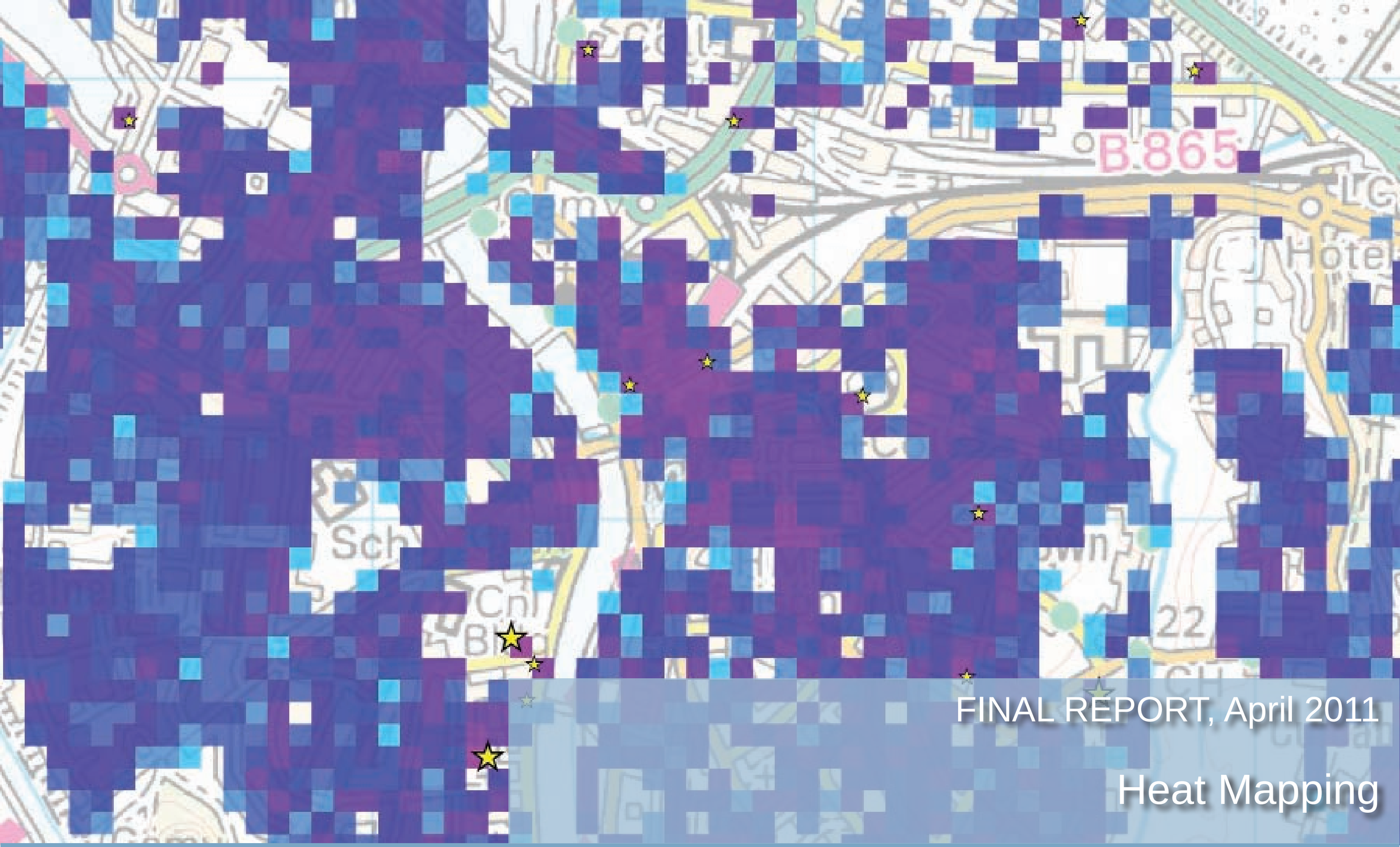


FINAL REPORT, April 2011

Heat Mapping

The Highland Council

List of Acronyms used in the report

AD - Anaerobic Digestion
AECB - Association for Environment Conscious Building
ASHP - Air Source Heat Pump
BGS - British Geological Survey
BM - Benchmark
CAG - Corporate Address Gazetteer
CHP - Combined Heat and Power
CIBSE - Chartered Institution of Building Services Engineers
CO2e - Carbon dioxide emissions
DE - Decentralised Energy
DECC - Department of Energy and Climate Change
DEFRA - Department for Environment, Food and Rural Affairs
DeMap - Decentralised Energy and Energy Masterplanning Programme
DH - District Heating
DTI - Department for Trade and Industry
ECI - Environmental Change Institute
EUETS - European Union Emissions Trading Scheme
FIT - Feed-in Tariff
FREDS - Forum for Renewable Energy Development Scotland
GHG - Greenhouse Gas
GIS - Geographic Information System
GROS - General Registers Office for Scotland
GSHP - Ground Source Heat Pump
HIE - Highlands and Islands Enterprise
IGZ - Intermediate Geography Zone
LDF - Local Development Framework
LDP - Local Development Plan
LFG - Landfill gas
LPG - Liquified Petroleum Gas
LSOA - Lower Super Output Area
MCS - Microgeneration Certification Scheme
MSOA - Middle Super Output Area
NAEI - National Atmospheric Emissions Inventory
NHS - National Health Service
RHI - Renewable Heat Incentive
SEPA - Scottish Environment Protection Agency
SHCS - Scottish House Condition Survey
SNH - Scottish Natural Heritage
SPRI - Scottish Pollutant Release Inventory
THC - The Highland Council
UPRN - Unique Property Reference Number

The Highland Heat Map is a Geographic Information System (GIS) based spatial planning tool which brings together a range of relevant spatial information relating to renewable heat opportunities with a suite of complementary GIS tools. These tools allow interrogation and analyses of the Heat Map providing users with a range of potential outputs including maps, statistics and predictions.

It has been developed specifically to help deliver the Scottish Government target of 11% of all heat demand from renewable sources by 2020. Existing renewable heat provision is estimated to be 2.8% (March 2011) of the existing non-electrical heat demand. The Heat Map will aid this process by providing a means to assess the impact of proposed development. This means that the Heat Map is a spatial planning tool which can be used to influence the planning decision making process.
This ability to allow users to test different development scenarios is a key highlight of the Highland Heat Map which distinguishes it from other Heat Maps that have been developed in the past.

The Heat Map is made up of two main elements:

- A range of GIS layers showing information relating to heat demand, potential heat supply, skills/ technology and opportunities and constraints
- A suite of GIS tools which allow the GIS layers to be analysed, in particular for the prediction of the impacts of different development scenarios

A key output of the study is the development of a methodology which is repeatable and consistent for the whole of Scotland. A template has been developed (Appendix A3) which outlines the key stages in preparing a Heat Map using this methodology. This template has been designed to support other Scottish local authorities in preparing their own Heat Maps.

Another key factor which distinguishes the Highland Heat Map from previous methodologies is the level of spatial detail used in its creation. Heat demand values have been calculated at an individual property level, unlike other Heat Maps which calculate heat demand using a coarser geography. This means the Highland Heat Map is a truly scaleable product which can be used at all scales from national to local depending on the circumstances.

The key learning outcome of the project is the need to ensure data quality and integrity throughout the process. The methodology has been developed using data sources which are both consistent and have a national coverage. Good communication with data providers is essential to help both understanding of the input data and to secure longer term commitment to providing updated data for future Heat Map revisions. The quality of the Heat Map outputs can only be as good as the inputs, so it is therefore imperative that a full understanding of the strengths and limitations of all inputs is gained. In addition, it is also necessary to be confident that updates to input data will be available at regular intervals in the future.

Additional learning outcomes relate to the need for good consultation. It has been evident during this project that existing perceptions of what a Heat Map is can vary greatly between individuals, if indeed they have any existing awareness. It is therefore essential that for any future heat mapping exercises that stakeholder consultation remains a key part of the process. Future stakeholder consultation exercises should use the experiences from the Highland Heat Map, relating both to the creation of the map and to case studies of the application of the Heat Map .

The Heat Map has been designed to be used as a spatial planning tool. In particular it offers users the opportunity to:

- understand the impacts of potential development scenarios by predicting future heat demand levels
- inform and test Local Development Plan allocations by summarising heat demand and potential heat supply
- test impacts of planning applications by allowing users to predict future demand and interrogate the map for opportunities for low carbon and renewable heat
- highlight strategic planning opportunities for low carbon and renewable heat opportunities by identifying locations containing clusters of high heat demand and potential heat supply sources

As a pilot study, one of the key future learning outcomes should be a range of case studies based upon the practical applications of the Heat Map as experienced by Highland Council. This will be of considerable value for any future heat mapping projects to help demonstrate the benefits and any potential issues for other organisations considering developing a Heat Map. It will also serve as an opportunity to highlight any further development areas for the Heat Map. This could relate to the provision of improved data sources or associated tools to improve the interrogation and analysis of the map.

The completion of the Heat Map should not be seen as the end of the process. It is in fact only the beginning of the process and is where the value and benefits of the Heat Map will be realised. The Heat Map is in fact a dynamic tool which will evolve constantly over time to reflect the ever changing situation in the real world. This will require a level of ongoing maintenance to ensure that the map remains up to date and of value to its users. Update protocols and GIS tools have been developed to aid this process. It is also expected, and indeed encouraged that the Heat Map will evolve over time to take advantage of the best available information and functionality as it is identified.

This will ensure that the Heat Map remains up to date and relevant to its users. If the information is not maintained, the danger is that the Heat Map will quickly fall out of use as the information contained within it becomes outdated. It is therefore essential that the issue of maintenance is addressed. A data custodian for the Heat Map should be appointed and the associated roles and responsibilities clearly set out in a maintenance plan. This should include details of the frequency and method to be used for updates as well as the resource required to carry out the maintenance. In order for the Heat Map to have the best chance of being adequately maintained it must be resourced adequately by the host organisation.

