Programme Area: Smart Systems and Heat

Project: Developing Knowledge from Data

Title: Review of Mass Surveying Techniques for Houses

Abstract:

The document was produced for internal decision making processes and not written with the intention of publishing. As part of the design process the current and future energy use of buildings together with the options for building retrofit must be known. Improved knowledge of local housing stock will help to improve estimates of energy demand in local areas and the appropriate retrofit measures. Knowledge of housing types and ages is an essential first step. Additional information on the size of individual properties, the level of insulation (or other retrofit measures), the glazing and the heating and hot water system can help to improve estimates beyond those possible when only a simple property archetype has been identified. It will also enable better estimates of the opportunities for retrofit with the potential benefits and associated costs. Cost effective methods will be required to collect and collate this data across large areas. This document reports the results of research into the methods available to establish information about buildings that is relevant to energy use over wide areas. The intention was to identify currently used methods, their benefits and limitations, and their suitability to providing input data to EnergyPath. Options for improvement of the current surveying techniques were also considered.

Context:

As part of its Smart Systems and Heat programme the ETI is developing EnergyPath Networks which is a software tool that will be used to develop future local area energy system designs to meet 2050 carbon emission reduction targets. The tool requires data in order to estimate current and future energy demands, and to assess the relative costs and merits of technologies.

Review of Mass Surveying Techniques for Houses

Summary

The ETI's EnergyPath model is intended to develop future local area energy system designs which meet 2050 carbon emission reduction targets. As part of this process the current and future energy use of buildings together with the options for building retrofit must be known. Improved knowledge of local housing stock will help to improve the quality of EnergyPath estimates of energy demand in local areas. Knowledge of housing types and ages is an essential first step. Additional information on the size of individual properties, the level of insulation (or other retrofit measures), the glazing and the heating and hot water system can help to improve estimates beyond those possible when only a simple property archetype has been identified. It will also enable better estimates of the opportunities for retrofit, the potential benefits and associated costs.

Cost effective methods will be required to collect and collate this data across large areas. This document reports the results of research into the methods available to establish information about buildings that is relevant to energy use over wide areas. The intention was to identify currently used methods, their benefits and limitations and their suitability to providing input data to EnergyPath. Options for improvement of the current surveying techniques were also considered. Research included discussions with local authorities, academics and providers of surveying techniques and housing databases.

The following conclusions were reached:

1) No single method of mass surveying is capable of providing all the information that can be gathered by using different methods.
2) Data on housing stock is commercially available but has limitations and can be augmented by data from other sources.
3) Clustering of data is likely to be required to achieve reasonable estimates of energy use. Data on individual buildings is likely to be inaccurate. By averaging across clusters of buildings it is possible to achieve reasonable estimates of energy demand on an area basis.
4) There are potential options for development in:
    a) Improved merging of data from multiple sources.
    b) Automated processing of map data and photographs to establish building archetypes.
    c) Processing of Lidar and photographs with map data to produce estimates of building size, construction type and construction materials to enhance energy use estimates based on archetype.
    d) Automatic identification of building features such as windows and doors using Lidar and photographic information to enhance energy use estimates based on archetype.
    e) Improved automation of processing of ground based thermal images.
    f) Use of aerial oblique thermal image cameras to give information on wall and roof insulation.

Contents

Introduction

Improved knowledge of local housing stock will help to improve the quality of EnergyPath estimates of energy demand in local areas. Knowledge of housing types and ages is an essential first step. The energy demand of a Victorian terraced house will clearly be different to that of a modern flat. Additional information on the size of individual properties, the level of insulation (or other retrofit measures), the glazing and the heating and hot water system can help to improve estimates of energy demand beyond those possible when only a simple property archetype has been identified. It will also enable better estimates of the opportunities for retrofit, the potential benefits and associated costs.

The objective of this piece of work was to research the methods available to establish information about buildings that is relevant to energy use over wide areas. The intention was to identify currently used methods, their benefits and limitations as well as any areas where there may be options for improvement. Research included discussions with local authorities, academics and providers of surveying techniques and housing databases.

1 Mass Survey Techniques

1.1 Lidar

Lidar is a technique that uses laser light to measure distance. Lidar is not an acronym, but a portmanteau of the words “light” and “radar”. The laser is fitted in a rotating mechanism to automatically scan wide areas. Data is processed in association with GPS and Inertial Navigation Unit information to generate a ‘point cloud’ which represents the surfaces that have been scanned. The latest devices can also gather information (in RGB format) on the colour of the surfaces scanned. Colour data is associated with every point in the cloud.

Lidar point clouds are normally classified into different surface types such as vegetation (2 types), roads, green areas, water and 3 to 4 building surface classifications.

Lidar data can be gathered using vehicle or aeroplane mounted devices. The density and accuracy of the point cloud generated from airborne Lidar must be balanced against the area covered in a single pass. Capability has improved over time.

Lidar data is routinely used for large scale landscape analysis for use in applications such as flood plain mapping, conservation and geology. Lidar is also used to generate detailed 3D models of buildings and industrial plant.

Building volume, height and number of floors can be provided from Lidar data in a semi-automated process. It may be possible to use building information from Lidar and the property boundaries on the OS MasterMap to establish whether houses are detached, semi-detached or terraced.

1.1.1 Limitations

The processes available to automatically generate detailed 3D models from Lidar data do not appear to be mature (see section 2) with most data processing currently requiring significant manual intervention to convert simple meshed surfaces into full parametric models. Work being done at Oxford University (section 2.2), however, is claimed to achieve automatic feature recognition from point clouds generated using low cost scanning devices.

1.1.2 Costs

Newcastle City Council's city wide Lidar data cost £20,000 and was sourced from Bluesky.

Haringey Borough Council were quoted £4,000 to £5,000 to have Lidar data collected at the same time as thermal image data (for which the quote was £8,500).

These costs do not include any processing required to produce building information from the point cloud.

1.1.3 Local Authority Example

Newcastle City Council have Lidar data for the whole city at 0.5m accuracy. This has been used to identify south facing roofs which may be suitable for solar systems and for identifying flood areas. The council are unaware of any automated processes for converting this data into 3D building models.

1.2 Thermal Images

Thermal image cameras allow visualisation of the temperature of objects. To measure building thermal properties they work in the infrared wavelength range 8-14µm. This is a different frequency to the best range for images of people and animals which is 3 – 5µm.

Both ground and aerial based cameras are used to measure building thermal properties. Images are produced in greyscale, typically with a 256 pixel range. This gives a relative temperature not an absolute temperature. Images are then processed to give a value on a scale with 6 to 10 steps. Aerial thermal images are typically 640x480 pixels with a target resolution on the ground of 50cm x 50cm per pixel. Accuracy for ground based thermal images is greater than for aerial images but the cost per property is higher.

Data from aerial images can be auto-fitted to the OS MasterMap. The values of the pixels on the area of a map polygon are used to estimate heat loss. Maximum, minimum and mean values across the polygon are normally calculated. From survey flight to data delivery can take as little as 2 weeks.

Thermal images are useful for 'quality control' of building thermal properties and can help to identify items such as poorly fitted insulation. Ground based images are of sufficient quality to show areas with thermal bridging and leaks. They could be used to target other improvements beyond cavity wall insulation.

Aerial thermal image surveys provide a very quick way to identify areas to target for domestic energy efficiency programmes.

Having surveys performed a number of years apart allows a comparison over time to see the effectiveness of interventions.

