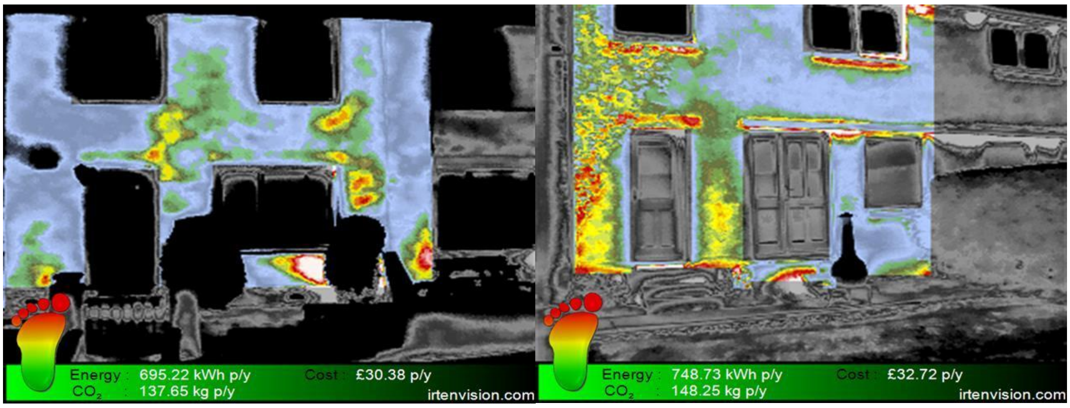
The use of thermal imaging to support area-based energy efficiency schemes

Final report

Analysis and interpretation of thermal images in Dunfermline and Eyemouth



Contents

EXECUTIVE SUMMARY 3
1.0 Introduction........ 5
2.0 Objectives........ 5
Objective 1: Documenting the thermal imaging process........ 5
Objective 2: Securing external wall insulation (EWI) images suitable for marketing purposes........ 5
Objective 3: Evaluating the increased uptake of insulation measures as a result of using thermal imaging used in marketing campaigns. 5
Objective 4: Investigating the potential of thermal imaging for identifying properties lacking CWI. 5
3.0 Method 6
3.1 Background........ 6
3.2 Using thermal imaging in marketing materials........ 6
3.3 Thermal imaging to detect and target unfilled cavities in Eyemouth 7
4.0 Results 7
4.1 Obtaining and utilising thermal images........ 7
4.2 The challenge of thermal imaging: unsuitable thermal images 8
4.3 The impact of EWI on thermal images 9
4.4 The effectiveness of thermal imaging in marketing materials 10
4.5. Using thermal imaging to identify CWI properties........12
4.6 Identifying properties suitable for CWI extracts 12
4.7 Thermal imaging of build types other than cavity wall........16
5.0 General lessons learnt about interpreting thermal images 18
5.1. Change in building material........18
5.2 Presence of air vents 19
5.3 Location of boiler / wind sheltering 20
5.4 Location of radiators 22
6. Summary of results........23
APPENDIX A: EWI letters to private tenure residents in Deans........25
APPENDIX B: Telephone survey questions........28

EXECUTIVE SUMMARY

In February 2014 the Energy Saving Trust (EST) commissioned Changeworks to investigate the effectiveness of thermal imaging as a tool to support the design and delivery of Home Energy Efficiency Programmes for Scotland: Area Based Schemes (HEEPS: ABS). This included its usefulness in marketing materials highlighting the benefits of HEEPS: ABS measures and for identifying uninsulated properties for inclusion in future programmes.

Thermal imaging allows analysis of heat loss from buildings without access to the property (e.g. physical inspections) and provides a visual aid for promoting energy efficiency measures to homeowners. It therefore has the potential to improve uptake of external wall insulation (EWI) and cavity wall insulation (CWI) through inclusion in marketing materials, as well as through identification of properties with inadequate insulation.

To investigate the potential of thermal imaging as a marketing tool, a sample of 25 solid wall properties in Dunfermline was selected to provide 'before' and 'after' images of EWI installation. These images were used in a marketing exercise to investigate whether they could be used to increase EWI sign-up. Finally, the potential of thermal imaging for identifying properties with unfilled cavities was trialled through capturing images of properties in Eyemouth.

Key findings

1. Thermal imaging captures good visual information. Together with supporting information, this has some potential for marketing purposes.
2. Thermal images may be most persuasive when used in booklets during door-knocking. The marketing analysis showed that thermal images in letters did not improve EWI sign-up; however, some residents cited thermal images as a factor when used by contractors in the area.
3. Based on the Eyemouth sample of 645 thermal images of cavity wall properties, no unfilled cavities were detected. This area was initially selected due to suspected high potential for CWI. Therefore this demonstrates the value of thermal imaging in refining the targeting of properties, in this case saving non-productive marketing effort.
4. In the Eyemouth sample the thermal imaging showed a high number of properties (119) with potentially deteriorated cavity wall insulation and follow-up physical surveys confirmed these findings. Thermal imaging therefore has potential for evaluating previous installs as a quality control technique and also the potential to encourage householders to take remedial action during extraction programmes.
5. The thermal imaging process is highly weather dependent with cold, dry and still conditions required to capture useable images. The Eyemouth project in particular was hindered due to a period of unseasonably mild weather at the project outset. This indicates the narrow window of opportunity during which thermal imaging can be completed (late October to early March). For inclusion in HEEPS: ABS bids, images should be captured over the preceding winter (i.e. over a full calendar

year before bid submission). Analysis of thermal images could then be carried out over spring/summer ahead of final bid preparation for the February deadline.

6. This project benefitted from additional advice and interpretation provided by the thermal imaging provider, IRT Surveys Ltd. This was useful since raw images have the potential to mislead the untrained eye. A number of building features can resemble deteriorated insulation on thermal images therefore Google Street View should be used for cross referencing.

1.0 Introduction

In February 2014 the Energy Saving Trust (EST), with funding from Scottish Government, commissioned Changeworks to investigate the effectiveness of thermal imaging as a tool to support the design and delivery of Home Energy Efficiency Programmes for Scotland: Area Based Schemes (HEEPS: ABS). This included its usefulness in marketing materials highlighting the benefits of HEEPS: ABS measures and for identifying uninsulated properties for inclusion in future programmes.

2.0 Objectives

The project had four key objectives:

Objective 1: Documenting the thermal imaging process.

This objective focused on understanding the timelines for obtaining thermal images; assessing quality of the images and data received; and the determining level of analysis required by the client.

Objective 2: Securing external wall insulation (EWI) images suitable for marketing purposes.

This objective centred on capturing images of solid wall households before and after installation of EWI.

Objective 3: Evaluating the increased uptake of insulation measures as a result of using thermal images in marketing campaigns.

This objective centres on understanding whether thermal imaging boosts interest and participation in insulation schemes.

Objective 4: Investigating the potential of thermal imaging for identifying properties lacking CWI.

This objective sought to test thermal imaging as a tool for identifying properties lacking CWI. As so many cavity wall properties have had CWI installed it is getting harder to identify those that have not and costlier to reach them when planning schemes.

3.0 Method

3.1 Background

Thermal imaging uses infrared cameras that are capable of detecting heat radiation from objects within its focus. The thermal images produced use different colours to highlight areas of high heat (red/white colour) and low heat (blue/black colour). This approach lends itself to analysing the quality of insulation in buildings since areas of poor insulation will show heat loss within these thermal images. Thermal imaging could therefore be useful in identifying uninsulated cavities or where insulation has either degraded or been poorly installed. It also has the potential to be used in marketing materials as it provides a visual image of heat loss to the householder. Thermal images may therefore have the potential to increase uptake of insulation measures when used in marketing materials.

One of the main advantages of thermal imaging is that prior householder consent is not required for image capture. This is in contrast to a physical inspection (often using a borescope or similar) where prior consent is required.

For the purposes of this project, IRT Surveys Ltd was commissioned to capture images. IRT carry out thermal imaging and quantification of walls and flat roofs, but not ground-based capture of pitched roofs. These thermal images can be used to visually identify regions of missing/ slumped/ deteriorated insulation.

IRT use patented analysis software to analyse thermal images and calculate an annual energy loss figure through the photographed elevation. This energy loss can also be interpreted as a potential energy saving through effective insulation. This potential energy saving figure is used to estimate the equivalent annual cost and CO_2 savings based on property assumptions.