Training users in how the Heat Map outputs can be applied is an additional area where ongoing effort will be required. The Highland Heat Mapping study has provided training for a number of individuals in both The Highland Council and other stakeholder organisations to improve understanding of what the Heat Map is and how it can be used. Further ongoing training should be considered for a wider range of Highland Council staff, drawing upon specific applications of the Heat Map within the Highlands. Consideration should also be given as to how new staff members are trained in the use of the Heat Map.

A wider aspiration of the Heat Map is to provide the outputs to a wider range of users, including the general public. A strategy for dissemination of the outputs should be developed by the host organisation to ensure that these are easy to understand and are provided in a format that users require. This should consider how best to train new users in understanding the Heat Map and its applications.

The next key steps for The Highland Council to consider for the Highland Heat Map are:

- to develop a strategy for wider dissemination of the map and its outputs.
- to develop a strategy for future maintenance of the Heat Map and define roles and responsibilities.
- to provide feedback to Scottish Government and other organisations on the ongoing use and application of the Heat Map.

The Highland Heat Map methodology provides a significant opportunity to influence the planning process, by providing a sound evidence base which can be used to identify and appraise renewable heat opportunities across Scotland.

Contents

CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

1.1 Introduction

AECOM were commissioned by The Highland Council, Scottish Government and Highlands and Islands Enterprise (HIE) in December 2009 to investigate and determine the potential structure, content and uses of a heat map and produce one for the Highland Council area using a methodology that is repeatable for all other Scottish local authorities.

There were three key objectives that were identified which needed to be addressed in order to successfully achieve this aim. These were:
1) To produce a multi layered, GIS based, map which directs and supports opportunities to maximise the generation and use of renewable heat within all planned new developments (industrial, commercial and domestic) and refurbishment projects. This includes the creation and/or extension of district heating (DH) networks, the use of waste heat and low carbon heat/Combined Heat and Power (CHP) where this could lead to greater opportunities for renewable heat in the future.

2) To deliver a Geographic Information System (GIS) based system suitable for use and updating by Highland Council staff. The resolution of the system must be significantly finer than the 1km x 1km scale used in the Forum for Renewable Energy Development Scotland (FREDS) report “Recommendations to Scottish Ministers, Feb 2008”, and be agreed by the steering group.

3) To produce a short training package on the system (to be owned by the steering group), to train Highland Council staff on how to update and/or revise the layers, and provide back up support for a subsequent 6 month period.

1.2 Policy Context

The Climate Change (Scotland) Act 2009 puts Scotland on a path to reducing Greenhouse Gas (GHG) emissions by 80% below the 1990 baseline by the year 2050. Deep reductions are required long before 2050, however, with an interim target set at a 42% reduction as soon as 2020.

Most developed economies are almost entirely underpinned by fossil fuels to support all economic activity and – in fact – our way of life. Thus, meeting these targets will involve dramatic changes in all aspects of the economy – including power generation, transport and all areas of energy demand. Even if Carbon Capture and Storage is successfully developed as a low carbon power generating technology, there is still certain to be a significant shift away from fossil fuel use in general.

Scotland’s Climate Change Delivery Plan (June 2009) highlights the scale of the challenge and identifies some of the steps that need to be taken. About 16% of Scotland’s GHG emissions in 2006 were associated with the supply of heat which amounts to about 9.3 Megatonnes of CO_2 emissions (this does not include emissions from the European Union Emissions Trading Scheme (EUETS) traded sector – such as power generators and some heavy industry). By 2020, it is anticipated that the corresponding figure will need to fall to about 5.0 Mt of CO_2e. Thus decarbonisation of heat will be required to contribute more than its fair share to the achievement of the 2020 target, as some of the other sectors (e.g. transport) face problems which are more intractable over such a short time period.

This reduction will be achieved through a mixture of demand side interventions such as energy efficiency measures (e.g. building insulation and air-tightness) and switching to lower carbon heating sources. Some of the reductions will also be attributable to the increasing uptake of heat pumps, which will result in reductions in fossil fuel use outside the EUETS traded sector, but increases in emissions from the traded sector – i.e. power stations (there should, however, be significant net reduction in GHG emissions).

The Scottish Government has set a target to deliver at least 11% of all heat demand from renewable sources by 2020. The Sustainable Development Commission Scotland has recently published (Nov 2009) Renewable Heat in Scotland – a report to the Scottish Government, which calculates the existing renewable heat provision to be 2.8% (March 2011) of the existing non-electrical heat demand. Therefore there is much to be done between now and 2020.

Recent policy developments include proposals for a Renewable Heat Incentive (RHI), which the UK Government published in March 2011. This will incentivise consumers (domestic and commercial) to install renewable heating systems by providing revenue payments based on the number of kilowatt hours of metered renewable heat used. Support for biomass heating systems in particular appears to be strong, and should provide sufficient incentive to many consumers, especially in areas not served by the mains gas network. Phase one of the RHI is expected in July 2011, with phase two following in July 2012: phase two will bring individual domestic properties into the scheme and possibly some technologies excluded from phase one (such as air source heat pumps).

The topics of heat, energy and waste are linked. The Scottish Zero Waste Plan (ZWS) requires a marked move away from landfill, with just a small residual fraction being landfilled by 2025 (up to a maximum of 5%): this means that landfill gas will decline as a potential contributor to renewable heat and power. On the other hand, the plan does allow for significant volumes (up to 25%) to go to energy from waste plants (excluding AD), opening up the possibility of new district heating networks linked to these facilities. The Scottish Government will introduce regulatory measures to support the delivery of landfill bans, by ensuring energy from waste treatment is only used to recover value from resources that cannot offer greater environmental and economic benefits through reuse or recycling. These measures will supersede the current 25% cap which currently applies only to municipal waste, and are likely to result in similar amounts of resources being available for energy from waste treatment.

The ZWS plan identifies that the remaining 70% of municipal solid waste should be dealt with through a combination of recycling, composting and AD. Some of the 70% recycling and composting target can be met through the use of anaerobic digestion: the biogas produced by this can also be used to provide heat and power (among other options).

1.3 Opportunities

Most of the existing renewable heat used is derived from biomass, with Heat Pumps and – to a lesser extent – solar and waste treatment technologies providing the balance. Whilst biomass use is expected to increase significantly, it is recognised that there is increasing competition for the biomass resource – not least from power generators. Therefore the other technologies will be expected to play their part. Examples of contexts in which renewable heating might be used include:

- Heat pumps – particularly suitable for modern or refurbished buildings, and especially when there is a suitable area of ground for installation of a heat collector. These are powered by electricity, but the investment of one unit of electricity typically extracts around 1.5 units of renewable heat, resulting in efficiency of 250% or more (e.g. =(1.5 units of renewable heat + 1 unit of electrical heat)/1 unit of electricity. Total of 2.5 units of heat for every unit of electricity used).

- Solar thermal – typically for domestic hot water, but also can contribute to space heating. Suitable for most domestic buildings with a suitable area of roof, reasonably exposed to direct sunlight. Also suitable for commercial and industrial buildings with a domestic hot water demand (hotels, schools, etc.).

- Biomass facilities vary in scale from wood burning stoves to the 100MW+ power stations that are currently in the planning system around the UK. There are, however, many instances of wood chip and wood pellet boilers being used in public and commercial buildings throughout Scotland at around the 100kW scale. There is also a network of small suppliers of woodchips and logs, and it is important that this network is nurtured and developed as the proximity principle is key to the sustainable growth of woodchip and log use. Wood pellet is much more energy dense than woodchip (energy / volume) and can feasibly be transported greater distances: accordingly there is merit in having centralised production of the pellet in larger plant offering significant economies of scale (as at Invergordon).

Figure 1.1 Wood pellet

- District heating networks (perhaps using biomass as the heat source, or spare heat from an industrial facility) are easier to install in new developments than retrofit in existing developed areas – but, of course, new developments are built to higher thermal standards than in the past, so do not need so much heat.

- Significant energy levels are embodied in a range of waste materials, and this can be harvested in one of a number of ways (depending on how the waste is selected, sorted, and / or pre-treated). These are typically linked to electricity generation, but it has long been standard practice in parts of Europe to set such waste treatment plants up as Combined Heat and Power (CHP) with heat being supplied to the neighbourhood through district heating networks. CHP is favoured in the UK, also, by the Best Practicable Environmental Option assessment. Examples of technologies include the following:

Anaerobic digestion – which converts biodegradable organic wastes into a biogas (mainly methane), which can be used in a variety of ways including – potentially – injecting into the gas main (after purification), thus adding a renewable component to the mains gas supply. Good for segregated food wastes and organic slurries.

Advanced thermal treatments – including gasification and incineration with energy recovery – especially suitable for dry wastes, as energy is not then wasted on evaporating water.

Figure 1.2 Roseisle distillery (which has an anaerobic digestion facility)

An example of this type of technology is the waste to energy facility on Shetland. Shetland Heat Energy and Power Ltd has been serving district heating to both domestic and non domestic properties in Lerwick since 1998. Hot water is pumped around Lerwick through underground insulated pipes and enters properties through a heat exchanger, supplying their heating and hot water needs. The heat used in the scheme is generated at a Waste to Energy Incinerator located on the outskirts of Lerwick. The incinerator at the Energy Recovery Plant burns domestic and commercial waste from Shetland, Orkney and from the offshore oil industry, reducing the amount of waste going to landfill. Up to June 2009 there was a total of 1002 connections and 961 of these are receiving heat.

- Landfill gas (LFG) is currently captured in many landfill sites in the UK and utilised in gas engine generators. There is scope for alternatives involving renewable heat – including CHP or cleaning up the gas and injecting into the gas main. Additionally, at landfill sites such as those in the Highlands where the LFG yield is reportedly too low for economic utilisation, it is currently flared (frequently with the addition of natural gas to keep the flare going): more sustainable alternatives involving the provision of heat may be possible, however. Over time, the opportunity for LFG utilisation will decrease as biodegradable waste is diverted from landfill, but it is likely that in general, some existing waste management sites will be preferred for future waste to energy facilities of other types.