1.2.1 Limitations

1) It is difficult to distinguish between buildings with good insulation and those that are unheated when thermal images are collected.
2) The 'relative' nature of the output means that absolute thermal properties cannot be established.
3) The biggest limit on the ability to collect aerial thermal images is the conditions required. These are:

- After 7pm on a winter evening (typically mid-November to end March).
- Wind speed <3m/s.
- Temperature <= 7°C.
- Minimal surface water and no snow.
- Clear sky or high level cloud.

There are typically 20 days per year which meet these criteria with 25 days in a good winter. Costs can be driven up due to problems with getting flight permissions and then having conditions change so that no data can be collected.

4) Aerial thermal images do not give information on the level of wall thermal efficiency. The ‘halo’ around buildings on an aerial thermal image can give an indication of the wall thermal efficiency but ground based or oblique aerial images would be required to give a true indication.
5) Ground based images show walls so loft insulation level is not easily established.
6) Newcastle City Council consider aerial thermal image surveying to be expensive when balanced against the limited uses.
7) Cardiff University consider that thermal image cameras are useful as a quality control mechanism for checking thermal performance but have little value for surveying due to problems of variability (internal temperature, calibration etc.).

1.2.2 Costs

Aerial thermal survey costs are based on:

- The area to be surveyed
- The shape of area to be surveyed
- The distance from ‘base’ for the surveying aircraft.

Cost per property is much less for urban than rural areas.

Recent (2014) quotes for thermal images alone (including data processing and delivery of pictures, GIS files etc.):

- $250km^2$ = £21,500
- $200km^2$ = £17,500
- $35km^2$ = £9,300
- $35km^2$ = £13,000 for an irregular shaped area.

A quote for Haringey Borough Council was £8,500 with Lidar £4,000 – 5,000 extra. Aberdeen City Council paid £25k for a survey of the whole city (97,000 households) in 2001.

One provider (Bluesky) typically retain the IP and customers pay a one-off license to use the data in perpetuity. There are few restrictions on data use in the license. Although data cannot be re-sold it can be supplied to sub-contractors working for the customers.

Ground based thermal images typically cost around £10 per property.

1.2.3 Local Authority Examples

Aberdeen City Council considered aerial thermal images to be a very cost effective way of identifying areas where more insulation was needed. Aberdeen Council passed the data to the Energy Savings Partnership who used it to identify improvement measures and to encourage householders to install the measures. Data was used at energy awareness days as part of community engagement around energy. It helps people to engage with the issue and to understand the standard of their property relative to others in the area and what is achievable. Mapped data was put on the internet as a method of allowing residents to perform their own comparisons.

The Aberdeen area required 2 nights of data gathering. Ideally these would be consecutive but this this was not achieved.

Aberdeen have used vehicle based thermal cameras to survey 22,000 social housing properties. This was considered particularly useful at retrofit project planning stage due to relative cheapness compared to full property surveys. It allowed targeting of more expensive survey techniques.

Isle of Wight Council collected drive by thermal images over 2 heating seasons (2010 - 2011 and 2011 - 2012). The drive by covered around 80% of properties on the island - very remote properties were not surveyed and some were not visible due to high hedges etc.

Data was used to target properties for insulation under CERT. Salesmen used individual property pictures to show to house owners. They then had generic before and after pictures to demonstrate the effectiveness of insulation. The scheme was targeted at private properties. Data is held by the Energy Savings Partnership, not the council. The Energy Savings Partnership clearly see value in the data as they did not provide thermal images to property owners and IoW staff only had access through a web portal for the duration of the project.

Nearly 3,000 properties had interventions as a result of the scheme.

1.3 Aerial Photographs

It is possible to identify building archetypes from aerial photographs (see information on GeoInformation Group in section 3.2). Building age is based on style, design, construction materials & evidence from the local context (such as road layout and building density). Items used include garden sizes, chimney pot size and location and roof material. Building type is easier to identify if property boundaries are clearly visible.

Stereoscopic aerial pictures can be used to produce 3D models although this is currently a time consuming, manual process and would be too expensive to use the results within energy path.

1.3.1 Limitations

Aerial photographs on their own have little value as a surveying technique. Highly skilled photo-interpretation is required to identify building archetypes from aerial photographs.

Precise building age is difficult to identify solely from aerial photographs. Areas built over time are difficult to date. The most difficult aspect is the number of floors so flats and terraces may be hard to categorise without more information.

1.3.2 Costs

To generate aerial pictures for the whole of Leicestershire costs £10,000. To build a 4km^2 3D model of Leicester city centre from aerial photographs cost £25,000.

See costs for GeoInformation building classification database – section 3.2.

1.3.3 Local Authority Example

Leicester City Council have a 3D model of the city centre produced using photo-grammetry from aerial photos. This is primarily used for planning. A model of the area is provided to developers to give a 3D context to help them improve building designs. The objective is improved regeneration. The model is also being used for communications to improve the quality of council marketing materials. LCC are aware of other potential uses and have talked to suppliers about adding heat map data to the models but have not pursued this as the 2 primary purposes have been sufficient. Model accuracy is 10cm which was defined by the resolution of the original aerial photos.

1.4 Energy Performance Certificates

It is a legal requirement to have an Energy Performance Certificate (EPC) for all domestic and commercial buildings that are built, sold or rented in England, Wales and Northern Ireland. A similar scheme is operated in Scotland. These require a property survey and estimate of the buildings thermal properties based on RdSAP (Reduced Standard Assessment Procedure) calculations for existing buildings and SAP for new build. The Standard Assessment Procedure is the UK Government's approved method for assessing the energy performance of dwellings. The method of calculating the energy performance and the ratings is set out in the form of a worksheet, accompanied by a series of tables.

Production of an EPC requires a building survey by an accredited Domestic Energy Assessor. Standard software is then used to produce the energy estimates for the building.

Figures are not readily available for the number of individual properties for which an EPC is available. However, from May 2013 to April 2014 around 77,000 non-domestic and 2.2m domestic existing building EPCs were registered for England and Wales. Some of these will be repeats for EPCs already held but the magnitude of the registrations gives an indication of the size of the resource available which is believed to be around 40% of the UK housing stock.

The EPC includes information on total floor area, windows, heating system type and heating controls. This could be used to improve energy use estimates based on building archetypes even if EPC estimated energy use is not considered reliable.

The team at Cardiff University consider that the database of EPCs is a valuable asset due to the size of the dataset and because all practitioners have received a certain level of training. Their view is that individual certificates have wide variability but that this appears to be random so that averaging over LSOA (800 – 1000 houses) gives good estimates. EPCs are used by Uno Energy as primary input to their housing database (section 3.3).

1.4.1 Limitations

1) The energy assessment is non-invasive. For insulation to be included in the assessment there must be evidence, either visual or documentary, of specific works relating to the property being assessed. If insulation has been added but there is no access for the energy assessor to observe it or relevant documentary evidence it cannot be included. In these cases the level of insulation is assumed based on the

age of the relevant part of the dwelling. This applies to roof insulation, floor insulation and wall insulation.

2) Quality of EPC data is considered to be highly variable although some argue that averages over hundreds of dwellings should be accurate. Quotes for as little as £35 can be found to produce an EPC for a 3 bedroom house. Given the amount of data that should be collected to perform the assessment correctly it is likely that many certificates are based on estimates or default inputs for the property type rather than proper assessment.
3) Input data to individual EPCs is not available although most certificates are publically available.

1.5 Other Options / Patent Search

Patent searches did not identify any new surveying techniques although there are numerous patents around processing of survey data such as aerial photogrammetry and Lidar. (See section 2.1).