3.2 Using thermal imaging in marketing materials

To assess the usefulness of thermal images in marketing materials, a sample of 25 Wimpey no-fines (solid wall) properties in Dunfermline underwent thermal imaging before and after EWI installation. These properties represented a small sample of a 570 property HEEPS: ABS EWI programme led by Fife Council. The Council identified these households as being at a high risk of fuel poverty due to the property structure having high U-value solid concrete walls with significant heat loss. Thermal images were captured in February 2014 before installation of EWI in summer 2014. Follow-up images were captured in October 2014 to analyse the level of improvement resulting from the installation of EWI.

The ‘before’ and ‘after’ thermal images for individual properties were used to estimate the energy, cost and carbon savings of properties as a result of EWI. These images were then used to examine whether thermal images can lead to improved EWI sign-up. The marketing exercise using these images was then carried out in Deans, West Lothian, a Wimpey no-fines site (the same build type as Dunfermline) selected for EWI as part of the 2014/15 HEEPS: ABS programme. Two letters were sent to 120 private tenure households in November 2014 with the following content (see Appendix A for copies of these letters):

* The first letter contained a standard text only offer for EWI from Home Energy Scotland;
* The second letter contained the same information as the first but also included the thermal images showing heat loss before and after EWI installation.

The number of households who agreed to EWI installation following receipt of one of the two letter samples was monitored over November and December. In January 2015 households in the standard letter (non-thermal image) sample who decided against EWI sign-up were sent a second letter containing thermal images (this letter had the same content as the original thermal image letter – see figure A2 and A3 in Appendix A).

In the last week of January 2015 all households in receipt of thermal image-based letters (both in the first and second wave of mailing) who agreed to EWI installation were contacted for a telephone survey. This survey aimed to establish what factors influenced their decision to install EWI. The survey questionnaire is provided in Appendix B. The results are discussed in Section 4.

3.3 Thermal imaging to detect and target unfilled cavities in Eyemouth

Eyemouth was targeted as a priority area by Scottish Borders Council due to high CWI potential and poor uptake in previous schemes (most recently a Universal Home Insulation (UHIS) campaign in 2012). Through thermal image capture, this project sought to determine the level of remaining CWI potential and opportunities for targeted marketing to properties with unfilled cavities.

This exercise targeted 1,546 addresses provided by Scottish Borders Council in conjunction with Changeworks and the local Home Energy Scotland Advice Centre. The aim was to establish the time taken to obtain images, ease of interpretation and ultimately usefulness in detecting previously missed homes. This acted to simulate and explore the process of commissioning and handling a large number of images from a local authority/insulation scheme promoter perspective.

4.0 Results

4.1 Obtaining and utilising thermal images

The thermal imaging provider carried out thermal imaging in the hours of darkness to allow any solar-gained surface heat to dissipate from the structure. Suitable cold, dry and still weather conditions are a key factor in producing useful images. If conditions are suitable, image capture can be rapid, with up to 200 – 400 images per night.

After thermal image capture and analysis using Envision software, quantified images were provided to Changeworks as an Excel file. This included an infrared image of each property, property reference number, full address, construction type and estimated potential annual energy, cost and carbon savings through the photographed elevation.

A great deal of the primary analysis was provided by the thermal image provider, meaning the client (in this case Changeworks) was only required to review the images and seek additional explanation, particularly in relation to anomalies. For identifying anomalies, Google Street View was a useful tool to study features of the building. Although the thermal image provider provided assistance, there were clear benefits to the client having a basic understanding of construction and thermal issues such as thermal bridging. With this knowledge it is possible to request additional explanation from the thermal image provider to verify images and insulation potential. The process of reviewing 700 images was completed within less than a week.

Key Finding: To maximise the usefulness of thermal images the client needs a basic knowledge of construction and insulation techniques and time to cross-reference the images with Google Street View. This analysis can be done rapidly.

4.2 The challenge of thermal imaging: unsuitable thermal images

Weather conditions are critical to the success of thermal imaging. Due to the initial time of survey (March 2014), this impacted both the Dunfermline and Eyemouth projects. In order to produce clearly defined thermal images there must be a temperature difference between the inside and outside of the building (a 'temperature differential') of at least 10°C; this is difficult to achieve in the spring months. In addition, the large amount of precipitation at this time of year can lead to thermal image degradation.

High levels of moisture, fog and high temperatures during the initial survey period hindered thermal image capture following installation of EWI in Dunfermline. This resulted in 797 properties of the 1,546 Eyemouth sample (52%) returning images of insufficient quality for analysis. The Eyemouth Excel file received from the thermal imaging provider contained a worksheet with an address list and accompanying thermal images for each of these unquantified images. Two examples of unquantified thermal images are illustrated in Figure 1.

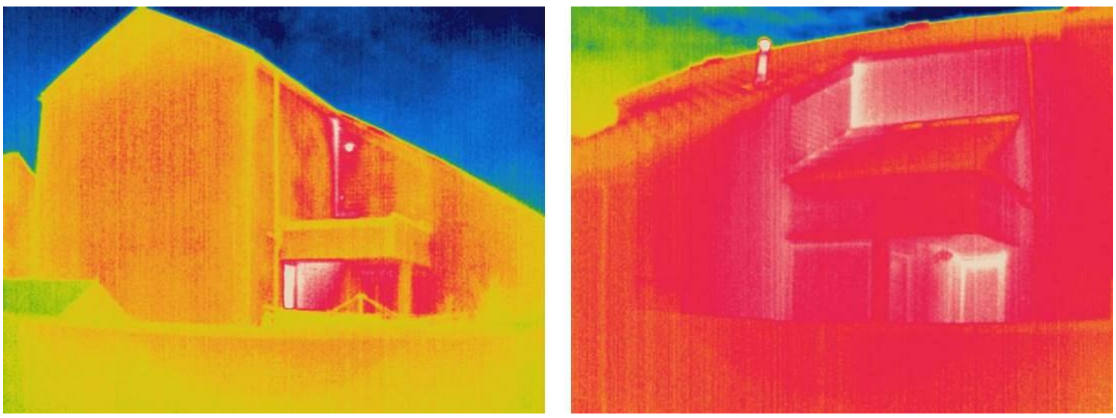


Figure 1: Example of thermal images of two properties that were unsuitable for analysis.

This negative effect of spring weather on thermal imaging will hinder the usefulness of thermal imaging in HEEPS: ABS bids preparation and strongly suggests the need to commission surveys in the previous heating season. For example, a bid in 2014/15 needs images to be captured in the winter of 2013/14.

There is no guarantee of a 100% success rate with thermal images even if weather conditions are ideal since there may be external factors (such as vacant households, insufficient use of heating etc.).

Key Finding: Weather conditions play a critical role in the success rate of thermal imaging, with cold, dry conditions in the winter months preferable. Careful forward planning is needed for use of thermal images in HEEPS: ABS bids. To minimise the risks of missed deadlines this means efforts must be directed during the heating season prior to the year the bid is prepared and submitted.

4.3 The impact of EWI on thermal images

All 25 sample properties in Dunfermline returned high quality thermal images before and after EWI. These were analysed using the thermal imaging provider's software and findings presented in individual energy reports. Thermal images of a property before and after EWI are shown in Figure 2 below. Here, the image on the left (before EWI) shows significant heat loss through the property walls (indicated by areas of red and yellow). In comparison, the image on the right (after EWI) demonstrates the improvement in thermal retention by the consistent blue colour across external walls.

The images also display the estimated annual energy, CO_2 and financial costs[1] associated with the estimated heat loss through the photographed elevation, as derived from the thermal imaging provider's analytical software.[2] So for example, in the left-hand image in Figure 2 prior to EWI, these are 8,166 kWh of energy use, 1.62 tonnes CO_2 and £253 per annum. After EWI, these are reduced to 594 kWh of energy use, 1.17 tonnes CO_2 and £18 per annum. The calculations for the property after insulation indicate a cost saving for the photographed elevation of approximately £235 per annum, which (especially for a householder in fuel poverty) represents a significant saving. Similar levels of savings were identified across the sample.

[1] The annual cost saving figure provided by IRT is based on the cost of gas, which can be modified on request. This is a useful feature since different regions can have different energy prices.
[2] It should be noted that the annual energy, CO_2 and cost savings contained in thermal images only refer to the photographed elevation, as opposed to the entire property.

