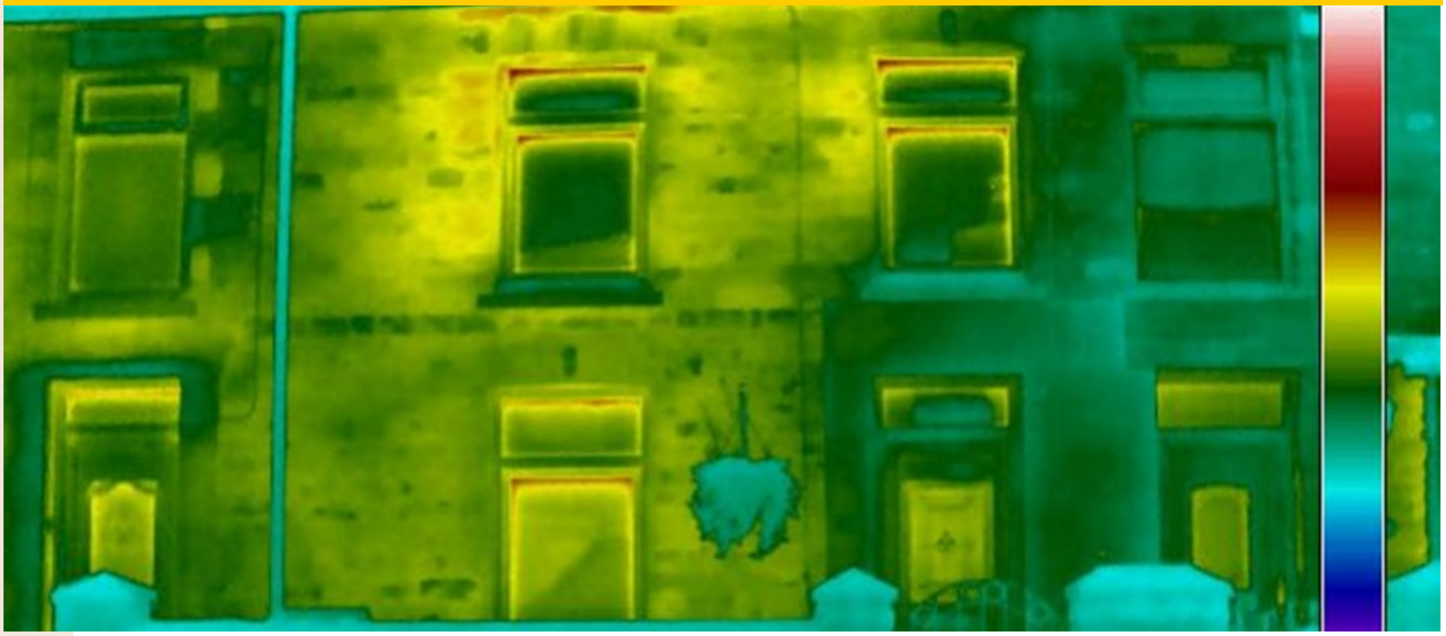
THERMAL IMAGING SURVEY:

AWEL AMAN TAWE CASE STUDY HOUSEHOLDS

EVALOC
EVALUATING LOW CARBON COMMUNITIES

COMMUNITY SUMMARY CI-TI FEBRUARY 2014



1. Introduction

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'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).

Within these six 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.

Awel Aman Tawe is one such community organisation. Whilst their activities are mainly focused community-scale energy projects, 17 households within the local area were recruited to participate in the EVALOC study. Although none of the households have received financial assistance directly from Awel Aman Tawe to help fund physical improvements to the dwelling in which they live, the majority have undertaken fabric improvements either by themselves, or with assistance from Government-led schemes. Table 1 demonstrates the improvements undertaken.

This report summarises the findings of a thermographic survey conducted on 21st February 2013 of these 17 homes.

1.1 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 enables objects to be seen in terms of their thermal properties, and highlights parts of objects invisible to the human eye (Figure 1).

1.2 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.

In terms of the dwelling, 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 in the thermal image are referred to as 'anomalies' and they may indicate any number of potential defects listed above.

	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 dwellings (total n. 17)	7	2	15	2	12	5	2	1

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

Table1: Type and number of improvements in EVALOC case study dwellings in Cwmllynfell and Ystradowen.

1.3 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 also can be restrictive, particularly in terms of 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 difference in temperature between the outside and inside of the home around 10°C. This allows any heat emissions to be seen more clearly.
- The survey should be carried out when dry, preferably cloudy and not windy (less than 5m/s), as this too can affect the reflectivity and emissivity of the building fabric.