2 Large Area 3D Models and Automated Data Processing

If accurate 3D building models are available then it may be possible to improve estimates of the thermal demand of buildings by considering the size of individual buildings along with their archetype. A review of the current landscape with regard to 3D building modelling over large areas was conducted to assess the feasibility of this approach.

2.1 Automated Building Extraction from Aerial Data

Various companies and academics are working on automating the process of extracting information from aerial data. Interest is predominantly in Lidar and aerial photographs. Use of either data source individually has limitations (1). For example, Lidar data only provides low density information around break-lines between horizontal and vertical surfaces. Promising options involve fusion of Lidar with aerial photos to provide better quality. Aerial Lidar is of lower resolution than ground based Lidar and may be more appropriate for large scale surveying to make file sizes, and the magnitude of the 'point picking' exercise more manageable.

In order to combine sources they need to be aligned (registered) with each other. This is normally done using

1) Features such as building corners or roofs.
2) Mutual information such as Lidar elevation and optical luminance or Lidar intensity values and optical luminance.
3) Frequency based registration to find optimal correspondence between regions from an optical image and Lidar intensity using methods such as FFT.

Algorithms are not currently considered to be sufficiently well developed to give robust results. As a result no fully automated systems seem to be available although semi-automated processing of Lidar and aerial photos to build digital models is available.

Since building footprint dimensions are available from MasterMap it may be possible to combine these with Lidar data to automatically extract building dimensions. One person experienced in processing map and Lidar data stated that you often find that Lidar data does not accurately match the MasterMap geographic points. This can cause problems when different data sources have a particular item at slightly different locations. It can be very labour intensive sorting out which is the master and aligning the others.

Processing of map and Lidar data together appears to be part of the algorithm used by Google Earth. This is the most readily available source of automatically generated 3D building models although quality and coverage is currently limited. See section 2.3.

2.2 Oxford University

The Mobile Robotics Group at Oxford University has developed a cheap laser scanning device for autonomously guided vehicles. A scan is performed of a local area and then the vehicle uses its own scanner and video information to position itself within the point cloud. Data can be collected at normal urban driving speeds.

The laser scanner uses commercially available lasers which scan in 2D rather than 3D and has a cost for the bill of materials of around £3,000 - £5,000. Commercial, military Lidar scanners typically cost €550,000. The laser is normally arranged to spin in a vertical plane so that it illuminates a thin strip of the surroundings. Stereo cameras are used to establish the location of each scan and the movement between them. This information is then used to 'stitch' the individual scans together to form a 3D point cloud. Accuracy is typically 2 to 3cm rather than the millimetre accuracy typical from military grade equipment. Since each scan is 2D there is little information on the sides of objects. There is an option to use multiple lasers to add points using orthogonal rotation axes. In this case calibration between the lasers can be used to increase accuracy. The basic system does not use GPS or inertial navigation techniques. All positional information is recorded relative to the start point of the scan. There is a possibility to tie this local frame of reference to a global position GIS enable data for individual buildings.

The group have developed machine learning software which allows them to identify features within the point cloud and extract them by combing the laser scan with digital photographs. They have used this for tools and fire extinguishers in internal environments and cars, cyclists and pedestrians in external environments. The algorithms identify surfaces from the point cloud to produce a mesh. Colour and geometric information are then combined to identify objects. The team believe that they could adapt this IP to automatically identify particular building features including the corners of buildings as well as the locations and sizes of windows and doors. They may also be able to identify different brick patterns to distinguish between solid and cavity walls. Combining surface texture from the laser scan with colour information can also enable identification of different construction materials. The machine learning algorithms may be able to identify building age and type by comparing captured building images with template images of local buildings of particular archetypes.

The technology and software being developed at Oxford University are currently at TRL 4 to 5. It appears to be sufficient for the purposes of scaling building models to improve the accuracy of EnergyPath inputs.

The University is currently establishing a spinoff company to tailor the IP for commercial exploitation. This might be hardware, software or licenses for the IP. They are currently trying to understand the range of applications to which the technology could be put and the opportunities within those applications. They anticipate full commercial deployment in the next 5 years. There is potential for them to do some sort of demonstration project for the ETI once the new company is established at the end of the summer.

2.3 Google Earth / Sketchup

Google Earth is an attempt to build a complete digital model of the earth including map data, images and 3D models. Apple Maps have a similar product although access is limited by Apple's business model. Google Sketchup is a tool that can be used to produce 3D building models that can then be associated with particular locations within Google Earth.

All 3D building models in Google Earth were originally 'handmade' using Google Sketchup. Google are slowly rolling out auto-generated 3D mesh buildings in Google Earth. They do not announce which cities have been modelled in this way. The current UK list (April 2014) is claimed to include (http://en.wikipedia.org/wiki/Google_Earth#Buildings_in_3D): Birmingham, Bradford, Cardiff, Leeds, Newcastle-upon-Tyne, Reading, Telford and Wolverhampton. None of these seemed complete when 'visited' in Google Earth at that time.

Within Google Earth buildings tend to be simple 'boxes' and are likely to have incorrect roof profiles and no detail with regard to features such as bay windows. Intersections between building models and the ground plane do not accurately represent local gradients as the ground plane appears to be horizontal. Areas in other cities (e.g. San Francisco) that have auto-meshed 3D buildings appear to be of low quality. Buildings appear to be better modelled close to the city centre but less good further out. Examples of these limitations are shown in figures 1 to 3.

Figure 1: Comparison of buildings in an area of Birmingham in Google Streetview with manually produced 3D building models in Google Earth. (Google copyright).

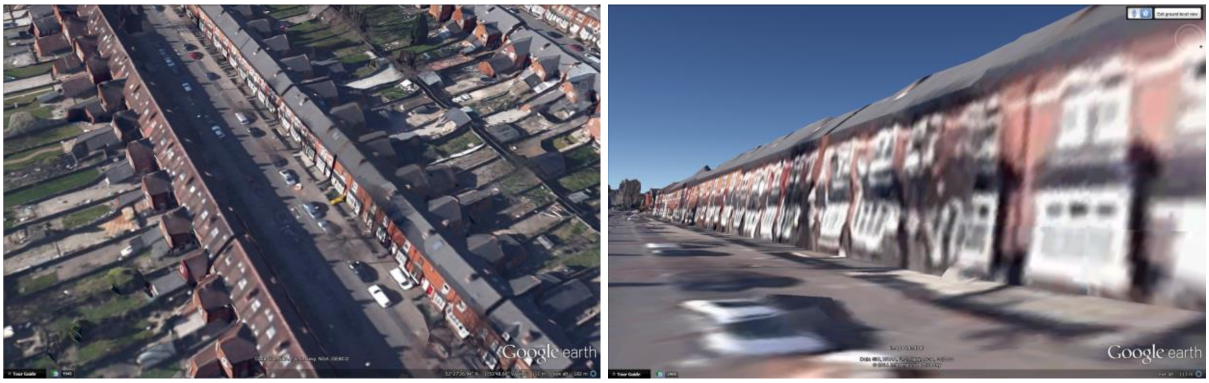

Figure 2: Comparison of building aerial and street level views in Google Earth in an area of Birmingham with automatically produced 3D building models. (Google copyright).

