1970.pdf

[2] http://www.parliament.uk/briefing-papers/POST-PN-417

[3] DECC (2013) Community energy in the UK: a review of the evidence (report 13D/109). London.

national carbon reduction targets as well as the wider environmental and socio-economic contexts.

This document should be seen as a complementary tool to the guidance for community groups developed as part of the Monitoring and Evaluation for Sustainable Communities (MESC) research project (http://www.geog.ox.ac.uk/research/technologies/projects/monitoringandevaluation.html), which seeks to give overall guidance to community groups on M&E of both group processes, and activities. This document provides in-depth guidance only relevant to activities that involve the retrofit (technological and physical) of domestic dwellings and/or behavioural interventions within the households themselves. However, it must be noted that the survey approaches and techniques outlined could also be applied to non-domestic buildings, and new builds.

Chapter 2
Overview of the EVALOC project

The EVALOC project seeks to assess, explain and communicate the changes in energy use due to community activities within six selected case study projects under the Department of Energy and Climate Change (DECC) Low Carbon Communities Challenge (LCCC) initiative to transform the way communities use and produce energy, and build new ways of supporting more sustainable living. These low carbon community projects are evaluated in terms of their impacts on changing individual, household and community behaviours, effectiveness in achieving real-savings in energy use, CO_2 emissions, and success in bringing about sustained and systemic change.

Through the research, the EVALOC project aims to generate evidence about:

- Role, effects, impacts and limits of community-led initiatives in motivating and achieving:
    - Reductions in energy use and carbon emissions;
    - Positive changes in energy behaviours;
    - Renewable investment amongst local residents.
- Importance of communication and learning within and between communities.
- Role of energy monitoring for individual and community wide energy reduction.

This evidence will be used for community benefit, and to help influence policy. In addition to the academic focused outputs, the research will produce:

- Materials and guidance for community energy projects, covering engagement, methods and evaluation.
- Community energy monitoring data, materials and map based tools.

Further information on the project can be found at www.evaloc.org.uk.

2.1 Overall project approach

Action research

The project adopts a collaborative action research based approach (Figure 1), which entails an iterative cycle of planning, action and reflection in which communities are involved as co-researchers in shaping the design, implementation, and interpretation of the research programme and its outputs, as well as being subjects of the research. Such an approach works well in the context of community energy action and household energy improvements due to its ability to both assess past and current activities, but also inform and adapt future activities concurrently.

> *"Action research takes real-world issues as its starting point, and seeks not just to understand them, but to do something about them at the same time." (*Transition Research Primer, 2013)

When using an action research approach all stages of the M&E process are vital; from the planning, through the 'doing', to the reporting and sharing of the data to enable effective reflection, revision/changing of plans and subsequent further action.

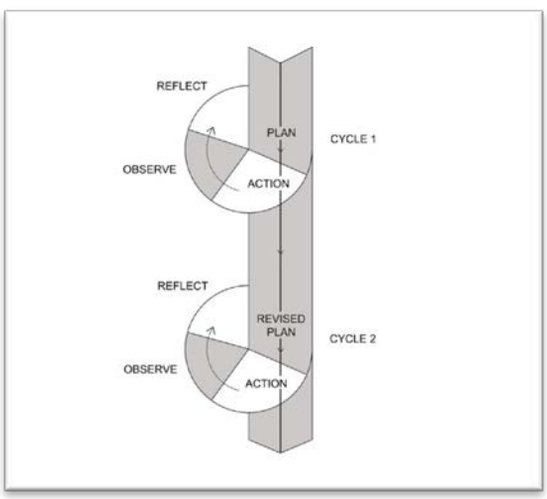


Figure 1. Reiterative action research approach

Project work packages

There are five inter-related work packages:

- WP1: Community-led action research (University of Oxford-led)
- WP2: Household-level measurement, monitoring and mapping of the actual performance of low-carbon interventions (Oxford Brookes University-led)
- WP3a: Communications, metering and feedback (University of Oxford and Oxford Brookes University)

- WP3b: Use of social network analysis in communication of new energy technologies (University of Oxford-led)

- WP4: Knowledge exchange and transfer (University of Oxford and Oxford Brookes University)

Research strands

The research is broken down into two strands of research enquiry:

- Community Level Research (University of Oxford-led, WP1, WP3a, WP3b, WP4)

- Household Level Research (Oxford Brookes University-led, WP2, WP3a, WP3b, WP4)

The community level research aims to stimulate further energy reduction, behaviour change and learning in the communities, through community-based events and focus groups which are co-organised with each case study community, followed by the evaluation of their impact.

The household level research aims to:

- Measure, monitor and map the impacts (on localised energy behaviours of inhabitants) and effectiveness (on achieving real-savings in energy use and CO2 emissions) of the low-carbon interventions both on a short and long term, from a technical and occupants' perspectives.

- Assess the interaction between user behaviour and physical aspects of housing performance in relation to energy use.

- Establish the actual energy savings achieved from low carbon interventions in households to inform future policy formulation and strategy implementation, for meeting national CO2 targets.

- Bring out differences and limits in household and community level approaches to changing energy behaviours.

Case study approach

At the household level, a case study approach was felt the most appropriate as it enables to researchers to be close to real-life situations, access a great wealth of details and receive direct feedback from the households (and communities) under study. Whilst this not only provides concrete experiences, it also creates an active learning process.

As Flyvberg notes, *'proof is hard to come by in social science because of the absence of 'hard' theory, whereas learning is certainly possible'.*

"Context dependent knowledge and experience are at the very heart of expert activity." (Bent Flyvbjerg, 'Five misunderstandings about case-study research'', 2006)

Chapter 3
Recruitment of households

3.1 Recruitment of EVALOC households

The original aim was to recruit 90 households across the six communities to provide case study evidence on low carbon interventions. The case study households were split into 3 groups:

- Group A: Households that have received technical/physical interventions (demand or supply side) from the Low Carbon Community (LCC), as a direct result of the DECC funded LCCC initiative.

- Group B: Households that have received behavioural change interventions from the Low Carbon Community (LCC), as a direct result of the DECC funded LCCC initiative; or would be willing to borrow and test one (or more) out.

- Group C: Households that have had no interaction with the low carbon community (or others) and will act as 'control'.

The households were to be retained for two years of the project, with their levels of involvement in the study varying in relation to their grouping.

In total, 88 were recruited; interviews with 95 households were arranged but only 88 first round interviews were completed due to seven households cancelling or simply being absent on the date in question and being non-contactable after.

3.2 Recruitment Approaches

Recruiting people to participate in a research project can be a challenging process. Several different means of recruiting people were undertaken, with varying levels of success in different communities. An added complexity to the recruitment of households was the requirement of Group C households to have had no involvement of the low carbon community organisation, in terms of household energy behavioural or physical activities.

As such, Groups A and B were recruited with help and guidance from the low carbon community organisation while Group C households were generally recruited independently through other networks in the communities.

The most appropriate for first contact of a potential Group C was felt to be face-to-face as it establishes an immediate relationship between researcher and potential respondent, unless the name of a trusted community member could be used. Visits to the community at times when events or workshops are scheduled within the community (but have no involvement from the LCC) were maximised where possible. The last point of call was contact with the LCC group to recommend possible Group C individuals as this impacted on the purity of the Group C respondent.

The following Table 1 outlines the different approaches taken within the different communities and codes them according to the relative 'success' of the approach.

The 'success' was based loosely on the balance between the number of potential participants approached and the number of positive responses (i.e. number of interviews confirmed) within each community. As shown, not all approaches were used in all communities. This was for a variety of reasons:

1. ***Resources*** not available for such an approach (e.g. LCC organisation could not give the time to door-to-door recruitment with EVALOC researcher, or a website/newsletter was not set up)
2. ***Safety of researchers*** (e.g. Door-to-door knocking was first thought to be a valid option, but it was felt that in certain areas this could cause not only safety risks to the researcher but also lead to mistrust in the community)
3. ***Practicalities*** of some approaches rendered it impossible (e.g. No schools in area, community events fell on dates that could not be met by EVALOC researchers due to distance of communities and available local information)

As Table 1 demonstrates, the most successful approaches throughout the different communities were through recruited households recommending local friends and family (often contacting them during the interview, and organising an interview with them directly); and through the contacts and activities of the LCC organisation. All contain the same element; a ***trusted member*** of the community.

Group C's proved the most difficult to recruit, which was to be expected as they required 'no active involvement in the low carbon community group'. As such, there was a reliance on existing recruited households to recommend friends, family and neighbours. This can be seen as a limitation of the study as it inevitably means that there is bias within the study, but does highlight the difficulties in undertaking a randomised study.

3.2.1 Reflections from EVALOC: recruitment approaches

Whilst approaches such as community events and community groups do not appear to be very successful, they cannot be ruled out for other

research projects. Much of this depends on the preparation time given prior to visiting the communities, and timing visits to coincide with popular community events such as fetes and school activities (plays etc). This was unfortunately not always possible due to time constraints on this project but should increase the success rate of such approaches.

Different levels of success were achieved in different communities; there was one community in which recruitment was particularly unsuccessful. This was potentially for several reasons; the LCC organisation was in a period of change, with all three of the original contacts for the EVALOC project leaving; and the area had a high level of private rented houses with a short turn-over. It was also found that there were certain cultural and language barriers and whilst some were overcome with the use of researchers who spoke the language as well as the recruitment of a respected and trusted member of the community who helped introduce the researchers to further participants, numbers of Groups B and Cs are lacking, and ultimately will have an impact on the evaluation and analysis of this community.

Table 1. Evaluation of recruitment approaches.

	Potential Recruitment Approaches	Community 1	Community 2	Community 3	Community 4	Community 5	Community 6
1	LCC list of potential participants						
2	Community newsletter						
3	LCC organisation website						
4	Letter from LCC						
5	Recruited household						
6	Door-to-door with LCC member						
7	Local businesses (cafes/hairdressers)						
8	Community meeting (LCC)						
9	Community event (LCC)						
10	Community event (general eg.cake sales, summer fete)						
11	Local community groups (social, religious)						
12	Local community buildings (schools, libraries)						
13	Street approach (direct contact on main thoroughfare in area)						
14	Door-to-door knocking						
15	Other (acquaintance of researcher)						

Key:

Used - good success	Used – no success
Used - some success	Not used
Used - little success	

Other communities were also difficult to recruit in despite large lists of potential recruits from the LCC organisation. It was felt in such communities that a level of research 'saturation' had been reached that meant potential participants simply had had enough of research participation (in other academic & LCC research projects), and the time it would involve.

As demonstrated, the most successful recruitment approaches are through community contacts, often previously recruited households providing names of friends and family in the area. In the case of the LCC organisation being unable to provide time and resources to recruitment for the study, this appears to be the best approach but is often down to good fortune in meeting the right individuals within a community. Whilst this is an interesting learning for the project in terms of social networking within the communities, the researchers should also be aware that this approach could lead to a certain bias in the project, with only a certain closed section of the community being researched.

3.3 Resources Required

Each approach also requires different levels of involvement from the researcher (and members of the LCCs), and the following table (Table 2) outlines the average researcher hours involved in relation to the various approaches, as well as providing a brief description of activities required.

It must be noted that these are approximate times, and often can take longer. Additional time should be given for a) prior office work including organising information packs, b) follow-up contact to arrange the interview formally; and c) travel time to and from the community as well as within the community.

3.3.1 Reflections from EVALOC: resources required

The location of the communities proved challenging for the researcher; due to the extensive travel times it was necessary to group activities together, thus recruitment was often dictated by other activities such as other interviews and/or attendance of community events or meetings.

In addition, the preparation time for recruitment activities should not be underestimated due to the variety of persons and groups that needed to be found, contacted and subsequently a visit coordinated and arranged. Administrative tasks also took up a large amount of time; with recruitment leaflets and information packs requiring designing, printing, sorting before distribution

3.4 Incentives

When approaching potential participants, there was a need to describe the research as well as explain the potential benefits to the householder. The incentives that produced the most successful uptake were:

- Energy saving (the potential financial benefits).
- Energy saving (the potential environmental benefits).
- Energy saving (awareness and knowledge).
- Helping the community.
- Financial incentives (financial 'thank you' for participation).
- Policy influencing.
- Research activities (whole house monitoring, thermal imaging, carbon mapping, action research methodology)

3.4.1 Financial Incentives:

The use of financial incentives in the recruitment of householders was felt necessary, due to the duration of the project and the extent of involvement required by the households.

It was agreed from the outset that:

- Group A's to receive £50 over 2 years;
- Group B's to receive £30 over 2 years;
- Group C's to receive £20 over 2 years.

The financial incentives were given as cash, not vouchers. The view was that the householder could use this for their own purposes instead of confining them to certain shops. Whilst there is an advantage to providing them with vouchers for, say B&Q, which sell energy saving appliances or items, based on past experience the researchers felt this didn't always work and the householders did not appreciate it as much as simple cash. It also negated the potential for 'favouritism' amongst choice of shops.

In order to retain the householders, the financial incentives have been split across the two years in relation to key involvement points from the householders (Table 3).

Table 2. Recruitment approaches used, in relation to time involved.

Approach	Desk-based	In community	Researcher Time*
1. LCC list of potential participants	Receive list from LCC, contact participants on list and coordinate contact details		10min
2. Community newsletter	Provide LCC with short paragraph		20min
3. LCC group website	Provide LCC with short paragraph.		20min
4. Letter from LCC	Provide LCC with short paragraph.		20min
5. Recruited household	Call/email recruited householders for potential participants; gather contact details or give contact details	Ask recruited householders for potential participants; gather contact details or give contact details	10min
6. Door-to-door with LCC member	Arrange meeting with LCC member	Travel to community, visit potential households with LCC member to provide introduction, give out information packs and gather contact details of interested parties	30min + 10 min/pp
7. Local businesses (cafes/ hairdressers)	Assess (using local knowledge) popular businesses	Assess (using local knowledge) popular businesses, visit businesses (with permission from managers/owners), approach individuals and gather contact details	30min + 1hr
8. Community meeting (LCC)	Arrange attendance of meeting with LCC	Travel to community, give brief presentation at meeting, give out information packs and gather contact details of interested parties	30min + 30min + 10min/pp
9. Community event (LCC)	Arrange attendance of event with LCC	Travel to community, give brief presentation at event, give out information packs and gather contact details of interested parties	30min + 1hr + 10min/pp
10. Community event (general)	Search out local events (internet, LCC, community contacts). Contact relevant person and arrange visit.	Travel to community, give out information packs and gather contact details of interested parties	30min + 1hr + 10min/pp
11. Local community groups	Search out local groups (internet, LCC, community contacts). Contact relevant person and arrange visit.	Travel to community, give out information packs and gather contact details of interested parties OR drop off information packs	30min + 10min/pp
12. Local community buildings	Search out local community buildings (internet, LCC, community contacts), contact person at building and arrange visit/delivery of information packs	Travel to community, provide presentation, give out information packs and gather contact details of interested parties OR drop off information packs	30min + 10min/pp
13. Street approach		Travel to community, assess areas with high foot traffic, approach potential participants, give out information packs and gather contact details of interested parties	10min/pp
14. Door-to-door knocking	Review potential areas for door knocking (use local knowledge including contacting LCC)	Travel to community, visit potential households, give out information packs and gather contact details of interested parties	30min + 10min/pp
15. Other (acquaintance of researcher)	Contact potential participant	Contact potential participant, gather contact details	10min/pp

**Researcher time does NOT include travel time from office to community nor travel between destinations within community, nor follow-up communication to arrange actual interview. Times for arranging meetings/attendance at events are total, and in reality likely to take place over several days.*

3.4.2 Reflections from EVALOC: incentives

Regarding incentives, most of the participants appeared to respond best to altruistic benefits, such as helping their community, and potentially influencing policy as well as energy saving possibilities in their homes rather than the actual financial incentive they were going to receive. This, in the end, appeared to be a nice 'bonus' to many. To many Group Bs, the chance to borrow and try out different types of energy display monitors, was also an incentive.

Table 3. Financial incentives for EVALOC households.

Group	1st Wave	Interim (post-monitoring kit installation)	2nd Wave
A	£15	£20	£15
B	£15		£15
C	£10		

3.5 Ethics and Consent

It is vital that any research study undertakes ethical procedures and ensures that informed consent has been granted by the participants. Personal anonymity must be ensured; especially in the communication of research findings. In addition, data protection laws must be respected and adhered to. An overall consent form (Appendix A) is useful for the initial stages, and if required, an additional more detailed consent form including consent for public use of data (for example images from a photographic survey in an academic paper or public report) should also be included. No photographs should be used without the written consent of the parties involved.

3.5.1 Reflections from EVALOC: ethics and consent

When gaining consent, it was important to be open about the amount of involvement required, and for updates to be given, even if this changed due to unforeseen circumstances. Therefore, it was important to have a description of the project, its length and what it would involve to participate to ensure the potential participants were fully aware of what it is and what level of involvement is required from them, but also to ensure the researchers in the field are thoroughly briefed, and run through the project description etc. and provide the participants time to ask questions. Within EVALOC, unforeseen changes to programming meant that it was difficult to keep all case study households up-to-date with certain information.

Chapter 4
Monitoring and evaluation (M&E) framework

The following section outlines the overall framework and approach taken within the M&E of household energy use in the EVALOC project. The approach taken in the EVALOC study may not be appropriate to other similar research studies, and as such, the EVALOC team have produced a short guide to choosing a suitable approach (*available online in the EVALOC energy and communities toolkit, ENACT; www.evaloc.org.uk*).

4.1 Overall M&E framework

An overall M&E framework was put in place to provide a robust approach throughout the EVALOC research activities (Figure 2).

In order to assess changes, it is important that a baseline is established. Whilst it may not always be possible to gather data on this prior to the M&E study taking place, often it is possible to retrospectively gather this information. However, this does have limitations as it is most likely to be based upon estimations and/or self-reporting, which can result in less rigorous and objective findings. It is also critical to ensure that the M&E methods and approaches enable 'unanticipated' impacts to be uncovered, for example in relation to potential changes in environmental conditions in the home due to improved fabric and air tightness, which may have a subsequent knock-on effect on occupant health, behaviours and comfort levels.