Figure 1.3 Landfill gas engine

1.4 Barriers

There are, of course, many potential barriers to the uptake of these technologies, including:

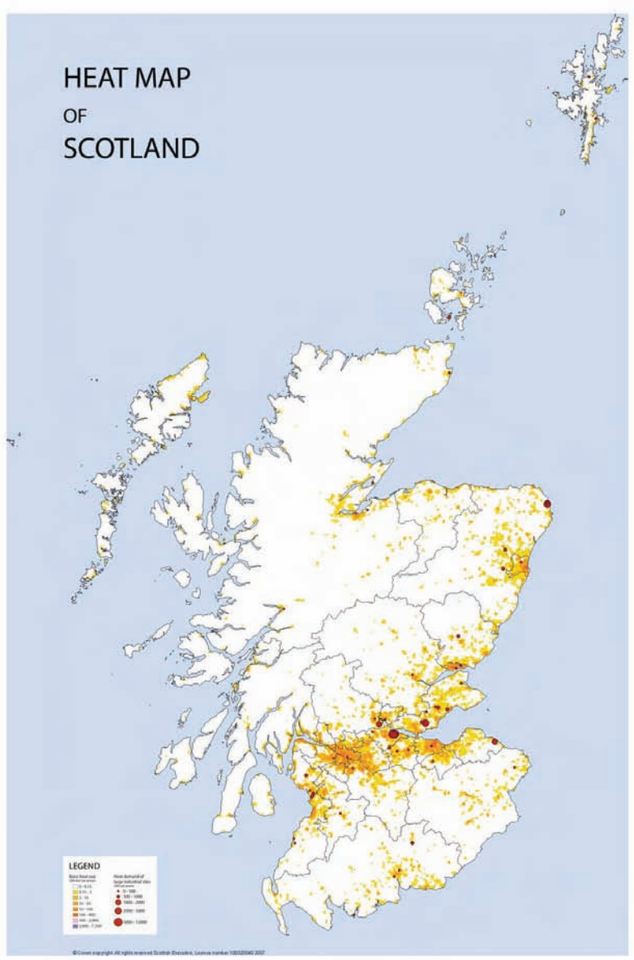
- planning barriers (particularly with reference to waste to energy);
- high density housing making comprehensive provision of solar thermal, heat pumps, and biomass boilers impossible in some existing developments;
- expense associated with retrofits – e.g. providing new district heat infrastructure in existing developments;
- competition for resources, such as alternative uses for timber and for some agricultural ‘wastes’ such as straw and chicken litter which can be productively used as fertiliser / soil improver as well as providing fuel for incinerators.

1.5 Prior Heat Mapping Initiatives

The requirement for this work arose from a previous study commissioned by the Forum for Renewable Energy Development in Scotland (FREDS) 2007. This study produced a heat map which was used in the FREDS report Scotland's Renewable Heat Strategy: Recommendations to Scottish Ministers which was published in 2008.

The map, produced by AEA Technology and presented to FREDS on 17 May 2007, contains a graphical view of a 1km grid of carbon dioxide emissions data adjusted to represent a proxy for heat use. The map was based upon information on CO2 emissions across the UK taken from the National Atmospheric Emissions Inventory (NAEI). This includes mapping of CO2 emissions at 1km resolution across the UK. This data set has been manipulated to map heat use and forms the basis of the heat map.

Figure 1.4 FREDS Heat Map

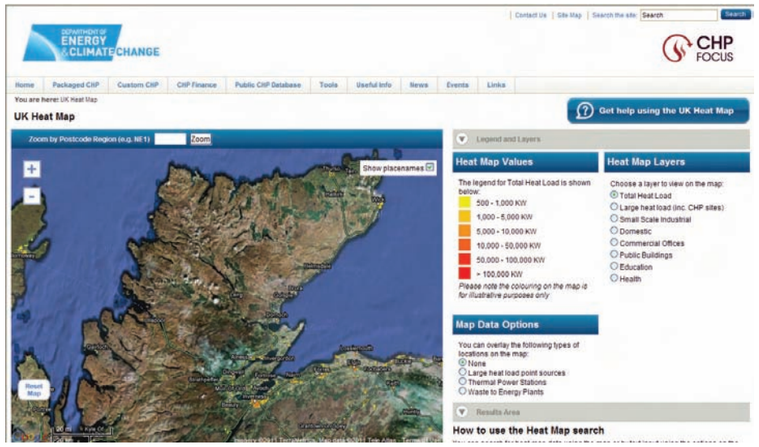


The heat map developed through that study provides a broad brush indication of heat demand and potential supply. It was noted however that "more detailed data would be required to develop an effective decision-making tool". Recommendations from this work identified that "there is merit, particularly at a local level, in developing heat maps to give a strategic overview of potential sites. However, there needs to be consistency in the approach adopted across all local authorities and the Scottish Government should provide the necessary guidance to achieve this."

Another example of heat mapping is the Industrial Heat Map, a piece of work carried out by the former Department for Trade and Industry (DTI) and Department for Environment, Food and Rural Affairs (DEFRA) to assist power station developers to explore opportunities to use CHP, including community heating, when developing proposals for new power stations.

This includes a series of map layers representing the heat demand across various sectors within the UK. Like the FREDS heat map, the resolution of the map output is 1km², but with additional more detailed point data source information.

Figure 1.5 Industrial Heat Map screenshot

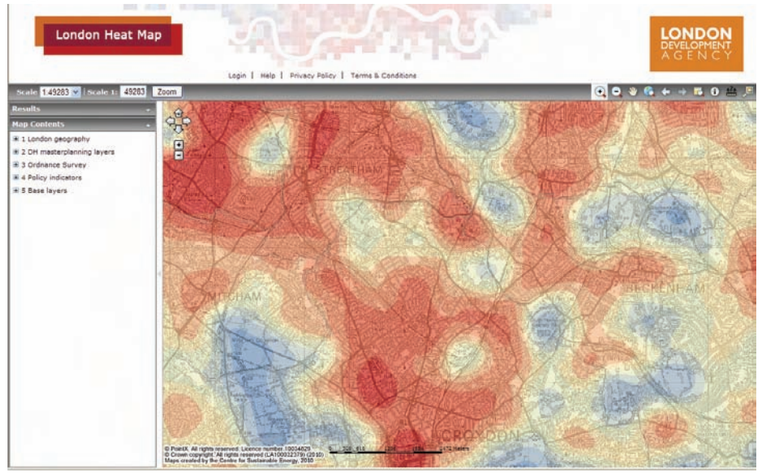


The London Heat Map has been developed by the Decentralised Energy and Energy Masterplanning (DeMap) Programme to assist both the public and private sector to identify Decentralised Energy (DE) opportunities in London. The London Heat Map is an interactive tool that allows users to identify opportunities for decentralised energy projects in London.

The London Heat Map provides spatial intelligence on factors relevant to the identification and development of DE opportunities: major energy consumers, fuel consumption and CO2 emissions, energy supply plants, community heating networks, heat density etc.

It is publicly accessible to anyone with an interest in DE. Local authorities can use the map as the starting point for developing detailed Energy Master Plans to inform DE policies in their Local Development Frameworks (LDF) and climate change strategies. Developers can use the map to help them meet London Plan DE policies (connection into an existing network or extending their own communal heating networks beyond their site boundaries).

Figure 1.6 London Heat Map screenshot



There are also quite a number of regional studies which have sought to spatially identify renewable energy opportunities including renewable heat. These are usually prepared using information available at Lower Super Output Area (LSOA) level. This can provide a strategic view of demand and supply at a regional level.

2.1 Management

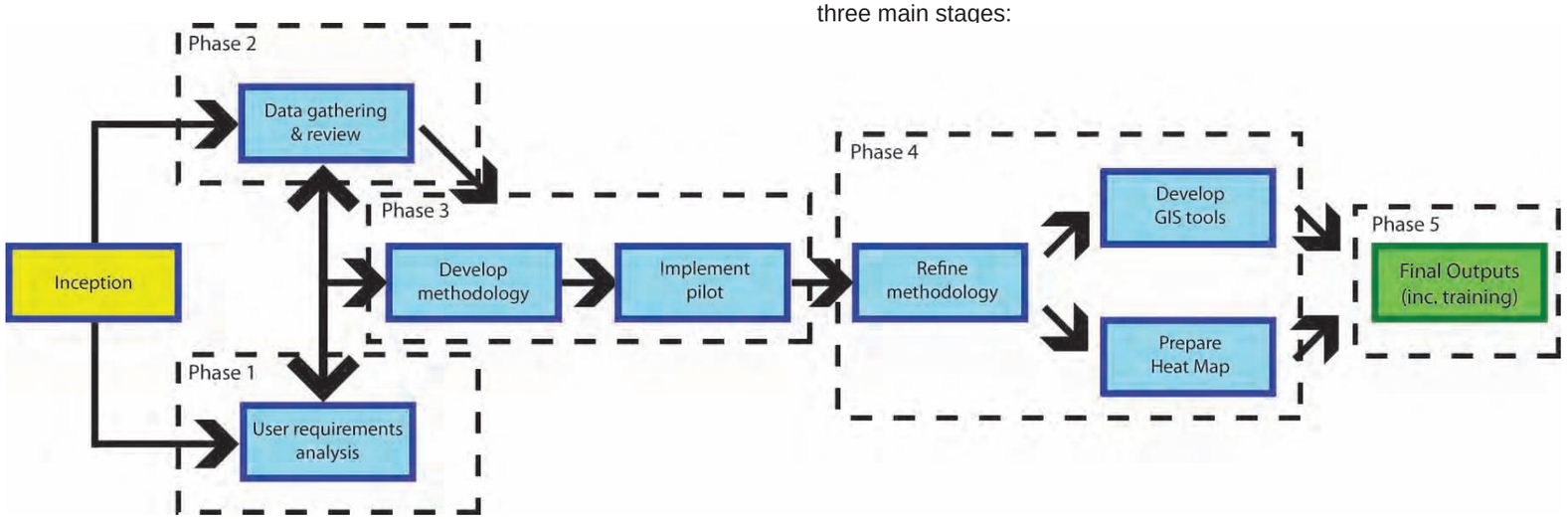
A steering group containing a number of key stakeholders was formed at the outset of the Highland Heat Mapping project. The role of its members was to provide direction through feedback at regular intervals and to act as ambassadors for the project within their respective organisations. Membership of the steering group included the following organisations:

- Scottish Government
- The Highland Council – Planning and Development
- The Highland Council – Housing & Property
- The Highland Council – TECS: Waste Management
- The Highland Council – GIS
- Highlands and Islands Enterprise

2.2 Project Phases

The proposed methodology was presented to the project steering group at the inception meeting and was subsequently refined as a result. Figure 2.1 outlines the key phases of the project and the order in which they were tackled.