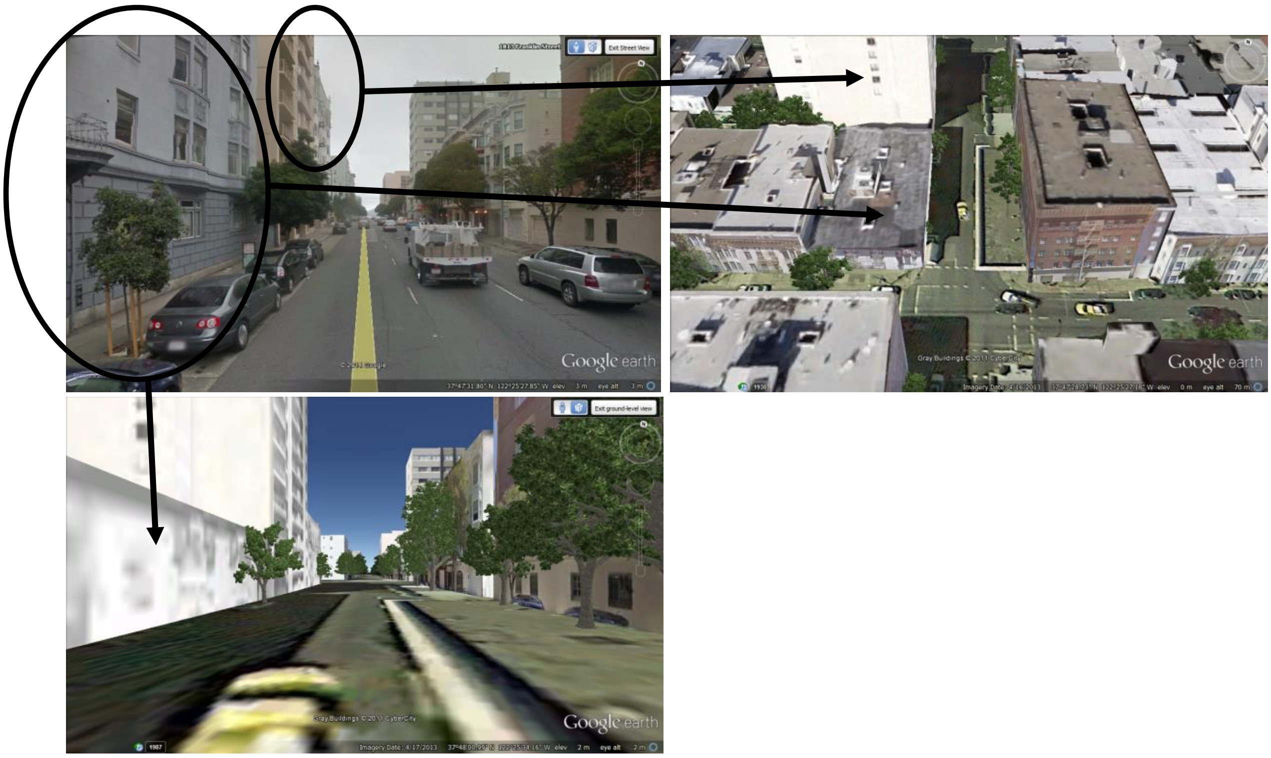

Figure 3: Google Streetview picture of an area of San Francisco with automatically produced 3D building models compared to Google Earth aerial view and street level view.

It is possible to manually measure individual model dimensions in Google Earth so it may be possible to use the 3D models to establish building dimensions to improve the accuracy of thermal models. However, the accuracy of the models is unknown so the value of doing this is unclear.

It seems likely that assuming houses of a particular archetype are a particular size will be as accurate (and more complete) than attempting to capture dimensions from Google Earth at this time. This is due to both the limited areas in which 3D models currently exist and problems with the quality of those models. This may be an option in future as the quality of models in Google Earth improves.

2.4 Video Games

Various video games (particularly flight simulators) contain 3D models of real locations with apparently high levels of fidelity. Due to the large areas covered by these models it was speculated that they may be produced using automated processes.

One of the market leaders are Earth Simulations who develop models of real world geography for use in flight simulator games. These are ‘photo realistic’ and considered to be of exceptional quality. Since the models include 3D buildings Earth Simulations were asked what method they use to create these accurately (location, size and shape) from commercially available data. Their reply was:

”On the large scale we simply place generic type 3D buildings at the right location. These do not reflect the exact shape / height etc. of the real world objects, but are essentially just a reasonable representation of the type of buildings seen. Occasionally we do go into far greater levels of detail within limited areas. These high detail areas are all hand made in 3D software and are pretty time consuming and expensive to produce. I'm not aware of any commercial data capable of producing the type of thing you are looking for."

2.5 Formula One Simulators

Formula One racing teams produce highly realistic circuit modes for use in their driver-in-the-loop simulators. These are based on Lidar data and are accurate to the level that they accurately reproduce the bumps in the road surface. All the buildings and other features that are visible from a car on the circuit are included in the models.

Discussions with teams established that:

1) Some automatic meshing of the Lidar point cloud is used to produce the 3D road surface as a series of connected surfaces. This is necessary to reduce the number of data points within the model in order to allow real-time processing of both the vehicle model and the images viewed by the driver.
2) All other features are handmade by picking points from the Lidar point cloud to establish their locations and sizes. 3D models are handmade from the picked points.

2.6 Cardiff University

Cardiff University have developed the Energy and Environmental Prediction (EEP) model. This is a model to quantify energy use and associated emissions at city level (http://www.cardiff.ac.uk/archi/eep.php). The model is GIS based and uses SAP calculations. It assumes certain building fabric and heating systems are associated with particular archetypes. The tool has been applied to both Camden and Leicester amongst others.

As part of developing the EEP tool the University has worked on analysis of OS MasterMap to establish building archetypes. Different methods of map analysis have been tried (2). These are:

1) Raster analysis:
   A shape based method using the outline of the building footprint. An analysis grid is overlaid on the map to identify the building polygon vertices. The shape of individual buildings can then be established.
2) Cluster analysis:
   From the results of the raster analysis buildings are clustered by shape using the lengths and numbers of individual building sides.
3) Context based analysis considering items such as:
   a. the connections between buildings
   b. the distance and angle of the buildings to the road
   c. plot size
   d. terrace length
   e. road network shapes

It is not clear how automated these processes are. Each technique gives different levels of success depending on building archetypes. There may be potential to enhance these methods with other data sources.

The team acknowledge that there is 'a maximum accuracy to which built age can be identified by an automatic analysis'. Changes in style with period of build are notable but gradual so that some properties will be allocated to incorrect age groups by automated processes. However, comparing automatic analysis with 'walk by' surveys allows a probability to be associated with any particular allocation.

The team suggest that uncertainty could also be placed on parameters such as installation of double glazing. This would appear to fit well with the EnergyPath approach. The automated analysis may be appropriate as the 'base level' of analysis for EnergyPath. It would allow an analysis of the benefits of collecting better data. However, the number of houses required to be averaged to get good data by this approach (LSOA scale) may be too large for EnergyPath.

The team at Cardiff University have used Google Streetview to confirm the archetypes identified, to see if cavity wall insulation has been installed, whether houses are connected to a cable network and to gain some information on whether back boilers or gas fires are fitted (from chimney cowls). Use of Streetview is likely to be a more cost-effective way of quality checking remote survey data than site visits depending on the level of detail required.

The team at Cardiff have been involved in development of an 'urban scale' energy modelling framework, that uses thermal simulation of buildings (http://www.cardiff.ac.uk/archi/computermodelling.php) and Google SketchUp to analyse groups of buildings and to provide visualisation of energy supply and demand at an urban or regional scale. Data for the model is collected from a variety of sources including maps, historical records and 'drive by' surveys. The EEP model acts as a database to store property based information that is collected. The methodologies involved are described above and may be applicable to data collection for EnergyPath.