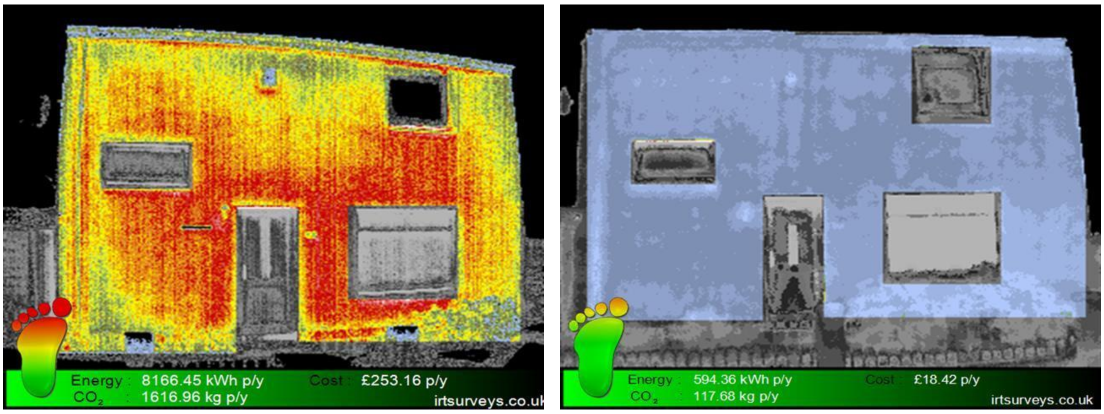


Figure 2: Thermal imaging of a property before (left image) and after (right image) EWI installation.

Based on the visual improvement shown by the thermal images following EWI installation (and therefore anticipated increased levels of thermal comfort) these potentially could be used as marketing materials. In addition, the quantified annual cost savings could be used to persuade residents of the merits of installing EWI; backing up the standard costs savings quoted on EST's website and in marketing materials.

Key Finding: Thermal imaging can be used to clearly and visually illustrate the benefits of installing EWI. Features that have good potential for marketing materials include the visual heat loss from properties and annual estimated cost saving calculated from the image.

4.4 The effectiveness of thermal imaging in marketing materials

The impact of using thermal images in marketing materials was tested in Deans, West Lothian. Deans contains a number of Wimpey no-fines properties that had been selected for EWI installation through HEEPS: ABS. During the sign-up process in November 2014, 64 private tenure properties were sent a standard mailing from Home Energy Scotland (not containing thermal images) and 65 were sent a letter containing thermal images before and after the installation of EWI (see Appendix A).

Over the subsequent two months, 27 residents (who had received the standard mailing from Home Energy Scotland (without thermal images)) agreed to EWI representing a 42% conversion rate. In contrast, there were 12 resultant sign-ups from residents who received the thermal image based letter representing an 18% conversion rate.

This finding was surprising since it is unlikely that the inclusion of thermal images would discourage residents from installing EWI. However, it was by necessity a small sample. Other contributory factors to sign-up could be the requirement for £800 owner contribution which, in an area of fuel poverty in particular, represents a significant outlay. Finally, the contractor (Everwarm) began door knocking in the area five days after residents received letters to encourage sign-up. However, since the properties were mailed at random, and Everwarm encouraged sign-up across the whole site, this is unlikely to have biased the finding on whether the thermal image influenced householder's decisions.

Thirty seven residents who decided against EWI installation and received the standard (non-thermal image) letter were mailed a second time in January. On this occasion they were provided with letters containing thermal images. This resulted in a further eight sign ups representing a conversion rate of 22%. This provided an interesting finding since residents who had originally decided against EWI agreed to installation when presented with thermal image based materials suggesting thermal imaging may be effective in marketing materials. However, again it is hard to isolate the impact of the images from other factors.

In order to gain further insight into the effectiveness of thermal imaging in marketing materials, all residents sent the thermal image-based letters (in the first and second round of mailing) and who decided to sign up for EWI were contacted by phone to establish their reasons for signing up. Of this 20 property sample, 10 were available and willing to participate in the phone survey. Initially, participants were asked what factors made them decide to sign up for EWI. This was open ended to avoid influencing responses. No residents specifically mentioned thermal images as a reason in itself, with 'good price', 'reduce energy bills' and 'make home warmer' the most popular responses, with seven each.

Six of the ten residents surveyed remembered receiving a letter from Home Energy Scotland, four of which remembered seeing the thermal images. These findings suggest that door knocking by Everwarm had a possible influence on sign-up. In support of this, a resident who remembered receiving the letter but did not remember thermal images within the letter, recalled the Everwarm site manager presenting thermal image-based materials in person. This suggests that thermal images can be a useful resource in booklets and marketing materials, particularly when presented in-person.

The four respondents that remembered seeing thermal images were asked further questions regarding the thermal images, with the following results:

- Respondents rated their understanding of the thermal images on average 9.5/10;
- Respondents rated how much the thermal images convinced them that EWI would improve their home on average 9/10;
- Respondents rated how persuasive the images were in signing up for the insulation on average 8.75/10.

These results suggest that, of the small sample that remembered seeing thermal images, they were effective as marketing materials in encouraging EWI sign-up.
The value of thermal imaging to this effect was demonstrated during the HEEPS: ABS programme in Dunfermline. Here, a householder questioned the effectiveness of EWI for improving the thermal comfort of their home. In response, a thermal image was used to highlight the significant heat loss prior to installation of EWI. This resulted in a positive outcome with the householder agreeing to EWI installation.

Key Finding: Due to the small sample size it is difficult to draw concrete conclusions regarding the effectiveness of thermal imaging in marketing materials. However, in this instance thermal images did not appear to increase uptake of EWI in Deans through mailing. This was reflected in both the sign-up rate of the mailing exercise (which was lower for thermal imaging-based materials) and the telephone survey (where 6 out of 10 respondents did not remember seeing thermal images). However, thermal images can be persuasive as shown by the four respondents and may also strengthen face to face discussions.

4.5. Using thermal imaging to identify CWI properties

The 749 useable property images from Eyemouth were quantified and reviewed by the thermal imaging provider. This revealed that whilst the area had been identified as one with a high proportion of cavity wall properties, not all properties on the address list were cavity wall structures. As part of their analysis, the thermal imaging provider categorised the build type in the Excel workbook, which showed:

- 645 cavity wall properties (86%);
- 65 solid wall properties (9%);
- 39 timber frame properties (5%).

Whilst this exercise could be done by an assessor using street view and site visits, thermal imaging offers an efficient and systematic alternative. It demonstrated that the initial targeting of the area was merited in relation to build type. In addition, it yielded results for other non-target property types, such as solid wall properties, which have potential for use in future marketing campaigns.

After analysis, none of the 645 cavity wall properties were considered to have unfilled cavities. Only four examples showed any potential but were deemed as having deteriorated insulation rather than unfilled cavities. Thermal images of uninsulated cavity walls have consistent heat loss across the surface of the property; this was not observed in the Eyemouth sample.

These initial findings suggest that this area previously identified as high in unfilled cavities is likely to have already been targeted by installers. The Eyemouth data shows that thermal imaging therefore offers the opportunity to quickly rule out areas and avoid unproductive marketing effort.

Key Finding: Thermal imaging could be used to eliminate areas of assumed potential before resources are expended on unproductive marketing.

4.6 Identifying properties suitable for CWI extracts

Although the Eyemouth sample contained no properties with unfilled cavities, 119 properties (18%) showed signs of deteriorated CWI. The identification of so many potentially deteriorated CW installations in this sample could indicate that thermal images could be used for this purpose to justify an energy efficiency scheme with potential to deliver cost savings to residents and emissions savings.

Deteriorated insulation can present itself in a number of ways on thermal images. The first example is shown in Figure 3 below, which has been annotated to show key features. This property has been identified as suitable for cavity wall extraction due to areas of patchy heat loss (illustrated in red and yellow) to the left of the thermal image mainly occurring around the front door. The walls to the right of the image exhibit very low heat loss as shown by the consistent blue colour of the structure.

An important aspect when interpreting thermal images is to discount heat loss through lintels and soffits as this is not due to poor insulation but rather an example of thermal bridging that spans the insulated space. This thermal bridging is therefore unrelated to the CWI quality and any heat loss showing a similar regular pattern of heat loss surrounding windows and doors should be discounted.