4.2 M&E Indicators

It is important to ensure that the data gathered and analysed are focused, concise and relevant. As such, the following indicators have been established as relevant to the study of community-led domestic energy improvements:

- ***Ind.1:*** Dwelling (physical) and household (socio-economic) characteristics
- ***Ind. 2:*** Energy use
- ***Ind. 3:*** Energy generation
- ***Ind. 4:*** Dwelling fabric performance
- ***Ind. 5:*** Internal and external environmental conditions
- ***Ind. 6:*** Occupant guidance process
- ***Ind. 7:*** Occupant satisfaction and perception of comfort and control
- ***Ind. 8:*** Occupant behaviours and interactions (household)
- ***Ind. 9:*** Occupancy levels and use patterns
- ***Ind. 10:*** Community engagement
- ***Ind. 11:*** Communication networks

It must be noted that there are many other possible indicators, and some indicators may not be relevant to all research studies, and as such the use of these is at the researcher's discretion.

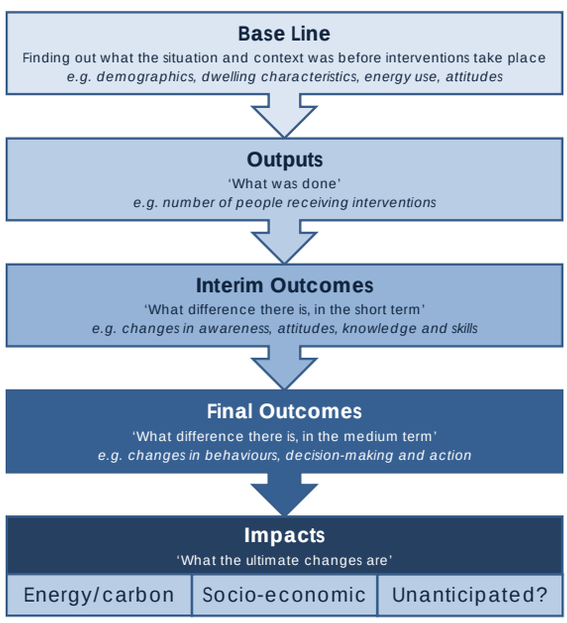


Figure 2. Overall M&E framework

4.3 Data Collection Framework

Data relating to the above indicators can be either quantitative ('hard' data) or qualitative ('soft' data). Whilst the quantitative (numeric) data provides detailed information on actual energy use, behaviours/interaction as well as performance of the built environment, the qualitative (narrative and images) allows further probing into the reasons, understanding and motivations behind household energy use and behaviours. The EVALOC project sought to integrate both types of data using a mixed methods approach as this enables data to gathered and cross-tabulated and provide invaluable and rich insights into the relevant fields of study.

It was felt important to use a multi-disciplinary approach that combines both building and social science data collection techniques due to the complex nature of energy use as well as ensure the socio-technical aspects of household energy use were covered in depth.

Whilst in essence a longitudinal study, the data was collected in both spot (one-off) measurements and continuous monitoring. This is because a number of aspects can be determined through one-off measurements (such as the performance of the building fabric), but it is desirable to repeat some of these one-off measurements throughout to capture any significant changes, or indeed no change. Therefore, as Figure 3 shows, the data collection framework for EVALOC incorporated both continuous monitoring but also waves of one-off measurements. The number of waves is dependent on the depth of investigation required, as well as availability of resources (particularly time and costs).

4.4 Survey Methods and Approaches

The possible survey methodologies and tools used to gather baseline, output, outcome and impact data relating to the above indicators vary widely. However, by using a variety of survey instruments and techniques, the data can be triangulated; minimising bias and enhancing the accuracy of the findings.

Table 4 outlines the different survey instruments and techniques that can be used, as well as highlighting which indicator/s they can be used for. Some of the survey tools used feed into more than one area of study, such as a photographic survey can also be used to capture evidence relating to user interactions within the home, and a semi-structured interview can also provide data on physical and household characteristics as well as occupant behaviours, energy use and perceptions. By drawing from different survey techniques and tools, both qualitative and quantitative data can be gathered and analysed, creating a robust and verifiable dataset.

Not all survey methods need to be used in every case study; and generally the selection of methods is dependent on:

- The level of detail required within the case studies;
- The level of involvement needed and/or desired by the participant;
- The timeframe of the study;
- The time, human and skills resources available;
- The amount of funding available.

Within the EVALOC study, a graduated approach was adopted, depending on the initial groupings and level of detail required in relation to each indicator. Whilst there are core survey methods that ran across all three approaches, additional techniques including more in-depth monitoring of energy use and environmental monitoring were undertaken in Group A and B households to provide more in-depth case studies of these households.

Chapter 5 outlines survey methods and approaches that were both used in EVALOC, and additional ones that were considered, and could be used in M&E studies on household energy use and behaviours.

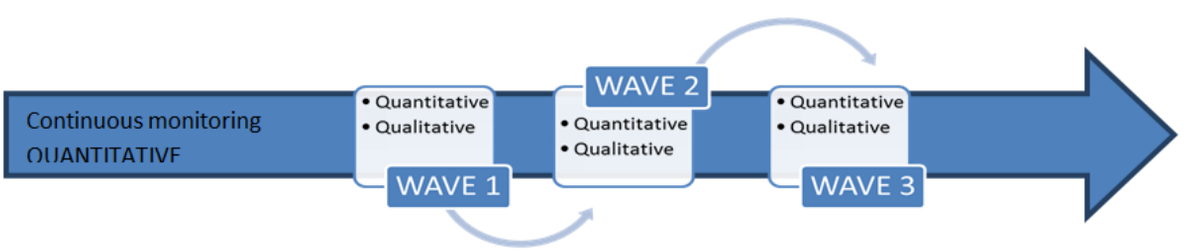


Figure 3. Data collection framework.

Table 4. Survey methods and approaches in relation to indicators.

Survey Instruments & Techniques	Indicator										
	1 Dwelling and household characteristics	2 Energy use	3 Energy generation	4 Dwelling fabric performance	5 Environmental conditions	6 Occupant guidance process	7 Occupant satisfaction	8 Occupant behaviours	9 Occupancy levels & use patterns	10 Community engagement	11 Communication networks
One-off Measurements											
Air permeability test				■							
Assessment of guidance material						■					
BUS questionnaire							■	■	■		
Co-heating test				■							
Desktop survey	■										
DomEARM survey		■	■					■	■		
Heating control questionnaire						■	■	■	■		
MVHR performance measurement		■			■						
Observation of user induction						■					
Photographic survey	■	■		■			■	■	■		
Remote visual inspection				■							
Self-completion questionnaire	■	■									
Semi-structured Interview	■	■	■	■		■	■	■	■	■	■
Social network analysis										■	■
Spot measurements (environmental)					■						
Thermal imaging surveys				■							
U-Value Tests				■							
Walkthrough	■			■		■	■	■	■		
Long-term monitoring											
Activity logging sheets		■					■	■	■		
Data logging (environmental)					■						
Metered energy use		■	■								
Remote monitoring (energy use)		■							■		
Remote monitoring (environmental)					■						
Remote monitoring (LZTs)		■	■						■		
Remote monitoring (occupancy/interact)								■	■		
Thermal comfort diaries							■				
Video diary						■	■	■			

Chapter 5
M&E Methods

The following section outlines the various methods that can be used in the M&E of household energy use. Whilst not all were used in the EVALOC project, all are recognised as appropriate techniques in the fields of building and social sciences.

The following section is sub-divided into the indicators, with the relevant methods described, along with reflections from EVALOC (where applicable) and an evaluation of the tool in relation to the required level of resources (costs, time and skills).

It must be noted that as previously discussed, some methods can be used to gather data on more than one indicator. Where this happens, the method is described in the most appropriate indicator, but highlighted as a cross-cutting method.

The following Figure 4 outlines how each survey method and technique is evaluated, in order to help future researchers to understand the implications of choosing each method. It must be noted that the time/effort is very dependent on how many case study households are being studied, and as such, are based on the resources required for one case study.

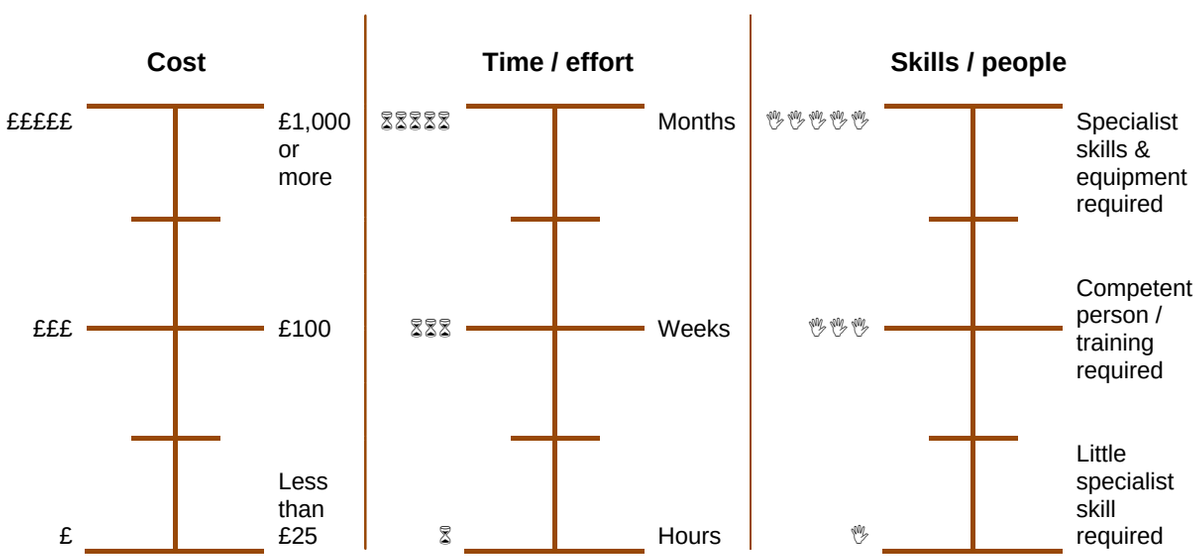


Figure 4. Evaluation diagram of survey methods and tools.

5.1 Dwelling and household characteristics

In order to understand what the effects and impacts of energy improvements are in terms of energy use, behaviours and CO_2 reductions, it is important to gather data on:

- The occupants of the households (socio-economic status, demographics, attitudes and awareness etc).
- The physical dwelling (type, age, construction, heating and hot water system and controls, appliances and lighting).

Such data can be gathered in a number of ways including a desktop survey, self-completion questionnaire, photographic surveys, semi-structured interviews and walkthroughs.

5.1.1 Desktop survey

Cost: £	**Time:** ⏳	**Skills:** ✋

A large amount of publicly available quantitative data relating to the physical characteristics of a dwelling can be found online including:

- Dwelling type;
- Dwelling age;
- Dwelling construction;
- Extensions and improvements.

Google StreetView, digimaps and online planning applications and EPCs can provide basic physical characteristics data, but care must be taken when using this information, particularly when both baseline and current characteristics are required as often the StreetView images and the EPCs have been completed at different times.

5.1.2 Self-completion questionnaire

Cost: £	**Time:** ⏳	**Skills:** ✋✋

cross-cutting method

A self-completion questionnaire is a useful, yet relatively simple tool to gather quantitative data on both dwelling and household characteristics. It can be produced in either paper or online form. Both formats have positives and limitations; an online survey has the added benefit of the answers being stored automatically (saving the researcher time in processing and managing the data) but do not often allow for additional (but relevant) comments to be made by the participant. It was found that a paper questionnaire garnered more additional comments that the online questionnaire, even though there were comment boxes online. Paper questionnaires also afford the researcher the potential to meet face-to-face with the participants, and were found to be very useful discussion tools when first approaching potential participants in the EVALOC project.

Designing and analysing the data gathered can be quite challenging and care must be taken to ensure that simple and understandable language is used and be of a length long enough to encompass enough detail for the researchers, whilst also being short enough to ensure all questions are answered. Visual tools within the questionnaire are often helpful to explain more technical or complicated questions.

Translating the questionnaires into a variety of languages, and not just English should be seriously considered, not only to increase the number of respondents but also to acknowledge the demographics of the study area.

If a questionnaire is being sent out, without prior engagement with householders, a cover letter explaining the research and its aims is required, along with a return SAE. In addition, a request for consent should be included as part of the questionnaires; either as a tick box on the questionnaire itself or as a separate consent form.

A pilot to demonstrate the length of time it takes, as well as to test the wording is recommended.

> ***Top tip:*** *a self-completion questionnaire should not take more than 5 minutes (on average) to complete.*

Further resources:

- Appendix B includes a questionnaire used to gather initial household and dwelling characteristics in the EVALOC project.
- A more comprehensive questionnaire based mainly on gathering dwelling characteristics can be found here: http://www.evaloc.org.uk/#!decorumquestionnaire/c8dg . This was developed from the DECoRuM carbon mapping questionnaire through the EVALOC project.
- For examples of questions, search the Survey Question Bank (http://surveynet.ac.uk/sqb/).

5.1.3 Photographic survey

Cost: ££	Time: ⌛	Skills: 👐

cross-cutting method

A photographic survey enables the researcher to investigate a variety of areas relating to energy use, behaviours and interactions as well as assessing the physical and technical characteristics of a dwelling. It provides triangulation for data gathered through other methods such as a questionnaire, which may be incomplete or inaccurate (due to respondents either not knowing, or not understanding). The person undertaking the photographic survey should have basic knowledge of construction and the technical systems within a home (i.e. heating and hot water systems, lighting and appliances).

A photographic survey can take place either with or without the occupant present, as long as written consent has been given. However, it is strongly recommended that they are for a number of reasons:

- Occupants can provide additional information relating to the area in question.
- Occupants can highlight particular issues that may not be apparent to the researcher; for example mould behind a wardrobe etc.
- Having an occupant present ensures the researcher is not liable for any potential changes to belongings/spaces.

Depending on the number of rooms to be visited, a photographic survey can take up to 30 minutes. It is useful for the images to take in as much context in order to enable the researcher to locate and understand the space at a later date. A photographic survey should include both the inside and the outside of the property.

When returning to the desk, it is recommended that the images are named in relation to a) the dwelling, b) the location, and c) focus. An example of this is: '24ARoad-Living-TRVs'. This will make future searches to find images of key aspects easy and efficient.

A photographic survey can be integrated with a 'walkthrough' so that the researcher can access further contextual knowledge of the building.

> ***Top tip:*** *Don't use 'zoom'. Images can always be cropped later and without context, you may forget why you took the photo in the first place!*

Reflections from EVALOC

A key concern from occupants was that the photographs would provide a judgement on the occupants themselves. It was necessary to assure the occupants that the photos were being taken simply to help build a picture of the physical and technical aspects of the home. Once this was clarified, the researchers were able to take photos of most areas freely, and without feeling intrusive.

The external photographic survey potentially posed the biggest issue, in that it at times aroused suspicions of neighbours and also did not give a good first impression to the respondent. As such, it was agreed that external images should be taken after the interview itself where possible as both the respondent and researcher were much more relaxed with the situation; on occasions, the occupant would also come out with the researchers and point out aspects of their home which would have been missed without the contextual knowledge.

5.1.4 Walkthrough

Cost: £	Time: ⌛	Skills: 👐

cross-cutting method

One way of recording the occupant's interaction, satisfaction and understanding of their home, as well as gather further detail on the physical characteristics is to 'walkthrough' the home with them, including the outside, and ask them to comment on aspects as they walk. Any cupboards containing services, controls or equipment should be accessed, where possible. Such a method can help uncover 'forgotten' issues as well as help the researcher gain a better understanding of the home as a whole. The researcher will need at least a basic knowledge in construction and technical aspects of a dwelling.

An open-ended, repetitive script to provide prompts regarding relevant issues and points of interest in relation to household energy use and occupant behaviours is useful. Time should be given to the occupants to bring up their own issues, and 2-5 minutes should be spent in each room. Generally a walkthrough will take between 15 and 45 minutes depending on the complexity and size of the spaces.

It is recommended that notes are taken throughout the walkthrough, as well as pictures, but the process is audio-recorded for future transcription.

Reflections from EVALOC

There were a number of practical challenges and issues discovered during the walkthroughs undertaken as part of the EVALOC project. One

such challenge was that the walkthrough was conducted directly following the SSI, which meant that often both the respondent and researcher had addressed the majority of themes and issues, creating a certain level of fatigue due to the repetitive nature.

There were also practical issues, for example often the rooms visited were too small for the occupant and two researchers at once as well as the amount of equipment to be carried and co-ordinated. The need for spot-measurements in all rooms was also an issue in relation to timings; ideally the researcher needed 10-15 minutes to ensure accuracy of readings per room; however, this was simply not practical.

> ***Top tip:*** *sketch a plan of the layout of the home for future reference of where issues were.*

5.2 Energy Use

To provide verifiable data on the causes, effects and impacts of improvements to the physical fabric, technical systems and occupants, it is important to establish the energy use within the household. Most desirable is data before and after such interventions have been made.

The two main aspects of energy use requiring measuring are:

- Heating (typically gas, but could also be electricity, oil and biomass).
- Non-heating (electricity) end uses such as appliances and lighting.

Depending on the level of detail to be analysed within the study, these two main variables can be broken down further into sub-groups including: heating, hot water, different circuits within the home, and even different appliances.

5.2.1 Annual metered energy use readings

Cost: £	**Time:** ⌛	**Skills:** ✋

Whilst annual energy use does not give insights into specific patterns of energy use, it can give an overview of the energy use within a household.

Annual metered energy use can be accessed in a number of ways:

- Occupant records;
- Energy supplier data;
- Government data.

Annual energy bills are often the easiest source of such data, but often records are not retained for a long enough period, particularly if the research study is retrospective (i.e. it began after the interventions took place). They also may not be an accurate representation due to some readings being estimated. Equally, being reliant on occupant records is difficult, as some readings may have been missed and/or read incorrectly.

Within EVALOC, it was found that the most direct method of accessing annual energy data was through the use of the MPAN and MPRN numbers for each house (Figure 5). These are unique codes for the gas and electricity meters within the household, and past annual data can be gained. Records for these are retained within the Department of Energy and Climate Change (DECC), and can be accessed as long as full consent has been given by the occupants. This approach has allowed energy data (electricity, and gas where applicable) for the majority of the case study households to be accessed within the EVALOC study.