2.7 Southampton University

Professor AbuBakr S. Bahaj of the Sustainable Energy Research Group at Southampton University has developed a methodology using various data sources to understand the state of housing stock and its current energy consumption and then to indicate the most appropriate interventions for different houses. This combines data from a variety of publically available national data sets. The model is GIS based with all information associated with individual buildings on the MasterMap.

The following data sets are used:

1) National address gazetteer database
2) Building footprints from MasterMap
3) National census data
4) DECC energy use data (at MSOA level)
5) Local authority data on publically owned building energy consumption.
6) Energy performance certificates

A trial project based in Southampton has also used aerial Lidar data. The project team have developed algorithms to reliably extract building heights from the Lidar point cloud (excluding items such as chimneys and TV aerials). These heights are used to improve the building physics model.

The EPC data was obtained as a spreadsheet and Matlab software has been written to allocate relevant data to individual buildings in GIS.

Algorithms have been developed to

1) Filter out bad data from the EPC database.
2) Allocate data from properties with an EPC to similar properties in the same area without an EPC based on distance and building shape and type.

Building details, such as the number and size of windows and doors are characterised based on building age and type. These details are contained in a table and appropriate details are allocated to individual buildings.

The model includes a SAP-based calculation that can be performed on each building to establish its current energy consumption. The influence of different improvements to building efficiency can then be tested.

Building energy use can be aggregated to provide city wide energy consumption broken down into smaller areas as required. The project team intend to benchmark these against DECC data.

The Sustainable Energy Research Group is also looking at the social implications of local energy solutions and the implications of policy on technology take up.

2.8 Iscope

3D modelling is an emerging technology with no standard language. Iscope is an EU funded project trying to establish a common language to integrate data in a 3D environment and to build 3D Urban Information Models which will include geometric, semantic, morphological and structural information. The intention is that models can be used to improve decision making in planning processes and policy design at city level. The developed toolkit will be open source and is based on CityGML. Included are services capable of creating CityGML models from data such as surface models (e.g. Lidar), terrain models and building floor plans.

The project lead is Gravitech in Italy. OS are involved in the project as they see potential business growth in the 3D arena. Newcastle City Council are involved in energy aspects in the 3D environment. They want to be able to add thermal images to a 3D model through an automated process. These would then be used to demonstrate to tenants and householders the impact of different interventions by comparison to similar properties where those interventions have already been carried out. For this process to work automatically meta data giving location, picture direction etc. must be attached to the thermal images of building facades. If the project is successful in establishing a standard language for 3D Urban Models then this may be important for EnergyPath development if it is used in the future to hold relevant building data.

2.9 Photogrammetric Software

3D models can be built by combining information from several photographs of an item taken from different angles. The higher the number of images available of an object the more accurately its 3D geometry can be reconstructed. Over time more complex strategies have evolved (3). These include use of heuristics about horizontal and vertical lines, analysis of shadows and colours and matching of shapes between different images.

Various software tools are available to generate 3D models using photogrammetry techniques. Some level of user interaction is required to produce models and none of the software tools identified are currently capable of producing accurate 3D building models in a fully automatic process. Some commercially available tools are discussed below.

2.9.1 Photomodeler

Traditional photogrammetry uses high quality lenses in order to diminish the influence of lens distortion. The Photomodeler software can be used with pictures from a 'standard' digital camera. It performs semi-automated processing of multiple pictures to create 3D models. To restrict the number of photos required user input is necessary to identify features common to multiple pictures. A reference dimension is required in order to produce a 1:1 model. Software cost from $1000. (http://www.photomodeler.com/index.html)

2.9.2 BAE Systems

BAE systems have a range of software tools for analysis and manipulation of aerial and satellite data which includes software to automatically generate 3D terrain models. Data can be GIS enabled. (http://www.geospatialexploitationproducts.com/content/products)

2.9.3 Datem

Datem produce a suite of software tools to manipulate data from stereo images and Lidar in order to produce 3D, GIS enabled models. (http://www.datem.com/products/software)

2.9.4 Intergraph

Erdas Imagine is described as a geospatial data authoring system. It incorporates image processing and analysis, remote sensing, Lidar processing and GIS capabilities. (http://www.hexagongeospatial.com/products.aspx)

3 Commercial Data Providers

3.1 Bluesky

Bluesky provide a range of services based around aerial imaging processing. These include Lidar, aerial thermal images, mapping, 3D modelling and linking data from different sources.

Bluesky have provided building classification and roof material type based on photo interpretation as well as building volume, height and number of floors from Lidar data in a 'reasonably' automated process. Data is routinely GIS enabled, typically linked to MasterMap.

Bluesky have facilities for RGB Lidar and have produced surface models based on photogrammetry for video game companies.

3.2 GeoInformation

The GeoInformation group is based around remote sensing technology (photo interpretation). Classification is based on aerial photographs. They argue that one of the strengths of their data is that it is based on 'real' data rather than modelling of areas.

The GeoInformation housing classification database is used by several UK councils including Newcastle City Council. GeoInformation have also supplied building classification to energy and insurance companies, fire and police services and Thames Water.

3.2.1 Data Quality

The Residential building classification covers 17.3m addresses in 578 UK towns with a population over 10,000. GeoInformation have a methodology for classification of off-grid areas which has been used in Huntingdonshire.

The classification of every building includes a confidence rating from A to C. Data accuracy of 95% is targeted through a QA process which includes physical checks of a subset of buildings against the classification from photo interpretation. If a new classification is required in a particular area (e.g. Newcastle had a particular local archetype that was not correctly identified in the original data) this new classification will not necessarily be rolled out to other areas. Planning information has been used to improve data quality.

Data can be provided at postcode level or by map polygon ID. GeoInformation suggested that the best method is to link to the OS Address Base which local authorities already have access to.

There are currently 6 age and 14 type classes giving 54 unique classes. A new age category (for post 2003 buildings) is being considered due to a significant change in building regulations in that year.

Within the residential data set non-residential buildings are identified by a single code.

GeoInformation are working on a commercial building classification. They are at the start of a 3 year project and only small areas have been classified. The target date for completion is July 2016. Buildings are divided into major components and then each is classified allowing complex sites to have multiple classifications. Buildings are classified by building use (24 groups), age (4 groups), number of floors and construction (sub structure, roof type, wall type). Historic issues of ‘The Builder’ magazine are being used to gather additional information.

3.2.2 Other Data

There are options to build on the Building Classification data set to add building height (for which Geo Information have data available for the whole country), building footprint, aerial photos and thermal images (as done for Aberdeen City Council).

The building height and footprint data is a country wide data set produced by GeoInformation for Vodafone and T-Mobile to assist in network design and telecoms mast positioning.

3.2.3 Time Scales

Delivery time is heavily dependent on the nature of the area and the amount of data already held. Maximum times of 6 to 8 weeks are usual.

3.2.4 Costs

Indicative cost for the housing data set for the whole of UK are £85,000 p.a.

Local authority / county level licensing is £8,000 p.a.

A 5% discount is given for a 3 year contract.

These costs are for a license for internal use. A sub-contractor license costs an additional 10-15%. A license to publish derived results on the internet costs 20% extra. GeoInformation will not license for direct publication of its IP on the internet.