Figure 2.1 Project outline



2.2.1 Phase 1 – User Requirements

It was identified at an early stage that it would be essential to carry out a stakeholder consultation exercise in order to fully understand what the hopes and apsirations of stakeholders in relation to the project outputs. Consultation was also required to provide an understanding of the existing knowledge of heat maps and their application in identifying renewable heat opportunities.

It was therefore important to identify at an early stage who the main users of the Heat Map outputs would be. Table 2.1 lists the main outputs from the study and identifies the main potential user groups for each one.

Table 2.1 Project outputs and potential users

Output	User Group
Heat Map	The Highland Council (THC) Scottish Government Developers General public
GIS Tools	The Highland Council staff
GIS Outputs (derived from GIS tools)	The Highland Council staff Scottish Government Developers
Training	Key stakeholders

Identification of these key user groups was crucial in identifying the organisations that were to be invited to participate in the user requirements consultation process. A consultation programme was developed which which identified how the consultation was carried out. This consisted of three main stages:

- Pre workshop questionnaire
- Stakeholder Workshop
- Follow-up

Appendix A1 provides a summary of the stakeholder consultation activities carried out during this phase.

2.2.2 Phase 2 – Data Gathering

Having defined what the Heat Map should include and how it should be analysed it was then possible to move to the next stage which was to gather the necessary data required for the Heat Map.

One of the challenges of this project was the dispersed nature of the relevant data across different organisations and locations. The data was not only dispersed in nature but in many cases was inconsistent or non-existent. In order to develop a methodology that could be used at a national scale it was important that data sources which also existed at this scale were utilised wherever possible.

A list of thirty two potential data sources were identified in the specification as being required for the heat map. These were split into five main categories: Heat Demand, Potential Heat Supply, Constraints/ Opportunities, Skills & Technology and Context. These were identified during the user requirements workshop and agreed as part of the Heat Map specification.

Appendix A2 lists each data set, its source, and how/ whether it has been used. It was important that any issues relating to data collection were understood to ensure that the same information can be gathered in the same format for future revisions of the Heat Map.

2.2.3 Phase 3 – Pilot Area Map Creation

The user requirements analysis and data gathering and review phases provided clear guidance on what the map should include and what existing information sources could be of value to the process. The original methodology was refined to take account of this information. This was then piloted on a small part of the study area. The reason for testing the methodology on a pilot area first was to determine whether it would work and to highlight any issues that may be encountered when preparing the map for the whole of the Highlands.

The pilot area that was chosen for the testing of the methodology was the settlement of Nairn. This was considered to provide a representative and substantial sample of the different property types we would expect to see across the rest of the Highlands.

The main lessons learned from this exercise were:

- Incomplete records within the Assessors data - within the assessors data it was noted that not all records were fully populated. For example, at least one element of information was missing (i.e. age, type or area). An approach was developed to address this issue. This is explained in Section 2.2.4.
- Currency - it was apparent from comparing the assessors data with the Corporate Address Gazetteer (CAG) data that the Assessors data was not as up to date as the CAG. This meant that some of the predictions for the newer CAG records were likely to be based upon less robust measurements as less detail was available about these properties.
- Distilleries - after reviewing the results of the pilot area, we took a decision to treat distilleries in a slightly different way. For the pilot, distilleries were treated as having both a heat demand and a potential heat supply. On review of the pilot it was felt that the heat demand of distilleries would in likelihood not be met from a renewable heat source.

The methodology was refined prior to the preparation of the heat map for the rest of the Highlands. The pilot area was also recalculated using the refined methodology.

2.2.4 Phase 4 - Map Creation

The first crucial step in the creation of a heat map is to establish and agree what a Heat Demand map is, what information it should contain and what its purpose is. This clarification helps to ensure that the map meets the needs of its many potential users. This information was established during the user requirements phase.

In simple terms, it was agreed that a heat map shows the spatial distribution of heat energy demand in a given area. Heat maps are useful for prioritising energy efficiency action, and considering the technical feasibility and financial viability of district heating options.

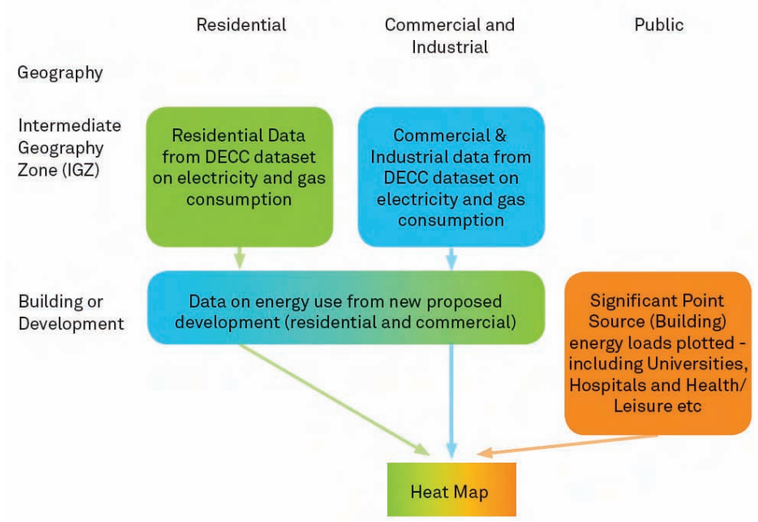
Heat maps generally have two components, existing and future demand for energy and existing and future sources of heat generation. In addition to these two components, the user requirements analysis identified that information relating to renewable heat skills, technology and training would also be valuable. These components were added to the heat map specification.

Current evidence suggests that there is no standardised method for preparing a heat map. This project therefore provided an excellent opportunity to develop a consistent national methodology for Scottish local authorities. It was therefore crucial that we not only understood what information a heat map should contain but also the data that was available at a national level that could assist in the creation of a national methodology.

There are currently two main methods used to create a heat map. These are the Top-Down and Bottom Up approaches. Our understanding of each approach is outlined below.

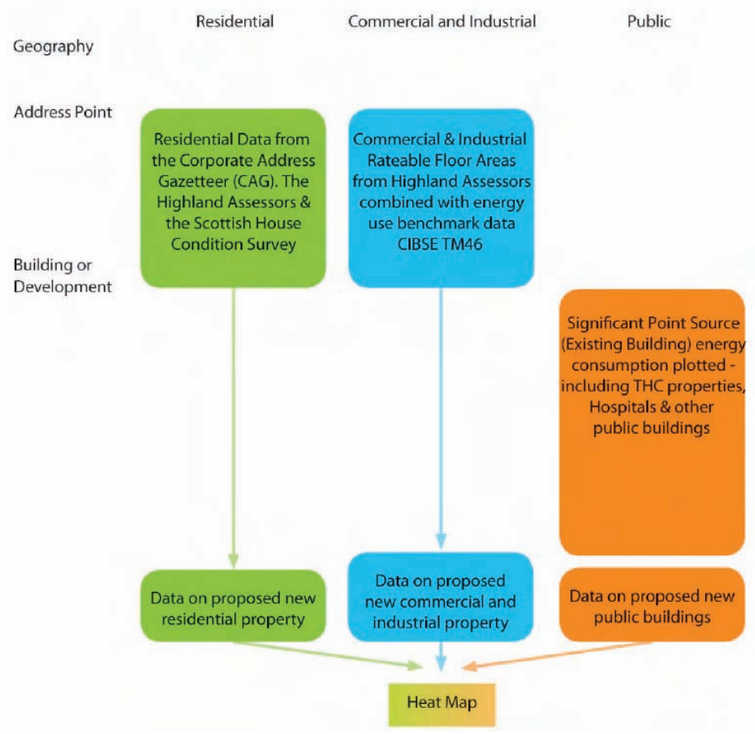
The Top-Down approach tends to be more practical for strategic level studies. This uses Department of Energy and Climate Change (DECC) Middle Super Output Area (MSOA) data, sometimes with additional point source energy demands overlaid. The flow chart in Figure 2.2 illustrates the technique.

Figure 2.2 Top-down approach



The Bottom-Up approach uses building level data (floor area) with energy modelling results or multiplied by standard energy benchmarks and maps these either at output level or as point sources. Figure 2.3 illustrates the data sources utilised for a bottom-up approach.

Figure 2.3 Bottom Up Approach



Our finalised methodology is based upon the bottom-up approach as this is more suitable as it supplies the level of detail required (i.e. significantly better than 1km x 1km scale). We have however refined this method in order to deliver an even greater level of detail to improve the accuracy of the Heat Map.

Figure 2.4 illustrates our refined methodology for the preparation of the Heat Demand map.