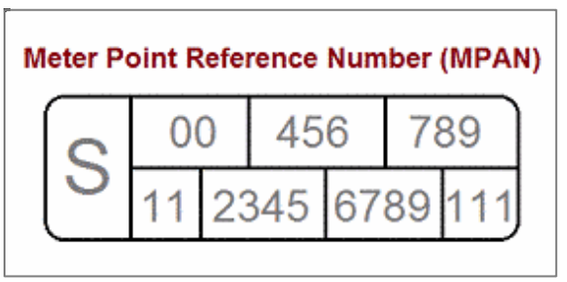


Figure 5. The MPAN is a unique code for each household electricity meter and enables past annual data to be gained from either the household energy supplier or DECC (with permission from the occupant).

Reflections from EVALOC

It was found that the original consent form issued to the case study households was not acceptable for DECC to provide the energy data related to the MPAN and MPRNs and as such a revised consent form (Appendix C) had to be sent out. As such, it is recommended that discussions relating to the accessibility of this data are undertaken at the beginning of any study.

5.2.2 Monthly metered energy use readings

Cost: £	Time: ⏳	Skills: ✋

Monthly metered energy use enables researchers to gain broader understandings of energy use within the household, and additionally provides seasonal variations and patterns to be analysed.

Despite this, monthly meter readings can be time consuming (the researcher needing to contact/visit the household every month on a specific day) and potentially inaccurate (the occupant writing down the wrong figure, or taking readings on different days).

There are also further practical issues in that the occupants may be away on the meter reading day, and that different occupants take readings on different days; reducing the potential for cross-comparison.

The method of data collection can also vary; online, paper (Appendix D), text message, email, and it is best to confirm with the participants which method is most likely to gain the greatest response.

Reflections from EVALOC

It was found that finding a comparative way of measuring oil use was difficult due to a number of practical issues including the location of some oil tanks making it difficult to access, and the non-visibility of the gauge. A recommendation would be that a piece of tape is placed on the oil tank itself, at its current level and the changes in level recorded using a tape measure. However, this still has inherent issues as the amount at the initial point of measurement may not be accurately known.

In addition, several occupants forgot to record their meter readings, and would have benefitted from prompts, either by text message, telephone call or email. However, this requires significant resource in terms of time and personnel.

5.2.3 Remote monitoring and sub-metering of energy use

Cost: £££££	Time: ⏳⏳⏳⏳⏳	Skills: ✋✋✋✋✋

cross-cutting method

The installation of additional remote monitoring equipment to monitor the long-term use of electricity (and gas or oil if applicable) uses wifi connection to provide remote access (via the internet) to the real-time energy metering data (Figure 6). This, in theory, allows for frequent and accurate readings of energy use. It also ideally, if connected to a suitable web-based platform, can provide real-time visual display

Figure 6. WiFi hub for remote energy monitoring equipment.

of the data to provide early detection and correction of any issues with the data collection. By creating a remote storage for the data, it allows data to be accessed by the researcher directly, saving time and enabling detailed analysis of the household's energy use.

The monitoring should cover at least two heating seasons (before and after) and as such the programming of the study, from recruitment to installation and trouble-shooting of the equipment should allow for this.

Remote monitoring is similar to smart metering, which is currently being rolled out across the UK; existing gas and electricity meters are being replaced with 'smart' meters that provide 'real-time' data to the household, and enable more accurate readings by the energy suppliers.

Sub-metering of electricity (and gas, if applicable) helps gain a fuller understanding of where energy is used (and potentially generated) within a home. Ideally, the sub-metering is a remote monitoring system that separately captures data on the energy used for:

- Heating;
- Domestic Hot Water (DHW);
- Lighting;
- Cooking;

- Ventilation (particularly MVHR);
- Appliances.

Whilst ideal, sub-metering requires not only specialist skills in terms of installation but also processing, management and analysis of the data.

Reflections from EVALOC

The installation of the equipment was not a smooth process due to a number of practical issues including:

- Limited space available in utility cupboards for additional metering equipment;
- Several independent specialists required (monitoring, electrical and gas engineers as well as RSLs) creating co-ordination issues;
- Lack of information on circuitry and wiring within homes.

This caused tension within some occupants due the intrusiveness of the installation process, which was regrettable although mainly unavoidable. It was also found that the 'trouble-shooting' period extended much further than anticipated. Such difficulties highlighted the need for a sophisticated protocol and programme in place prior to any works taking place, as well as the need for both technologies and specialisms to 'join-up' to provide an alternative, less intrusive monitoring system.

Due to the 'ownership' of the existing meters in the households belonging to the energy supplier, separate meters were required to be installed on the household side of the electricity and gas supply. This added to installation and space issues, however, with the new smart meters being rolled out, such issues should be reduced in the future.

In addition, it was found that the processing of the data required significant time and specific software skills as the data was being collected every 5 minutes; meaning that over the 18month period the equipment was installed, one sensor in one household created over 150,000 datapoints alone.

Furthermore, due to the remoteness of some of the locations, and subsequent lack of phone signal, meant that data was received intermittently. Other issues with the reliability of the data were due to poor installation of the monitoring equipment; and complex existing wiring in the households.

Further resources:

- A variety of monitoring systems are available and further advice can be found within documentation from the Technology Strategy Board's Building Performance Evaluation project; orsis.com; ewgeco.com and the Energy Saving Trust.

5.2.4 DomEARM energy and appliance audit

Cost: £££	**Time:** ⏳	**Skills:** 👐👐👐

cross-cutting method

DomEarm is an energy assessment and reporting methodology for domestic energy use and has been developed by Arup and Partners Ltd in collaboration with Oxford Brookes Institute for Sustainable Development: Low Carbon Building Group (OISD:LCBG). It is based on both total and individual fuel and power data and provides a much more detailed understanding of how and where energy is used in the home.

The DomEARM survey requires a physical survey of the dwelling by a competent and knowledgeable researcher follows a spreadsheet-based assessment and operates on three levels:

- Level 1: Simple Dwelling Assessment (total fuel and power data, provides benchmarking);
- Level 2: Simple Dwelling Assessment with System Adjustments and Renewable Energy Reporting (as level 1 but with additional information on heating, hot water, cooking and LZTs);
- Level 3: Dwelling Systems and Equipment Assessment (based on individual pieces of equipment used in the dwelling).

Reflections from EVALOC

DomEARM energy audits were undertaken in 58 households as part of the EVALOC study. A physical survey template (Appendix E) was created to enable easy recording of the data required for the DomEARM assessment.

Generally, the surveys and assessment went smoothly and could be completed either through a sit-down conversation with the occupants, or a physical walkthrough of the home. Preferably the same researcher that undertook the physical survey would also complete the desk-based assessment.

5.3 Energy Generation (low-zero carbon technologies (LZTs))

Where LZTs are installed, it is useful to understand how they are performing and used in order to build a picture around household energy use and behaviours. Where possible (and applicable) the energy generation as well as the energy consumed by the systems should be monitored.

5.3.1 Metered solar PV electricity generation

Cost: £	**Time:** ⏳	**Skills:** 👍🏻👍🏻

Similar to providing monthly electricity and gas meter readings, if remote monitoring systems are not suitable, a useful way of collecting basic data on the performance of solar PVs is to record monthly meter readings from the generation (and export, if present) meter.

Reflections from EVALOC

This method of data collection may not be possible due to the location of the generation meter; examples were found in attic spaces requiring significant effort to access them.

It is also reliant on the occupants remembering to take down recordings; in the case of the EVALOC households, they maintained the records. However, this may not happen in all cases, and some households may need prompting.

5.3.2 Remote monitoring of LZTs

Cost: ~~£~~£££	**Time:** ⏳⏳⏳⏳⏳	**Skills:** 👍🏻👍🏻👍🏻👍🏻👍🏻

cross-cutting method

Similar to remote monitoring of energy use, it is possible to remote monitor LZTs such as:

- Solar PV systems
- Solar thermal systems
- Air/ground source heat pumps

The equipment required includes:

- Electricity meters (to monitor power used by pump; PV generation and export)
- Heat flux meters and temperature sensors (to monitor heat output/performance of heat pumps) (Figure 7)
- Pyranometers (to monitor solar irradiation)

Figure 7. Heat flux meter installed in air source heat pump system to measure system heat output. Following installation, it should be fully insulated as per the piping around.

Remote monitoring of heat pumps can provide frequent and accurate data on:

- The system heat output (using a heat flux meter)
- Electricity (power) used by the pump
- Ground/air temperature

By monitoring these variables over an extended period of time, it is possible to calculate the CoP (Co-efficient of Performance), and establish how the heat pump is performing in relation to its modelled/estimated performance.

In terms of the solar PV monitoring, this monitoring enables the calculation of generated electricity that is used within the household. This will then allow the researcher to calculate overall electricity use in the household and not just how much electricity is being used from the National Grid. However, it must be noted that this does not take into account any losses due to the inefficiencies of the system etc.

In addition it is useful to monitor the solar irradiation, which can be done through the installation of a pyronometer. This has a number of practical issues in that it needs to be mounted at the same angle and face as the PV system and may require working at height as well as drilling into the external fabric of the dwelling.

Such monitoring enables the collection and analysis of accurate monitoring data in terms of the performance of LZTs as well as the behaviours of the occupants.

Reflections from EVALOC

Appendix F contains a guide to the monitoring equipment installed in the EVALOC case study households. Whilst the remote monitoring equipment of the solar PV systems in EVALOC households was generally very successful, there were significant issues with the equipment monitoring the solar thermal and air source heat pumps in the case study households. As such, very little reliable data was available for analysis.

Whilst in part this was due to the poor installation of the monitoring equipment, it highlights the complexities of not only monitoring LZTs but also retrofitting The installation of heat flux meters within the EVALOC project was also relatively unsuccessful for a number of reasons including difficulties relating to the existing electrical wiring and circuitry and low flow rates within the existing systems.

Such issues could have been reduced by more detailed information being given to the monitoring equipment installers. However, this was difficult due to a lack of information present with the owners (other than the MCS certificates) and also the fact that several of the original installers had since gone out of business, or there were 'bad' relations between the owners and installers due to problems at the time of installation.

Further resources:

- The monitoring of solar thermal systems is complex due to the wide variation in systems, in terms of both circulation and power. Further information can be found in Monitoring energy and carbon performance in new homes, Energy Saving Trust (2008).

Top tip: *collect essential information on LZTs prior to any monitoring, including: manufacturer, make, model, system size and expected output, installer*
Most of this information can be found on the MCS certificate

5.4 Physical Fabric Performance

To understand how and where there is heat loss (and therefore its impact on the energy use within the dwelling) it is seen as increasingly important to measure the performance of the physical fabric of the dwelling. Such measurements can also be used to detect potential defects, which in turn can lead to increased running costs and energy use as well as decreased thermal comfort levels and even deterioration of the building fabric itself.

Figure 8. Thermal imaging camera, similar to that used in the EVALOC surveys.

5.4.1 Thermal imaging surveys

Cost: £££££	**Time:** ⌛⌛	**Skills:** 👐👐👐

Thermal imaging is a particularly useful tool in terms of assessing the physical fabric of a dwelling as not only can it be used a diagnostic tool, but also, due to its visualising of heat loss, it can also be used as an engagement and awareness tool. It is also a non-contact method yet allows an assessment of the installation of wall insulation, any potential failures in the thermal performance of the building fabric and the extent of thermal bridging across the façade. Where possible, it is worth undertaking a survey before and after changes have been made to the physical fabric to assess the impact of these improvements.

There are two survey approaches to thermal imaging; internal and external. Whilst an external survey involves less disruption of the occupants and can locate potential areas of heat loss, it is more difficult to get accurate results due to the reliance of thermal imaging on specific climatic conditions (no sun, dry, still, cold and cloudy). Internal surveys allow more accurate interpretation of issues related to heat loss, air leakage and the presence of moisture due to the more stable environmental conditions.

The high cost is mainly due to the initial upfront cost of the camera (Figure 8). However, less expensive versions, albeit the images are of lower quality, are available.

Top tip: *Remember to take wind, temperature and relative humidity measurements during the survey*

Reflections from EVALOC

When conducting an external thermal imaging survey, it is necessary to contact the police so that they are aware of the survey and as such are prepared if/when contacted by neighbours etc. For practical and safety reasons, two researchers are required to undertake the survey, and a period of at least 5-10minutes per dwelling should be allocated.

When undertaking an external survey, it is useful to find out the internal temperature as well as the external environmental conditions.

It is difficult to enable comparisons between images due to the many influencing factors such as sky radiation and internal temperature. Therefore, it is recommended that when reporting with the images that this is made clear, or the images are processed by a competent person.

Further resources:

Thermal imaging camera manufacturers such as FLIR (www.flir.com) and FLUKE (www.fluke.com) have online resources publicly available.

5.4.2 Air permeability tests

Cost: £££	**Time:** ⌛⌛	**Skills:** ✋✋✋✋✋

Air permeability tests (Figure 9) are mandatory for new buildings under the current Part L Building Regulations. They are useful and accurate measurement of air leakage pathways, which is an indication of the airtightness of the building. The airtightness of the building is important to measure in relation to improvements to the building fabric as generally the more air-tight, the fewer draughts there are and there is a reduction in the heating requirements of the dwelling.

The testing can only be undertaken by a specialist, and should be done to the ATTMA Standard (2007). The test is usually completed within one day but involves significant works within the dwelling including blocking up doors temporarily, and as such, the occupants should be made aware of the full procedure.

Air permeability tests were not undertaken during the EVALOC study.

Further resources

- Further information on the test procedure can be found in 'Post-construction testing – a professional's guide to testing housing for energy efficiency', Energy Saving Trust (2005).

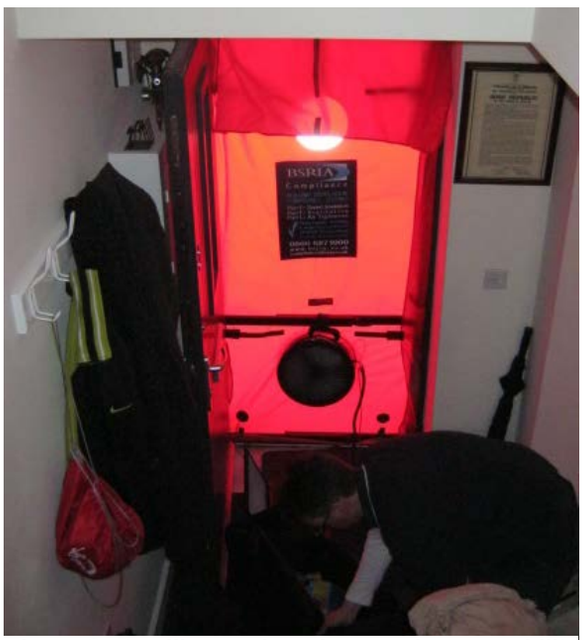


Figure 9. Dwelling undergoing an air permeability test.

Figure 10. Dwelling undergoing an U-Value test.

5.4.3 U-Value tests (heat flux sensors)

Cost: £££££	**Time:** ⌛⌛⌛	**Skills:** ✋✋✋✋✋

A U-value is a measure of heat loss in a complete building element, for example a wall, roof or floor. A low U-value indicates high levels of insulation. The U-values of an existing dwelling can be measured in-situ through the installation of heat flux sensors. These provide a direct measure of heat flux through

the building element, and subsequently the actual U-value of that element.

The testing requires both specialist skills and equipment. The testing is also undertaken over a period of at least two weeks and the installation of the equipment can require intrusive scaffolding or similar elements.

U-Value tests were not undertaken during the EVALOC study.

Further resources

- Further information can be found in 'Field investigations of the thermal performance of construction elements as built', BRE report 78132, Doran, S. (2000).

5.4.4 Remote visual inspection

Cost: ££	**Time:** ⏳	**Skills:** 🤚🤚🤚

Borescope (or fibrescope) investigation (Figure 11) of a cavity provides a means to inspect possible hidden defects within the construction of the wall itself which may impede the performance of retrofitted insulation. Although generally a hole is required to be drilled in the wall to provide access to the cavity, this technique inflicts minimal damage on the building structure. It is particularly useful as a follow-on tool to a thermal imaging survey; allowing areas of potential heat loss highlighted in the thermal imaging to be investigated more thoroughly for the reasons 'why'.

Remote visual inspections were not undertaken during the EVALOC study.

Further resources

- Further information can be found in 'Field investigations of the thermal performance of construction elements as built', BRE report 78132, Doran, S. (2000).

Figure 11. Borescope (image by www.extech.com).

5.4.5 Co-heating tests

Cost: £££££	**Time:** ⏳⏳⏳	**Skills:** 🤚🤚🤚🤚🤚

A co-heating test is a method of measuring the heat loss from a dwelling. It involves maintaining a constant temperature within the dwelling over a period of 1-3 weeks, whilst unoccupied. This allows the amount of electrical energy that is required to maintain the internal temperature to be measured, alongside the difference in temperature between outside and inside, from which the total heat transfer from the dwelling to outside can be measured. The testing requires both specialist skills and equipment.

Co-heating tests were not undertaken during the EVALOC study.

Further resources

- Further information on the test procedure can be found at: http://www.leedsmet.ac.uk/as/cebe/projects/coheatinc_test_protocol.pdf

5.5 Internal and External Environmental Conditions

The measurement and monitoring of internal and external environmental conditions enables the researcher to understand occupant comfort levels as well as the potential impact of physical and technical improvements on the environmental conditions of the dwelling. External temperature and relative humidity data are important to collect and analyse in relation to energy use (normalisation of heating data) as well as assess any correlation between internal and external conditions.

5.5.1 Spot measurements

Cost: £££	**Time:** ⏳	**Skills:** 🤚🤚

Spot measurements are one-off measurements of:

- Light (lux)
- Noise (dB)
- Relative Humidity (%RH)
- CO2 (ppm)
- Temperature (°C)

They are relatively simple to undertake, with a small amount of training in how to use the equipment (Figure 12) and how to record and analyse the data correctly and accurately. They are useful if the

Figure12. Equipment required for undertaking spot measurements.

installation of remote monitoring and/or long-term data loggers is not possible. It is recommended that measurements are taken over a period of at least 5 minutes, with an average then taken.

Reflections from EVALOC

The spot measurements were taken during both the semi-structured interview and walkthrough, which led to a number of practical issues being raised:

- Difficulties of handling equipment relative to the number (and hands) of the researcher/s particularly when there are time and space constraints.
- Undertaking measurements in someone's home; often occupants are not comfortable with researchers entering certain rooms or moving/handling furniture and furnishings to ensure standardised conditions (eg. Removing blinds to get accurate light levels, asking occupants to be quiet in their own homes in order for accurate sound measurements to take place).
- Timings; due to the length of survey, often the internal and external measurements were at different times of the day and as such reduce the comparative nature of the findings. In addition, the surveys had to take place at times to suit the occupant, thus some measurements were taken at night (light levels not comparative).
- Calibration of environmental meters; in reality the accuracy of the equipment varies despite similar make and model being used. In addition to this, the need to plug in the Watchdog places constraints on the results.