Specific costs for Huntingdonshire (for a corporate, internal use licenses):

- Building classification: £8,000
- Data capture on non-domestic: £3,000
- Off gas grid rural data capture: £5,000

3.3 Uno Energy

Uno Energy produce a housing database with an inbuilt energy calculation capability. Buildings are classified by age band and type with sub-types containing information such as flat floor level and the number of exposed walls. Non domestic buildings are not included. Data can be linked to GIS systems and OS MasterMap.

3.3.1 Energy Calculation

A geometric model, based on a BREDEM type analysis, is used to predict heat demand for water and space separately. If precise geometry data is not available for a property then a parameterised geometric model is scaled by floor area. UNO used data from WarmFront (2.5m home calculations done by UNO) to generate the geometric building model of housing stock (floor areas, number of rooms, type, age etc.).

The models can be used to predict the benefits and costs of efficiency improvements. The model has a shopping list of ‘improvements’ and will produce a list of interventions which meet particular conditions. Standard coding is for the Green Deal Golden Rule but other interest rates and payback periods can be specified. Interventions are listed in descending order of cost effectiveness as long as the total package meets the Golden Rule (not all interventions will achieve this individually).

There are built-in assumptions that theoretical benefits will not be realised. SAP outputs can be generated.

3.3.2 Data Sources

UNO use date from a variety of data sources, primarily:

1) Energy Performance Certificates
2) Council building control and planning records. Many measures must be reported to Building Control (e.g. new windows, wall insulation (not loft insulation), new boiler). This is often done through trade associations.
3) Information from council run insulation schemes

EPC Data may come from the inputs used to produce certificates or from the certificates themselves. Data from EPCs includes floor areas, controls fitted and whether a boiler is condensing.

All data sources are recorded in the database.

Data is merged depending on dates and quality to give a ‘best fit’ to current housing stock.

UNO perform ‘reasonableness tests’ on the data e.g. floor area vs. number of rooms and check for outliers that appear different to other data in the area. UNO experience is used to decide which data is more likely to be correct.

3.3.3 Data Quality

The data is claimed to be accurate to address level, not just postcode level. UNO believe that they can reach 'reasonable knowledge' for 50% of housing stock. The data on social housing should be close to 100% complete. It is more difficult to gather data on private stock. The number of records that cannot be processed in a particular area is heavily dependent on the input data (e.g. Gateshead achieves 85% of properties with good data, Nottingham 58%). Properties where the calculations cannot be performed are readily identifiable.

Energy calculation results have been compared to real energy consumptions and are considered accurate at LSOA level where enough data can be gathered on housing so that errors are reduced through averaging. Results cannot be guaranteed at a smaller scale for private housing stock.

For social housing the variability within a particular area is less (both in house design and level of maintenance). This combined with better quality data means that better estimates can be made. Minimum stock numbers of 120 houses are advised to maintain a reasonable level of heat estimate accuracy for private housing stock. Estimates for social housing can be accurate at individual address level. At the other extreme to social housing, estimates for private flats in London would be bad below LSOA due to the wide variability.

Energy estimates are often lower than might be expected (typically 10% on gas) implying that, even in affluent areas, people do not heat their homes to the level that might be expected. UNO calculations typically match SAP values from the EPC.

If a database does not include information on all housing stock then weightings can be applied. E.g. Sheffield’s data is only for private housing stock (mainly based on the Affordable Warmth scheme and EPCs). They hold information on social housing separately.

3.3.4 Costs

Data belongs to clients who are free to use it how they like. UNO place no restrictions on sub-licensing.

Cost depends on LA size and how easily they can provide data. Costs are to gather and merge data, produce calculation results and produce outputs in a useable format.

Data collection and input would cost £5,000 - £6,000 alone.

For Camden (mostly flats with a mixture of affluent people and social housing) cost would be around £5,000.

If clients buy a license to UNO’s software this is £6,000 and the cost for data collection is normally discounted. Total costs per LA are generally kept below £10,000.

3.3.5 Local Authority Customers

UNO have over 50 local authority clients and have worked with a few housing associations.

The database is used by Sheffield, Leeds, Hull, Manchester City and Salford. UNO do not consider Sheffield's data to be the best quality - other LAs have collected more data over a longer time period. The product was also recently bought by Islington.
Sheffield comments:

"The common output is their ability to generate SAP profiles, and to efficiently sift household and property data characteristics that can be used for targeting etc. Although they can be used for detailed property by property assessments, their main strength is to generate ratings at the RdSAP level that is accurate enough to model and monitor large numbers of properties."

3.4 Environment Agency Geomatics

Geomatics is a specialist business unit within the Environment Agency. They provide terrestrial and airborne survey services including Lidar, thermal imaging and aerial photography. Their Lidar offering was historically focused on coasts and floodplains but urban data is also available and can be ordered on line from Geomatics. (https://www.geomatics-group.co.uk/GeoCMS/Products.aspx)

3.5 IRT

IRT surveys provide ground based thermal imaging with a SAP based analysis to give estimates of building energy loss and the energy and cost savings available from different retrofit options. They can typically survey 500 homes a night.

IRT have 10 offices spread across the UK to provide national coverage. They have surveyed around 250,000 properties across the UK.

3.5.1 Thermal Image Analysis Methodology

IRT have developed a methodology to process thermal images in order to provide better insight than that available from the raw images and to reduce human variability which results from manual processing.

1) The position of the camera relative to the building and the local air temperature are recorded when images are taken. Knowledge of the camera locations allows the area covered by each pixel of the thermal image to be calculated.
2) The image is manually cropped to remove items like neighbouring properties, drain pipes and vegetation which may influence the analysis results.
3) Different parts of the thermal image are manually selected to distinguish between walls, windows and doors.
4) A histogram of the number of pixels at different temperatures is produced.
5) U-values for building materials are used along with recommended internal temperatures for different rooms from BRE to calculate the expected temperature of the building’s external surfaces (SAP, Bredem and EnergyPlus building models can be used to perform the calculations). Knowledge of the building archetype is required. A template system is used to select a benchmark building that best reflects the actual building, its occupancy and usage. This then gives the appropriate U-values.
6) A comparison can be made between the measured external temperatures and those expected from the building model calculation. This allows areas where heat loss is

higher than expected to be identified. Adjustments can be made to the internal temperature assumptions if required. It is also possible to work backwards from the measured external temperatures to estimate internal temperatures by assuming the construction materials and insulation level.

7) The change in U-value required to meet targets for different parts of the building can be calculated (or the influence of fitting particular insulation quantified).

3.5.2 Analysis Visualisation

IRT provide a 'Carbon Dashboard' to allow analysis of the results of the energy calculations. This can work on individual properties or any subset of the surveyed properties (e.g. a particular postcode, LSOA or archetype).

The group analysis runs a SAP calculation for each individual building surveyed and then aggregates the results. The influence of different retrofit measures can then be quantified in terms of energy, carbon and cost.

Pictures and analysis results can be mapped so that the location of properties in relation to items such as areas of deprivation can be established (this can influence the level of funding available for retrofit). In addition pictures can be linked to Google Earth. This allows properties to be viewed in StreetView to establish the local context.

3.5.3 Data Quality

All IRT cameras are calibrated annually. All images include a time and GPS location. This allows IRT to reject images that have not been taken at the right time of day.

The analysis must be performed on individual building elevations separately as exposure to the prevailing weather conditions (sun, wind etc.) can influence temperatures.

3.5.4 Costs

Costs for the Scottish Federation of Housing Associations project was £12.50 per property.

IRT have offered special rates to organisations such as the Green party at £20 per property.

