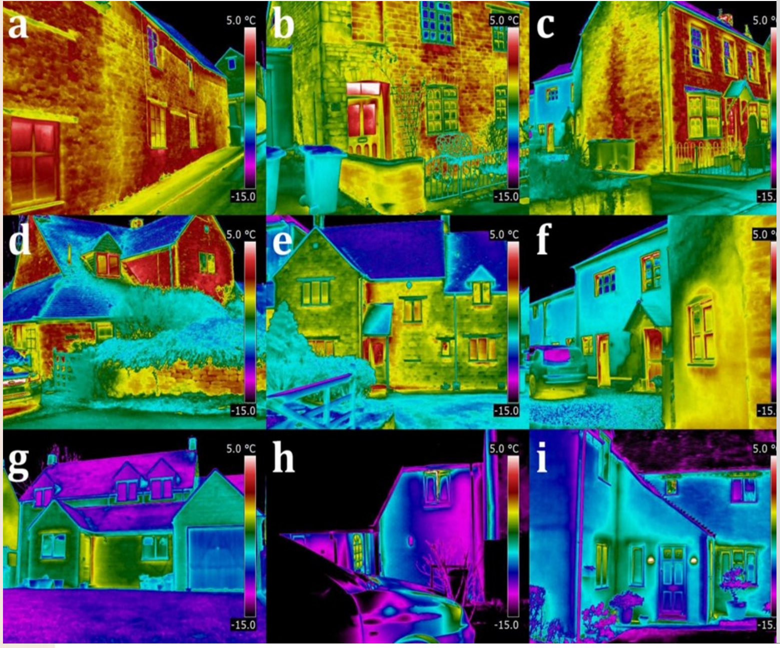
EVALOC
EVALUATING LOW CARBON COMMUNITIES

THERMOGRAPHIC SURVEY: HOOK NORTON

C4 - 1

CASE STUDY



This Thermal Imaging survey was prepared by the Low Carbon Building Group, Oxford Brookes University as part of the EVALOC project. Please be advised that whilst every effort has been made to ensure their accuracy, these thermograms should be interpreted within the context of the constraints of the survey, including access, weather conditions and physical context (as outlined in section 1). Oxford Brookes University accepts no responsibility for any works arising as a result of these findings and strongly recommends further investigation of the thermal performance of these properties before any such works are undertaken.

Figure 1. Images a-c are of dwellings with solid wall construction; Images d, e are of cavity wall dwellings with insulation as existing; Image f is of a solid wall dwelling with retrofitted external wall insulation; Image g is of a cavity wall dwelling with recent fabric improvements; Images h and I are of cavity wall dwellings with insulation as existing..

Introduction

The EVALOC project seeks to assess, explain and communicate the changes in energy use due to community activities within six selected Low Carbon Communities (LCC) under the Department of Energy and Climate Change's (DECC) Low Carbon Communities Challenge (LCCC) initiative, a government-supported initiative to transform the way communities use and produce energy, and build new ways of supporting more sustainable living. The majority of these initiatives included behaviour and awareness programmes, energy display monitors, physical and technical retrofits (from wall insulation and draught-proofing to low carbon technologies such as air source heat pumps and solar PVs).

Hook Norton Low Carbon (HNLC) is one of the six LCCs. The project was delivered through a co-operative and community benefit society, set up by volunteers from the local community group, Low Carbon Hook Norton. The LCCC funding helped with a number of initiatives in the area including interest-free loans for householders to undertake substantial retrofit projects.

Within the six case study communities, 88 households were recruited to provide further in-depth evaluation of the community initiatives in relation to individual household energy use. To understand the effectiveness of physical fabric improvement measures, thermographic surveys of all 88 dwellings were undertaken between February and March 2013. In the Hook Norton community, 17 dwellings were surveyed as part of the EVALOC project.

Table 1. Type and number of improvements in EVALOC case study dwellings in Hook Norton.

