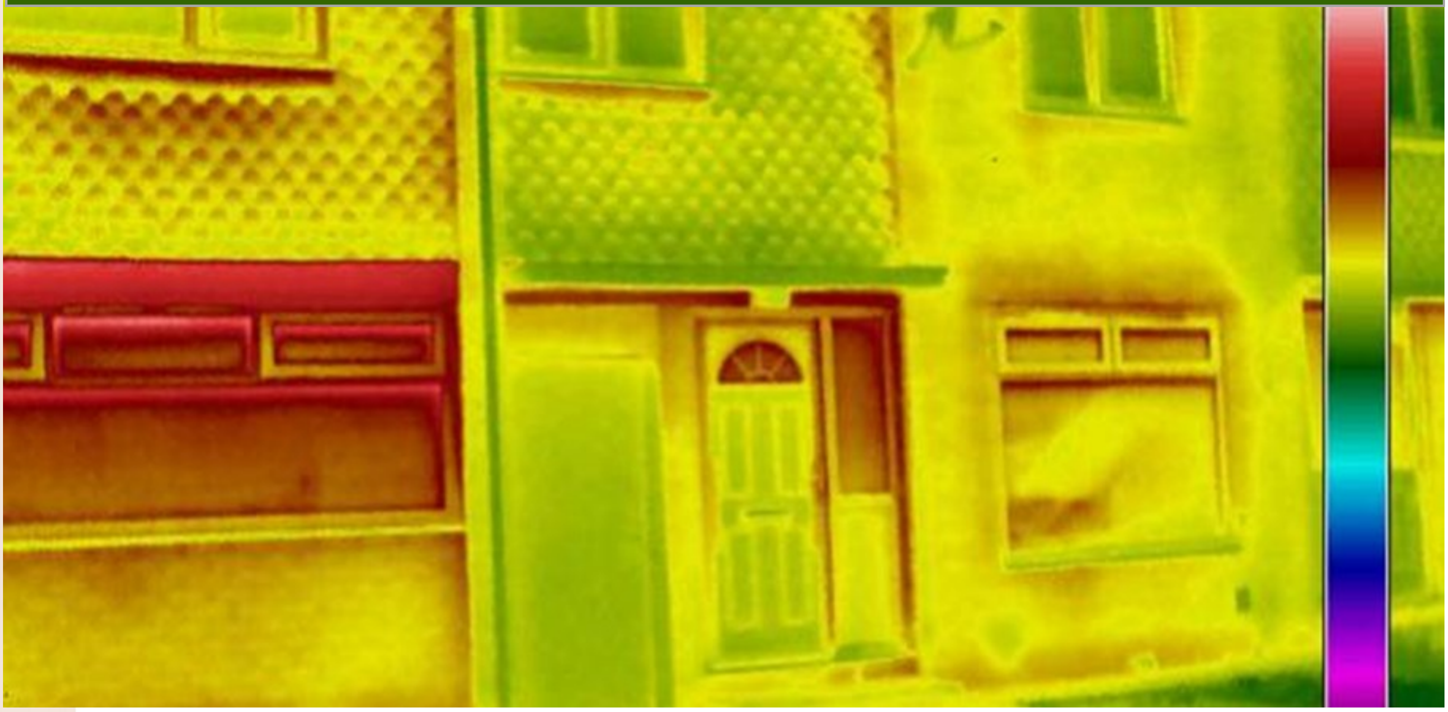
THERMAL IMAGING SURVEY:

EASTERSIDE CASE STUDY HOUSEHOLDS

EVALOC
EVALUATING LOW CARBON COMMUNITIES

COMMUNITY SUMMARY C3-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).

Eco Easterside is one of the six case study community initiatives. The project was delivered by Middlesbrough Environment City (a local charitable organisation) in partnership with Middlesbrough Council, Fabrick Housing Group and the Easterside community and funded by DECC's Low Carbon Community Challenge. As part of the work;

- 325 properties received cavity and wall insulation.
- 10 dwellings had solar PV panels installed.
- 6 had solar thermal systems installed.
- 4 dwellings had air source heat pumps installed.