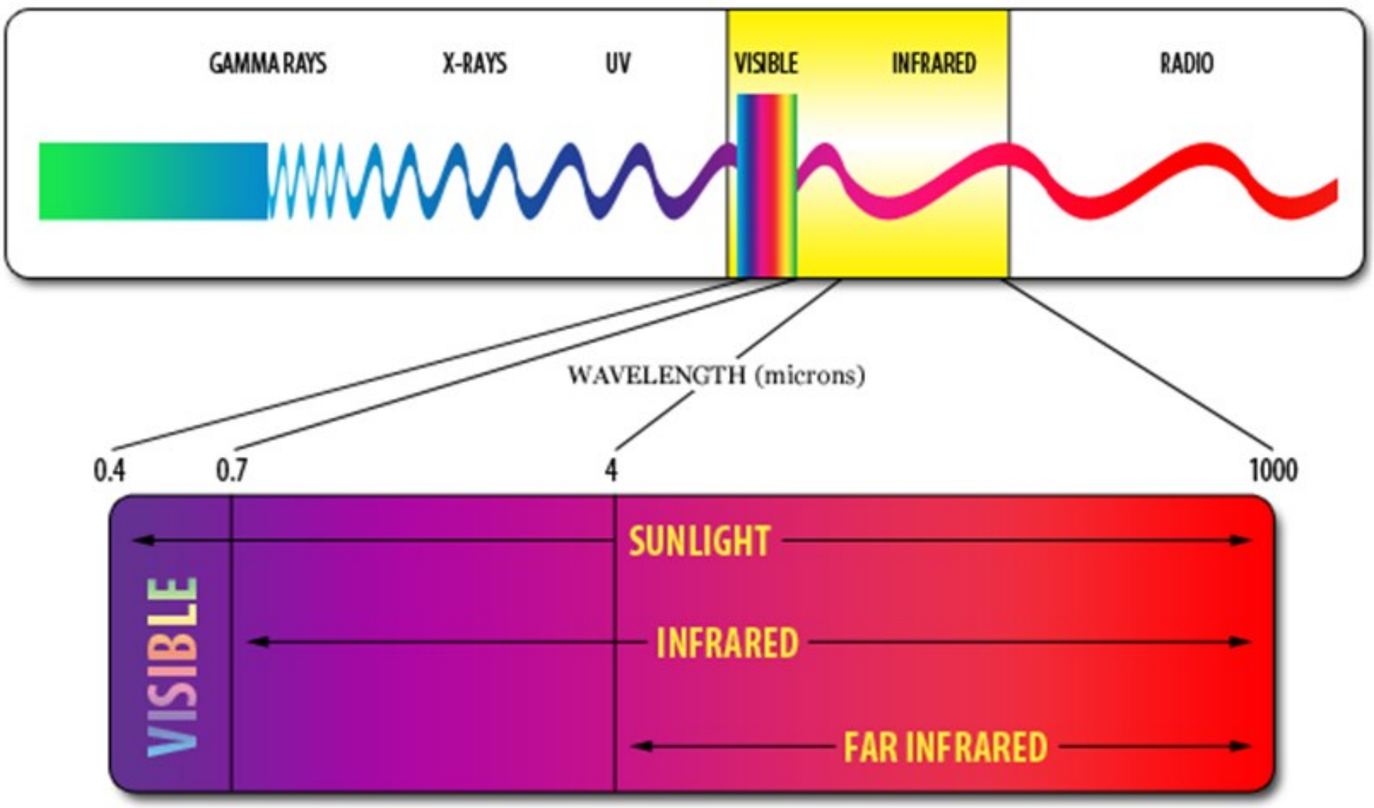


Figure1. The electromagnetic spectrum (http://www.biosmartsolutions.com/heaters/portable/why-far-infrared-heat, accessed March 2013)

1.4 Difficulties in the interpretation of thermograms

In terms of interpreting a thermogram, a number of physical aspects 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 image and therefore care must be taken when looking at roofs and the corners of walls.

A clear night sky can also significantly impact the apparent surface temperatures as shown in the thermal image. As such, the temperatures as shown in the images cannot be used to accurately quantify heat loss, and the images in this report should be used only to highlight the locations of potential areas of heat loss.

2. 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.

Table 2 outlines the test equipment used during the survey.

3. Environmental Conditions

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.

The 21st February 2013 was a still, cold overcast winter day. There was no significant change in weather conditions during the

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

Table2: Test equipment used in survey.