Figure 2.4 Heat Demand methodology outline

During the data gathering exercise we were able to identify a number of data sources that would assist in the preparation of the Heat Map. The final list of data that has been used and its purpose is shown in Table 2.2.

Table 2.2 Finalised data list

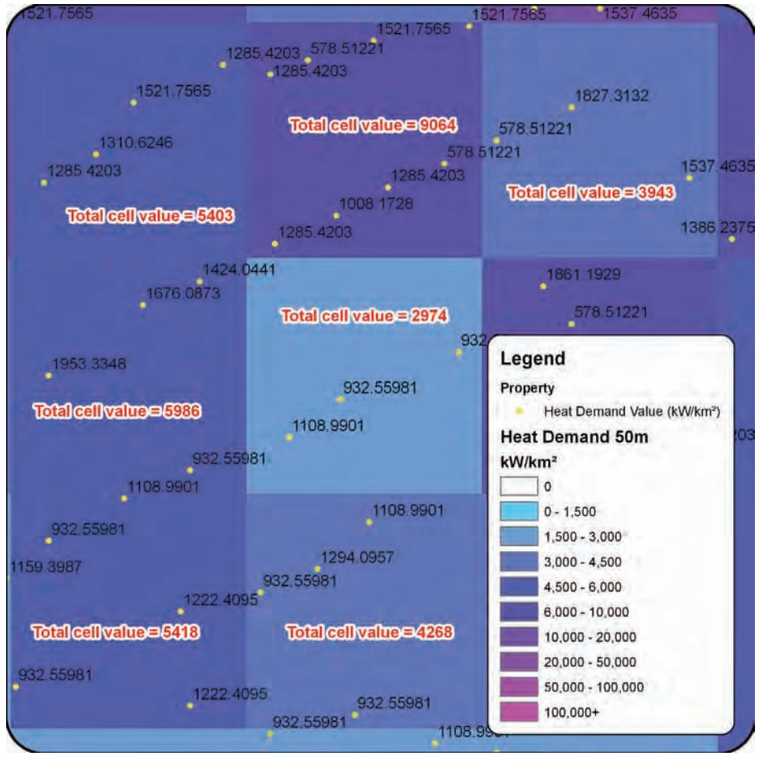
Heat Demand	
Name	Purpose
Assessors valuation data	Attributes relating to type, age and floor area used in heat demand calculations.
Existing public building energy loads	Used to assign heat demand values to public buildings.
Rural fuel poverty indicator	Used to identify locations of fuel poverty within the Highlands.
Commercial/ industrial building locations	Used to identify locations and types of non domestic buildings for heat demand calculations.
Scottish House Condition Survey	Used to calculate heat demand values for different types of property.
Potential Heat Supply	
Waste production and existing landfill sites	Used to identify locations of potential opportunities for energy from waste.
Existing industrial heat production	Used to identify locations of potential heat supply from existing facilities.
Woody biomass production capacity	Used to identify locations for woodfuel suppliers and the type of product they supply.
Gas grid	Used to identify locations that are currently off the gas grid.
Existing DH & CHP systems	Highlights existing renewable heat projects and supply in the area.
Existing fossil fuel suppliers	Used to identify existing locations of fossil fuel supply including coal, oil and LPG.
Skills and Technology	
Renewable technology suppliers/ facilities	Used to identify locations of existing skills/ facilities in the Highland area.
Educational establishments	Used to identify locations of renewable energy related courses within the Highlands.
Opportunities and Constraints	
Local Development Plan expansion sites	Used to highlight potential areas of opportunity relating to the LDP. Contains information relating to the locations of major proposals, future expansion sites and regeneration sites
Highland Forest and Woodland Strategy	Used to highlight policy areas identified in the Forest and Woodland Strategy.
Flood risk	This data provides locations of coastal and fluvial flood risk relating to a 200 year flood event.
National Nature Reserves	Used to highlight locations of nationally important designated sites.
Sites of Special Scientific Interest	Used to highlight locations of nationally important designated sites.

The Heat Map is made up of five different elements, heat demand, potential heat supply, opportunities/ constraints, skills and technology and context. Each layer needs to be prepared before it is collated into the final Heat Map product. The process required to prepare each of these elements is outlined in detail in the following paragraphs.

2.2.4.1 Heat Demand

This is the most complex layer to prepare as the input data has to be manipulated in order to provide a realistic estimate of the heat demand for every building. This layer is developed by allocating heat demand values to all point data sources (buildings) that may have a need for heat. The information assigned to each building is then aggregated to form a continuous surface providing heat demand values at a user specified scale. Figure 2.5 illustrates the concept. Each property (yellow dots) have a heat demand value assigned (black text labels). The sum of the heat demand for each property within each cell is calculated (red text) to give a continuous surface of heat demand values based upon the property level information.

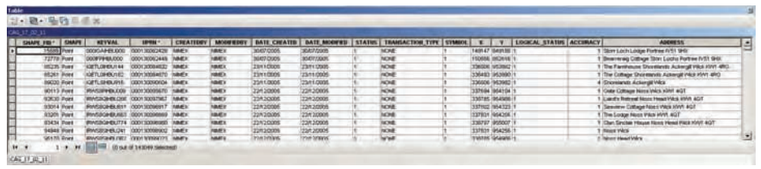
Figure 2.5 Aggregation of point values to heat demand surface



In order to achieve this, it was first necessary to identify a data source which identifies all buildings in The Highlands. It was also important, given the aspiration to use this methodology more widely in Scotland that this data source should also be nationally available. This will also help to ensure the long-term availability of the data that the methodology is based on.

Corporate Address Gazetteer (CAG)
In Scotland, each Council holds and manages a CAG. The Highland CAG is a spatial dataset that provides the location of every address in the Highlands with a range of relevant attribute information. Figure 2.6 illustrates the attributes included within the CAG.

Figure 2.6 CAG attributes



At a national level, the National Address Gazetteer provides a standardised and consistent national address product for the whole of Scotland. This has been created from the CAG of each local authority and is managed and maintained at a national level. It also provides consistent attribution and would be the natural base for any future heat mapping work in Scotland.

The information provided in the CAG is not in itself useful for calculating heat demand, but it does accurately record the spatial location of each address. The key attribution included within the CAG which can be utilised to access information that could be used to model heat demand is the "UPRN" field. The Unique Property Record Number (UPRN) is a unique number given to every building within the CAG. Using this unique record it is possible to link the CAG to other data sources which also use the UPRN.

There are a range of additional data sources that have been used to calculate heat demand for properties in the Highlands. These are:

- Scottish Assessors valuation data
- Highland Council Properties Energy Bills
- NHS Highland Energy Bills
- CIBSE TM46: 2008 - Energy Benchmarks

Scottish Assessors Valuation Data
Information relating to floor area, property age and property type are required in order to model heat demand for each building. There was one data source in the Highlands where this information was known to exist, and more importantly was known to exist for the rest of Scotland. This data is the Scottish Assessors valuation data.

The Scottish Assessors are responsible for the valuation of both domestic and non domestic properties within one or more Council Areas. A valuation of non domestic properties is undertaken every five years and is referred to as the Revaluation. The Assessor must provide a Valuation Roll listing of these properties, which is available for public inspection. There are a total of 14 Assessors which cover all 32 Scottish local authorities. The Highlands are covered by the Highlands and Western Isles Valuation Joint Board.

In addition to information relating to valuation, the Assessors hold a range of information that is of value in the production of a Heat Map. The Highlands and Western Isles Assessor held information relating to property age, property type, house type, internal floor area and a property description. These were all used in the preparation of the Highland Heat Map.

The data held by the Assessors does contain some confidential information, so care needs to be taken to ensure that only useful and non sensitive attribution is used in the Heat Map production. Access to this information can also be difficult, as not all the Assessor organisations are currently able to easily share this information. Gaining access to this information for this project and the need to cleanse it introduced a considerable delay, resulting in the Heat Map being delivered a year later than originally programmed. Because of the significant added value that the Assessors data was able to bring to the project a decision was taken by the steering group to accept a delay in programme to ensure that this data could be utilised.

This perseverance was also important from a strategic perspective. As a pilot study it was felt that it would be worthwhile to work through these issues now, so that a precedent could be set for future access to and use of this data.

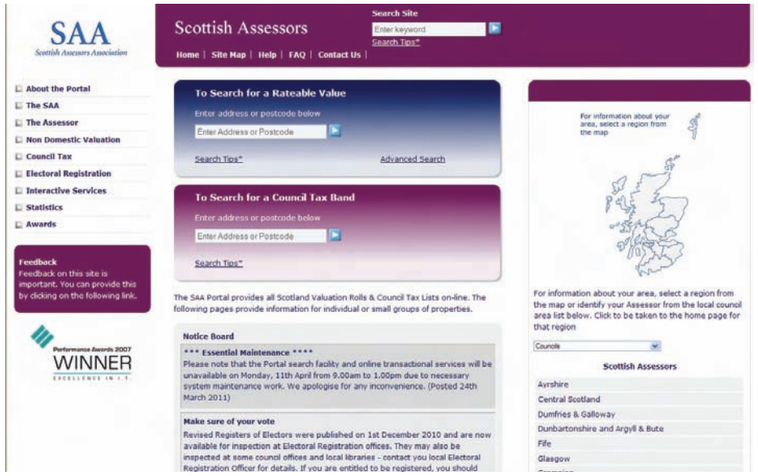


Figure 2.7 Scottish Assessors Portal
Upon receipt of the Assessors data, Highland Council staff carried out a cleaning process on the data. This consisted of ensuring that as many records as possible had UPRNs which could be matched to the CAG. This cleaned data was then provided to AECOM for use in producing the heat demand map.