3.5.5 LA Customers

IRT conducted surveys of 25,000 social properties across Aberdeen over 3 heating seasons. During this project it was found that monetising the cost of energy loss was the most effective way to engage with residents. More abstract uses of the data (simply using thermal images or estimates of energy loss) were less effective.

IRT performed a survey for the Scottish Federation of Housing Associations with 60,000 properties surveyed and included into a web-accessed Carbon Portal. This is the same idea proposed for the joint ETI - National Housing Federation project (section 6.2).

3.5.6 Horizon 2020 Bid

IRT Surveys are trying to construct a consortium to bid for funding through Horizon 2020. This will use vehicle mounted cameras with Lidar to survey buildings in large quantities. The intention is to work with thermal camera manufacturer, Flir to develop the camera mount and stabilisation system.

Thermal images will be projected into Google Earth so that property owners can compare their building to others. In addition each property will have a link to the Carbon Dashboard so that owners can assess the options for, and potential benefits of, retrofit. IRT hope to be able to monetise this solution through a web-based comparison site which would allow owners to find suppliers to complete the work.

This work is of interest to the ETI for:

1) The options for mass scale surveying to improved EnergyPath inputs through use of the IRT software to improve knowledge of the state of retrofit of individual buildings.
2) The possibilities for engagement with residents and the potential to encourage retrofit.

4 Sensitivity of Home Energy Use Estimates to Different Input Parameters

In order to understand the value of improving the quality of information on individual buildings the sensitivity of estimates of annual building energy use to different inputs was analysed.

4.1 Analysis Method

A building thermal efficiency model was developed as part of the ETI's Optimising Thermal Efficiency of Existing Housing (OTEoEH) project. This model is uses the BREDEM – 8 methodology and is pre-programmed with all the main UK housing archetypes. For each of the 10 most popular archetypes in the UK the model inputs were varied and the change in the estimated annual gas use was recorded.

The range of each changed input for each archetype was obtained from the English Housing Survey (2009 and 2010). For each input the 10^{th} and 90^{th} percentiles were used as the possible range for each archetype. Entering these minimum and maximum values for each model input produced the range of expected annual gas use for each archetype assuming all other inputs maintain their default value. The results show the maximum potential improvement in energy use estimates that can be expected from improving knowledge of the building.

The 10 most popular archetype used in the analysis were:

1. Pre 1919, Mid Terrace
2. 1945 – 1964, Semi-Detached
3. 1919-1944, Semi-Detached
4. Post-1980, Detached
5. 1965-1980, Semi-Detached
6. 1965-1980, Detached House
7. 1965-1980, Flat Low Rise
8. Post-1980, Flat, Low Rise
9. Pre-1919, Semi-Detached
10. 1965-1980, Mid Terrace

Sensitivity analysis was completed for the following model inputs:

1. Ground floor area: 10% and 90% values for each archetype
2. Roof area: 10% and 90% values for each archetype
3. Wall area: 10% and 90% values for each archetype
4. Window area: 10% and 90% values for each archetype
5. Number of doors: influence of adding 1 door.
6. Window U-value: changed from default to single glazed and triple glazed, argon filled, low-E coated.
7. Wall insulation: add external or internal wall insulation with U = 0.15.
8. Loft insulation: add loft insulation with U = 0.15
9. Boiler type: compare regular to modulating, combi regular and combi modulating

4.2 Analysis Results

Figure 4.1shows the influence of each item on the estimated annual gas use of each of the individual archetypes. The maximum changes for each item across the range of archetypes are given in Table 4.1

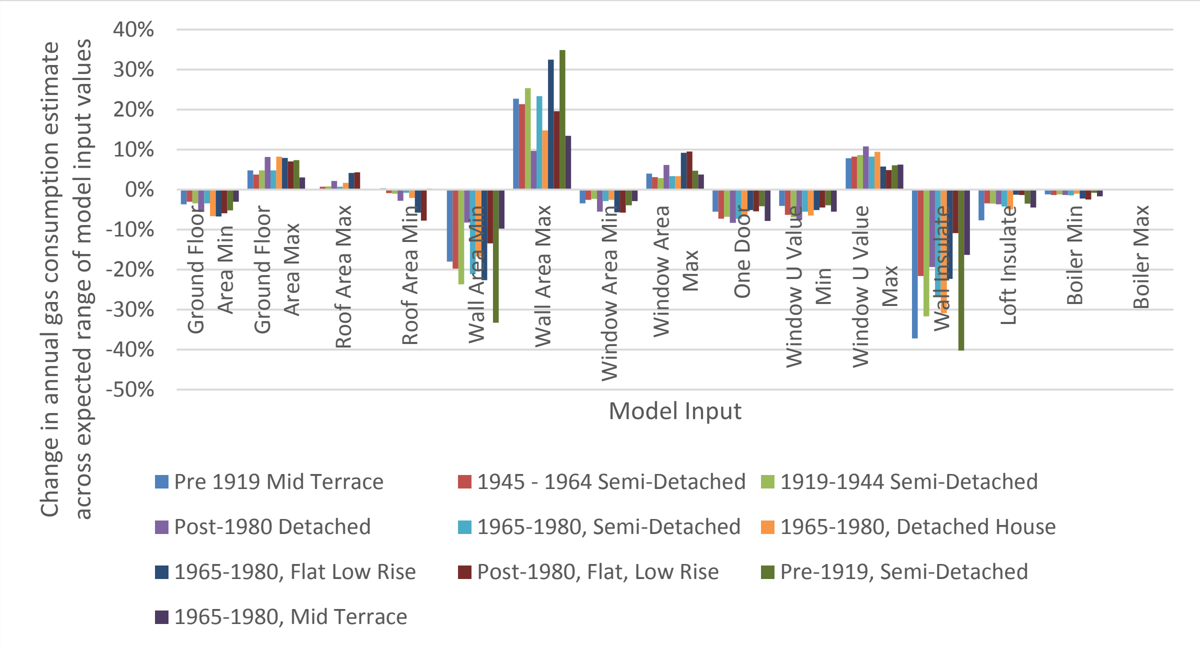

Figure 4.1: Influence of different factors on estimated annual gas consumption for individual archetypes

Table 4.1: Scale of the influence of different factors on estimated annual gas consumption across all archetypes.

Model Input	Change from typical predicted energy consumption		Importance Ranking
Ground Floor Area	-6.7%	8.2%	5
Roof Area	-7.7%	4.3%	6
Wall Area	-33.3%	34.8%	1

Model Input	Change from typical predicted energy consumption		Importance Ranking
Window Area	-5.8%	9.5%	4
Add One Door		8.3%	7
Window U-value	-7.5%	10.8%	3
Insulate Walls	-40.3%		2
Insulate Loft	-7.7%		8
Change Boiler	-2.5%	0.0%	9

It can be seen that accurate knowledge of a property's wall area and the level of wall insulation will be most important in determining its energy consumption. Knowledge of the boiler type has the least influence on energy consumption estimates.

4.3 Appropriate Survey Techniques

The table below identifies the most appropriate method of obtaining information about the different factors which influence energy consumption estimates. Under planning regulations various retrofit measures must be notified to the local authority building control department. This is likely to be the easiest, and cheapest way of obtaining information on these measures.

Table 4.2: Survey techniques for different building information.