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. In the Easterside community, 15 dwellings were surveyed as part of the EVALOC project.

Seven of the EVALOC case study homes benefitted directly from physical fabric improvements from the Eco-Easterside project. In addition, a number 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.

This report summarises the findings of a thermographic survey conducted on 3rd March 2013 of these 15 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

	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. 15)	8	5	13	2	7	7	0	1

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

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

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.

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

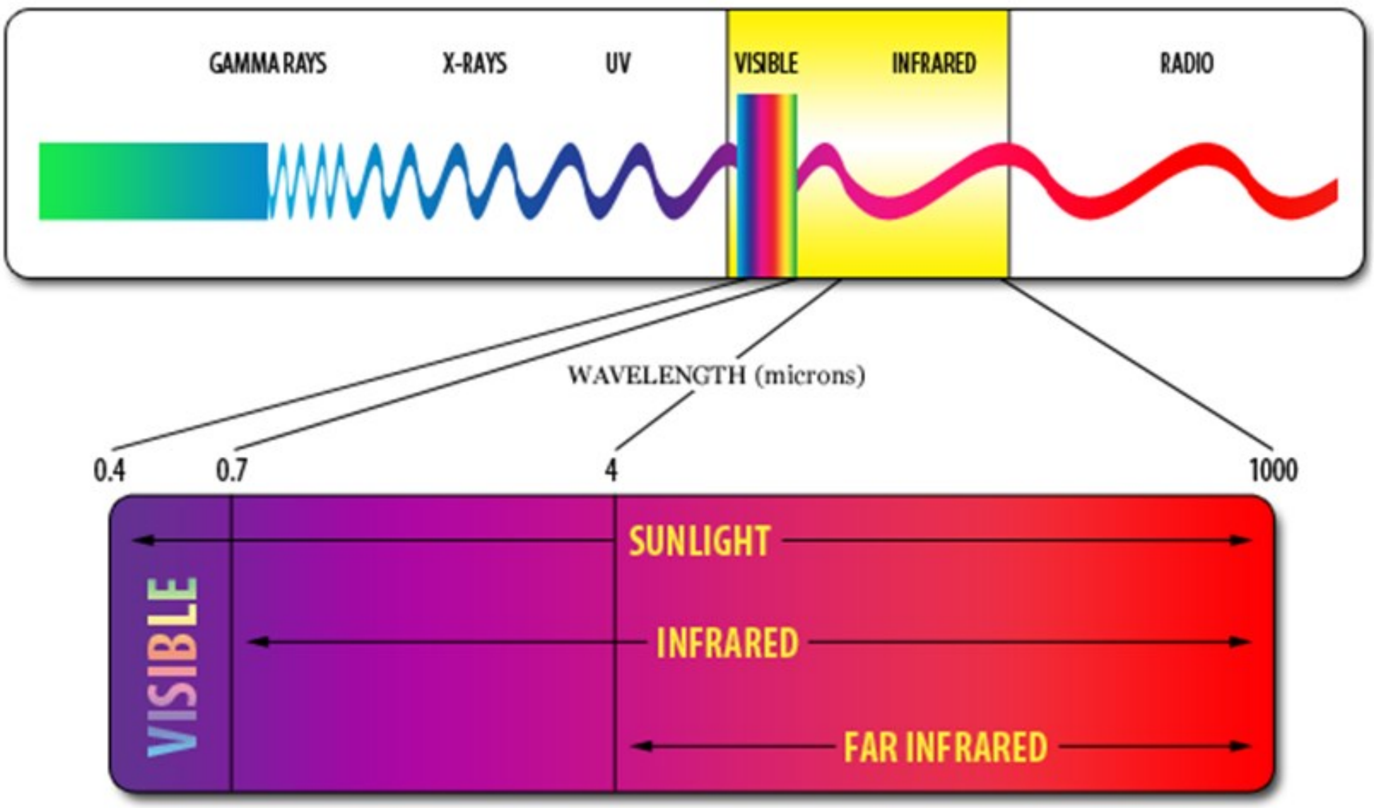


Figure1. The electromagnetic spectrum (http://www.biosmartsolutions.com/heaters/portable/why-far-infrared-heat, accessed March 2013)

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.