Time	Temperature (°C)	Relative Humidity (%)	Wind Speed (m/s)	General weather description
23:00	**0.2**	**62.5**	**0.08-0.57**	**Dry, cold and cloudy**

Table3: Environmental conditions during survey.

survey (from 23:00 – 03:30); with a final temperature reading of 1°C at 03:00hrs.

4. 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.

4.1 Dwelling Construction

The dwellings included in the survey exemplify the typical age and type of dwellings in this area, mainly consisting of solid stone dwellings, with a range of detached, semi-detached and terraced houses. The properties have also had varying levels of maintenance and refurbishment work undertaken.

4.2 Summary of Observations

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

A large number of the dwellings in this area are of solid wall construction. Whilst the solid wall dwellings do not appear to be losing much heat overall, there are 'patchy' areas, particularly to the sides and around windows. However, the majority of these 'hot' spots are in rooms that are known to be kept at higher temperatures than other rooms, and as such this could create ambiguities in the interpretation of the images.

Nine dwellings have cavity wall insulation. Of the dwellings with insulation installed 'as built', the evenness of the walls in the thermograms indicates that the construction was of high quality, and little improvement can be made. This is in contrast to dwellings where top-up cavity wall insulation has been installed. In these dwellings, the external wall appears patchy, possibly indicative of uneven wall insulation in hard-to-reach areas and poor quality workmanship.

Of particular interest is the comparison between dwellings of different ages. Images a-f in Figure 2 show dwellings of both cavity and solid wall construction built prior to 1944 (a-c are solid wall; d-f are cavity wall), whilst Images g-i are dwellings built after 1965. There appears to be a consistent improvement in heat loss reduction and evenness of wall temperatures achieved by the newer dwellings. The images also emphasise the potential issues when retrofitting cavity wall insulation into older dwellings that are likely to have smaller cavities, as shown in the patchiness of