	Wall insulation		**Improved glazing**		**Loft insulation**		**Improved draught-proofing***	
	Pre-2008 top-up	Post-2008 top -up	Pre-2008	Post-2008	Pre-2008 top-up	Post-2008 top -up	Pre-2008	Post-2008
No. of dwell-ings (total n. 17)	2[a]	4	11	6	7	10	1	11

**Draught-proofing installation over and above upgraded glazing units/doors etc.*

[a] – an additional four dwellings with cavity wall had insulation installed during the original construction.

Four of the EVALOC case study homes benefitted directly from physical fabric improvements from the interest-free loans provided by HNLC. In addition, the majority of the case study homes have undertaken fabric improvements through other means including by themselves, social landlords or with assistance from Government-led schemes. Table 1 demonstrates the overall improvements undertaken within the participating dwellings. Seven dwellings are solid stone, two of which have partial insulation. Of the ten cavity wall dwellings (all insulated), five had insulation installed during the original construction of the dwelling.

This report summarises the findings of a thermographic survey conducted on 13th March 2013 of these 17 homes.

What is a thermal image?

A thermal image, or thermogram, is a visual display of the amount of infrared energy emitted, transmitted, and reflected by an object. It allows objects to be seen in terms of their thermal properties, and highlights parts of objects invisible to the human eye.

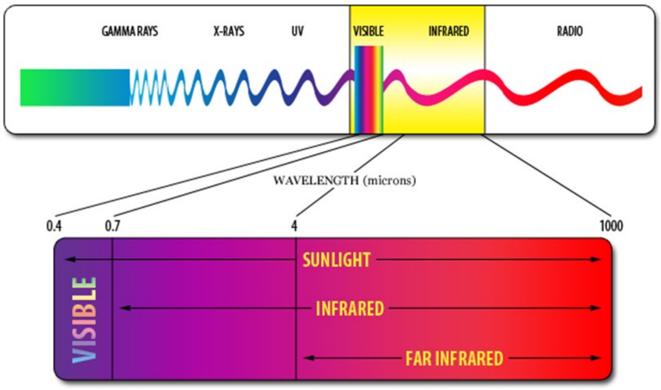


Figure 2. The electromagnetic spectrum (http://www.biosmartsolutions.com/heaters/portable/why-far-infrared-heat, accessed March 2013)

What can it tell us?

A thermal imaging survey is particularly useful in terms of buildings as it provides a quick assessment of issues that involve heat generation and/or transfer. When a building is heated, a temperature difference between inside and outside is created, so that heat flows through the walls, windows, doors, roof and even floor.

Regarding dwellings, a thermal imaging survey of the building fabric is a way of identifying potential defects such as thermal bridges, discontinuity of insulation, areas of dampness and air leakage paths (cracks and voids) by visualising changes in temperature across an object (ie highlighting the heat flows from inside to outside). Inconsistencies depicted by the thermal image are referred to as 'anomalies' and they may indicate any number of potential defects listed above.

Constraints

There are a number of constraints to thermal imaging, and the correct interpretation of the thermograms themselves. On a technical level, because there are always multiple sources of the infrared energy, it is often difficult to get an accurate temperature of an object using this method.

The conditions in which thermal imaging can be undertaken can be restrictive, particularly regarding external building surveys:

- The survey must be carried out at night, ie after sunset or early morning before sunrise. This prevents infra-red reflections from the sun, and also any absorption of heat by the building fabric from affecting the thermograms.
- The survey should be carried out, ideally, in cold conditions, with a temperature difference between indoors and outdoors of around 10˚C. This allows any heat emissions to be seen more clearly.
- The survey should be carried out during a dry, preferably cloudy and not windy (less than 5m/s) day, as this too can affect the reflectivity and emissivity of the building fabric.