Top tip: *Only take spot measurements in key areas of the house (e.g. main bedroom, living, kitchen and bathroom), and outside.*

5.5.2 Data loggers

Cost: £££	**Time:** ⌛⌛	**Skills:** 👐👐

Light-touch environmental monitoring is a relatively simple and accessible method of providing temperature, relative humidity and even CO2 data on a continuous and regular basis (30 minute intervals recommended). This information is useful when building an overall profile of a dwelling and assessing the impacts physical interventions such as improved fabric measures (insulation, draught proofing etc) have made on the internal environmental conditions of the home; for example evidence relating to warmer average temperatures (winter and/or summer).

It is recommended that data be gathered before and after interventions have taken place, but post-intervention is still useful, and when several case study dwellings are analysed, can provide insights into the differences (and similarities) between dwellings.

The data loggers, such as hobos (Figure 13) and ibuttons, can log at a variety of rates; from one minute to daily and weekly. The rate of logging is dependent on the level of detail required for the study as well as the length of study.

It is crucial to record exact date, time and data logger references in order to ensure that the data can later be 'stitched' together and avoid inaccurate data being included in the overall analysis.

Top tip: *Use the return visits to change batteries etc. to gather further information (but only if required!)*

Reflections from EVALOC

It was often quite difficult to co-ordinate repeat visits to suit all households in one community to change the data loggers, increasing travel time etc. It was also not always possible to install the data loggers in 'standardised' locations due to occupant preference

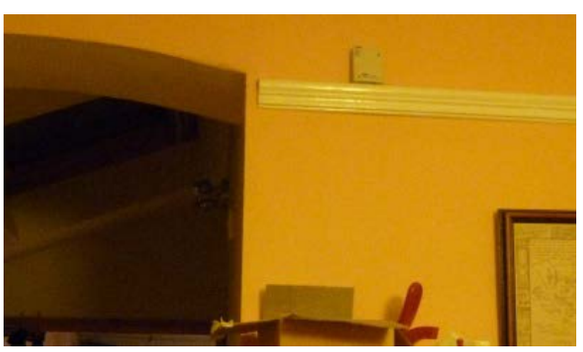


Figure13. Data logger installed in case study household.

and use of the rooms. It became obvious that it was important that the locations needed to be out of the way, and fixed to immoveable objects; as there were examples of furniture being re-arranged and the data loggers going missing. However, some occupants (and researchers) were hesitant to fix the loggers to the walls in case of damage to the finishes. It is recommended that data logger location and installation and removal protocols are to be put in place prior to the installation of any data loggers to ensure consistency across a set of case study dwellings.

5.5.3 Remote monitoring of environmental conditions

Cost: ££££	**Time:** ⏳⏳⏳	**Skills:** 🤚🤚🤚🤚🤚

The remote monitoring of environmental conditions only allows the researcher access continuous data from anywhere. It is usually collected at 5 minute intervals, providing deeper insights into the overall profiles of the home, and when analysed in relation to occupancy and energy use, can create understanding into comfort levels and correlations between energy use and environmental conditions.

Whilst the actual data collection units are not always vastly expensive, the remote monitoring hub increases costs substantially. In addition, some sensors require an electrical socket and this should be considered when installing the systems for a long period of time.

The types of data to be collected are:

- Internal:
    - Temperature (main living area and main bedroom)
    - Relative humidity (main living area and main bedroom)
    - CO2 (main living area and bedroom)
- External:
    - Temperature (sheltered, and out of direct sunlight)
    - Relative humidity (sheltered, and out of direct sunlight)

The data collection, storage and processing systems should also be considered carefully.

Reflections from EVALOC

The processing of the data proved difficult, particularly of sensors that had large amounts of

Figure 14. CO2 data logger plugged in, in case study household.

data missing. Missing data happened for a number of reasons including occupants switching sensors off to use the sockets for other purposes, occupants switching CO2 sensors off due to the irritation caused by the flashing light (particularly in bedrooms), and times when the main signal from the hub failed.

The issue of some data loggers requiring to be plugged in (Figure 14) was notable as often the occupants unplugged the loggers to access the socket, or if they were going away for an extended period of time. However, data loggers are now being produced where this is not required.

5.5.4 MVHR performance measurement

Cost: ££	**Time:** ⏳	**Skills:** 🤚🤚🤚

Often deep retrofits include the installation of a mechanical ventilation system, which controls the ventilation rates (air flow) within the dwelling. This can have an impact on the internal environmental conditions, as well as energy use of the household (see sub-metering section).

Therefore it is useful to undertake an MVHR performance measurement test. This involves the

Figure 15. MVHR performance test in progress.

measurement of the flow with an airflow device, in both ‘clean’ and ‘dirty’ filter conditions. Measurements are taken over a period of 15minutes (1 minute intervals).

Generally the test requires a competent person, who has undergone training in the equipment and test procedure (Figure 15).

MVHR performance measurement tests were not undertaken during the EVALOC study.

5.6 Occupant Guidance Process

A specific area of study within the wider field of household energy use is the interaction between occupants and the technical and physical aspects of their home. Of particular interest is the change in this interaction following refurbishment or installation of LZTs, and recent research shows that the guidance given to the occupants can have an impact on how they use their home, and control their environment.

5.6.1 Assessing guidance material

Cost: £	**Time:** ⏳	**Skills:** 👐

A variety of guidance material, including user guides, is given to occupants following both new build and retrofit building projects. Where possible, these should be evaluated by the researcher in terms of its:

- Clarity
- Comprehensiveness
- Usability

A number of aspects relating to these should be assessed including the format, quality of illustrations use of simple and understandable language as well as an adequate explanation of how to use, maintain and even future adaptation of all the key features. In addition such guidance material should have two sections; one specifically for the occupants and the other for the required professional services.

In addition to this assessment, it is important to understand the occupant’s perspectives and attitudes towards the guidance material. This can be done in the form of a self-completion questionnaire, or through an open-ended question in a semi-structured interview.

This was not undertaken during the EVALOC study.

5.6.2 Observation of user induction and guidance process

Cost: £	**Time:** ⏳	**Skills:** 👐

Where possible, the process in which the occupant is provided with guidance, and inducted into the various elements of their homes physical and technical systems should be directly observed by a researcher with knowledge and understanding within the building science field.

The process (both written and oral) should be evaluated in terms of: clarity, communication and user engagement. Similar to a walkthrough, it is also useful to take photos of the procedure but always with the written consent of all parties involved. Typically an induction visit will last about half an hour to an hour.

This was not undertaken during the EVALOC study.

5.7 Occupancy Satisfaction and Perception of Comfort and Control

Assessing the occupant’s levels of satisfaction and perception of their comfort and control provides understanding in terms of how they use and interact with their home, particularly in relation to the heating systems. This can be undertaken through a number of methods, both one-off measurements and more long-term monitoring. Whilst only two methods are discussed here, semi-structured interviews and walkthroughs are also useful techniques in evaluating this area.

5.7.1 BUS questionnaire

Cost: ££	**Time:** ⏳⏳	**Skills:** 👐

cross-cutting method

A BUS questionnaire is a self-completion questionnaire that is used throughout building performance evaluation and post-occupancy evaluation research studies, and is licensed through Arup. It is an effective way of making quantitative assessments of qualitative factors.

It is recommended that a questionnaire is sent to the occupants at least twice in one year (winter and summer) and the findings triangulated against actual physical performance of the homes data.

Due to the licensing, it is a requirement that the completed questionnaires are processed and analysed by Arup (Figure 16).

Figure16. Output from Arup analysis.

BUS questionnaires were not undertaken as part of EVALOC but similar questions were incorporated into the semi-structured interview to provide qualitative feedback on the occupants satisfaction and perception of comfort and control.

5.7.2 Thermal comfort diary

Cost: ££	**Time:** ⌛⌛	**Skills:** 👋👋

cross-cutting method

A longer-term survey method is the thermal comfort diary (Appendix G). This allows the occupants to record their levels of comfort over a period of one or two weeks, during the summer and winter periods (minimum). When undertaking more than one case study, it is useful if the occupants of the different dwellings complete the diary over the course of the same period. However, this is often not possible due to practical limitations.

It is useful to include both a normalisation sheet as well as a sheet for a specific week as this enabled the researcher to establish usual behaviours and comfort levels as well as atypical occasions and the response to this.

The diary can either be posted or hand-delivered by the researcher; both with advantages and disadvantages. Hand-delivering allows the researcher to fully explain how to complete it, as well as provide a visible reminder to complete it, but obviously increases the time involved by the researcher in the overall process.

Reflections from EVALOC

Thermal comfort diaries were given to 29 households (Group A) in the heating and non-heating seasons (2013). 20 completed forms were received from the non-heating season round and 18 were received from the heating season round. Most occupants found them relatively simple to complete.

In practical terms, it was felt necessary to visit the occupants, in person, with the first diary sheets to be completed. This enabled the researcher to explain the sheets and answer any queries the occupants may have had. The return of the diaries were reliant on the occupants posting them back to the researchers (using SAEs). It is possible that the completion rate of the diaries would have been increased if researchers visited in person to pick up the diaries. However, this takes significant resources, which may not be available.

5.8 Occupant Behaviours and Interactions

Understanding the behaviours and interactions of the occupants in relation to energy use in their home is vital to building a picture of household energy use, as well as providing explanations for patterns (and/or anomalies) in the actual energy use of the household.

5.8.1 Semi-structured interview

Cost: ££	**Time:** ⌛⌛	**Skills:** 👋👋

cross-cutting method

A semi-structured interview provides a more open structure, allowing answers to general topics to be explored further by the researcher. This allows themes relating to household energy use and behaviours to be discussed in detail, and often ensures more contextual data relating to the individual households are investigated.

A semi-structured interview provides the ‘why’, ‘how’ as well as insights into the attitudes, beliefs and perceptions of the occupants in relation to many aspects of energy use. It can provide corroboration of data from self-completion questionnaires, and affords the occupants more time to discuss a variety of related topics in detail. Generally, it should not take more than 1 hour and be undertaken within the home so that the occupants can refer to aspects of their own environment.

Whilst a semi-structured interview can include as open-ended questions as liked, it is very useful to have an interview guide (Appendix H) for the researcher. It is also recommended that two researchers are present; one engaging in discussion with the occupant/s whilst the other records notes and observes the physical environment. Audio recording the interview also enables the interview to be transcribed at a later date, which increases the potential for analysis.

Reflections from EVALOC

A number of challenges and issues were uncovered during the interviews; generally related to the practicalities of the organisation and administration of the interviews. Preparation for the SSIs often took as long as the interviews themselves, despite systems in place to reduce this.

Pilot interviews were undertaken prior to the researchers beginning the actual surveys. The interviews were estimated to take between one and two hours. Despite this, in reality, some interviews took over four hours. This was for a variety of reasons including; longer than expected answers by the respondent, interruptions to the SSI process. It was found that often if more than one person was present during the interview (often with couples, both had been involved in the LCC and were interested in participating), this provided rich answers, but at the same time, increased the overall length of the interview. It was also often found difficult to keep to the questions/themes required to ensure all aspects were covered.

All 88 interviews were completed between mid-May and mid-August 2012 by 4-5 researchers (two researchers per interview). Generally, three interviews were completed during one day (morning, afternoon and evening interview) which, although reduced the time out of the office, did place pressure on the mental and physical faculties of the researchers and often did not allow time for post-processing to be undertaken immediately after the interview (it was found that the post-processing and data input took over two times as long as the interview length). Also, flexibility on the side of the researcher was required as often respondents were not able to undertake weekday interviews and thus the researcher was often needed to work evenings and weekends.

Top tip: *Take time immediately after the interview to record your observations, in relation to the key themes, in written format*

5.8.2 Video diary

Cost: ££	**Time:** ⌛⌛	**Skills:** 🖐🖐

cross-cutting method

A video diary (by the occupants) over an extended period of time is an effective way of identifying issues with control and functional aspects of the home, but does require sustained involvement from the occupants, which may result in research fatigue.

It is recommended that a video recorder and memory cards are given to the occupants for use over one year (to cover all seasons). It should be stated that the video is only to be used to record events relating directly to: satisfaction, comfort, control and changes in the demographics and physical and technical aspects of the home.

Video diaries were not undertaken during the EVALOC study.

5.8.3 Heating control questionnaire

Cost: £	**Time:** ⌛	**Skills:** 🖐🖐

cross-cutting method

A self-completion questionnaire specifically related to what heating controls the occupants have and use is useful as a triangulation tool for findings relating to control, comfort, interactions and behaviours from other survey methods such as semi-structured interviews, walkthroughs etc.

The questionnaire used in the EVALOC project can be found in Appendix I.

Reflections from EVALOC

The use of the heating controls questionnaire provided the researchers an opportunity to verify answers given in the SSI, particularly in relation to the respondents understanding of the heating controls that they used, as opposed to what they had. It also provided the occupants to respond to questions relating to heating during the heating season (the SSI was undertaken during the summer months) and as such is not reliant on memory, but could assess their heating controls within an appropriate context.

Sent out as a paper questionnaire, approximately two-thirds of the households returned the questionnaires, without additional prompting. It was felt that in the cases of some households, a reminder would have been useful to increase the number completed. However, the majority of completed questionnaires were returned between 5-7 days after receipt, with another block of returns after the second week.

5.8.4 Remote monitoring of interactions (windows/doors)

Cost: £££	**Time:** ⌛⌛⌛⌛⌛	**Skills:** 🖐🖐🖐🖐🖐

To provide continuous data on the interactions of the occupants with the physical aspects of their home, open/close sensors on windows and doors can be installed with the remote monitoring system (Figure 17).

The type of fixings should be discussed with the occupants in advance of installation as they can prove problematic and often damage the finishes (if not uPVC frames).

Reflections from EVALOC

Whilst the data gathered is useful in terms of establishing when the windows and doors were opened, due to the data being gathered every 5

minutes, it was not possible to accurately establish how many times the windows and doors were opened; e.g. the window could be opened and closed many times within the five minute logging interval, but this would not be recorded.

In addition, the fixings were often inadequate (particularly on doors) and often fell or became loose creating false readings. Furthermore, due to a lack of communication between the sensor installer and the occupants, it was found that some sensors were placed on windows that simply were never opened. This highlights the need for discussions and a pre-installation meeting (on site) between all parties to ensure resources are not wasted.

> ***Top tip:*** *Take a sensible approach to the locations of the sensors e.g. not on windows/doors that are not used and in rooms that wider environmental conditions are not being monitored either.*

5.9 Occupancy Levels and Use Patterns

A critical aspect for analysing the energy and environmental data is to capture the occupancy levels and use patterns within the home.

5.9.1 Remote monitoring of occupancy

Cost: £££	**Time:** ⌛⌛⌛⌛⌛	**Skills:** 👋👋👋👋👋

A passive infrared presence detector (PIR) can be used to monitor the occupancy of the home, when placed near the front (main) entrance and/or in different rooms (depending on the level of detail required within the research project). Occupancy levels identified from the PIR can be compared with the normalization sheets (described below) to see if there is any variation. They can also be triangulated against physical data for energy use and used to help explain variations.

Reflections from EVALOC

In reality it was difficult to install a PIR in many of the homes due to the location and lack of sockets in hallways. Furthermore, the PIR could not distinguish between numbers of people entering the home. Establishing occupancy levels has been difficult in numerous research projects, but developments in alarm systems etc. suggest that the technology to fully capture this data is near (price dependent!).

Figure 17. Window sensors monitoring the opening and closing of the windows in case study households.

Figure 18. PIR sensors can monitor occupancy, but are very dependent on being placed in a suitable position.

5.9.2 Activity logging and normalisation sheets

Cost: £	**Time:** ⌛⌛	**Skills:** 👋👋

cross-cutting method

It is vital to record how the occupants are actually using their home. Whilst sub-metering is very useful, it is worth providing verification of this with normalisation and logging sheets, which are completed by the occupants and capture how the occupants use the home. Ideally, this would be undertaken for 2-4 weeks over both the winter and summer.

A normalisation sheet is completed by the occupants, and describes the whole household's 'typical' activities and occupancy patterns.

In addition to the normalisation sheet, occupants should be given a set of paper copies (with spares) of an activity logging sheet (Appendix J) to cover a set time period (preferably one month). Ideally the sheets should be completed in both winter and

summer. The researcher should describe how to use and complete the sheets to the occupants face-to-face. The sheets can either be returned via SAE or during a follow-up visit from the researcher, depending on resources etc.

Reflections from EVALOC

By hand-delivering the sheets, the researcher was able to communicate the reasons for the sheets directly, setting the respondent at ease, as well as finding out if and when the respondent would be able/willing to complete the sheets. This allowed more personalised reminders to be sent, if and when the time came and it is also believed that this led to greater input and understanding of what was required by the occupants, as they were able to ask questions to the researcher directly. It was found that the return was higher in some communities than others; this may have been for several reasons including the fact that the areas with least response were communities with the least direct LCC participation.

Reviewing the sheets, it was obvious that some respondents provided more detailed responses than others, which does have an impact on the level of analysis that can be undertaken on individual households. The timing of issuing the sheets is critical in terms of successful response rate; in one case, the household was leaving the next week for 3 months. Also, the school holidays fell during the period of return, and as such, it meant that there was the potential to get non-typical responses. This was combatted in a number of ways; the researcher expressly stated to choose a typical week (even if it meant returning the sheets after the given deadline); and creating a two-sided sheet allowing the typical weekly routine to be captured as well as any differences/changes in the week in which the sheets were completed.

5.10 Community engagement

Whilst this indicator may not be relevant in every household energy use study, it is useful when trying to establish how low carbon communities can incorporate a wider local audience, as well as understand the type and motivations of people who become involved in community energy projects. Two techniques to garner this information are the semi-structured interview and social network analysis (discussed in the next section).

5.11 Communication networks

The importance of energy communication, and consequent passing of knowledge and information (informally and formally) relating to energy use as well as retrofit measures is being more and more recognised. An established social science method designed to capture such information is social network analysis.