The cleaning process allowed the Assessors data to be linked to the CAG and calculations made for heat demand for each building. There were however a couple of issues relating to the Assessors data which should be noted:

- The date of information in the Assessors data is not synchronised with the data in the CAG. This means that within the CAG there exists a number of newer properties which have not yet been picked up within the Assessors data. The result of this is that the calculations carried out for these newer properties are not as robust as those for which Assessors data exists. These will of course be picked up over time, but it is likely there will always be some newer properties which are not included in the Assessors data, unless updates for the Assessors are synchronised with those of the CAG.
- The attribution provided within the Assessors data is not complete. This means that for some properties, not all information has been included within each attribute.

Table 2.3 summarises the completeness of the attributes relating to house type, property age and floor area for the Highlands.

Table 2.3 Completeness of assessor attribution

Attribute	Number of records	% complete
ASSR_Housetype	86907	92
ASSR_Built	60317	64
ASSR_Area	88508	94
Total	94449	NA

The section describing the construction of the heat demand layer explains how these issues have been addressed in making the heat demand calculations.

Energy Consumption Billing
Energy bills associated with Highland Council properties were another source of information that was utilised to quantify heat demand relating to individual buildings. Buildings where energy consumption figures were available included swimming pools, police stations, Council offices and schools. This information was supplied by The Highland Council, Housing and Property Services department.

Information was provided for all energy bills for each Highland Council property for a full calendar year. This included consumption of oil, gas

and electricity. Each property would have either one or more accounts associated with it. For each property there is a record for every account and for every bill associated with that account for 12 months. Very few properties have bills relating to all three energy types. In most instances properties would have bills relating to either one or two of the three energy types.

HEAT mapping data.xls [Compatibility Mode]

	A	B	C	D	E
1					
2	**Sites with Oil heating**				
3					
4	Conversion factor= litres of oil into kWh-> Litres*10.3				
5					
6	Site	From Date	Read Date	Meter vol	kWh
7	Abernethy Primary School	01/01/1970	12/01/2009	1443	14,863
8		01/01/1970	09/02/2009	3500	36,050
9		01/01/1970	18/02/2009	1101	11,340

HEAT mapping data.xls [Compatibility Mode]

Gas bills overview

1-Jan-2009 to 31-Dec-2009

Site & Unit	Account	From Date	Read Date	Est	Cons	Units
Auldearn Primary School	011297388	04/12/2008	07/01/2009	E	24675.79	kWh
		08/01/2009	04/02/2009		67971.03	kWh
		05/02/2009	02/03/2009	E	21343.22	kWh
		03/03/2009	02/04/2009		51857.88	kWh
		03/04/2009	03/05/2009		20278.19	kWh
		04/05/2009	01/06/2009	E	15130.52	kWh
		02/06/2009	02/07/2009		15046.87	kWh

HEAT mapping data.xls [Compatibility Mode]

	A	B	C	D	E	F	G	H	I	J
1	Site	Acct#	MPAN	From Date	Read Date	Day (kWh)	Night (kWh)	Day%	Night%	Total (kWh)
2	67 Carsegate Road	ac 591141786	mpan 0351035017000516360007	29/10/2008	27/01/2009	3870	0	100	0	3870
3	67 Carsegate Road	ac 591141786	mpan 0351035017000516360007	28/01/2009	30/04/2009	1171	0	100	0	1171
4	67 Carsegate Road	ac 591141786	mpan 0351035017000516360007	01/05/2009	29/07/2009	1935	0	100	0	1935
5	67 Carsegate Road	ac 591141786	mpan 0351035017000516360007	30/07/2009	28/10/2009	1760	0	100	0	1760
6	Aldourie Schoolhouse	ac 351092227	mpan 0180110017121062955O7	16/12/2008	19/03/2009	275	0	100	0	275
7	Aldourie Schoolhouse	ac 351092227	mpan 0180110017121062955O7	20/03/2009	19/06/2009	275	0	100	0	275
8	Aldourie Schoolhouse	ac 351092227	mpan 0180110017121062955O7	20/06/2009	10/09/2009	330	0	100	0	330
9	Aldourie Schoolhouse	ac 351092227	mpan 0180110017121062955O7	11/09/2009	15/12/2009	462	0	100	0	462
10	Alistair Murray Memorial Hall	ac 481207692	mpan 0380115017127101647O1	10/12/2008	12/03/2009	100	0	100	0	100
11	Alistair Murray Memorial Hall	ac 481207692	mpan 0380115017127101647O1	13/03/2009	15/06/2009	103	0	100	0	103
12	Alistair Murray Memorial Hall	ac 481207692	mpan 0380115017127101647O1	16/06/2009	04/09/2009	94	0	100	0	94
13	Alistair Murray Memorial Hall	ac 481207692	mpan 0380115017127101647O1	05/09/2009	09/12/2009	311	0	100	0	311
14	Altnaharra Primary School	ac 411207648	mpan 0380115017124640555O0	08/11/2008	13/02/2009	1640	0	100	0	1640
15	Altnaharra Primary School	ac 411207648	mpan 0380115017124640555O0	14/02/2009	13/05/2009	850	0	100	0	850

Figure 2.8 Energy Consumption tables for oil, gas and electricity

The format in which the data is supplied, as a series of spreadsheets within a Microsoft Excel workbook means that it is necessary to first manipulate this information before further use.

In order to achieve this it is necessary to manipulate the source data as follows:

- make a copy of the source data
- remove any records in the worksheet prior to the record containing the field names
- ensure all site name records are populated (this is essential as this is the field that is used to join the information from each of the worksheets together)
- rename the fields to ensure there are no spaces/ invalid characters and the names are relevant
- rename the worksheets to ensure there are no spaces/ invalid characters in the name

Figure 2.9 illustrates the format of the data before and after manipulation.

HEAT mapping data.xls [Compatibility Mode]

	A	B	C	D	E
1					
2	**Sites with Oil heating**				
3					
4	Conversion factor= litres of oil into kWh-> Litres*10.3				
5					
6	Site	From Date	Read Date	Meter vol	kWh
7	Abernethy Primary School	01/01/1970	12/01/2009	1443	14,863
8		01/01/1970	09/02/2009	3500	36,050
9		01/01/1970	18/02/2009	1101	11,340

HC_Energy_Data_ALL_Edit.xls [Compatibility Mode]

	A	B	C	D	E
1	Site	FromDate	ReadDate	Meter_vol	kWh
2	Abernethy Primary School	01/01/1970	12/01/2009	1443	14,863
3	Abernethy Primary School	01/01/1970	09/02/2009	3500	36,050
4	Abernethy Primary School	01/01/1970	18/02/2009	1101	11,340
5	Abernethy Primary School	01/01/1970	01/07/2009	1000	10,300
6	Abernethy Primary School	01/01/1970	08/09/2009	900	9,270
7	Abernethy Primary School	01/01/1970	22/09/2009	621	6,396
8	Abernethy Primary School	01/01/1970	19/10/2009	500	5,150

Figure 2.9 Oil consumption table - Before and after editing

Once the data has been cleaned, each worksheet is joined to the Site_ details worksheet using GIS. The resulting joined table can then be summarised to provide a total for consumption of each energy type. This information was then joined using the HC_Code (a unique Highland Council (HC) property code) to a dataset containing all Highland Council buildings. This data includes the UPRN for each HC building and is the key element to allow this data to be linked to the CAG.

NHS Highland Billing

Hospitals are acknowledged as being properties that have a high heat demand associated with them. Billing information was supplied by NHS Highland for all hospitals in the Highlands for a full calendar year relating to the consumption of oil, gas and electricity.

This information is treated in a similar fashion to the Highland Council property billing with the source data requiring some manipulation prior to use in the Heat Map. The steps for modifying this data are:

- make a copy of the original worksheet
- remove any records in the worksheet prior to the record containing the field names
- add additional fields for oil, gas and electricity
- populate each of these fields with the relevant information ensuring that each hospital has only one record in the edited worksheet.

CIBSE TM46: 2008 - Energy Benchmarks

Energy benchmarks have been developed for the purpose of predicting energy usage for a range of public buildings. The benchmarks provide energy values for 29 different types of public building broken down into typical electricity and fossil-thermal use.

These benchmarks have been used to predict the energy demand for public and commercial buildings where there is no existing billing information available.

Distilleries

Within the Highlands, distilleries are properties which have a significant heat demand and potential heat supply. In order to estimate the heat demand associated with each distillery, public domain information about production levels (megalitres per year) was sourced, mainly from scotchwhisky.net.

Construction of Heat Demand layer

The previous sections have explained the data sources that are required to calculate heat demand across the Highlands. This section explains how these data sources are utilised and the energy demand calculations made.

Figure 2.10 outlines the heat demand calculation process from the inputs required to the outputs that are generated.

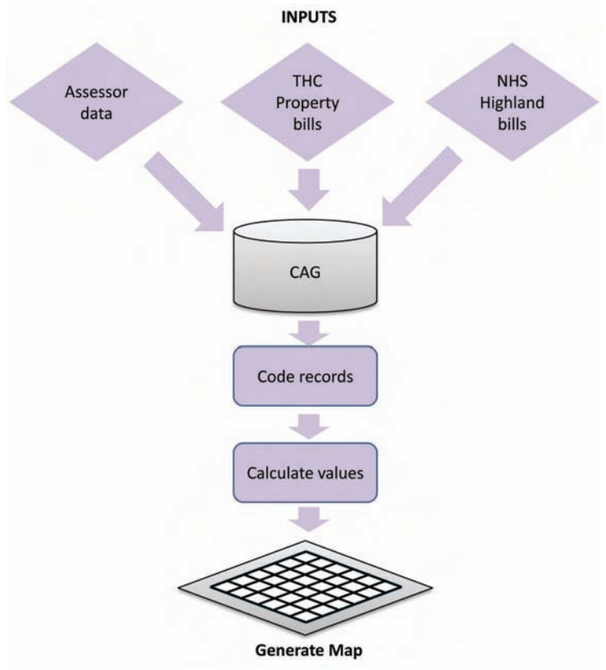


Figure 2.10 Heat Demand calculations process diagram
The following processes have been carried out to calculate demand for different properties depending on the information that is available. Issues relating to each data source have already been discussed in the previous section.