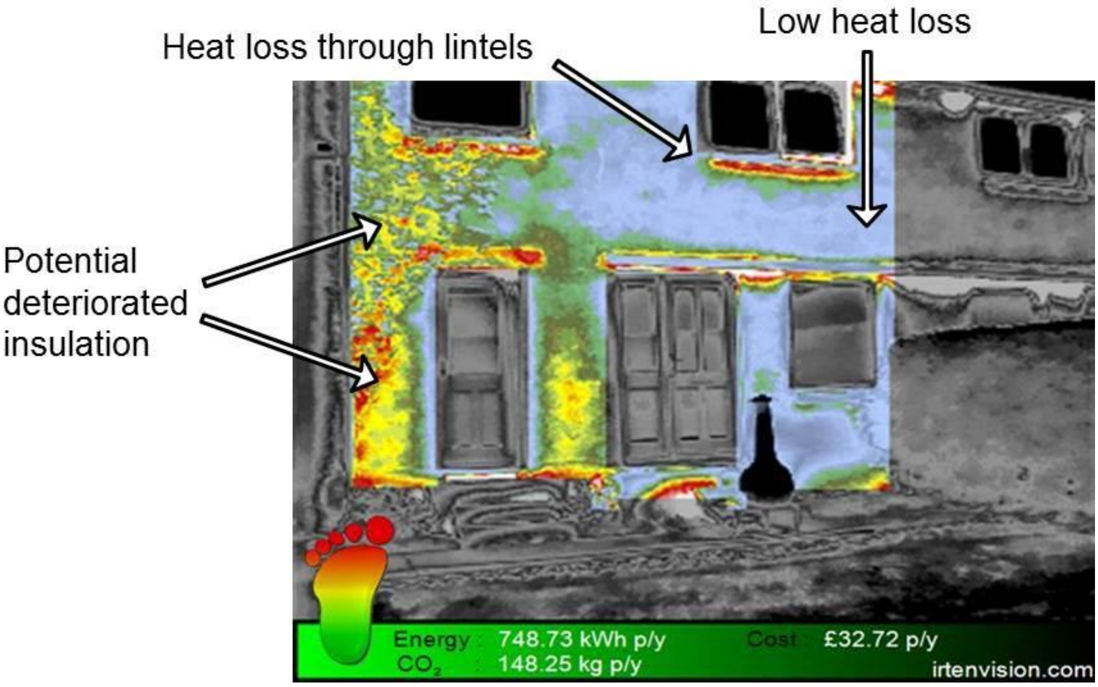


Figure 3: Example thermal image of a property suitable for CWI extraction indicated by patchy heat loss patterns.

Figure 4 below provides a second example of a property suitable for cavity wall extraction. In this case, areas of deteriorated insulation are more localised in discrete areas dispersed across the property exterior. If these hot patches are indeed representative of deteriorated insulation it would allow an insulation installer to target these areas more effectively. The second point to note is that this image shows less thermal bridging through lintels and demonstrates that this feature is not universal in all property types.

Figure 4: Example thermal image of a property suitable for CWI extraction and replacement as indicated by localised areas of heat loss.

Finally, Figure 5 shows an example of a property suitable for CWI extraction due to extensive heat loss around the eaves and extending to the base of the property. This suggests that insulation is most ineffective around the eaves and could represent degradation of insulation which has slumped down the cavity.

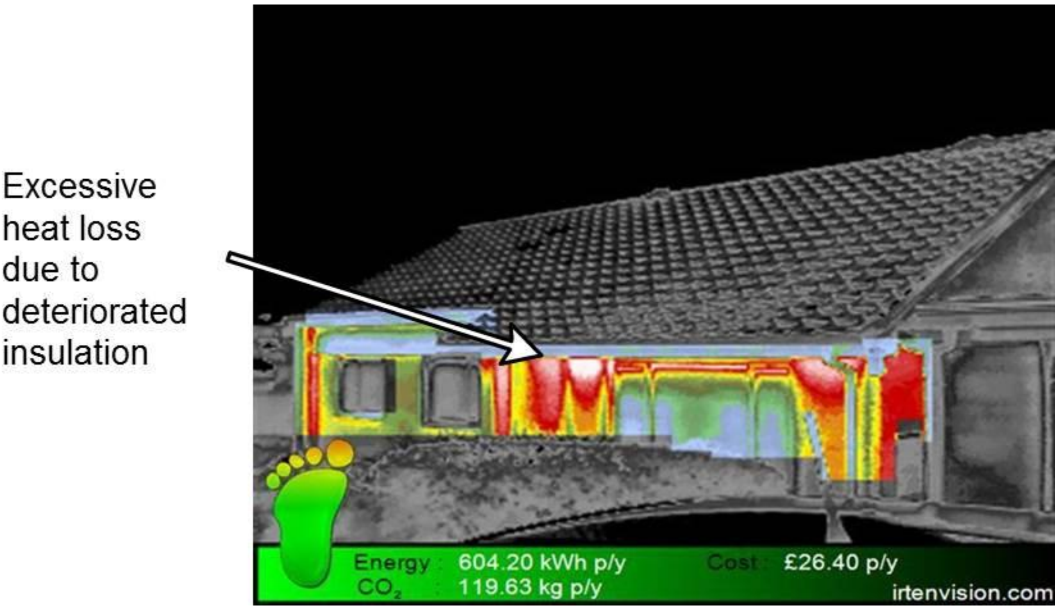


Figure 5: Example thermal image of a property suitable for CWI extraction and replacement indicated by extensive heat loss from lintels.

Case study: Using thermal imaging to identify potential deteriorated cavity wall insulation

Scottish Borders Council worked alongside Berwickshire Housing Association in Eyemouth to create an area-based scheme that targets both private and social tenure properties for CWI extractions and refills. Thermal imaging of the area identified 119 properties with potentially deteriorated CWI.

The owners of these 119 properties were contacted by the Council and offered a physical survey of their property. Eight agreed to a survey which showed that all eight had CWI deterioration. The thermal image and borescope image of an example property indicate voids as shown in Figure 6. The thermal image illustrates broad, patchy heat loss through walls suggesting deteriorated CWI. Borescope findings show that heat was escaping into the cavity due to a gap running behind the existing foam insulation which had shrunk over time. These findings validate the use of thermal images for identifying the potential for addressing deteriorated CWI. These eight properties will be included in the Council's CWI extractions and refills programme funded through HEEPS: ABS.

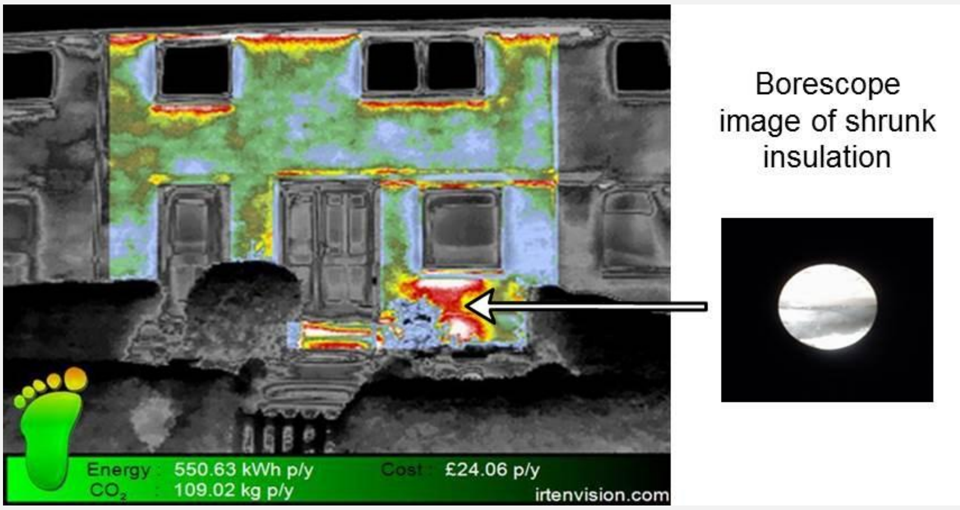


Figure 6: Thermal image of a property with suspected deteriorated CWI and a borescope image confirmed shrunk foam insulation.

These findings show that thermal imaging has great potential for identifying properties with deteriorated insulation. This information would allow an assessor to target specific households for CWI extraction in an informed manner before physically inspecting the areas showing signs of failure. These images could also be used to encourage uptake of CWI extractions by homeowners, working as a visual aid to show heat loss. The only drawback to identification of deteriorated cavities in this manner is that it is individual to specific properties; therefore this could be used as a quality control technique in isolated situations. This could include checking CWI installs following HEEPS: ABS programmes on a sample that represents the various archetypes of the programme.

Key Finding: Thermal imaging is potentially effective at identifying areas of heat loss from cavity wall properties that stem from deteriorated CWI installations. There is a strong case for exploring how thermal imaging can be used as a quality control tool and to promote remedial action to ensure previous and future schemes are up to standard. Physical surveys carried out in the current study have validated the use of thermal imaging for these purposes.