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 7°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 3rd March 2013 was a still, cold overcast winter day. There was no significant change in weather conditions during the survey as demonstrated in Table 3.

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.

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.

4.1 Dwelling Construction

The dwellings included in the survey exemplify the typical age and type of dwellings in this area, mainly consisting of post-1944 cavity wall semi-detached and terraced houses. The properties have also had varying levels of maintenance and refurbishment work undertaken as most were built as council housing, but have since become privately owned or continue to be owned by social landlords.

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.

The majority of the dwellings in this survey were built post-war (1945-64) with cavity wall construction. Most have had both cavity wall and loft insulation top-ups in the last twenty years. When comparing the images of the dwellings, distinct 'patchiness' to the external walls can be seen on most of the buildings. This could indicate an overall issue with retrofitting cavity wall insulation in this area.

A difficulty presenting itself in the interpretation and comparison of the images is the fact that the indoor temperature is unknown. Figure 2c particularly highlights this as it is highly likely that the dwelling to the left of the image is not being heated to the same levels as the adjoining property (due to contextual data known to researchers). As such, although this dwelling appears to be losing less heat, it may simply be due to the variation in the difference in internal and external temperatures between the two dwellings.

From the survey, it is also very difficult to assess the performance of loft insulation in the dwellings; in some there is a clear definition of the line of loft insulation (Figure 2i) but in a number of other dwellings the line is not visible. This suggests that a similar amount of heat is being lost from the loft as the walls. As the loft is unlikely to be a heated space, this is an area that is worth further investigation.

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 symptomatic of poor installation of cavity wall insulation or the glazing systems themselves.

Whilst such 'hot spots' appear to be indicative of a lack of sealing and insulation around the window systems, in a number of buildings it also appears the fundamental construction of the walls is making it difficult to reduce heat loss in this area. In the majority of these buildings the area below the window (particularly ground floor) is an infill panel which lacks the insulative properties of the rest of the wall and also provides additional junction detailing between different materials and surfaces.

A key learning of the thermographic survey of dwellings in Easterside appears to be the difficulties in retrofitting cavity wall insulation in certain dwelling types in the area; mainly 1945-64 dwellings. Whilst this may be due to the buildings having narrow cavities, it is possible that poor installation and workmanship has also contributed to this. The majority of the buildings surveyed undertook the cavity wall insulation retrofits as part of Government Schemes and a number of occupants reported that it was completed after a 'cold call' offering free insulation. Although this is speculative and fluctuations in surface temperature is highly reliant on contextual variables such as weather conditions, nearby vegetation and adjacent lighting

Time	Temperature (°C)	Relative Humidity (%)	Wind Speed (m/s)	General weather description
21:20	6.95	73.05	0.01-1.99	Dry, cold and cloudy
22:10	6.95	71.72	0.03-0.77	Dry, cold and cloudy
23:00	6.42	73.63	0.02-1.94	Dry, cold and cloudy

Table3: Environmental conditions during survey.

Problem area	Potential reasons	Potential constraints
Roof and eaves		
Eaves and loft *(images d, f, h & i)*	- 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-i)*	- 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 d, f & h)*	- Thermal bridging due to lack of insulation at junctions between walls etc. - Poor workmanship of retrofit improvements - Junctions between original building and new extensions not adequately detailed and constructed	- Sheltered nature of feature, resulting in slow dispersal of heat accumulated here during daylight hours
Windows and doors		
Heat loss around lintels *(images b, c, f & g)*	- Thermal bridging - Gaps in draught-proofing of windows/ doors - Tricklevents in windows left open (required for ventilation)	- 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 & e)*	- 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-g)*	- 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
Door alcoves *(image a)*	- Lack of insulation in external walls in door alcoves - Poorly fitting doors and/or original doors and glazing panels retained with poor sealing/draughtproofing measures	- Sheltered nature of feature, resulting in slow dispersal of heat accumulated here during daylight hours
Other		
Ground level heat loss *(image 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 - Different materials

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

sources, it does appear to indicate an specific issue with dwellings of this type, and the need for good workmanship and immediate follow-up diagnostics can only emphasised.