Step 1 – Add additional fields to the CAG
Step 2 – Identify and code different scenarios (i.e. different attribution available)
Step 3 – Make calculations

Step 1- Add additional fields
Additional fields that are added to the CAG are displayed in Table 2.4.

Table 2.4 Additional fields added to the CAG

Name	Type	Purpose
Code	Integer	Identify the calculation method used.
Heat_Demand	Float	Heat demand value in kWh.
BM	Integer	The number of Benchmark (BM) to be used in calculating heat demand for commercial/ industrial buildings.
MM_Calc_Area	Float	MasterMap footprint area. Only used when no other floor area information is available.
EV_KmKWH	Float	Heat demand value in kW/km².
TOID	Text	MasterMap toid for building footprint that the CAG record intersects.
Confidence	Integer	Used to record the Confidence level value.

Step 2 - Identify and Code different attribution scenarios
The data that has been sourced is not always consistent in the attributes that are included. It has already been noted for example that in the Assessors data not all attributes are populated for every record. It has therefore been necessary to take a range of different approaches when calculating the heat demand value for each record. In order to audit how each record has been calculated, a code has been entered in the “Code” field which explains which method has been used for the calculation. Table 2.5 lists each code and the calculation process that has been used.

Table 2.5 Heat demand calculation codes

Code	Process
0	No heat demand anticipated. These records have been removed from the heat demand calculations. This includes non property related records (e.g. plots of land, trig points etc.)
1	Calculation is based upon actual energy consumption data as supplied by THC and NHS Highland.
2	Calculation for residential properties is based upon records with populated attributes for age, house type and floor area.
3	Calculation for industrial/ commercial properties is based upon records with populated attributes for property description and floor area. A benchmark is generated from the property description field, which is then used with the floor area to calculate a heat demand value.
4	Calculation for industrial/ commercial properties is based upon records with populated attributes for property description only. A benchmark is generated from the property description field. This is then used with the MasterMap building footprint area to calculate a heat demand value.
5	Calculation for residential properties is based upon records with populated attributes for house type and area, but no age. A weighted average based upon fully populated records is used in place of age.
6	Calculation for residential properties is based upon records with populated attributes for house type and age, but no area. A weighted average based upon fully populated records is used in place of area.
7	Calculation for residential properties is based upon records with populated attributes for age and area, but no house type. A weighted average based upon fully populated records is used in place of house type.
8	Calculation for residential properties is based upon records with populated attributes for house type only. Weighted averages based upon fully populated records are used for each house type.
9	Calculation for residential properties is based upon records classified as domestic in “Category” field. No other information is available. A weighted average is used to assign heat demand values to these records.
10	Calculation for public buildings based upon the Property Function as defined by THC buildings dataset. Each property type is assigned a benchmark and the heat demand value is calculated using the MasterMap building footprint area for each record.
11	Calculation for residential properties where no other attribution is known. A weighted average is used to assign a heat demand value to these records.
12	Calculation for residential properties is based upon records that are identified as flats/ rooms. A weighted average for flats has been used to assign a heat demand value to these records.
13	Calculation for industrial/ commercial properties that have been identified through various address queries. Each record is assigned a benchmark and a heat demand value is calculated using the MasterMap building footprint area.
14	Calculation for residential properties is based upon records identified as new houses. A weighted average has been applied for new properties.
15	These records have been identified as having an inquantifiable heat demand (e.g. caravan park)
16	These records have been identified as having a possible heat supply and/ or heat demand (e.g. waste water treatment works).
17	These records have been identified as distilleries. Heat demand calculations have been based upon production levels.
19	These industrial/ commercial properties records have been assigned a benchmark but a heat demand calculation is impossible as no area figure exists (e.g. no area figure in assessors data and the record does not intersect a MasterMap building footprint).

Step 3 - Make Heat Demand Calculations
Once each record is coded it is a relatively straightforward task to assign the relevant heat values to each record.

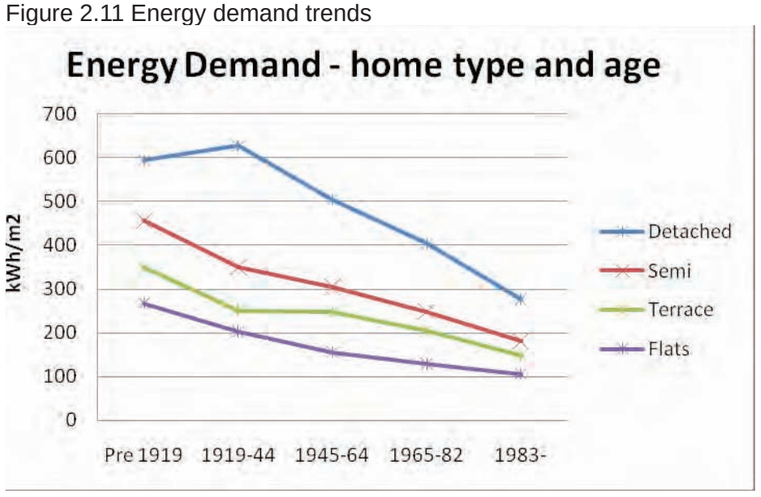
There are two main approaches that have been taken to assign heat demand values. These are:
Domestic properties
Non-domestic properties

Domestic Properties
Heat demand values for domestic properties have been extracted from the Scottish House Condition Survey (SHCS) 2009. This provides heating values for five different time periods and four different residential property types. The data survey includes properties in the Highlands, but the sample size is too small to allow us to base our calculations on these alone. We have used the data for the whole of Scotland to identify a heat demand value for each of the 20 different categories (i.e. age and type). Table 2.6 lists the values that we have used in our calculations and Figure 2.11 illustrates the downward trend in energy demand over the last 100 years.

Table 2.6 Energy intensity values (kWh/m²/yr for space & water heating) for the 20 different dwelling categories.

	Pre 1919	1919-44	1945-64	1965-82	1983-2010
Detached	594	627	505	404	276
Semi	456	350	305	249	181
Terrace	349	251	249	204	149
Flats	268	203	156	129	106

Figure 2.11 Energy demand trends



The Heat Map can also be used to predict the impact of development on future heat demand in an area. We have taken the basic philosophy that users can input their own values based on the timing and design of the development. Otherwise default values can be calculated for residential development using the following figures:

2011 – 2016: 65 kWh/m² per annum
2017 onwards:
Flats and Terraces – 39 kWh/m² per annum
Detached & Semi-detached – 46 kWh/ m² per annum

Calculations have been based upon the Zero Carbon Hub Task Group recommendations – to be fully implemented by 2017 (year when the Sullivan Report recommends “net zero carbon buildings” hit the ground in Scotland).

We have compared these with Passivhaus and AECB (Association for Environment Conscious Building) gold standard of 15 kWh/m², and AECB silver standard of 40 kWh/m². These figures do not include water heating. We have added 25 kWh/m2² for hot water (based on 100 litres per day for 100m² house). Using this calculation the gold standard is equivalent to the zero carbon standard.

For the period 2011 - 2016 we have based the values on the AECB silver standard, which amounts to around 65 kWh/m² per annum (space and water heating) for all dwellings. From 2017onwards we have used the gold standard (“net zero carbon buildings”) values listed above.

Non-domestic properties
Heat demand values for these properties have been calculated using the CIBSE TM46: 2008 energy benchmarks. Each property has been assigned to the relevant benchmark and calculated using floor areas derived from either the Assessors valuation data or Ordnance Survey MasterMap building footprints.

The approach for calculating values for new non-domestic properties is the application of a fixed percentage reduction of the CIBSE benchmark figures. This is the approach that has also been suggested by the AECB. The reductions that have been applied are:

- Silver standard - 70% reduction. 2011 - 2016.
- Gold standard - 95% reduction. 2017 onwards.

The AECB energy performance standards of silver, passivhaus and gold have been developed as clear and achievable targets designed to help guide all those involved in the delivery and use of energy efficient, low-carbon new-build properties.

Confidence Levels
An additional layer has been developed which can be used in conjunction with the heat demand layer to determine the confidence levels associated with every cell on the heat demand layer. The confidence levels have been calculated by assigning a confidence score to each property based upon the method that was used to calculate. For example, a property where the heat demand value was taken from actual energy consumption data would be assigned a score of 4 to signify a high level of confidence. In contrast, a property where little information was known other than type, a score of 1 would be assigned to signify low confidence. Table 2.7 lists the 4 confidence levels and the calculation methods that they include.

Table 2.7 Confidence level definitions

Confidence Level	Calculations codes included (refer to table 2.7 for codes) in confidence level
1	1
2	2, 3, 17
3	5, 6, 7, 8, 12, 14
4	4, 9, 10, 11, 13
NULL	No value calculated

2.2.4.2 Potential Heat Supply
Understanding heat demand is just one part of a Heat Map. The locations of potential heat supply sources are equally important if the Heat Map is to provide guidance on matching demand with supply. There were a number of sources identified within the specification and these have been sourced wherever possible. This includes where there are opportunities for low carbon heat including mains gas-fired CHP (as used for district heating in Aberdeen, alongside some biomass DH); and some types of waste to energy scheme (which would not be renewable if, for instance, burning plastics).

Details of the information included in the Heat Map relating to potential heat supply has been included in Table 2.4.

2.2.4.3 Skills and Technology
Another important element to consider when assessing the potential for renewable heat within an area is whether there are existing skills and knowledge within the area which could be utilised in any new initiative. This includes skills relating to both low carbon and renewable heat. A lack of local skills or suppliers could be a significant handicap for the implementation of renewable heat technology in a particular location.

Table 2.4 provides a list of the information gathered relating to existing skills and knowledge within the Highlands.