Case study: Maximising social and private tenure funding streams to create larger area-based schemes

Berwickshire Housing Association (BHA) carried out a significant cavity extraction and refill programme of its Eyemouth housing stock using £250,000 of Green Homes Cashback scheme funding. In anticipation of this, Scottish Borders Council included Eyemouth as a target area for the 2014/15 HEEPS: ABS programme. Eyemouth was a suitable HEEPS: ABS area not only due to its lack of CWI uptake through previous schemes such as UHIS, but also due to its high levels of child poverty, fuel poverty and a low ranking in the Scottish Index of Multiple Deprivation (SIMD).

Inclusion of Eyemouth as a HEEPS: ABS area has allowed Scottish Borders Council to work alongside BHA to create an area-based scheme that targets both private and social tenure properties for CWI extractions and refills. To emphasise this point, the Eyemouth mailing exercise and subsequent surveying of eight properties with deteriorated CWI was funded through HEEPS: ABS. These eight properties will now be included in the wider CWI extractions and refills programme, fully funded through HEEPS: ABS, while BHA properties will be funded through the Green Homes Cashback scheme.

This case study highlights the potential for coupling social landlord and private sector funding streams to create larger area based schemes. This approach is likely to reduce overall costs of installation and ensures both private and social tenure residents are provided with energy efficiency improvements. Finally, it highlights the importance of Local Authorities forward planning their HEEPS: ABS applications as well as underlining the benefits of collaboration with Housing Associations.

4.7 Thermal imaging of build types other than cavity wall

Given the lack of unfilled cavities in the Eyemouth sample, time was taken to consider insulation opportunities relating to other property types captured in the sample. A typical solid wall property thermal image from the Eyemouth sample is shown in Figure 7. This shows a high amount of visible heat loss as shown by the large area of yellow in the thermal image.

On average, solid wall properties in the Eyemouth sample were shown to have lower estimated annual energy, carbon and cost savings than the Dunfermline ‘before EWI’ sample (see Section 4.3). This could be due to the Eyemouth solid wall structures being stone built constructions with thicker walls in contrast to the Dunfermline Wimpey no-fines concrete constructions, which have thinner walls with poorer thermal retention properties. However, as shown by the thermal images, these solid wall properties in Eyemouth have a high heat loss and would benefit from EWI or internal wall insulation (IWI). Thermal images could therefore be used in marketing materials to householders for this wall type.

Figure 6: Example thermal image of a solid wall property in Eyemouth.

In the sample,39 were identified as timber frame properties. For these, thermal images showed low heat loss characteristics. This indicates most of these properties are of modern construction with expected levels of insulation. The thermal imaging provider's accompanying analysis allowed these properties to be eliminated from target property lists. This was a useful resource provided as part of the thermal imaging provider's service prior to visual inspection and site visits.

Key Finding: When the thermal imaging provider assesses the build type of properties from the thermal images, the client will be able to filter results and refine the target property lists. This may provide useful information for use in the development of schemes.

5.0 General lessons learnt about interpreting thermal images

When interpreting thermal images, it is a risk of mistaking areas of heat loss as an indication of deteriorated CWI. Changeworks observed 110 instances of such potential misdiagnosis in this sample. To avoid future misdiagnosis, images require careful analysis; this highlights the need to employ staff with sufficient knowledge to interpret the images and request appropriate explanation from the thermal imaging provider.

5.1. Change in building material

Changes in the external building material of a property may produce apparent anomalies in thermal images. Figure 8 shows one such example where the ground floor of the property appears to have significant heat loss, which could be interpreted as poor insulation. However, as can be seen from the Google Street View image of this property, the ground floor exterior is a stone construction whereas the top floor is a wood construction.[3] Since stone has a higher thermal mass than wood, this can affect the thermal image of a property through more effective retention of solar heat into the night. This results in higher infrared radiation shown in the thermal image.

It should be noted that this anomaly is likely to be greatest when thermal images are taken during the spring/autumn months (in this case in April), since it will allow for increased solar gain during daylight hours than during winter months.

This example highlights the benefit of comparing thermal images with Google Street View images. Greater insight can be gained from comparing the two, and can often avoid misinterpretation of thermal images.

[3] Google Street View images are shown throughout this report in accordance with Google's 'fair use' guidelines. These images are used in an academic and non-commercial context.

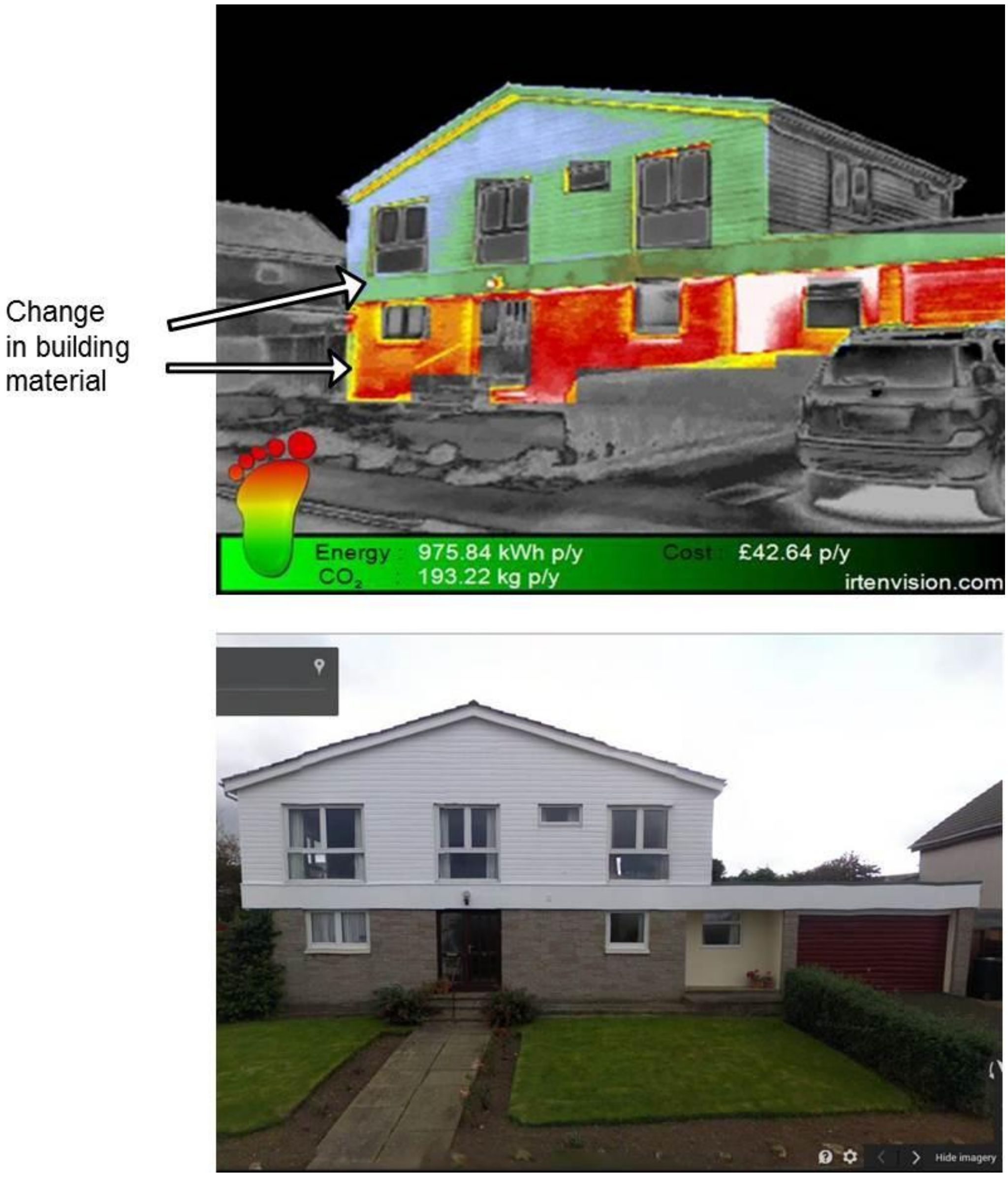


Figure 8: Example of a property where two different surface materials (shown in the Google Street View image) can significantly affect the heat loss seen in the thermal image.

5.2 Presence of air vents

Another building feature that results in thermal images resembling failed insulation is the presence of air vents. Air vents can result in heat loss through the building envelope and give the impression of deteriorated CWI, as shown in the example in Figure 9.

In the thermal image shown, there is minimal heat loss across most of the exterior of the building except for three areas with apparently high heat loss in discreet areas. However, as can be seen in the accompanying Google Street View image, these are likely due to heat loss through air vents rather than deteriorated insulation.