5.11.1 Social network analysis

Cost: £	Time: ⌛	Skills: ✋✋✋✋

cross-cutting method

Social network analysis (Figure 19) is a social science research tool that provides data relating to energy communications; who, when and where people discuss energy-related topics. This can provide crucial information on:

- Connections within existing communities;
- Changes in energy communications;
- Impact of low carbon community groups in terms of providing advice/support.

A fun and relatively simple tool, it takes approximately 10 minutes (but can be longer depending on participants) and can be incorporated easily into a wider survey and/or semi-structured interview. It provides a prompt for the respondents and guidance on how to undertake it, and what questions to ask are included in Appendix H.

Learnings from EVALOC

The social network analysis in the EVALOC project was undertaken within the semi-structured interview. Although this did work well; providing prompts for further, related discussion, it was also felt that due to the length of the interview and the fact that it was undertaken at the end meant that a lot of relevant discussion had already happened, and the respondents found themselves repeating statements.

In addition, a high level of specific skills and knowledge are required to analyse and report on the results competently.

Figure 19. Social network analysis being undertaken as part of the EVALOC study.

Chapter 6
Data management and analysis

The quantity of data collected during the M&E of household energy use activities can be huge, and in a variety of formats. This raised challenges within the EVALOC study in terms of both data management and analysis, which are both critical aspects of M&E; without good management, the data cannot be analysed to its full potential and the information collected will not be disseminated and used to inform future work and add to the body of evidence relating to household energy use.

The data gathered during the monitoring and evaluation of household energy use is both qualitative and quantitative, thus requiring various management and analysis methods.

6.1 Qualitative Data

A data management tool such as NVivo is useful as it provides 'space' for a large variety of qualitative sources (researcher observations, images, transcripts, audio, video) to be collated into one place. Practical challenges relating to the need for several researchers to access the data, sometimes simultaneously, should be taken into consideration.

When analysing qualitative data, it is important to code the data, i.e. identify categories and themes within the data that are relevant to the indicators, and overall research questions.

6.2 Quantitative Data

Substantial quantitative data can be collected, especially if remote monitoring and smart metering is used. It is therefore critical to ensure this data is processed, managed and analysed in a co-ordinated manner. A variety of software is available to manage, process and analyse quantitative data including Excel, Matlab, Clover and SPSS. The choice of which is dependent on what is most suitable for the type of data, as well as the resources and skills available. For example, Excel and SPSS are suitable for analysing quantitative responses from self-completion questionnaires, and whilst Matlab and Clover allow automatic processing of time-data (remote monitoring), they require training.

6.2.1 Reflections from EVALOC

Critical lessons were learned during the EVALOC study particularly in relation to the quantitative data gathered through remote monitoring. Due to failures with the monitoring kit itself, but also the sheer amount of data generated, it was found to be difficult to ensure all data was accurate and managed effectively. As such, it is vital to have available resources to enable checking of the data (either through in-person home visits by expert persons or a web-based diagnostic tool that allows quick and simple analysis of the data to be run in order to uncover any potential anomalies.

6.3 Overall data analysis framework

There are four major activities within the analysis framework, as shown in Figure 20: data collection; data reduction; data display; and conclusions – drawing and verifying[4]. Following the collection of data, the process of reduction must be undertaken to select, simplify and focus upon key analysis themes to organise the data to allow conclusions and verification in relation to the research questions to be formed.

Data display is simply that; a way to display the data in an organised, compressed manner that allows conclusions to be drawn. There are many types; and the choice of which will evolve as the analytic work continues. However, the majority of types to be used within this study are: matrices, graphs, charts, and networks.

By using the iterative process of verification and conclusion drawing, the researcher can test the data as findings emerge; regularities, patterns, and explanations.

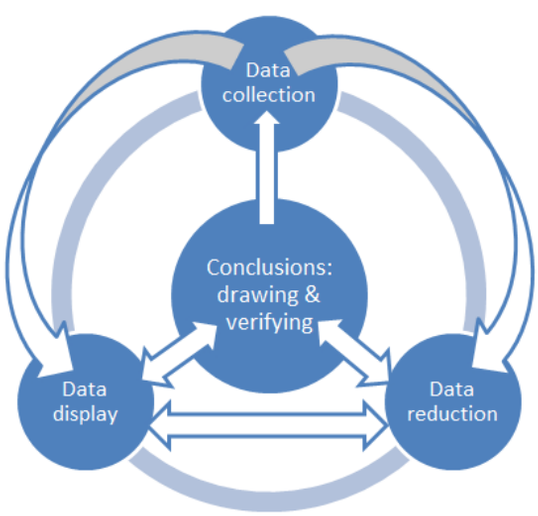


Figure 20. Data analysis framework.

[4] Miles, M and Hubrman M.(1994). Qualitative Data Analysis: an expanded sourcebook. SAGE

Chapter 7
Outputs and dissemination

It is necessary to be able to communicate the data to relevant stakeholders including:

- Individuals
- Community organisations
- Fellow academics
- Practitioners
- Policy makers

Due to the wide variation in technical knowledge, interests and focus of these different audiences, it is important that the data is packaged appropriately; both in terms of language used and visual presentation.

Figure 21 outlines the different types of output the EVALOC project seeks to undertake.

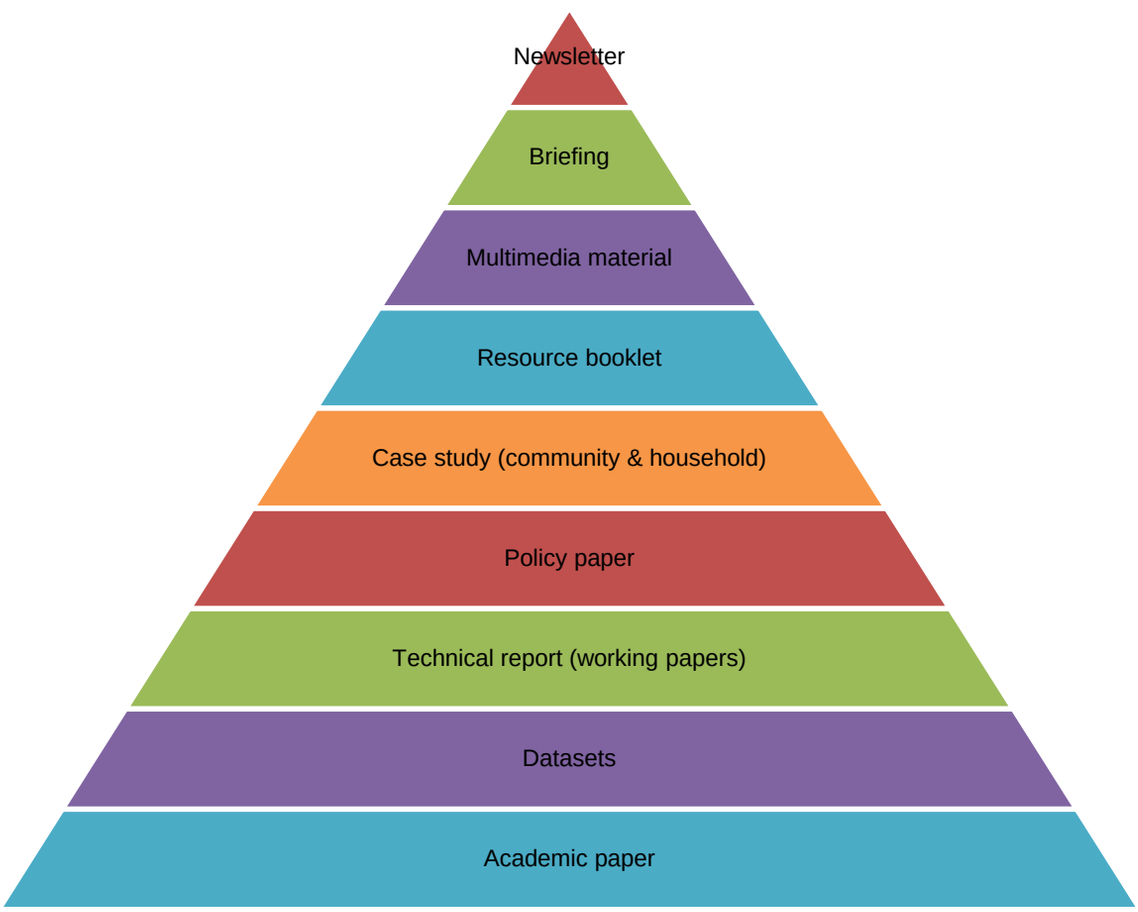


Figure 21. Types of outputs used to disseminate knowledge learned from M&E of household energy use research studies.

Appendices

Appendix A: Basic consent form

CONSENT FORM – Household survey

Full title of Project: Evaluating the impacts, effectiveness and success of DECC-funded low carbon communities on localised energy behaviours (EVALOC)

Name, position and contact address of Researcher:
Professor Rajat Gupta.
School of Architecture, Oxford Brookes University,
Headington Campus, Gipsy Lane, Oxford OX3 0BP
Email: rgupta@brookes.ac.uk , Tel: 01865 484049

		Please tick (✓) box Yes	No
1.	I agree to allow EVALOC researchers to access my electricity and gas usage data over the past years. I can show them my bills, or they can use my meter registration numbers to find the data from government records.	☐	☐
2.	I agree to allow EVALOC researchers to take digital photos of my home from inside and outside during and after this survey.	☐	☐
3.	I agree to allow EVALOC researchers to take a thermal image (infra-red photo) of my home during winter, to identify any areas with high heat-loss. (see example of thermal image at the end of the form)	☐	☐
4.	I agree to allow EVALOC researchers to share the thermal image of my home with my Low Carbon Community through community events, without giving my name or address.	☐	☐
5.	I agree to allow EVALOC researchers to use a thermal image of my home (without giving my name or address) in written publications.	☐	☐
6.	I agree to allow EVALOC researchers to estimate the energy use and emissions from my home and show them on a mapping system. (see example of Carbon Map at the end of the form)	☐	☐

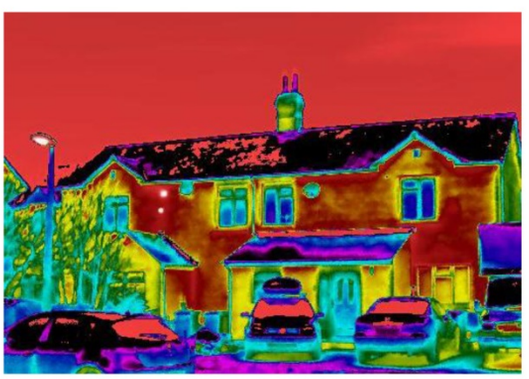
7. I agree to allow EVALOC researchers to share the mapped energy estimates with my Low Carbon Community through community events and publications. ☐ ☐

8. I agree to provide to EVALOC researchers monthly readings from my gas and electricity meters for the coming 2 years (2012-2014) ☐ ☐

Name of Participant	Date	Signature

Name of Researcher	Date	Signature

Example of a Carbon Map for a Community



Example of a Thermal Image

9. I have received an amount of £_____ from EVALOC researchers as a gift for particpating in the household survey. ☐ ☐

Name of Participant	Date	Signature

Name of Researcher	Date	Signature

Appendix B: Essential information questionnaire (building and household characteristics)

ESSENTIAL INFORMATION QUESTIONNAIRE

EVALOC
EVALUATING LOW CARBON COMMUNITIES

For Office Use only

Researcher:
Community ID:
Household ID:
Respondent ID:

Street View of the House

Name of Community:

Building Address:

Telephone:

Email:

Preferred Means of Contact (email/telephone/sms):

Preferred Week/s for Interview

Date of EIT Completion:

CONTACT INFORMATION

1 Main respondent:

2 Gender:
O Male O Female

3 Age:

BUILDING CHARACTERISTICS

4 Which of the following best describes your house?
O Bungalow O Detached O Flat O End-terrace
O Mid-terrace O Semi-detached O Other, please specify:

5 When do you think your house was constructed?

HOUSEHOLD CHARACTERISTICS

6 Which of the following best describes your household?
O Owner occupied O Local authority O Private rented
O Registered Social Landlord O Shared Ownership
O Other, please specify:

7 Family Composition:
O Single O Couple O Family O Other

8 How many people live in your house?
Adults: Children: Total:

9 How long have you lived in your house?

10 Are you aware of any energy/climate change groups in your area?
O Yes O No

11 If **YES**, please provide the name of the group

ENERGY SAVING IMPROVEMENTS (physical)

12 Are there any energy saving improvements installed in your home?
O Energy efficient lighting O Energy efficient appliances (A+ rated)
O Draught proofing O Wall insulation O Cavity wall insulation
O Double glazing O Triple glazing O Insulated pipework
O Floor insulation O Loft/roof insulation
O Improved heating system incl. improved controls
O Renewables (solar thermal, pv, air source heat pumps, ground source heat pumps etc)
O None
O Other, please specify:

13 Did you receive any funding towards these improvements from an energy scheme/programme/initiative?
O Yes O No

14 If YES, who helped you?

ENERGY SAVING IMPROVEMENTS (behavioural)

15 Have you received any information that has changed the way you use energy in your home?
O None
O Community event/workshop
O Energy display monitor/smart meter
O Leaflet/brochure
O In home advice on energy use by an energy advisor
O Independent advisor
O Other, please specify:

16 Who provided this information?

17 If you have not used an energy display monitor previously, would your household be interested in borrowing one?
O Yes O No

Thank you for your time and cooperation in completing this questionnaire

Appendix C: Annual energy data consent form

CONSENT FORM – Retrieval of energy data

Full title of Project: Evaluating the impacts, effectiveness and success of DECC-funded low carbon communities on localised energy behaviours (EVALOC)

Name, position and contact address of Researcher:
Professor Rajat Gupta.
School of Architecture, Oxford Brookes University,
Headington Campus, Gipsy Lane, Oxford OX3 0BP
Email: rgupta@brookes.ac.uk , Tel: 01865 484049

EVALOC Household ID: _____

Participant Name: _____

Participant Address: _____

_____

Participant Primary MPAN No: _____

Participant Secondary MPAN No: _____

Participant MPRN No: _____

	Please tick (✓) box	
	Yes	**No**
I agree to allow EVALOC researchers to access my electricity and gas usage data over the past years. I can show them my bills, or they can use my meter registration numbers to find the data from government records.	☐	☐

_____ _____ _____

Name of Participant Date Signature

_____ _____ _____

Name of Researcher Date Signature

HOUSEHOLD MONTHLY METER READINGS

NAME:_____ ADDRESS:_____

Please could you fill in this form every month so that we have a record of your monthly energy use. It would be really helpful if the date of the reading is the same each month ie the 1st of each month so please record the exact date of the reading and try to keep the date as similar as possible. We will collect it every 3 to 6 months when we come to replace the data loggers in your home. Thanks very much!

Any issues such as how to access your meters etc please contact:
Laura Barnfield
Email: lbarnfield@brookes.ac.uk
Phone: 01865 484206

	DATE	ELECTRICITY 1 (day only if applicable)	ELECTRICITY 2 (night only if applicable)	GAS	OIL	Comments (note oil delivery dates and amounts etc)
0						
1						
2						
3						
4						
5						
6						

NB. Electricity 2 may not be applicable to all houses; if unsure please contact us directly.

Appendix E: Energy audit template

Energy Audit Completion Sheet: All rooms

	TV	DVD/VCR	Blu-Ray	Modem/Router	Set top box	Radio	Games console	Energy display
Text description *(incl. size and energy efficiency class)* ***For TV: CRT/LCD/plasma***								
No. of similar units								
Make								
Model								
Date of purchase								
On/in use time (hrs/day & days/wk)								
Standby/sleep time (hrs/day & days/wk)								
Weekend/Seasonal variance?								
Tick if picture taken	❑	❑	❑	❑	❑	❑	❑	❑

	Computer	Monitor	Laptop charger	Printer/Scanner	Phone charger	Power adaptor	Tablet	
Text description *(incl. size and energy efficiency class)* ***For TV: CRT/LCD/plasma***								
No. of similar units								
Make								
Model								
Date of purchase								
On/in use time (hrs/day & days/wk)								
Standby/sleep time (hrs/day & days/wk)								
Weekend/Seasonal variance?								
Tick if picture taken	❑	❑	❑	❑	❑	❑	❑	❑

Kitchen

	Hob	Oven	Grill	Microwave	Kettle	Toaster	Iron	Vacuum
Text description *(incl. energy efficiency class) Hob: induction/electrical resistance*	Fuel:	Fuel:						
No. of similar units								
Make								
Model								
Date of purchase								
Funding source								
On/in use time (hrs/day & days/wk)								
Standby/sleep time (hrs/day & days/wk)								
Weekend/Seasonal variance?								
Tick if picture taken	❑	❑	❑	❑	❑	❑	❑	❑

	Washing machine	Tumble dryer	Dishwasher	Fridge	Freezer	
Text description *(incl. size and energy efficiency class)* ***For washing: weight(kilos) & drying function***						
No. of similar units						
Make						
Model						
Date of purchase						
Funding source						
Number of cycles (per week) ***@40deg***						
Number of cycles (per week) ***@60deg***						
Number of cycles (per week) ***@90deg***						
Standby time (hrs/day & days/wk)						
Weekend/Seasonal variance?						
Tick if picture taken	❑	❑	❑	❑	❑	❑

Bathroom

	Shower	Hair dryer	Straighteners/curlers	Electric toothbrush				
Text description *(incl. size and energy efficiency class)*	Electric:							
No. of similar units								
Make								
Model								
Date of purchase								
On/in use time (hrs/day & days/wk)								
Standby/sleep time (hrs/day & days/wk)								
Weekend/Seasonal variance?								
Tick if picture taken	❑	❑	❑	❑	❑	❑	❑	❑

Additional

	Mobile heater	Mobile fan	Dehumidifier	MVHR	Burglar alarm			
Text description *(incl. size and energy efficiency class)*								
No. of similar units								
Make								
Model								
Date of installation								
On/in use time (hrs/day & days/wk)								
Standby/sleep time (hrs/day & days/wk)								
Weekend/Seasonal variance?								
Tick if picture taken	❑	❑	❑	❑	❑	❑	❑	❑

Lighting

	Lighting type A								Lighting type B							
Room	Type/Wattage (CFL, LED)	No.	Daily hours on (win)	Daily hours on (spr)	Daily hours on (sum)	Daily hours on (aut)	Funding source/ date of install	Photo	Type/Wattage (CFL, LED)	No.	Daily hours on (win)	Daily hours on (spr)	Daily hours on (sum)	Daily hours on (aut)	Funding source/ date of install	Photo
								❑								❑
								❑								❑
								❑								❑
								❑								❑
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								❑								❑

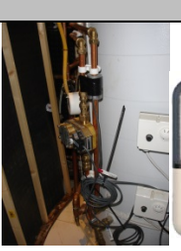
Appendix F: Monitoring equipment guide

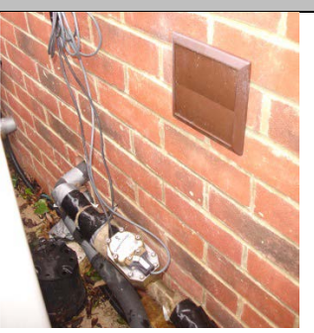
Energy monitoring (using smart metering)				
The electricity and gas consumption in your house will be monitored through the installation of secondary meters and a pulsed output device. It will enable the recording of real-time energy use, which will be collected remotely via a GPRS network.				
	Location	**Equipment**	**Power**	**Picture**
Electricity				
In the case of an electricity meter a pulse output corresponds to a certain amount of energy passing through the meter (Kwhr/Wh).	Meter cupboard	Pulse output single phase electricity meter Radio-tech Ecochirp pulse transmitter (35x35x170)	240V	
Gas/Oil				
A secondary gas meter will monitor the total gas supplied from mains. NB. If oil, a sensor will be fitted to the boiler	Next to existing gas meter	Secondary gas meter Radio-tech Ecochirp pulse transmitter (35x35x170)		

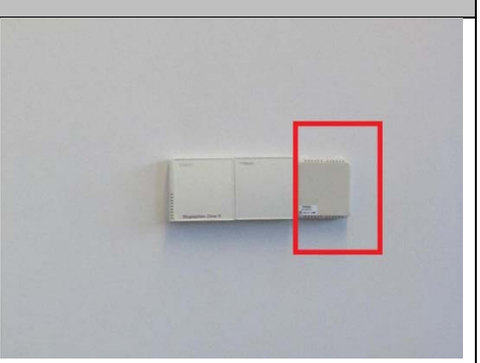
Performance of Low-zero Carbon technologies

The performance of the low-zero carbon technologies is monitored using heat flow meters and secondary electricity meters.