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.

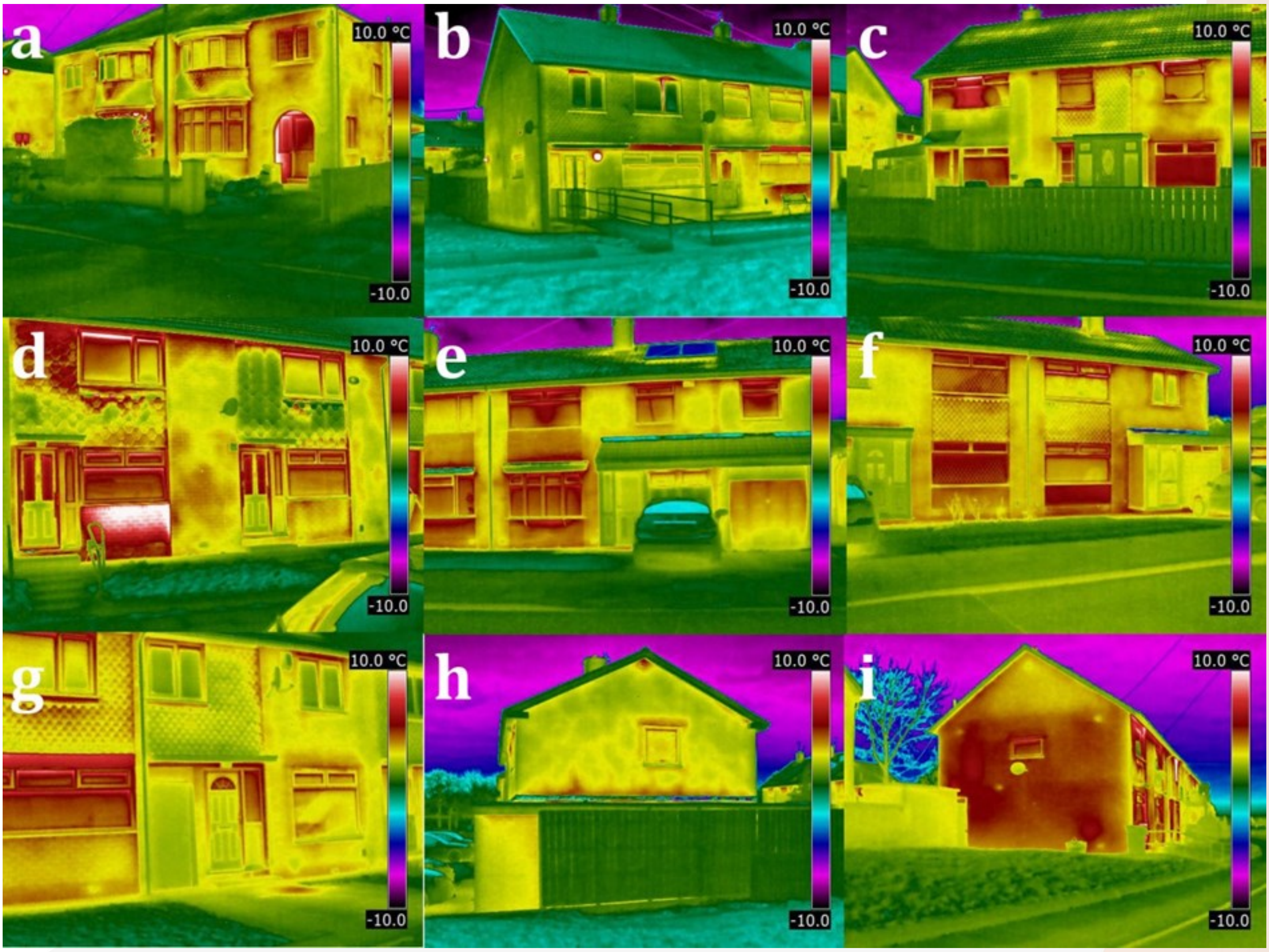


Figure 4. Set of images showing common issues highlighted during the thermal imaging survey.

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