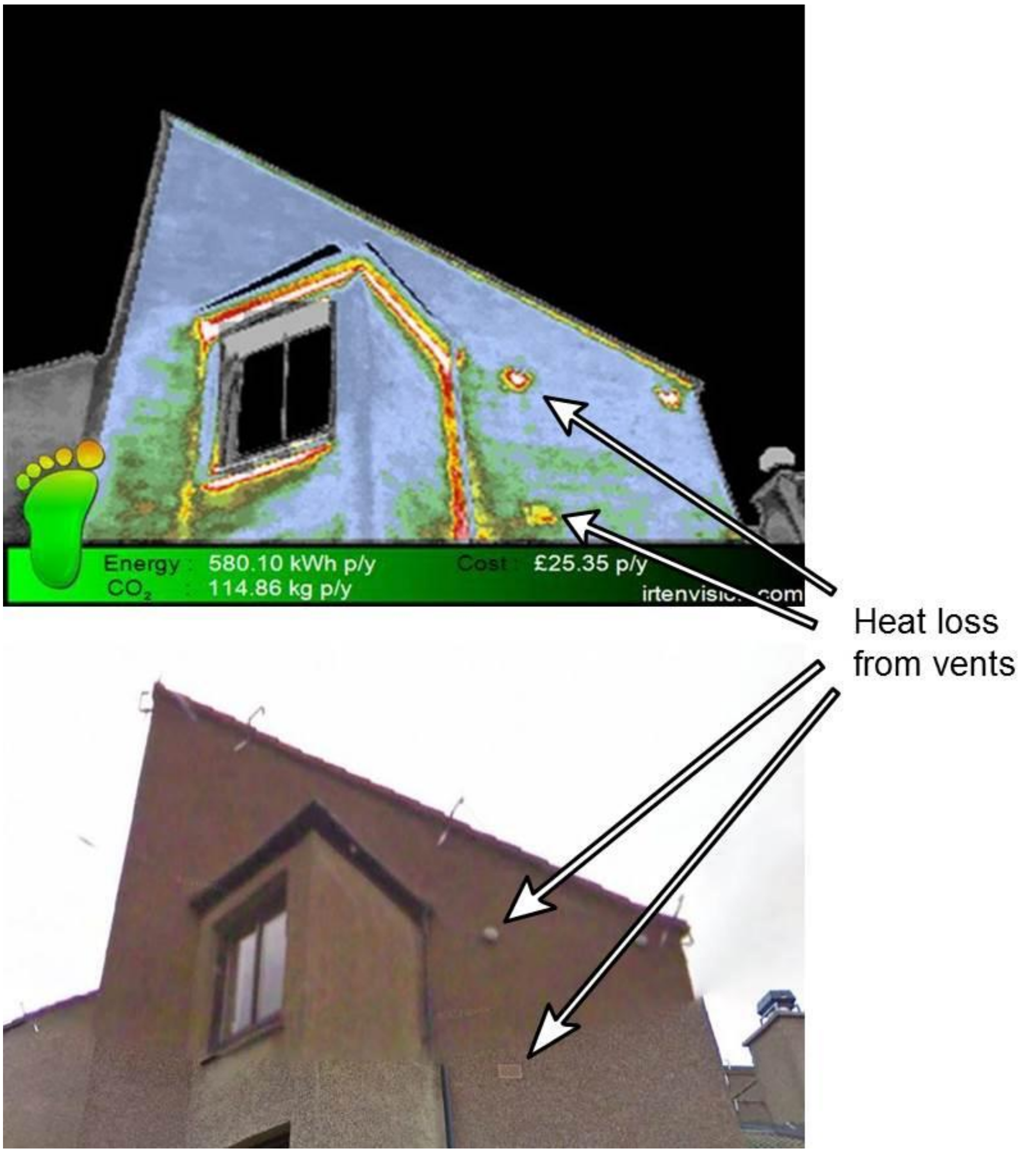


Figure 9: Example of a property where air vents (shown in the Google Street View image) can mimic deteriorated insulation heat loss patterns in a thermal image.

5.3 Location of boiler / wind sheltering

Figure 10 is representative of two anomalous interpretations of thermal images: 1) wind sheltering and 2) the presence of an internal heat source. There were a significant number of properties of similar build type (approximately 80 properties) in the sample with most of these exhibiting similar thermal characteristics.

These properties had one wall showing a large amount of heat loss and the adjacent wall showing continuous, fairly consistent heat loss from the corner of the two walls. After inspection of the Google Street View image of this property it is clear that the lack of heat loss above the door is likely to be due to the wooden exterior (as covered in Section 5.1 above). The large amount of heat loss on the right-hand wall could be due to the presence of a boiler behind this wall. This is indicated by the presence of a boiler flue which can be seen in the Street View image above this general area.

This would explain why many properties of this build type show high levels of heat loss in a similar place, since the boiler location is likely to be similar in all of these properties. However, in spite of the potential boiler location, this area of heat loss is large and therefore could be due to additional factors (e.g. poor insulation on this wall in all cases).

The high amount of heat loss on the left hand wall in areas close to the corner could be due to the shape of the property, with this section of the wall experiencing greater shelter from wind than the upper section i.e. it is further from the corner. Walls that are exposed to high levels of wind undergo faster rates of cooling after sunset than sheltered walls. Therefore if a building has an irregular shape, with some areas that are sheltered from the wind, this factor should be taken into account when attempting to interpret heat loss patterns of thermal images.

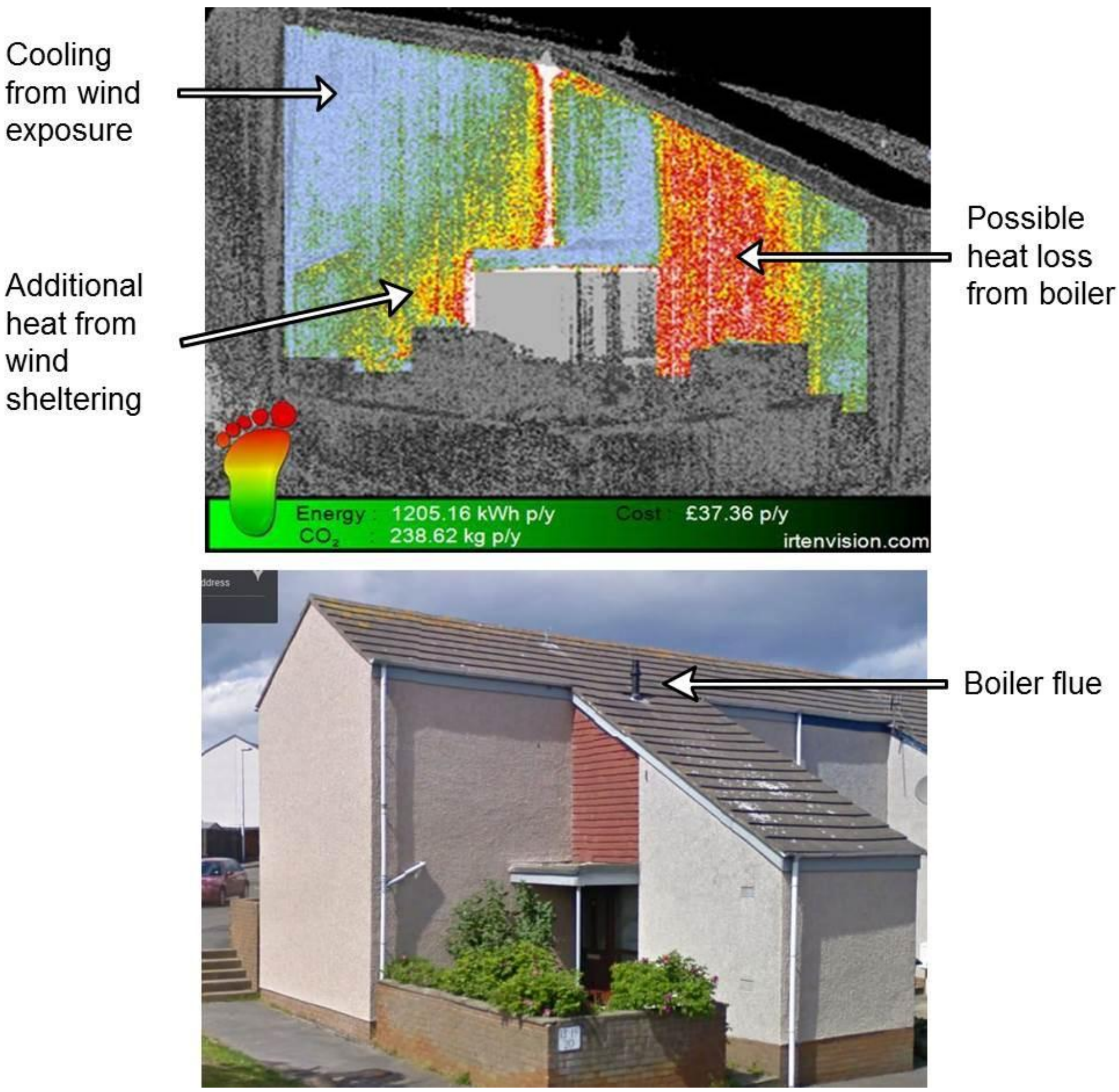


Figure 10: Example of a property where the location of a boiler and wind sheltering due to the shape of a building (shown in the Google Street View image) can affect the heat loss patterns of a thermal image.