Note: the electricity meters used to monitor power input; solar generation, and solar export are similar to those used to monitor the electricity import (see image above).

	Location	Equipment	Power	Picture
Solar PV				
An electricity export meter will provide information on the energy exported to the grid which cannot be registered by a normal electricity meter.	Meter and pyranometer are placed on the roof. A cable is running along the dwelling to a 230V socket outlet.	Electricity meter to be placed in AC side of solar PV system Pyranometer with transmitter.	Local 230 V socket required.	 
Solar Thermal				
The measurement of the collectors heat output is calculated through meters installed on the flow and return of the solar thermal system. The system's electricity consumption is also measured through a secondary electricity meter for the solar thermal controller and pump.	Meter and pyranometer are placed on the roof. A cable is running along the dwelling to a 230V socket outlet.	Heat flux meter and pulse transmitter for energy. Secondary electricity meter and pulse transmitter. Pyranometer c/w transmitter (if not existing for PVs)	Local 230 V socket required.	  

Heat Pump				
The heat output of a heat pump is usually through a water loop feeding either to space heating or to hot water tank. This is where the heat flux meter is inserted to measure the system output. The system's electricity consumption and the ground or appropriate air temperature are also measured.	Attached to the system flow and return pipes.	Heat flux meter and pulse transmitter for energy. Secondary electricity meter and pulse transmitter.		 

Internal Environment Monitoring				
Temperature, Relative humidity, CO_2 levels and a schedule of opening/ closing of windows is going to be monitored in two selected spaces within the households (living room and bedroom). In addition occupancy levels will be established by a passive infrared detector (PID) which is critical for understanding the monitoring results. The monitoring equipment will comprise of small-sized, non-intrusive data loggers approximately the size of a room thermostat that will be attached to the wall with temporary adhesive pads. The loggers will record the internal conditions and submit half hourly data to the central data hub.				
	Location	**Equipment**	**Power**	**Picture**
Temperature and humidity transmitters				
The temperature and humidity of each room is going to be measured by portable data loggers.	Living room and bedroom. Positioned at half room high (e.g. next to existing thermostats) away from direct sunlight, heat sources and draughts. Not behind room furniture.	Radio-Tech Temp/RH sensor/transmitter 80x80x25 mm	Battery	

CO_2				
A CO_2 sensor will monitor the air-quality of the spaces in terms of their carbon dioxide CO_2 levels.	Living room and bedroom. Positioned at half room high. The transmitter contains a small flashing light in the form of the sensor.	CO_2 probe Radio-tech Ecochirp pulse transmitter (35x35x170)	Local 230 V socket required.	
Opening and closing of windows				
Contact sensors will measure the open and closed status of the external windows and doors of the home. The seasonal differences of the window and door opening behaviour will be analysed in relation to the indoor and outdoor temperature**.**	All window openings in living room, kitchen and bedroom.	Integrated sensor and transmitter	240V	
Occupancy levels				
A Passive Infrared Detector (PID) device will establish the occupancy levels of the house. PID acts as a motion detector catching the heat emitted by animated objects and recording changes in a specific area.	Next to the main entrance.	PID transmitter	Local 230 V socket required.	

External Environment monitoring

An external temperature and relative humidity sensor will be used to provide information on the external environmental conditions.

Note: There will be only one external sensor in every community and will be located as appropriate. Thus, it may not necessarily be outside your house.

	Location	Equipment	Power	Picture
External temperature and relative humidity sensor				
Outside temperature and Relative Humidity.	Outside. High level, shaded wall if possible.	Radiotech weather station with small mounting brackets fixed with two screws. 210x180x75 mm	Battery	

Data acquisition system

A Data Acquisition unit will collect the data from all the transmitters and secondary meters and send them to a web server via GPRS (mobile telephone where they are retrieved and analysed by Oxford Brookes researchers.

	Location	Equipment	Power	Picture
Data acquisition hub				
	Inside a cupboard or at loft space (ideal). Mobile telephone reception must be available at hub location.	RT:WI5 Data Hub	240V Local 230 V socket required.	

Appendix G: Thermal comfort diary

THERMAL COMFORT DIARY

This diary is used to record your thermal comfort over the course of one week. Please answer each of the questions below by ticking one of the options provided. If you are away from the house during a time period please indicate this in the location box.

Name:							Week beginning: / / 2013					
	Monday			Tuesday			Wednesday			Thursday		
	Morn	Aft	Eve	Morn	Aft	Eve	Morn	Aft	Eve	Morn	Aft	Eve
LOCATION *(room you are in at time of completing form)*												
1. COMFORT How do you feel at this time? *(please indicate with tick or 'x')*												
Much too cool												
Too cool												
Comfortably cool												
Comfortably neither warm nor cool												
Comfortably warm												
Too warm												
Much too warm												
2. You would prefer to be: *(please indicate with tick or 'x')*												
Much warmer												
A bit warmer												
No change												
A bit cooler												
Much cooler												
3. At this time, how would you rate your overall comfort? consider temperature, humidity, air quality *(please indicate with tick or 'x')*												
Very uncomfortable												
Moderately uncomfortable												
Slightly uncomfortable												
Acceptable												
Slightly comfortable												
Moderately comfortable												
Very comfortable												
4. ACTIVITY LEVELS What have you been doing in the last hour? *(tick all that apply)*												
Sitting (passive)												
Sitting (active)												
Standing (passive)												
Standing (active)												
Walking (indoors)												
Walking (outdoors)												
5. CLOTHING At this time, what layers of clothing are you wearing? *(tick all that apply)*												
Short sleeve shirt or top												
Long sleeve shirt or top												
Vest												
T-shirt												
Long-sleeved sweater/cardigan												
Sleeved robe/dressing gown												
Jacket/coat												
Trousers/long skirt												
Shorts/short skirt												
Dress												
Leggings												
Tights												
Socks												
Shoes												
Slippers												
Sandals/flipflops												
Other (please describe):												
6. CONTROLS *(tick all that apply; in case of doors, windows and extracts please note number of opened/in use)*												
Internal doors open												
External doors open												
Window open												
Blind down												
Curtain closed												
Localised light on												
General heating on												
Localised heater on												
Air conditioning on												
Fan on												
Extract on												

Please turn over to complete Friday, Saturday and Sunday

THERMAL COMFORT DIARY

	Friday			Saturday			Sunday		
	Morn	Aft	Eve	Morn	Aft	Eve	Morn	Aft	Eve
LOCATION *(room you are in at time of completing form)*									
1. COMFORT How do you feel at this time? *(please indicate with tick or 'x')*									
Much too cool									
Too cool									
Comfortably cool									
Comfortably neither warm nor cool									
Comfortably warm									
Too warm									
Much too warm									
2. You would prefer to be: *(please indicate with tick or 'x')*									
Much warmer									
A bit warmer									
No change									
A bit cooler									
Much cooler									
3. At this time, how would you rate your overall comfort? consider temperature, humidity, air quality *(please indicate with tick or 'x')*									
Very uncomfortable									
Moderately uncomfortable									
Slightly uncomfortable									
Acceptable									
Slightly comfortable									
Moderately comfortable									
Very comfortable									
4. ACTIVITY LEVELS What have you been doing in the last hour? *(tick all that apply)*									
Sitting (passive)									
Sitting (active)									
Standing (passive)									
Standing (active)									
Walking (indoors)									
Walking (outdoors)									
5. CLOTHING At this time, what layers of clothing are you wearing? *(tick all that apply)*									
Short sleeve shirt or top									
Long sleeve shirt or top									
Vest									
T-shirt									
Long-sleeved sweater/cardigan									
Sleeved robe/dressing gown									
Jacket/coat									
Trousers/long skirt									
Shorts/short skirt									
Dress									
Leggings									
Tights									
Socks									
Shoes									
Slippers									
Sandals/flipflops									
Other (please describe):									
6. CONTROLS *(tick all that apply; in case of doors, windows and extracts please note number of opened/in use)*									
Internal doors open									
External doors open									
Window open									
Blind down									
Curtain closed									
Localised light on									
General heating on									
Localised heater on									
Air conditioning on									
Fan on									
Extract on									
Total number of internal doors (open & closed in house):									
Total number of external doors (open & closed in house):									
Total number of extract fans in house:									

Thank you very much – please don't forget to return this to us using the SAE provided

Appendix H: Semi-structured interview guide (including social network analysis and walkthrough)

Contact Details	
Community ID:	Main Respondent:
Household ID:	Address:
Respondent ID:	
Date/Time of Interview:	Telephone Number:
Interview Room:	❑ *Switch mobile phones off*

Checklist for Items Required Prior to Interview
(confirm that these are present at start of interview and state that they will be copied/photographed at the end of the main interview)

❑ *SAP rating/calculations*	❑ *EPC rating*
❑ *MPAN number/electricity meter number (ask to see electricity bills)*	❑ *MPRN number/gas meter number (ask to see gas bills)*

Introduction

❑ Introduce yourself and co-researcher

❑ Establish contact with main respondent:

'hello, good to meet you, can we go somewhere where we can all sit down together?'

Thank you very much for giving your time to take part in this interview today.

Before we begin, can we just **confirm that you have your latest energy bills and energy performance certificate** (if applicable) to hand? If so, we would like to take copies/photographs of them at the **end of the interview** – thank you.

To explain a bit more about what we shall do today; we shall be taking a few **spot-check measurements of temperature, light levels, CO2, noise** and **air humidity**.; we shall be **photographing** aspects of your home such as the **boiler type**; any **energy saving improvements**; any unique **elements to the layout/use/controls**. And with your permission we will **take annual gas** and **electricity meter readings**. We will take these after the main interview during the walkthrough where you can explain any issues/aspects of each room. The whole process should not last longer than **2hrs.** *There will be some structured questions, and some semi-structured but* ***PLEASE REMEMBER THAT THERE ARE NO RIGHT OR WRONG ANSWERS*****!**

Please remember that **all information gathered will remain anonymous except to the core EVALOC researchers**.
Although we already have a **signed consent form**, can you also sign this [consent form]...and then if you are happy with everything, we shall begin!

❑ Consent form signed
❑ Audio equipment switched on
❑ Watchdog plugged into socket in interview room
Instructions*: this is more of a 'road map' for the semi-structured interview and walkthrough to ensure all variables required are covered and all relevant questions within the Household Survey Guide are asked.*

Total time for section: 5mins **Overall Time: 5mins**

1. About your household		Interviewer's Notes *...Thanks for answering the quick telephone questionnaire previously...can we just check a few of the details?*
Q1	You have **lived here** for [____] years/ months, yes?	
Q2	And there are [___] **adults** and [____] **children**?	
Q3	What **relationship** are they to you? i) What are their **ages?** ii) ...and their **gender?**	
Q4	Do you have any **pets?** i) If so, **how many?** **ii) What**	
Q5	So, to confirm, this is a [_____] **(tenure)** house? Is this right? i) ...and it was built [___]?	*Prompt for confirmation of tenure* *NB. If 'other/social landlord' prompt for description/name – who is it?*
Q6	Can I ask how many **bedrooms** there are? And there are....**(floors)**?	*Prompt for additional information on layout of home ie open plan kitchen/dining etc*
Q7	What reasons, if any, prompted you to **move to this house?**	

Additional comments:

Total time for section: 5mins **Overall Time: 10mins**

2. Heating and Hot Water		Interviewer's Notes *...Now I have a few questions about your heating and hot water...*
*Q8	Can you tell me, what is your **main type of heating**? i) What **type of fuel** does it use? ii) Do you know **when** it was **installed**, approximately? iii) And **which rooms** in the house are heated by this?	***FLASHCARD – heating systems*** ***FLASHCARD – fuel types*** ***Observer*** *to write down response here:*

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2. Heating and Hot Water		Interviewer's Notes
*Q9	... What sort of **heating controls** do you have in the property? i) Where are they **located**? *...Would it be possible for you to show me the controls after the sit-down interview?*	***Prompt or show HIDDEN FLASHCARD** – heating controls*
*Q10	As well as this, do you have any **other heating source**? i) ...and **what is it**? **ii) Which rooms** do you use this/these in?	***HIDDEN FLASHCARD** – secondary heating types* ***Observer** to write down response here:*
*Q11	...Onto **hot water**, what is your hot water system? *i) CONDITIONAL QUEST....Does your water cylinder have insulation?* *ii) CONDITIONAL QUEST....If so, what type is it, and could you tell me the approximate thickness?*	***FLASHCARD – hot water systems*** ***Observer** to write down response here:*
*Q12	*CONDITIONAL QUEST.....if they **have an immersion heater** ...So you said that you have an immersion system, do you have it switched on for **different times during the day**?* *i) Can you indicate on this scale what times it is **ON** during a typical day (**Monday – Friday**)* *ii) What about the **weekends**?* *iii) Does it vary from **winter** to **summer**? In what way?*	***FLASHCARD – time settings*** ***Observer** to write down response here:*
Additional comments:		
Total time for section: 5mins		**Overall Time: 15mins**

3. Home Improvements		Interviewer's Notes *...Can we talk a bit about the home improvements in your home...*
Q13	...Did you decide to install : *1. (FILL IN EIT INFO HERE except Energy Efficient lights)* i) ...and can you give us some more **information** on it? ii) Do you remember **when** they were **installed**? **iii) Who arranged** to have them **installed**? **iv) Why** did you have them **installed**? **v) Who or what prompted** you to install them? vi) Has the installation of the energy saving improvements in your home **influenced** your **behaviour**?...in **what ways**? OR/ You haven't got any **energy efficient improvements** to your home, is this for any particular **reasons**? i) **What** has got **in your way**?	***Prompt** for additional information e.g. Loft insulation thickness, size, etc*
Additional comments:		
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3. Home Improvements		Interviewer's Notes *...Can we talk a bit about the home improvements in your home...*
Q14	Are there any **other** home **improvements** you have undertaken? *eg. Conservatories, extensions, new bathrooms, kitchens, new shower, water saving features, etc.* i) ...and can you give us some **more information** on it? ii) Do you remember **when** they were **installed/built**? **iii)** **Who arranged** to have them **installed**? **iv)** **Why** did you have them **installed**? **v)** **Who or what prompted** you to install them? **vi)** Has the installation of the energy saving improvements in your home **influenced** your **behaviour**? In terms of **energy use**. ..in **what ways**?	***Prompt:** if any other additional improvements*
Q15	So, you **haven't** got any **renewables installed** in your home, is this for any particular **reasons**? i) **What** has got **in your way**?	
Q16	...**Do** you think there is anything **else** that you could do to **improve** the **energy performance** of your house?	
Additional Comments:		
Total time for section: 5mins		**Overall Time: 20mins**

4. Lighting and Appliances		Interviewer's Notes *...Thanks, moving onto lighting and appliances...*
***Q17**	...I notice from the information you gave us earlier that you have some **energy efficient lighting** in your home...is this correct? i) Do you know **what type** they are? ii) And roughly, **how many** do you have? Did you **install** them? i) Do you remember **when**? **ii)** **Why** did you have them installed? *Prompt for financial reasons, environmental, friend doing it, leaflet, LCC council promotion, in shop etc* **iii)** **Who** or **what prompted** you to install them? iv) Has the installation of the energy saving lights in your home **influenced** your **behaviour**? In terms of **energy use**. ..in **what ways**? OR/ ...I notice from the information you sent that you have **NOT** got any **energy efficient lights** in your home...Is this correct? **What** has got in your **way**?	***FLASHCARD – prompt with energy efficient light bulb types – number scale*** ***Observer** to write down response here:*
***Q18**	...I notice from the information you gave us earlier that you have some energy efficient appliances in your home...is this correct? i) Do you know what **rating** they are? ii) Were they **already in the house**? iii) Of the others, **which did you** decide to **buy**? iv) Do you remember **when**? **v)** **Which** ones have you bought in the **last 2 years**? **vi)** **Why** did you buy them? **vii)** **Who** or **what prompted** you to install them? OR/ ...I notice from the information you sent that you have **NOT** got any **energy efficient appliances** in your home...is this correct? What has got in your way?	***FLASHCARD – appliance table*** *Prompt for financial reasons, environmental, friend doing it, leaflet, LCC council promotion, in shop etc*
Total time for section: 5mins		**Overall Time: 25mins**