Difficulties in the interpretation of thermograms

In terms of interpreting the thermograms, a number of parameters can distort the temperatures if near to the building fabric including; cars, vegetation and street lamps. An example of this is areas under eaves and cills, which in the presence of street lamps, can appear to be warm relative to the rest of the façade. This may be the result of light reflection distorting the apparent reflected temperature of other areas of the façade. In addition, different materials have different emissivity and thermal properties and as such require different thermographic settings. This is not always possible to achieve in one thermogram and care should be taken when interpreting images where mixed material finishes are present, eg. render and brick wall finishes with wooden door frames. Glazing is particularly tricky to interpret due to the reflective nature of glass, and no interpretation of glazing is undertaken within this report.

Another difficulty in external thermal surveys is that the internal temperatures within the properties may vary (the living room likely to be warmer than the bedroom etc) and as such may show a greater heat loss through the walls that is an inaccurate picture of the performance of the wall.

Furthermore, images taken at an oblique angle can also reduce the accuracy of the thermograms and therefore care must be taken when looking at roofs and the corners of walls.

Test Method

The survey was undertaken over a three hour period beginning approximately three hours after sunset allowing for any residual heat from the sun to disperse. Thermograms were taken of external elevations accessible from public land only. Due to the time at which the survey was undertaken entry was not sought into occupant's homes and gardens.

No further analysis of any abnormalities in the construction elements was undertaken as part of this thermographic survey, and it is recommended that where there are anomalies, further investigation is undertaken.

All thermal images are presented in the rainbow-hi palette for increased thermal definition.

Test Equipment Information

The test equipment used during the survey is shown in Table 2.

Environmental Conditions

External temperature was monitored throughout the course of the survey and was found to be less than 6°C. Under these conditions the minimum 10°C differential between internal and external temperatures should be achieved.

Wind speed was also monitored throughout the study to ensure this did not climb above the 5m/s that could disrupt thermal currents and therefore distort the thermograms. The results of these environmental measurements can be found in Table 3 below.

The 13th March 2013 was a still, cold overcast winter day. There was no significant change in weather conditions during the survey (from 23:00 – 03:30); with a final temperature reading of 1°C at 03:00hrs.

However, the clear sky and sun during the day before will have a detrimental impact on the south elevations in terms of surface temperature, due to the thermal storage properties of the solid stone walls. Subsequently the interpretation of the images should take this into account.

Analysis

The thermograms were analysed in relation with physical characteristics data gathered during interviews with occupants of the homes in Summer 2012. Common issues relating to the external façade were identified, and further explanation is given in the following sections.

Dwelling Construction

The dwellings included in the survey exemplify the typical age and type of dwellings in this area, mainly consisting of either pre-1919 solid wall detached/terrace dwellings or post-1965 cavity wall (insulated)detached dwellings. All are privately owned except one and have undergone varying levels of refurbishment and expansion.

Summary of observations

Within the dwellings built post-1965, there appeared to be quite a disparity in surface temperatures. Whilst external constraints should be taken into consideration, it does suggest differences in quality of construction between dwellings. Figures 1d and 1g are both 1965-80 detached dwellings, with stone finish. However, the dwelling shown in 1g has undergone substantial renovation, and improved fabric interventions. Similarly, Figures 1e, 1h and 1i are all

Table 2. Test equipment used in survey.

Manufacturer	Model	Description	Calibration Expiry
FLIR	T620bx	640x480 pixel, infrared camera set on rainbow colour palette	August 2013
Vaisala	Humicap HM40	Humidity and temperature meter	February 2013
ATP	DT-8880	Anemometer	October 2013

Table 3. Environmental conditions during survey.

Time	Temperature (°C)	Relative Humidity (%)	Wind Speed (m/s)	General weather description
22:15	-2.2	96.4	0.01 – 0.18	Dry, cold and clear
23:10	0.1	80.9	0.02 – 0.39	Dry, cold and clear
00:25	-1.3	82.9	Less than 5m/s	Dry, cold and clear

Table 4. Summary of most common issues identified through thermographic survey.