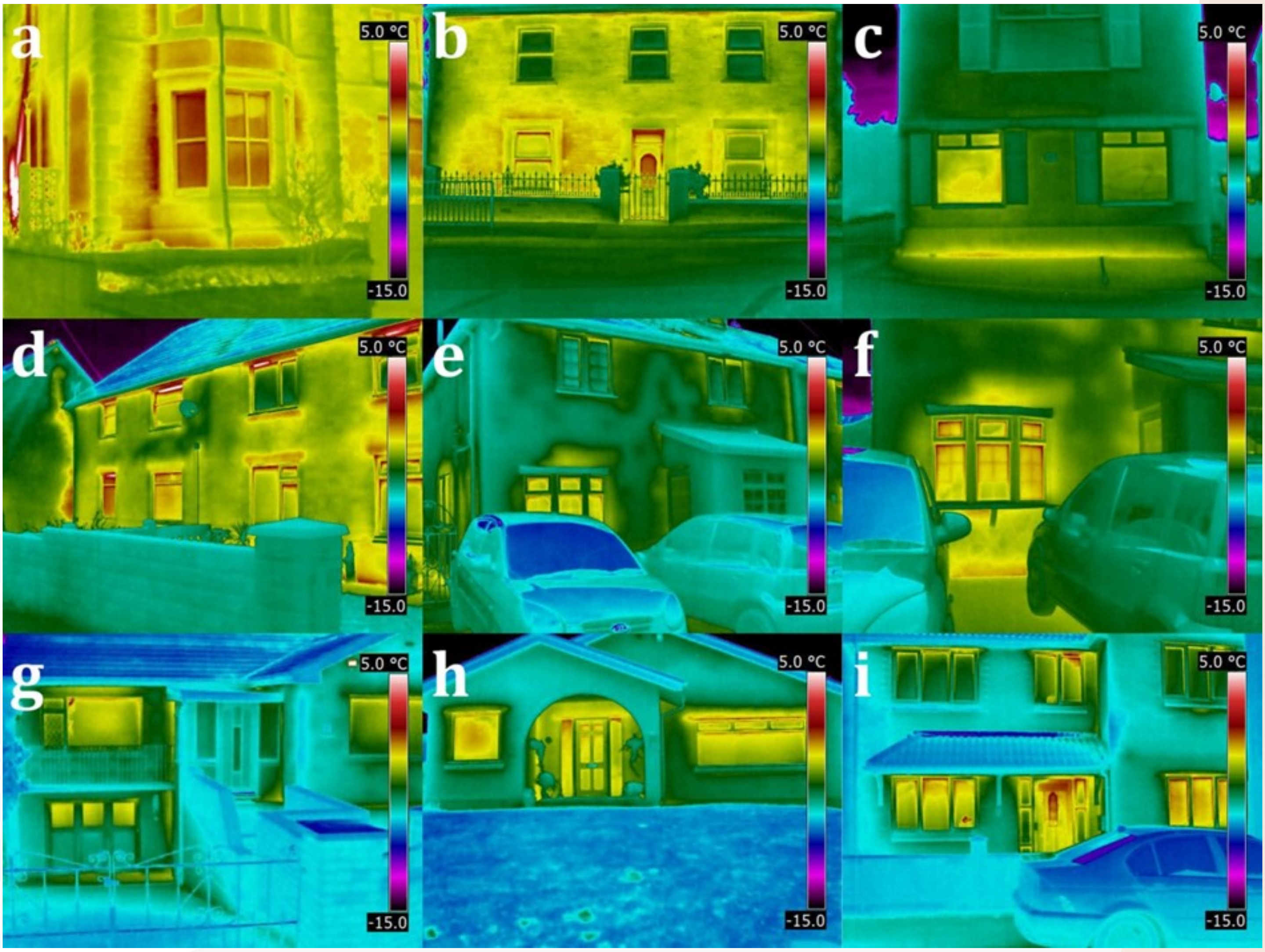


Figure2. Images a-c are of dwellings with solid wall construction; Image d is of cavity wall dwelling with no insulation; Images e-f are of cavity wall dwellings with retrofitted insulation; Images g-i are of cavity wall dwellings with insulation installed at time of original construction.

Problem area	Potential reasons	Potential constraints
Roof and eaves		
Eaves *(images b & d)*	- Thermal bridging (not packing loft insulation in tightly to edges) - Gaps in wall/loft insulation (difficulties in installation at construction joints)	- Sheltered nature of feature, resulting in slow dispersal of heat accumulated here during daylight hours - Ventilation gap in loft space
Walls		
Patchy walls *(images a, b, d, e & f)*	- Poor workmanship of retrofitted cavity wall insulation - Areas of inadequate cavity wall insulation - Blocked-up vents with inadequate insulation and/or thermal bridging - 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 a, e & g)*	- Thermal bridging due to lack of insulation at junctions between walls etc. - Poor workmanship of retrofit improvements	- Sheltered nature of feature, resulting in slow dispersal of heat accumulated here during daylight hours
Chimney breasts *(image a & d)*	- 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 lintels *(images d, e, f & h)*	- Thermal bridging - Gaps in draught-proofing of windows/ doors	- Lintels made of different materials (eg. Concrete, timber) - Sheltered nature of feature, resulting in slow dispersal of heat accumulated here during daylight hours
Bay and extruded windows *(images a & f)*	- 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 d, e, f & i)*	- Lack of insulation (difficult to install) - Gaps in draught-proofing of windows - Poor workmanship in relation to sealing and draught-proofing window frames - Indicative of localised 'hot' spots (generally due to radiator located on external wall beneath window)	- Sheltered nature of feature, resulting in slow dispersal of heat accumulated here during daylight hours
Other		
Ground level heat loss *(image 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

Table4: Summary of most common issues identified through thermal imaging survey.

the walls in Images 2e and 2f in comparison to Image 2h.

Selected thermograms for each dwelling along with a brief description of the dwelling, physical constraints and any specific anomalies that are present are available for the residents; contact the EVALOC team for further information.

5. 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 cavity wall insulation or the glazing systems themselves.

A key learning of the thermographic survey of dwellings in Cwmllynfell and Ystradowen appears to be the difficulties in retrofitting cavity wall insulation in certain dwelling types in the area; mainly 1919-44 dwellings with narrow cavities. Out of the four dwellings of this type in the study, all have much patchier external walls than the other dwellings in the area. Whilst fluctuations in surface temperature is highly reliant on contextual variables such as weather conditions, nearby vegetation and adjacent lighting sources, it does seem to indicate a specific issue with dwellings of this type and the high level of workmanship required in order to significantly reduce heat loss through retrofit measures. In a large number of the dwellings studied, 'hot spots' beneath windows, even in a relatively new dwelling (post-1990), indicate that sealing of window systems, and ensuring insulation is fully packed at these junctions are critical issues. In addition, a number of properties appear to suffer from high temperatures (ie heat loss) at ground level, which is indicative of the importance of floor insulation and/or high quality construction of the foundation details and wall/ground junction.

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.

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