Model Input	Survey Technique / Data Source
Building Archetype	Aerial photo interpretation by commercial provider or MasterMap analysis combined with automated photo recognition.
Wall Area	Building perimeter from MasterMap. Building height from Lidar (MasterMap topography layer or commercial provider)
Wall Insulation	Cavity and solid wall insulation from building control records and Energy Performance Certificates Ground based thermal images
Window U-value	Building control records and Energy Performance Certificates
Window Area	Front elevation may be possible from Lidar scan with photo recognition
Ground Floor Area	From MasterMap

Model Input	Survey Technique / Data Source
Roof Area	From MasterMap
Number of doors	Hard to establish without individual property visits. New doors with >50% glazing must be notified to building control.
Loft Insulation	Aerial thermal images
Boiler Type	Building control records

4.4 Survey Technique Priority Order

Based on the information in tables 4.1 and 4.2 a priority order for development of different survey techniques to supplement knowledge of building archetype can be established.

1) Merging data from different sources to enhance building knowledge.
2) MasterMap analysis and automated photo recognition for archetype.
3) MasterMap analysis for wall and floor areas.
4) Automated Infra-red photograph processing for insulation levels and thermal properties.
5) Lidar and photo recognition for window areas and building construction types and materials.

5 Conclusions

A review of the methods commonly used to produce housing stock information was undertaken to establish their suitability to providing input data to EnergyPath. Options for improvement of the current surveying techniques were also considered. The following conclusions were reached:

1) No single method of mass surveying is capable of providing all the information that can be gathered by using different methods.
2) Data on housing stock is commercially available but has limitations and can be augmented by data from other sources.
3) Local Authority building control departments hold data on:
    a. Installations of cavity and solid wall insulation
    b. Replacement window and glazed door installations
    c. Boiler replacements
4) Clustering of data is likely to be required to achieve reasonable estimates of energy use. Data on individual buildings is likely to be inaccurate. By averaging across clusters of buildings it is possible to achieve reasonable estimates of energy demand on an area basis.
5) There are potential options for development in:
    a. Improved merging of data from multiple sources.

   b. Automated processing of map data and photographs to establish building archetypes.
   c. Processing of Lidar and photographs with map data to produce estimates of building size, construction type and construction materials to enhance energy use estimates based on archetype.
   d. Automatic identification of building features such as windows and doors using Lidar and photographic information to enhance energy use estimates based on archetype.
   e. Improved automation of processing of ground based thermal images.
   f. Use of aerial oblique thermal image cameras to give information on wall and roof insulation.
6) There are no automated processes to generate complete building information from Lidar to a level of accuracy that would be sufficient for use with EnergyPath input data.
7) Thermal images have limitations associated with
   a. the relative, rather than absolute, nature of the data produced
   b. problems associated with gathering images for all building surfaces
   c. distinguishing between unheated and well insulated buildings
   d. the need for specific atmospheric conditions when collecting images
8) Aerial photographs on their own have little value as a surveying technique. Highly skilled photo-interpretation is required to identify building archetypes from aerial photographs
9) Energy Performance Certificates vary widely in quality but the large number of houses surveyed makes them an attractive data source.
10) An automated categorisation of buildings from MasterMap may be appropriate as the ‘base level’ of analysis for EnergyPath. It would allow an analysis of the benefits of collecting better data. However, the number of houses required to be averaged to get good data by this approach (LSOA scale) may be too large for EnergyPath.

During investigation for this report concerns were raised over ‘the legal nature of data’ with regard to data owners, licensing and the quantities of data required for building information models. This report does not consider this further but data privacy and security will clearly be important when implementing future solutions.

6 Future Projects / Options

There are several potential areas for development of mass surveying techniques to improve the quality of inputs to EnergyPath. These include both development of hardware and data processing techniques.

It is proposed that we proceed with the data merging project (6.1). The National Housing Federation project (6.2) is approved and in development. Discussions with Oxford University (6.3) are continuing to better understand the options for development of a trial project on Lidar data collection and processing. This process has the potential for integration with ground based thermal images (which would be collected at the same time). On this basis it is not clear that the ETI should invest in aerial, oblique thermal image technology (6.4) at this stage.

6.1 Data Merging

Combining the outputs from a different surveying techniques could enhance the level of knowledge about buildings in a local area. Merging of the following data is proposed:

1) **Building Archetype**. There is potential to develop algorithms from Cardiff and Southampton Universities to identify archetypes and building information from MasterMap and other data sources. It may be possible to improve archetype identification through video analysis using machine learning techniques.
2) **Building size, number of windows and doors** from automated Lidar processing with a possible extension to identifying construction materials and distinguishing between solid and cavity wall brick patterns.
3) **Thermal properties** from infrared images supplemented by EPC data.
4) **Building control** data on installations of wall insulation and new windows and doors.

The ETI would need to create a project team that included the following partners:

1) Southampton University
2) Cardiff University
3) Oxford University
4) IRT

This project has the potential to produce robust building information at a post-code level at low cost using national and local datasets. The project would include an analysis of the benefits of adding to this data using ‘drive by’ Lidar and thermal images to establish whether this more detailed information gives sufficient benefits to justify the increased cost.

Bluesky have proposed a pilot project (cost £500) to help establish the potential of merging data from multiple sources to improve knowledge of building archetypes in a local area. The ETI would provide a list of data they are interested in. Bluesky would then extract as much data as possible from vertical thermal, Lidar and aerial photography across a 1km^2 area. Bluesky will also provide quotations to provide additional data from 3rd parties where this is not available from their internal data set. This project will not develop a fully developed, merged data set. However, for a small investment it might give a good indication of the potential for data merging.

6.2 NHF Project

A project is being developed to collaborate with the National Housing Federation to collect thermal imaging surveys of 20,000 properties. This work will be performed by IRT surveys who will also process the data to produce energy performance predictions for the buildings surveyed. In addition the ETI proposes to conduct a physical survey of around 2% of these properties to a standard at least equal to that required to perform RdSAP calculations. Understanding gained from this project with respect to surveying will include:

1) The value of thermal images as a survey technique to improve energy estimates for EnergyPath.
2) A quality check on IRT energy estimates compared to more robust RdSAP calculations.

3) Using EPCs already produced for surveyed properties we should gain insights into the quality of typical EPC results by comparison to a robust set of good quality EPC energy estimates.

6.3 Feature Identification from Lidar

Machine learning algorithms developed by Oxford University to identify features in a Lidar point cloud and relate them to photographic images have potential in collection of building data. These are:

1) Identification of construction materials and distinguishing between solid and cavity wall brick patterns.
2) Identification of building age and type by comparison to template images of buildings typical of local archetypes.
3) Improved knowledge of building details (size, number of windows and doors).
4) Automatic identification of features in thermal images to reduce the manual image processing conducted by IRT surveys. This has particular relevance to their proposed Horizon 2020 project to survey large numbers of buildings.

The low cost Lidar scanner, also developed at Oxford, may help to significantly reduce the capital costs of survey equipment.

It is proposed that these techniques are developed as part of the wider project discussion in section 6.1

6.4 Oblique thermal imaging

Bluesky are interested in developing an aerial, oblique thermal camera installation (4 additional cameras) which would give a good indication of wall thermal properties.

They have made some progress with this in collaboration with the company that designed and built their existing thermal and Lidar sensors. They have been provided with technical drawings (which are currently confidential) and an estimated cost of the hardware and the associated rack and mount. Further investigation into processing work-flow and data output is required but they are confident that an oblique thermal systems is viable and could be designed and built with a relatively short lead time.

The estimated cost of getting a system to an operational stage to include hardware, processing workflow, software development, test flights and labour/R+D time to be between £550 and £650k.

7 References

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