5.4 Location of radiators

The final potential misinterpretation example relates to the location of radiators and is in many respects similar to the issue of boiler location mentioned previously. Unlike boilers (where the presence of a flue can offer clues to the location of a boiler) the location of a radiator cannot be determined from the exterior of a property. However, radiators are often installed below windows and therefore if thermal images illustrate minimal heat loss across the exterior except for below windows, this can suggest that a radiator is responsible for these heat loss patterns.

An example of a thermal image with heat loss patterns possibly due to an internal radiator is shown in Figure 11. If this were confirmed by an on-site inspection, it would highlight the need for effective radiator reflector panels as a low cost solution.

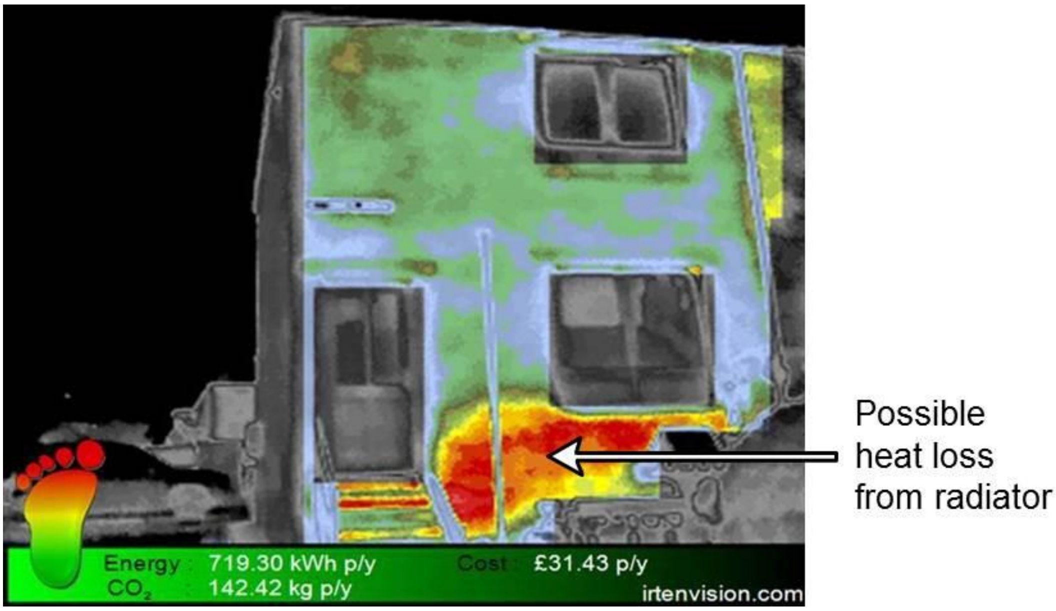


Figure 11: Example of a property where the location of a radiator can affect the heat loss patterns of a thermal image.

Key Finding: A number of building features can resemble deteriorated insulation on thermal images. These include: thermal bridging through lintels/soffits, a change in the external build material, air vents, the locations of boilers and radiators, and wind sheltering. Thermal images should be compared with Google Street View as an aid to avoid misinterpretation. Clients working with the images need to understand these features and may require advice and support from the thermal imaging company when compiling target lists of properties.

6. Summary of results

This report resulted in a number of key findings:

1. Thermal imaging highlights the benefits of EWI

Thermal images before and after EWI visually demonstrate its benefits plus potential annual cost savings. Thermal images have some potential in encouraging residents to sign up to EWI programmes.

2. Thermal images are most useful as marketing materials when used through door-knocking.

In the marketing analysis, including thermal images in mailings did not increase sign-up for EWI. However, a telephone survey of residents suggested that thermal images may be of benefit when used in booklets by door knocking face to face in the area.

3. Thermal imaging is useful in identifying properties with unfilled cavities.

Thermal imaging has merit in eliminating potential target areas to avoid unproductive marketing effort. A cost effective approach may be to identify a number of areas that could be suitable for CWI and take thermal images of a handful of properties from each area. This would allow assessment of each area‘s suitability for potential HEEPS: ABS programmes.

4. Thermal imaging is an effective evaluation tool for identifying deteriorated insulation.

The Eyemouth sample showed that although no unfilled cavities were identified, up to 18% of properties surveyed potentially had deteriorated CWI. Surveying of these properties validated the use of thermal imaging for these purposes. Thermal imaging therefore has potential for evaluating previous installs as a quality control technique and also the potential to encourage householders to take remedial action during extraction programmes.

5. Thermal imaging should be carried out in winter months, which requires careful planning ahead of HEEPS ABS bids.

The thermal imaging process is highly weather dependent with cold, dry and still conditions required to capture useable images. The Eyemouth project in particular was hindered due to a period of unseasonably mild weather at the project outset. This indicates the narrow window of opportunity during which thermal imaging can be completed (late October to early March). For inclusion in HEEPS: ABS bids, images should be captured over the preceding winter (i.e. over a full calendar year before bid submission). Analysis of thermal images could then be carried out over spring/summer ahead of final bid preparation for the February deadline.

6. Getting the most out of thermal imaging needs knowledgeable staff with time to work with the images and seek guidance from the thermal image provider.

Google Street View should be used for cross referencing features that can resemble failed insulation. Examples include thermal bridging through lintels/soffits; a change in the external build material; air vents; the locations of boilers and radiators; and wind sheltering.

APPENDIX A: EWI letters to private tenure residents in Deans

Figure A1: Standard Home Energy Scotland letter to private tenure residents in Deans without thermal images.

Home Energy Scotland
South East
36 Newhaven Road
Edinburgh, EH6 5PY

0808 808 2282
Mon-Fri 8am-8pm, Sat 9am-5pm.
Calls are free from landlines
and all major mobile networks.

HOME ENERGY SCOTLAND

Dear Householder,

EXTERNAL WALL INSULATION FOR HOMES IN DEANS

We're writing to let you know that West Lothian Council and Scottish Government's Home Energy Scotland are working together to provide external wall insulation* for suitable homes in Deans, whether you own your home or rent from a private landlord**.

WHY INSTALL EXTERNAL WALL INSULATION?

Some homes are not suitable for cavity wall insulation, because they have solid walls. The best way to insulate them is usually to add insulation to the outside of the house and then render over it. Improving your home with external wall insulation will make it cheaper and easier to heat, meaning you can expect to save around £270** each year on your heating bill and the exterior of your home will look refreshed due to the new external render.

HOW MUCH WILL EXTERNAL WALL INSULATION COST?

Thanks to Scottish Government funding, we can now offer you external wall insulation at a heavily subsidised price. External wall insulation would usually cost up to £10,000 but is available to homeowners within Deans at the subsidised cost of £800***. There are interest-free loans available until 31 March 2015 to help householders pay their contribution.

WHO WILL DO THE WORK?

The company selected to carry out surveys and installations is Everwarm.
However you should be aware that a number of other companies offer external wall insulation. Home Energy Scotland can help you compare all of your options; explain what is involved in installing this kind of insulation and the details you should check when comparing offers.

NEXT STEPS

Please register your interest in the project at insulation@se.homeenergyscotland.org, or call Home Energy Scotland free on 0808 808 2282 for further information.
We'll be in touch shortly to confirm when Everwarm will be in your neighbourhood and invite you to a householder information session.

Yours sincerely,

John Scott, Campaign Development Officer
West Lothian Council Energy Advice Service
westlothian.gov.uk

Jill Fenton, Manager
Home Energy Scotland, South East
homeenergyscotland.org.uk

*Subject to funding and confirmation by technical survey. **Based on a three bed semi-detached house with gas central heating.
***Some householders may qualify for fully subsidised insulation.