5. General View of the House			Interviewer's Notes *...Now I would like to ask you some more general questions about your views on your home...*
*Q19	**How satisfactory** would you say the **overall location** of your home is?...as in **the local area as a place to live**... *Allow response...then* ...to **summarise**, would you say it is...?		*Prompt for additional comments ie sense of community / facilities / environment* ***FLASHCARD – satisfaction*** ***Observer** to tick relevant response*
	1	*Unsatisfactory*	
	2		
	3		
	4		
	5		
	6		
	7	*Satisfactory*	
Q20	...Now talking about your **home**, what would you say are **the best aspects**?		*Leave question open*
Q21	What about its **worst aspects?**		*Leave question open*
*Q22	Would you say that **the house** provides you with the **space you need**? *Allow response...then* ...to **summarise**, would you say it is...?		*Prompt for detail: ample living space, enough workspace for cooking, working etc, visitors – spare bedroom, comfortable sitting space?* ***FLASHCARD** – space* ***Observer** to tick relevant response*
	1	*Not enough space overall*	
	2		
	3		
	4		
	5		
	6		
	7	Enough space overall	

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5. General View of the House			Interviewer's Notes
*Q23	Would you say that the **layout** of the house is suitable for your **needs**? *Allow response...then* ...to **summarise**, would you say it is...?		***FLASHCARD – suitability*** ***Observer** to tick relevant response*
	1	*Poor layout*	
	2		
	3		
	4		
	5		
	6		
	7	*Good layout*	
*Q24	Would you say that the amount of **storage** in your house is suitable for your **needs**? *Allow response...then* ...to **summarise**, would you say it is...?		***FLASHCARD – storage*** ***Observer** to tick relevant response*
	1	*Not enough storage*	
	2		
	3		
	4		
	5		
	6		
	7	*More than enough*	

Additional comments:

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5. General View of the House			Interviewer's Notes
*Q25	How well do the **facilities in your home** meet your **needs**? *Allow response...then* ...to **summarise**, would you say they meet your needs...?		*Facilities ie downstairs bathroom/wc; kitchen; garage etc* ***FLASHCARD – facilities*** ***Observer** to tick relevant response*
	1	*Very poorly*	
	2		
	3		
	4		
	5		
	6		
	7	*Very well*	
*Q26	How would you rate the **appearance** of your house from the outside? *Allow response...then* ...to **summarise**, would you say it is...?		***FLASHCARD – facilities*** ***Observer** to tick relevant response*
	1	*Poor*	
	2		
	3		
	4		
	5		
	6		
	7	*Good*	
*Q27	**Overall,** how would your rate the **design** of the house?		***FLASHCARD – satisfaction*** ***Observer** to tick relevant response*
	1	*Unsatisfactory*	
	2		
	3		
	4		
	5		
	6		
	7	Satisfactory	

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5. General View of the House			Interviewer's Notes
Q28	Do you or the **other occupant**s have any **health problems**? i) ....if so can you please describe any **particular requirements** that you/ or other occupants might have..?		*Allow **explanation** before summary* *Prompt for detail*
*Q29	Do you feel that the **conditions in the property affect** your **health, if** at all? *Allow response...then* ...to **summarise**, would you say it is...?		***FLASHCARD – health*** ***Observer** to tick relevant response*
	1	*Less healthy*	
	2		
	3		
	4		
	5		
	6		
	7	More healthy	

Additional comments:

Total time for section: 10mins **Overall Time: 35min**

6. Comfort and Control						Interviewer's Notes *...In terms of comfort...*
Q30	Are there any **particular rooms** that are **uncomfortable** in terms of **TEMPERATURE**? i) How do you **cope with this**? ii) If too warm – **what do you do to cool down**? iii) If too cold – **what do you do to warm up**?					***Prompt** use of windows; open doors; turn heating up – at radiator or thermostat?*
Q31	In terms of **temperature** .... How would you say temperature varies in throughout the day in **WINTER/SUMMER**? *Allow response...then* ....In which **rooms or floors**? ...to **summarise**, would you say it is...?					*Prompt: Stable...Varies throughout the day*
***Q32**	Regarding your home in **winter,** would you say it is **(*easy to keep warm*)**:					***FLASHCARD – easy to keep warm***
	Very easy to keep warm					
	Fairly easy to keep warm					
	Fairly difficult to keep warm					
	Very difficult to keep warm					
	Don't know (DO NOT READ)					
***Q33**	In terms of **COMFORT,** how would you describe **typical conditions in WINTER/SUMMER**? *Allow response...then ask .....in terms of* **temperature** ...to **summarise**, would you say it is...?					*Allow explanation before summary* ***FLASHCARD –uncomfortable/comfortable, too hot/too cold,*** ***Observer** to tick relevant response*
	1	*Uncomfortable*		1	*Too hot*	
	2			2		
	3			3		
	4			4		
	5			5		
	6			6		
	7	*Comfortable*		7	*Too cold*	

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6. Comfort and Control						Interviewer's Notes
Q34	.... in terms of **AIR**..... Are there **any particular rooms** that are **uncomfortable in** terms of **AIR**? i) How do you **cope with this**?					***CONTROLS**: Prompt for opening windows, fans, extractor fans, use of secondary heaters, turning up the thermostat, turning up the TRV* *Allow explanation before summary*
***Q35**	How would you describe the typical **AIR CONDITIONS** in **WINTER/SUMMER**? *Allow response...then* ...to **summarise**, would you say it is...?					***FLASHCARD** – air* ***Observer** to tick relevant response*
	1	*Still*		1	*Fresh*	
	2			2		
	3			3		
	4			4		
	5			5		
	6			6		
	7	*Draughty*		7	*Stuffy*	
Q36	Are there **any particular rooms** that are **uncomfortable in** terms of **damp/mould/condensation**? i) How do you **cope with this**?					*NB. The respondent may have answered this already; prompt for further information on USER CONTROL*
***Q37**	In terms of **dryness/humidity** in the **WINTER/SUMMER**, how would you describe the typical conditions in your home? *Allow response...then* ...to **summarise,** would you say it is...?					*Allow explanation before summary* ***FLASHCARD - air humidity*** ***Observer to tick relevant response***
	1	*Dry*				
	2					
	3					
	4					
	5					
	6					
	7	*Humid*				

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6. Comfort and Control			Interviewer's Notes
*Q38	Overall, how would you rate the **COMFORT** of your home environment? *Allow response...then* ...to **summarise,** would you say it is...?		*Allow explanation before summary* ***FLASHCARD** – comfort* ***Observer** to tick relevant response*
	1	*Unsatisfactory*	
	2		
	3		
	4		
	5		
	6		
	7	*Satisfactory*	
*Q39	How **NOISY** is your home? i. From people **between rooms** ii. From **neighbours** (if have adjoining walls) iii. **From outside** *Prompt for too little/too much* *Allow response...then* ...to **summarise,** would you say it is...?		*Allow explanation before summary* ***FLASHCARD – noise*** ***Observer** to tick relevant response*
	1	*Unsatisfactory*	
	2		
	3		
	4		
	5		
	6		
	7	*Satisfactory*	
Additional comments:			
Total time for section: 10mins			Overall Time: 45mins

6. Comfort and Control					Interviewer's Notes
*Q40	How would you describe the **quality** of: i) **Natural** light? *Prompt for too little/too much; different rooms?* *Allow response...then* ...to **summarise,** would you say it is...?				*Allow explanation before summary* ***FLASHCARD – light levels- Satisfaction*** *Observer to tick relevant response*
	1	*Too little*	1	*Unsatisfactory*	
	2		2		
	3		3		
	4		4		
	5		5		
	6		6		
	7	*Too much*	7	*Satisfactory*	
Q41	Do you have anything **to control** the level of **NATURAL LIGHT?** *Discuss . Prompt for controls, eg curtains, blinds*				
*Q42	How would you describe the **quality** of: i) **Artificial** lighting? ...to summarise, would you say it is...?				*Prompt for too little/too much; different rooms?* *Allow response...then*
	1	*Too little*	1	*Unsatisfactory*	
	2		2		
	3		3		
	4		4		
	5		5		
	6		6		
	7	*Too much*	7	*Satisfactory*	
Q43	Do you have anything in particular **to control** the level of **ARTIFICIAL LIGHT?** i. Is your artificial **lighting bright** enough for what you want? ii. How often do you need **extra artificial light?** *Discuss . Prompt for controls, eg dimmers*				*CONTROL: dimmers*
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6. Comfort and Control			Interviewer's Notes
*Q44	How much **personal control** do you feel you have over: i) **Heating** ii) **Cooling** iii) **Ventilation/airing** iv) **Lighting** v) **Noise** *Allow response...then* ...to **summarise,** would you say you have...?		*Allow explanation before summary* ***FLASHCARD – Controls*** ***Observer** to tick relevant response*
	1	*No control*	
	2		
	3		
	4		
	5		
	6		
	7	*Full control*	
Q45	Overall, is **control important to you**? *Prompt for y/n and additional comments*		***Observer** to tick relevant response – Y/N*
	Heating		
	Cooling		
	Ventilation/airing		
	Lighting		
	Noise		

Additional comments:

Total time for section: 10mins **Overall Time: 45mins**

7. Energy Behaviour		Interviewer's Notes *...We are now going to ask a few more general questions on yourself to help ensure we have a good spread of people taking part in the survey...*
*Q46	Which of these groups do you consider you belong to **(ethnicity)** ?	***FLASHCARD – ethnicity*** ***Observer** to tick relevant response*
*Q47	Are you **working** at the moment?	*Prompt for **unemployed, employed – full-time, part-time, retired, self-employed***
	i) What about your **partner/children?** ii) Can you tell me about your **qualifications?** iii) And what about your **(other members)**...? iv) **How often** are you (and other occupants) at **home**?	***FLASHCARD – qualifications*** *Prompt for: **Most of the time, evenings and weekends only, other – please state***
*Q48	How many **cars** does your household own? i) What **type** of cars? ii) Approximately how many **miles** do you **travel** in, say **an average week/annually** (household average)? iii) Are you a **member of a car club**?	***FLASHCARD – car type*** ***Observer** to tick relevant response* *NB. If they do not know avr miles/wk, ask for annual* *Prompt for description - work car share, car pool etc.*

Additional comments:

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7. Energy Behaviour					Interviewer's Notes *...Thanks, now we are going to ask more specific questions on your views towards energy and your household energy use...*
*Q49	In relation to the following scale, how **concerned**, if at all are you: *i) About* **global warming/climate change***?* **Why is this?** *ii) That* **energy supplies** *will be* **interrupted** *or run out in the future?* **Why is this?** *iii) About* **rising energy prices** *and fuel bills?* **Why is this?**				***FLASHCARD – level of concern*** ***Observer** to tick relevant response*
i)	*ii)*	*iii)*			
			Very concerned		
			Fairly concerned		
			Not very concerned		
			Not at all concerned		
			No opinion/not stated		
*Q50	.... Regarding your **home** ...To what extent do you agree with the following **statement:** ***"I think that it is important to reduce energy use in my home."*** **.....Why** is this?				*Allow explanation before summary* ***FLASHCARD – agreement*** *Probe for sense of personal responsibility, belief their action will make a difference* *Observer to tick relevant response*
	Strongly agree				
	Tend to agree				
	Neither agree nor disagree				
	Tend to disagree				
	Strongly disagree				
*Q51	So...how **often** do **you think about energy use in your home**? .....**Why** ? *Allow response...then* ...So **to sum up**, would you say you think about energy use:				*Allow explanation before summary* ***FLASHCARD – oftenest*** *Observer to tick relevant response*
	Always				
	Often				
	Sometimes				
	Not very much				
	Not at all				

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7. Energy Behaviour		Interviewer's Notes
*Q52	To what extent do you agree with the following **statement:** ***"I feel capable of reducing energy use in my home"*** i) ...and what are **your reasons** for this?	***FLASHCARD – agreement*** ***Observer** to tick relevant response*
	Strongly agree	
	Tend to agree	
	Neither agree nor disagree	
	Tend to disagree	
	Strongly disagree	
*Q53	....Regarding you r **BILLS** Do you normally **keep a record** of how much **energy** you are **using?** **i) How** do you **pay** your bills? ii) Can I ask **how much** you pay, on average, for your **fuel (Gas/ electricity / other)**? **(monthly/weekly)**	***FLASHCARD –Possible options of bill payment type***
*Q54	And just to have a scale of **what percentage of your budget** the bills take up – could you tell me **in** which of these bands your **annual household income** fits into? i) Does this include **any benefits** you receive?	***FLASHCARD – annual income*** ***Observer** to tick relevant response*
	Up to £10,400	
	£10,400 and less than £20,800	
	£20,800 and less than £36,400	
	£36,400 and less than £50,000	
	£50,000 or more	
	Benefits?	
Q55	Is there anything you **do not understand** about **heating** your home and **paying** for your energy?	*Prompt for controls, boiler, radiators/heaters. Appliances, how to use energy saving options, leaving things on stand-by, energy saving measures, bills, other*

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7. Energy Behaviour		Interviewer's Notes
Q56	...You also said that you had received **information** that had changed the way you use energy recently, **who/where was this from**? i) **What changes** did you make? ii) Overall **how important** would you say the advice and/or support received has been in **helping reduce** your home energy use? iii) Was there anything you thought was **particularly effective** about the **information/advice/support**? iv) **What else prompted** you to make the changes? v) Are there any **changes you intended** to make but haven't? vi) **What has got in the way** of you making these changes to your behaviour? OR/ Have you made any changes to the way you use energy in your home recently? i) If so, what changes? ii) What prompted you to make the changes? iii) Are there any changes you intended to make but haven't? iv) What has got in the way of you making these changes to your behaviour?	*Prompt for involvement in other groups including political, social and cultural groups; seminars; events*
Q57	Have you made any other changes, or actions you have taken recently? i) If so, **what changes?** ii) **What/who prompted** you to make the changes? iii) **Why** did you undertake such changes? iv) Are there any **changes** you **intended** to make but haven't? v) **What has got in the way** of you making these changes to your behaviour?	*Prompt for more environmental changes such as use less water, drive less, recycle more* *Prompt for involvement in other groups including political, social and cultural groups*

Total time for section: 10mins **Overall Time: 55mins**

7. Energy Behaviour		Interviewer's Notes
*Q58	...**How often** do you do the following things ...? ...and **what** are your **reasons** for this? i) Leave your TV or PC on standby for long periods of time ii) Switch off lights when you are not in the room iii) Close windows before turning on or up the heating iv) Put more clothes on if you are feeling a bit cold, before putting the heating on v) Boil the kettle with more water than you are going to use vi) Spend less time in the shower, and/or use less hot water for baths vii) Wash clothes at 30 degrees or lower viii) Hang clothes out to dry rather than tumble drying ix) Leave a mobile phone charger switched on at the socket when not in use	***FLASHCARD – how often...*** ***Observer** to tick relevant response*
	Always	
	Very often	
	Quite often	
	Occasionally	
	Never	
	Don't know	
	Not applicable	
Additional comments:		

Total time for section: 10mins **Overall Time: 55mins**

8. Energy Display Monitors		Interviewer's Notes *...more specifically now, can we talk about energy display monitors?...*
Q59	You have previously told us **that you have an energy display monitor**? **i) what/who prompted** you to get one? ii) Do you remember **when** you got it? **iii) Who/where** did you get it from? **iv) What** kind is it? **v) Why** did you choose that particular type? OR/ **...You have previously told us that you do not have an energy display monitor...have you ever considered getting one?** **i) why/why not?**	
Q60	...How **easy** was it **to install**? i) Did you need **help installing** it? ii) And setting **it up**? iii) Did/does it **work properly**? **iv) What**, if any are the **problems** with it?	
*Q61	...**How often** do you **look** at it?	***FLASHCARD** – frequency scale* ***Observer** to tick relevant response*
	Several times a day	
	Once a day	
	Every few days	
	Once a week	
	Hardly ever	
Q62	...And in comparison to when **you first set it up**, how often do you **look** at it **now?**	***Observer** to tick relevant response*
	More often	
	About the same	
	Less often	
Q63	...**Where** do you keep the display? i) Is this for any specific reason?	
Q64	Are there any **particular times** of the **day** that you **read the display**? *Eg. Last thing at night, when you leave the house?*	
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8. Energy Display Monitors		Interviewer's Notes
Q65	...Is there anything you have **learnt** about your household energy use from **using the energy display**? i) Do you think that the display has **affected** your overall **electricity use at home?** ii) ...can you **give an example?** iii) ...has the energy display **influenced** your **energy use in heating** your house? iv) In **Water heating**? v) What about any **other areas**? **vi) Why**, how is this?	
Q66	**Which type** of **information** provided by the display did you find most **useful**? *...such as electricity use second-by-second, looking back over previous week/month, cost, CO2 emissions, comparison with target...* i) And le**ast useful**?	
Q67	Are there any **characteristics** of the display that you **particularly like/ don't like**?	
Q68	Are there any ways the energy display could be **improved**?	
Q69	Finally, has the display **prompted any discussions** in **your house** about energy use? i) What about with **other members** of your family? ii) What about **friends and neighbours**?	*Prompt for further explanation*
Total time for section: 5mins		**Overall Time: 1hr**

9. Involvement with Community Interviewer's Notes		Interviewer's Notes *Now I am going to ask some questions on your local area and community...*
*Q70	How strongly do you feel you belong to your immediate neighbourhood?	***FLASHCARD** – agreement scale* ***Observer** to tick relevant response*
	Very strongly	
	Fairly strongly	
	Not very strongly	
	Not at all strongly	
	Don't know	
*Q71	....**To what extent do you agree** or **disagree** with the following **statement**? *'in my area trying to reduce your energy use (or carbon footprint) is the 'normal' thing to do'* i) ...and what are your reasons for this?	***FLASHCARD** – agreement scale* ***Observer** to tick relevant response* *Probe to explore who they think in the community would approve or disapprove*
	Strongly agree	
	Tend to agree	
	Neither agree nor disagree	
	Tend to disagree	
	Strongly disagree	
*Q72	To what extent do you agree with the following statement: *"It is important to help my community reduce its energy use."* i) ...and what are your reasons for this?	***FLASHCARD** – agreement scale* ***Observer** to tick relevant response* *Probe to find out about value added of collective action, capacity of local group*
	Strongly agree	
	Tend to agree	
	Neither agree nor disagree	
	Tend to disagree	
	Strongly disagree	
Q73	Have you noticed any **changes** in **community attitudes** about **energy over the past two years?** ...Please explain...?	