Problem area	Potential reasons	Potential constraints
Walls		
Patchy walls *(images a, b & e)*	• Poor workmanship of cavity wall insulation • Areas of inadequate cavity wall insulation • Air gaps within wall construction	• Different materials used within wall construction • Location of external lights (both on dwelling itself and streetlights reflecting light (and heat) onto external wall • Internal rooms heated to higher temperatures than others
Joints/ connection details *(images d, e & g)*	• Thermal bridging due to lack of insulation at junctions between walls/dormer windows etc.	
Chimney breasts *(image c)*	• High temperatures due to use of fire; lack of insulative lining • Direct access for air flow in and out of building	
Windows and doors		
Heat loss around windows/doors *(images b, e & f)*	• Thermal bridging • Gaps in draught-proofing of windows/doors • Poor construction particularly at joints allowing heat loss • Lack of insulation (difficult to install)	• Different materials used within wall construction • Sheltered nature of feature, resulting in slow dispersal of heat accumulated here during daylight hours
Heat loss under window cills *(images a, c, e & g)*	• Lack of insulation (difficult to install) • Gaps in draught-proofing of windows • Poor workmanship in relation to sealing and draught-proofing window frames	• Cills made of different materials (eg. Concrete, timber) • Sheltered nature of feature, resulting in slow dispersal of heat accumulated here during daylight hours
Other		
Ground level heat loss *(images a, c & f)*	• Ventilation due to suspended flooring • Lack of insulation on ground floor of dwelling • Lack of damp-proofing course (DPC)	• Dampness at ground level • Vegetation at ground level

detached properties built between 1981-90, yet demonstrate potential different levels of heat loss. It must be noted however, that the dwellings shown in Figures 1h and 1i are brick finish, whilst 1e is stone. Overall however, the appearance of the cavity wall dwellings appears generally ‘smooth’ and as such suggests a good quality of construction.

Within a number of dwellings, there appear to be ‘hot spots’ below windows, which suggests a need for draughtproofing and/or poor quality window installations (Figures 1a and 1e). Interestingly, in Figure 1a, there are no radiators below the windows, indicating that this is not simply an issue of increased localised heating.

A number of the solid wall dwellings show ‘patchy’ surfaces to the external wall but these generally correspond with the stone, and it is believed that due to the majority of these dwellings being built with random stone, this may simply be indicative of the different types of stone used in the construction. Figure 1f demonstrates the impact of external solid wall insulation on reducing heat loss, whilst also highlighting possible areas of heat loss around window and door frames. Figures 1b and 1c further indicate two main areas of heat loss (other than below windows) in solid wall dwellings in this survey; poorly sealed external doors and fanlights, and chimneys.

Table 4 is a summary of the most common issues identified, as also demonstrated in the images in Figure 2.

Reflections

Given the complexities in interpreting thermal images, it is often difficult to ascertain the exact causes of anomalies in the images. Further investigation of ‘hot’ spots below windows in particular would be recommended, as it could be indicative of poor installation of the glazing systems.

A key learning of the thermographic survey of dwellings in Hook Norton appears to be the difference in potential performance of similar dwellings (age, type and construction). However, it must be remembered that fluctuations in surface temperature are highly reliant on contextual variables such as weather conditions, nearby vegetation and adjacent lighting sources. The surface temperatures on the majority of dwellings built after 1980 suggests that they perform well in terms of heat loss. In solid wall dwellings, the main issues appear to be with openings, and the difficulties in sealing and draughtproofing windows and doors to ensure heat loss is reduced.

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The **EVALOC** research project brought together an interdisciplinary team of researchers from Oxford Brookes University and University of Oxford, to assess, explain and communicate the changes in energy use due to community activities within six low carbon community projects, funded under the Department of Energy and Climate Change's (DECC) Low Carbon Communities Challenge (LCCC). The LCCC programme was a government-supported initiative that was designed to test the effectiveness of community-scale approaches that combine low and zero carbon technologies with engagement and behaviour change activities.

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