HOMEENERGYSCOTLAND.ORG
0808 808 2282
FUNDED BY THE SCOTTISH GOVERNMENT

West Lothian Council

natural scotland
SCOTTISH GOVERNMENT

Home Energy Scotland is funded by the Scottish Government and delivered by Energy Saving Trust.
Changeworks Resources for Life Ltd, a separate legal entity, operates the Home Energy Scotland advice centre in South East under contract to Energy Saving Trust. Changeworks Resources for Life Ltd.
Registered Office: 36 Newhaven Road, Edinburgh, EH6 5PY. Company Registration No: SCO103904.

Figure A2: Page 1 of Home Energy Scotland letter to private tenure residents in Deans with thermal images.

Home Energy Scotland
South East
36 Newhaven Road
Edinburgh, EH6 5PY

0808 808 2282
Mon-Fri 8am-8pm, Sat 9am-5pm.
Calls are free from landlines
and all major mobile networks.

HOME ENERGY SCOTLAND

Dear Householder,

EXTERNAL WALL INSULATION FOR HOMES IN DEANS

We're writing to let you know that West Lothian Council and Scottish Government's Home Energy Scotland are working together to provide external wall insulation* for suitable homes in Deans, whether you own your home or rent from a private landlord**.

WHY INSTALL EXTERNAL WALL INSULATION?

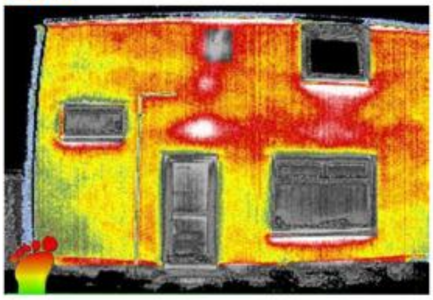
Some homes are not suitable for cavity wall insulation, because they have solid walls. The best way to insulate them is usually to add insulation to the outside of the house and then render over it.

Improving your home with external wall insulation will make it cheaper and easier to heat, meaning you can expect to save around £270** each year on your heating bill and the exterior of your home will look refreshed due to the new external render.

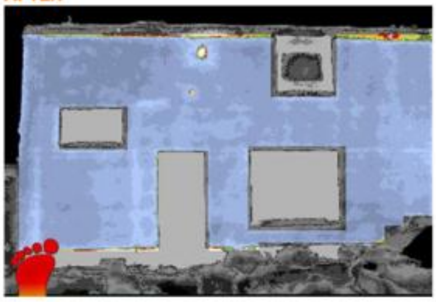
HEAT LOSS - BEFORE AND AFTER

Take a look at these images to see why external wall insulation is so important, the hotter the colours the more heat that is escaping. You can see what a difference the external wall insulation makes.

BEFORE



AFTER



CONTINUED

HOMEENERGYSCOTLAND.ORG
0808 808 2282
FUNDED BY THE SCOTTISH GOVERNMENT

West Lothian Council

natural scotland
SCOTTISH GOVERNMENT

Home Energy Scotland is funded by the Scottish Government and delivered by Energy Saving Trust.
Changeworks Resources for Life Ltd, a separate legal entity, operates the Home Energy Scotland advice centre in South East under contract to Energy Saving Trust. Changeworks Resources for Life Ltd.
Registered Office: 36 Newhaven Road, Edinburgh, EH6 5PY. Company Registration No: SCO103904.

energy saving trust

Figure A3: Page 2 of Home Energy Scotland letter to private tenure residents in Deans with thermal images (to follow on from Figure A2).

Home Energy Scotland
South East
36 Newhaven Road
Edinburgh, EH6 5PY

0808 808 2282
Mon-Fri 8am-8pm, Sat 9am-5pm.
Calls are free from landlines
and all major mobile networks.

HOME ENERGY SCOTLAND

HOW MUCH WILL EXTERNAL WALL INSULATION COST?

Thanks to Scottish Government funding, we can now offer you external wall insulation at a heavily subsidised price. External wall insulation would usually cost up to £10,000 but is available to homeowners within Deans at the subsidised cost of £800***. There are interest-free loans available until 31 March 2015 to help householders pay their contribution.

WHO WILL DO THE WORK?

The company selected to carry out surveys and installations is Everwarm.

However you should be aware that a number of other companies offer external wall insulation. Home Energy Scotland can help you compare all of your options; explain what is involved in installing this kind of insulation and the details you should check when comparing offers.

NEXT STEPS

Please register your interest in the project at insulation@se.homeenergyscotland.org, or call Home Energy Scotland free on 0808 808 2282 for further information.

We'll be in touch shortly to confirm when Everwarm will be in your neighbourhood and invite you to a householder information session.

Yours sincerely,

John Scott, Campaign Development Officer
West Lothian Council Energy Advice Service
westlothian.gov.uk

Jill Fenton, Manager
Home Energy Scotland, South East
homeenergyscotland.org.uk

*Subject to funding and confirmation by technical survey. **Based on a three bed semi-detached house with gas central heating. ***Some householders may qualify for fully subsidised insulation.

HOMEENERGYSCOTLAND.ORG
0808 808 2282
FUNDED BY THE SCOTTISH GOVERNMENT

West Lothian Council

natural scotland
SCOTTISH GOVERNMENT

Home Energy Scotland is funded by the Scottish Government and delivered by Energy Saving Trust.
Changeworks Resources for Life Ltd, a separate legal entity, operates the Home Energy Scotland advice centre in South East under contract to Energy Saving Trust. Changeworks Resources for Life Ltd.
Registered Office: 36 Newhaven Road, Edinburgh, EH6 5PY. Company Registration No: SCO103904.

APPENDIX B: Telephone survey questions

Introduction

1. Details:

Name

Address

Hello, my name is XXX. I'm calling from Home Energy Scotland about the external wall insulation you recently signed up for on your home. We're doing some research for the Scottish Government on what has encouraged people to sign up for this. Would you be able to answer a few questions? It will take no longer than ten minutes. All answers will be anonymous and confidential, and will be used for the purposes of this research only.

2. What made you decide to sign up for the external wall insulation? (Don't read out the answers but tick any that they mention)

- ☐ Good offer/price
- ☐ Reduce my energy bills / save money
- ☐ Make home warmer
- ☐ Thermal image
- ☐ Improve appearance of home
- ☐ Render needed replacing anyway
- ☐ Talked to friends / family / neighbours
- ☐ Government / Council approved offer

Other (please specify)

3. We sent you one or two letters explaining the offer of external wall insulation. Do you remember receiving this/these letter(s)?

◯ Yes ◯ No

4. Which of the following pieces of information do you remember seeing on the letter (s)?

	Yes - definitely remember	Think I remember	Don't remember
The insulation would save you money on your energy bills (£270 per year)	◯	◯	◯
The insulation would make your home easier to heat	◯	◯	◯
The insulation would improve the exterior appearance of your home	◯	◯	◯
The insulation would be available at a subsidised cost of £800 (or less)	◯	◯	◯

5. On a scale from 1 to 10, to what extent did the following pieces of information persuade you to sign up for the insulation?
1 = not at all and 10 = to a great extent

	1	2	3	4	5	6	7	8	9	10	Not aware of it	Don't know (don't read)
The insulation would save you money on your energy bills (£270 per year)	○	○	○	○	○	○	○	○	○	○	○	○
The insulation would make your home easier to heat	○	○	○	○	○	○	○	○	○	○	○	○
The insulation would improve the exterior appearance of your home	○	○	○	○	○	○	○	○	○	○	○	○
The insulation would be available at a subsidised cost of £800 (or less)	○	○	○	○	○	○	○	○	○	○	○	○

6. One of the letters also contained colour images showing heat loss before and after the insulation was installed. Do you remember seeing these?

○ Yes - definitely remember ○ Think I remember ○ Don't remember

Thermal images

7. On a scale of 1 to 10, how much did you understand these images?
1 = Did not understand at all and 10 = Understood very well

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

8. On a scale of 1 to 10, how much did these images convince you that external wall insulation would improve your home?
1 = Not at all and 10 = very much

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Don't know (don't read)

9. On a scale from 1 to 10, to what extent did these images persuade you to sign up for the insulation?
1 = not at all and 10 = to a great extent

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Don't know (don't read out)

10. Do you have any other comments about the external wall insulation or what made you sign up for it?

Thank you very much for answering these questions.