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9. Involvement with Community				Interviewer's Notes
Q74	Are you aware of any social or economic changes in the community since January 2012? ...can you give examples?...such as: *changes in jobs, environment, community cohesion/division, energy, poverty, community participation, social networks* i) Who/What do you think may have caused/contributed to these changes?			*Prompt examples: changes in jobs, environment, community cohesion/division, energy, poverty, community participation, social networks*
	Yes	*No*	*Unsure*	***Observer:** circle response*
Q75	Are you aware of any energy or climate change related projects in the community? i) How did you hear about them? ii) ...what is/was your involvement with them? iii) Can you remember specific dates? iv) ...and what were the most important factors in your decision to get involved?			
Q76	You have previously told us that you are aware/involved in [__**LCC Group**__] is this correct? i) How did you hear about them? ii) ...what is/was your involvement with them? iii) Can you remember specific dates? iv) ...and what were the most important factors in your decision to get involved?			
*Q77	Overall how important would you say [__**LCC Group**__] advice and/or support has been in helping reduce your home energy use?			***FLASHCARD** – agreement scale* ***Observer** to tick relevant response*
	Not at all			
	A little			
	A lot			
	It was crucial/I wouldn't have done it otherwise			
Q78	Was there anything you thought was particularly **effective** about the advice/support you received from [__**LCC Group**__]?			
Q79	Do you have any suggestions for how [__**LCC Group**__] could improve its energy advice and support to residents?			

⇩

9. Involvement with Community		Interviewer's Notes
Q80	Other than the changes in your home energy use mentioned previously, have you experienced any other changes as a result of your involvement in [_**LCC Group**_]? i) ...In your home...such as: - *Other energy related changes, ie changes to your awareness about energy use or your knowledge/skills about how to save energy* - *Financial changes ie to bills, value of house* - *Quality of life changes ie changes to temperature/comfort, health, family and relations* ii) ...In your community...such as: - *Sense of belonging to the community* - *Number and types of relationships in the community* - *Participation in community organisations* - *Ability capacity to make changes in your community*	
***Q81**	...So, to finish, how strongly do you agree/disagree with the following statements about [__**LCC Group**__]: *i) It is helping people like me to reduce their energy consumption* *ii) It is helping people like me reduce their bills* *iii) It is encouraging the wider community to reduce energy consumption* *iv) It is accessible to me* *v) It is relevant to me* *vi) It is increasing the sense of community locally* *vii) It is bringing jobs to the neighbourhood* *viii) It is bringing benefits to the community* *...Explain...in what ways? ...what benefits?*	***FLASHCARD** – agreement scale* ***Observer** to tick relevant response* *Probe for wider beneficial aspects such as local farmers markets, better cycle facilities, more responsive city council etc*

i)	ii)	iii)	iv)	v)	vi)	vii)	viii)	
								Strongly agree
								Tend to agree
								Neither agree nor disagree
								Tend to disagree
								Strongly disagree

Q82	...and so finally, we aim to give feedback to [_____], do you have any other reflections, comments or suggestions for them?	

Total time for section: 10mins **Overall Time: 1hr 15mins**

10. Social Network Analysis	Interviewer's Notes *REPEAT ANYTHING THAT IS DEMONSTRATED VISUALLY, AUDIBLY FOR THE TAPE; OBSERVER RECORD NAMES/DETAILS*
Q83	***Now for something a little different...as part of the study we are looking at people's social networking...(not facebook!)...so if we could just clear a little space we can begin...*** ***The purpose of this is to create a map of the people with whom you discuss home energy issues...don't worry too much about getting it right – each social network is unique to the individual so feel free to change it as many times as you like...*** ***What you have in front of you is a name template. The purpose of this name template is to generate names...follow the prompts on the flashcards accordingly*** ***Probe on:*** ***1) DECC interventions*** ***2) LCC interventions*** ***3) Energy displays*** ***4) Community events (esp. EVALOC events)*** ***...by asking the following questions on each person with a green sticker:*** • ***Did they help to change your attitudes and/or behaviours?*** • ***Did you help to change their attitudes and/or behaviour?*** - ***Did you talk to anyone else you have identified about this same issue?*** • ***Did they help to change your attitudes and/or behaviours?*** • ***Did you help to change their attitudes and/or behaviour?*** - ***Did you talk to anyone else about a different energy issue?*** • ***Did they help to change your attitudes and/or behaviours?*** • ***Did you help to change their attitudes and/or behaviour?*** - ***Does anything get in the way of discussing energy issues with these people?*** - ***Do you talk about energy use in different ways, eg. The price of energy bills?*** ***TAKE A PHOTO OF THE SOCIAL NETWORK EXERCISE DIAGRAM!***
Additional comments:	

Total time for section: 15mins **Overall Time: 1hr 30mins**

11. Walkthrough		Interviewer's Notes
*...Ok, so now we have completed the main part of the interview, it would be great if you could tell us a bit about each room and perhaps show us all the things that you think were done as part of the low carbon retrofitting work...if you don't mind we will take spot checks for temperature, humidity, light and noise levels in **the living/kitchen, main bedroom and hallway**...* ❑ HOBO in living room (pref. on door). Take photo		
ROOM BY ROOM		
Q84	**Spot Checks:** ❑ Temperature ❑ Humidity ❑ Lux Levels ❑ Noise Levels	
Q85	**Use:** i) How much do you/other occupants use this room? ii) So, for how long each day? iii) At what times?	*Prompt for description - Why is this*
***Q86**	Please indicate on this scale how this room feels normally in terms of temperature...what about in the WINTER/SUMMER? i) What do you do if you are too warm/too cold in this room? ii) How easy do you find it to control the temperature in this room? iii) Are there any other ways you control the temperature in this room? What are these?	*Allow explanation before summary* ***FLASHCARD** – too hot/too cold* ***Lead Researcher** to tick relevant response*
Q87	Do you have any issues with damp/mould or condensation in this room? i) Can you describe these issues? ii) How do you cope with this?	
Q88	Do you find you need to air this room ever? i) When is this? ii) How do you air this room? Eg. Open windows/internal doors/fan? iii) How easy do you find it to control the air flow in this room?	
Q89	Do you have any issues with noise in this room? 1. From the next room? 2. From your neighbours? 3. From outside? i) What do you do to cope this?	
Additional comments:		
⇓		

11. Walkthrough	Interviewer's Notes
ROOM BY ROOM	
Q90	How do you find the level of natural light in this room? i) ...how often do you use...[blinds/curtains]...to control the level of natural light? ii) Do you close them at any other times? iii) ...Are there particular times (other than night time) that you need extra light? Ie artificial light? iv) How easy do you find it to control the light levels in this room?
Q91	Do you have any other issues in this room? i) How do you cope with this?
Q92	Do you have anything else to add in terms of control or use in relation to this room?
Q93	IF THEY HAVE WALL INSULATION: i) Has the wall insulation affected this room in anyway? ii) If so, in what ways?
Additional comments:	
⇓	

11. Walkthrough	Interviewer's Notes
Heating System & Controls – ask to see boiler/controls/meters	
*Q94 **Heating controls:** ...So you mentioned that your heating system is...[_____]...could you show me how the controls work? i) how **quickly** does the heating system respond? ii) so **overall** how does the heating system **perform**? iii) do you find the controls **easy or difficult** to use? iv) Why is this? v) How could the instructions/training be better? vi) ...and do you use a timer/programmer, or do you normally switch it on/off **(turn** thermostat up/down**)** manually? **vii) At what temperature** do you normally set your heating? viii) Is this **different from the summer to the winter**? ix) Do you turn the heating **OFF in the summer**? If you do, approximately when do you turn it ON again? x) ...During winter, **when do you** have your central heating ON during a typical day? **(**mon-fri**)**...*can you show this on this card?* xi) ...what about the weekends?	***FLASHCARD** – time settings* *Prompt: if typical day not known, as for previous weekday and weekend settings* ***Observer** to write down response here:*
Additional comments:	
⇩	

11. Walkthrough	Interviewer's Notes
Low carbon improvements...if they have these...	
Q95 For all measures (active and passive): i) Do you understand what it is supposed to do? ii) ...what is this? iii) Do you think it works? iv) Has someone shown you how it works? v) Can you show me how it works? vi) Could the instructions/training/information have been better? vii) ...how could the instructions/training/information be better? viii) Have you had any problems with this measure? ix) If so, what was the problem? x) How did you/do you deal with this? xi) Do you feel you can resolve/control the problem? xii) How common do you think this type of technology is? xiii) Do you like it?...why/why not?	
...these are additional questions for specific low carbon measures...	
Q96 Wall Insulation: i) Do you know if it is external or internal? ii) Do you know the type? iii) Do you know the thickness?	
Q97 Solar hot water: i) Do you use the solar heated water when you bath/shower? ii) How often do you/the other occupants have a bath/shower? iii) ...for how long, typically? iv) ...and at what times of the day? v) Has this changed since the installation of the panels?	
Additional comments:	
⇩	

11. Walkthrough		Interviewer's Notes
Low carbon improvements...if they have these...		
Q98	**Solar PV:** i) ...thinking about your use of appliances, how often do you use these in a typical week? ii) ...and at what times of the day? iii) Has this changed since the installation of the panels? iv) ...and do you know how much it generates?	
Q99	**Heat Pump:** i) How noisy is it? *ii) if noisy...what do you do to cope with this?*	
Q100	**Mechanical Ventilation and Heat Recovery (MVHR):** i) how **quickly** does the system respond? ii) so **overall** how does the system **perform**? iii) do you find the controls **easy or difficult** to use? iv) Why is this?	
Total time for section: 25mins		**Overall Time: 1hr 55mins**

Interview Close		Interviewer's Notes
	Ask for additional comments	
	Reaffirm confidentiality	
	Confirm further contact will be soon	
	Hand over cash in appreciation (consent form to be signed)	
	Thank you very much...and goodbye!	
Total time for section: 5mins		**Overall Time: 2hrs**

Appendix I: Heating controls questionnaire

HEATING CONTROLS QUESTIONNAIRE

A/B/C

This questionnaire is designed to assess your heating preferences, identify the heating controls within your house and determine how these controls are used to manage the environment within the house. Instructions on how to complete this questionnaire are given in italics.

EVALOC

Name: Date:

THERMAL PREFERENCES

1. How do you feel at this time?
(Please indicate your response by ticking an option on the scale below).

- ☐ *Much too warm*
- ☐ *Too warm*
- ☐ *Comfortably warm*
- ☐ *Comfortably neither warm nor cool*
- ☐ *Comfortably cool*
- ☐ *Too cool*
- ☐ *Much too cool*

2. You would prefer to be?
(Please indicate your response by ticking an option on the scale below).

- ☐ *Much cooler*
- ☐ *A bit cooler*
- ☐ *No change*
- ☐ *A bit warmer*
- ☐ *Much warmer*

3. How do you manage your comfort in the house in the WINTER? *(please tick all that apply)*

- ☐ Open/close internal doors
- ☐ Open/close windows
- ☐ Use Blankets
- ☐ Open/close blinds
- ☐ Open/close curtains
- ☐ Increase/decrease clothing
- ☐ Switch on/off central Heating
- ☐ Localised Heating (e.g. Blower etc.)
- ☐ Other (please specify below)

Other:

4. To what extent are you able to control your heating system to make the house comfortable? *(please indicate by circling a number on the scale.)*

UNABLE 1 2 3 4 5 6 7 ABLE

CONTROLS

5. For each of the controls below, please indicate by ticking the appropriate box, which controls you HAVE, which controls you USE and HOW OFTEN you use them. *Please refer to attached Heating Controls Guide to assist with identification of your heating controls.* **Finally, please indicate the location of these controls** *(e.g 'hallway' or '1 per room').*

	I **HAVE** this control.	I **USE** this control.	I **ADJUST** this control							Location(s)
			Very often	Daily	Weekly	Monthly	Seasonally	Annually	Never	
Room Thermostat/Roomstat										
Time Clock/Timer/Programmer										
Thermostatic Radiator Valve/TRV										
Controller/Programmable Room Thermostat										
Night set back										
Manual override function on any listed above.										
Other: Please specify:										

6. Who sets the timer or programmer?

☐ Self ☐ Another member of the household. ☐ A friend relative or neighbour who is not a member of the household. ☐ A tradesperson such as a plumber or electrician. ☐ Someone else *(please specify below).*

Other person :

7. Have you had any problems with the heating system/heating system controls over the last 3 months? Please explain.

PLEASE TURN OVER

8. When considering your timer/programmer control, please indicate how strongly you agree with each of the statements given below on the by circling a number on the adjacent scale.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
a. The purpose of the control is clear	1	2	3	4	5
b. The control is easy to access.	1	2	3	4	5
c. The control is intuitive to use.	1	2	3	4	5
d. The labelling and annotation are easy to understand.	1	2	3	4	5
e. The control is easy to use.	1	2	3	4	5
f. It allows me to make fine adjustments.	1	2	3	4	5
g. The control gives an indication it is responding to instructions.	1	2	3	4	5

USAGE

9. Please use the chart below to tell us about your typical heating schedule.

Please record at what times the heating is switched on and off each day and at what temperatures(°C) or setting (if temperature not applicable).If you do not work Mon-Fri, please provide us with one example of a working day and one example of a non-working day.

Daily Heating Period	Period 1			Period 2			Period 3			Period 4		
	Time on	Time off	°C	Time on	Time off	°C	Time on	Time off	°C	Time on	Time off	°C
Typical Weekday (working day)												
Typical Weekend (non-working day)												
Other (please specify):												

10. How is the room thermostat used? (Tick all that apply).

☐ Turn the Thermostat up until it clicks.	☐ Turn the thermostat up high to warm the room up quickly.	☐ Turn the thermostat up to a particular number you choose.	☐ Turn the thermostat up without choosing a specific number.	☐ Some other method (please specify below).
Other method:				

11. When is the thermostat turned down? (Please tick all that apply and then give the temperature/setting the thermostat is turned down to below).

☐ At night.	☐ When we are out.	☐ When we are on holiday.	☐ Other (please specify)
Setting/Temp:	Setting/Temp:	Setting/Temp:	Setting/Temp:

12. What are your typical Thermostatic Radiator Valves/TRV settings in winter, (where applicable)?

(please add any additional rooms with TRVs in the blank boxes below)

Room	Setting	Room	Setting	Room	Setting	Room	Setting
Living Room		Bedroom 3		Kitchen		Study	
Bedroom 1		Dining Room		Bathroom		WC	
Bedroom 2		Hallway		Utility		Conservatory	
Please advise how the scale on your TRVs is labelled? *(e.g 1-5 where 5 = hottest):*							

13. Do you turn off radiators in unused rooms? *(delete as appropriate).* **YES/NO**

14. Do you feel your knowledge and understanding of the controls effects your management of the heating system? If yes, please explain. **YES/NO**

15. When the central heating system was installed, were you given any information (instructions/user manual etc.) about the function of the controls and how to adjust them? **YES/NO**

If yes, how helpful were the instructions or the user manual?
(Please indicate by circling a number on the scale)

NOT AT ALL USEFUL 1 2 3 4 5 6 7 VERY USEFUL

Thank you! Please remember to return the completed questionnaire to the EVALOC researchers using the envelope provided.

Appendix J: Activity logging sheets

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ACTIVITY LOGGING SHEET – *IN A TYPICAL WEEK, ON A TYPICAL DAY…*

Please describe your **typical** activities relating to the headings and questions below in as much detail as possible for each day over the period of one week.

Name:	Address:

	Occupancy: Who is normally at home, and when?	**Heating:** How many hours is your heating on, when & why?	**Ventilation:** a) Which windows/trickle vents are opened, when and why? b) Which extract fans are used, and when?	**Cooking & cleaning:** a) When is the hob/oven used, and for how long? (please specify gas, electric or oil) b) How many dishwasher loads are done, and when?	**Washing & drying:** a) How many baths/showers are there, and when? b) How many loads of washing/tumble drying are done? What temperature and settings?	**Home entertainment:** For how long is the TV/home entertainment equipment used, by whom, and when? What is used?	**Home office:** For how long is the computer/laptop/home office equipment used, by whom, and when? What is used?
'EXAMPLE MONDAY'	*1 person working from home during the day, whole family (4 people) from 6pm..*	*Usually 6 – 11 pm (5hrs) like to be 'cosy' when sitting in the evenings.*	*Bedroom windows opened AM to air rooms. Extract used mornings for showers.*	*Oven used for 1-2hrs in evening. 1 dishwasher load approx. every 2 days.*	*4 showers every morning, 2 extra on Mondays after rugby. No clothes washing.*	*1 TV in living room on for 3-4hrs in evening. Used by all.*	*1 PC used between 9am and 6pm. For work.*
MONDAY							
TUESDAY							
WEDNESDAY							
THURSDAY							
FRIDAY							
SATURDAY							
SUNDAY							

Please see overleaf

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ACTIVITY LOGGING SHEET – *ANYTHING UNUSUAL THIS WEEK?*

Please describe any activities that happened this week that are **unusual** in relation to your typical activities. Please tell us about any **changes** in **use**, extra **people**, additional **appliances** used, additional **heating** and reasons why this change has occurred.

	Occupancy: Is the house empty, or are visitors staying? If so for how long?	**Heating:** Has the thermostat been turned up higher?	**Ventilation:** Have you opened more windows up today? Why was this?	**Cooking & cleaning:** Have you used the hob or oven more? If so, why and when?	**Washing & drying:** Has the shower/bath been used for a longer period, or have extra showers/baths been taken, if so by whom and for how long?	**Home entertainment:** Has the TV been used for a longer period of time? Have additional home entertainment appliances such as the playstation been used? If so, when and for how long?	**Home office:** Has the laptop/computer been used for a longer period, if so, when and for how long?
'EXAMPLE UNUSUAL MONDAY' Date 9/11/13	*School inset day. 3 people in all day. Friends over for dinner so 10 people 8-11 pm.*	*No change*	*Opened kitchen window in afternoon - lots of cooking needed more ventilation.*	*Cooked for 3-4 hrs in afternoon. Extra dishwasher load afterwards.*	*No evening showers today. 1 load of washing at 40 degrees.*	*Playstation used 2-3hrs in afternoon by kids.*	*PC used for work morning only.*
MONDAY Date_____							
TUESDAY Date_____							
WEDNESDAY Date_____							
THURSDAY Date_____							
FRIDAY Date_____							
SATURDAY Date_____							
SUNDAY Date_____							

Thank you for completing this log sheet, please return to the EVALOC team in the stamped addressed envelope provided.