2.2.4.4 Opportunities/ Constraints
It is important to understand and recognise the full range of potential opportunities and constraints that might impact upon the potential for renewable heat in an area. It is therefore sensible that these opportunities and constraints should also form part of the Heat Map.

The user requirements workshop explored these issues with stakeholders and identified a range of opportunities and constraints as well as potential data sources where this information might be accessed. An agreed list of opportunities and constraints was included in the specification for further investigation.

Table 2.3 lists the layers that were identified as part of this process, the data source (if applicable) or the reasons for non-inclusion.

Phase 4 - Tool Development, Testing and Implementation
The initial user requirements workshop explored with stakeholders the type of functionality that they would like to see complement the Heat Map through the use of GIS models. The purpose of the added functionality was to extend the use and value of the Heat Map beyond a simple static map output.

A range of functionality was identified and included in the map specification. Table 2.8 lists the functionality that was identified during the stakeholder workshop for further investigation with a brief description.

Table 2.8 User specified functionality

Functionality	Description
ArcGIS Map document	The Heat Map is to be accessible through an ArcMap mxd.
Layered pdf option	The map should also be available as a layered pdf.
Data grouping	Different data layers should be grouped according to themes of information
Geographic bookmarks	The user should have the ability to quickly navigate from one geographical location to another on the map.
Legend Symbology	Appropriate symbology should be supplied to ensure good legibility of the map layers.
Layout Template	A standardised print template should be provided for preparation of printed outputs.
Data Update protocols	Protocols for updating data sources should be supplied.
Data Update for Heat Demand Maps	A model should be created to assist the update of values for the heat demand layer.
Scenario Development	A model should be created to help users to understand the impact of new development on heat demand.
Proximity – Development Proposals	A model should be created to provide users with a summary of heat demand and potential supply within a specified distance.
Search – Areas of High/ Low Heat Demand	A model should be created to illustrate the locations of significant clusters of heat demand.
Search – Skills/ Suppliers/ Knowledge	A model should be created to provide users with a summary of skills, suppliers and knowledge within a specified distance.
Postcode reporting	A model to provide a summary of heat demand & potential heat supply within a distance of a postcode.
Appropriate Energy	A model should be created to identify most suitable technology.
Locational Adjustment	Functionality should be provided to make an adjustment based upon location.

The tools were developed using ArcGIS Modelbuilder to provide trained Highland Council staff with a simple method for carrying out specific types of analysis which would be required on a regular basis in a consistent fashion.

These tools were tested by Highland Council staff, including both technical staff and end users of the analysis. The purpose of the testing was to identify any issues relating to the operation of the tools and also to understand whether the tools were meeting the needs of the end users. Feedback from the testing was provided to AECOM and the tools were subsequently refined.

Some of the key issues identified during testing have been listed below:

- It was identified that users would need the ability to input development scenarios at a more detailed level than the planning application boundary (e.g. at the individual housing unit level). This was agreed and the tool is being refined to allow this.
- Concerns were raised that because the tools need access to the underlying point data, there could be a data sensitivity issue. All sensitive information has already been removed from the point data by this stage, so this should not present a problem in the future.
- Some of the information relating to potential heat supply is currently quite limited in nature. The point was made that it would be good to improve this over time as better quality information becomes available. With more extensive information about potential heat supply sources available, users will be able to interrogate the map in more detail.
- The need for comprehensive documentation to support the use of the tools was identified as essential to ensure that staff could use the tool in confidence that they were using them correctly and to their full potential.

2.2.5 Phase 5 – Training

At the outset of this project it was identified that there would be a requirement to provide potential heat map users with information about the contents of the map, its strengths and limitations and how it could be used.

It was agreed with the steering group that the best way to achieve this would be through a training seminar which would be offered to a range of end users from a range of key stakeholders. The seminar was held on the 24th March 2011 at the Highland Council HQ in Inverness. A total of 20 people attended this event representing 7 different organisations with an interest in renewable heat in the Highlands and more strategically.

The seminar followed the following format:

- Introduction – background to the project and the need for a Heat Map from both a National and Highland Council perspective
- What is the Highland Heat Map? – a first look at the Highland Heat Map and what it includes
- Heat Map Methodology – an explanation of how the Heat Map has been constructed and its strengths and limitations
- Potential applications of the Heat Map – an exploration of how the Heat Map can be used.
- Discussion forum - this provided an opportunity for attendees to participate in an open discussion relating to all aspects of the Heat Map.

The feedback gained from the event included the following comments and discussion points amongst others:

- The Heat Map itself is scaleable but what is the best scale to illustrate hard copies of the Heat Map (e.g. national, strategic, local etc.)
- It would be useful to provide additional information relating to non MCS installers, plumbers, heating engineers to help target and respond to training needs
- Is there potential to link the Heat Map to e-planning when considering new development applications?
- The addition of energy advice providers would be useful.
- Consider removing some of the constraints layers to improve legibility.
- Forestry layers could be improved to highlight areas significantly protected, productive, and replanting –with predicted harvesting year.
- Heat mapping for new development – well understood. But retrofit to demand side might also meet public sector duty in climate change legislation: but less relevant to planning (e.g. fuel poverty response).

The feedback gained from the training seminar provides a valuable initial list of potential issues/ areas of discussion for future development of the Heat Map. It is however expected that this initial list will be expanded upon as the Heat Map comes into more general use by both Highland Council staff and other organisations.

It is important that any feedback gained is recorded and addressed in order to allow the Heat Map to evolve in a way which increases its value to all users. We recommend that THC manage and share all feedback received with Scottish Government. SG can then use this information to refine future Heat Maps for other locations.

Appendix A3 contains a template for the production of a Heat Map for use by other local authorities.

Appendix A4 will be prepared by THC and will contain guidelines for use of the Heat Map once it has been fully tested on real world applications by Council staff.

3.0 The Heat Map

The Heat Map is the sum of all the outputs described in Section 2.0 (Table 2.2) and not just heat demand. It is made up of 23 different layers, relating to heat demand, potential heat supply, constraints/ opportunities and skills/ technology. These are accessible within a GIS for display, interrogation and more complex spatial analysis (Section 4 will explain the types of spatial analysis in more detail).

This section contains a series of map outputs showing the range of information available within the Heat Map at different scales of operation.

3.1 Heat Demand

Figure 3.2 illustrates the existing modelled heat demand across the whole of the Highlands. At this scale the heat demand values have been aggregated to a 1km resolution. This provides a quick visual impression of the key hot spots of heat demand across the Highlands.

The map has been designed so that it can be used at a range of scales including national, regional and local. The use of point data in the methodology to assign heat demand values ensures that the heat demand values can be aggregated up to any resolution required by the user. This provides the user with considerable flexibility.

A series of different resolution heat demand layers have been included in the Heat Map to ensure that users can view the information at the appropriate level of detail in relation to the map scale. The heat demand layer has been supplied at 1km, 500m, 250m and 50m resolution. Figure 3.1 illustrates the differences in these layers at different resolutions.

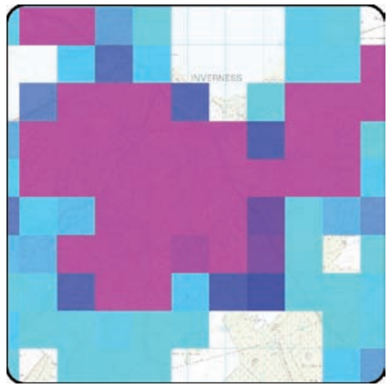
Figures 3.3 - 3.6 illustrate a series of large scale map outputs for the Heat Demand layer for different locations within the Highlands. At these larger scales the level of detail available to the users is increased with not only a finer resolution of output available but a point data source indicating locations of major energy loads across the map.

Figure 3.7 illustrates the confidence levels associated with the heat demand calculations for the Inverness area. This information is available for all locations in the Highlands and should be used by users to understand the robustness of the calculation method used. The assignment of confidence levels is discussed in more detail in Section 2.2.4.1.

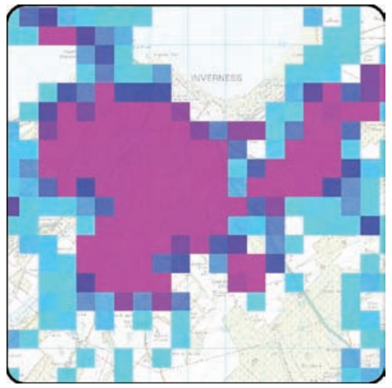
Figure 3.8 displays information from the remaining heat demand layer. This illustrates the percentage of households that are currently experiencing fuel poverty. This information is available at a datazone level and also includes information relating to the number of Council homes and Housing Association properties within each datazone as additional attributes which can be interrogated. A datazone is a spatial geography which on average covers an area containing approximately 750 households.

Figure 3.1 Heat Demand resolution (Inverness)

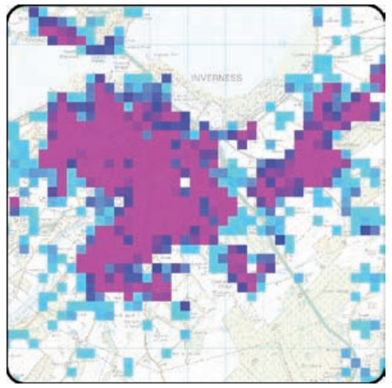
1km resolution



500m resolution



250m resolution



50m resolution

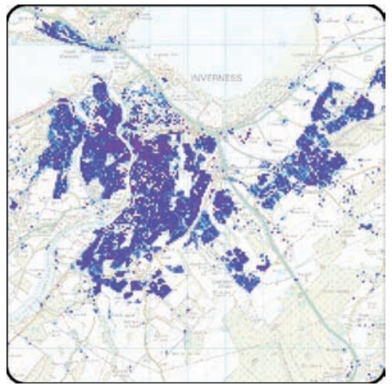


Figure 3.2 Highland wide Heat Demand

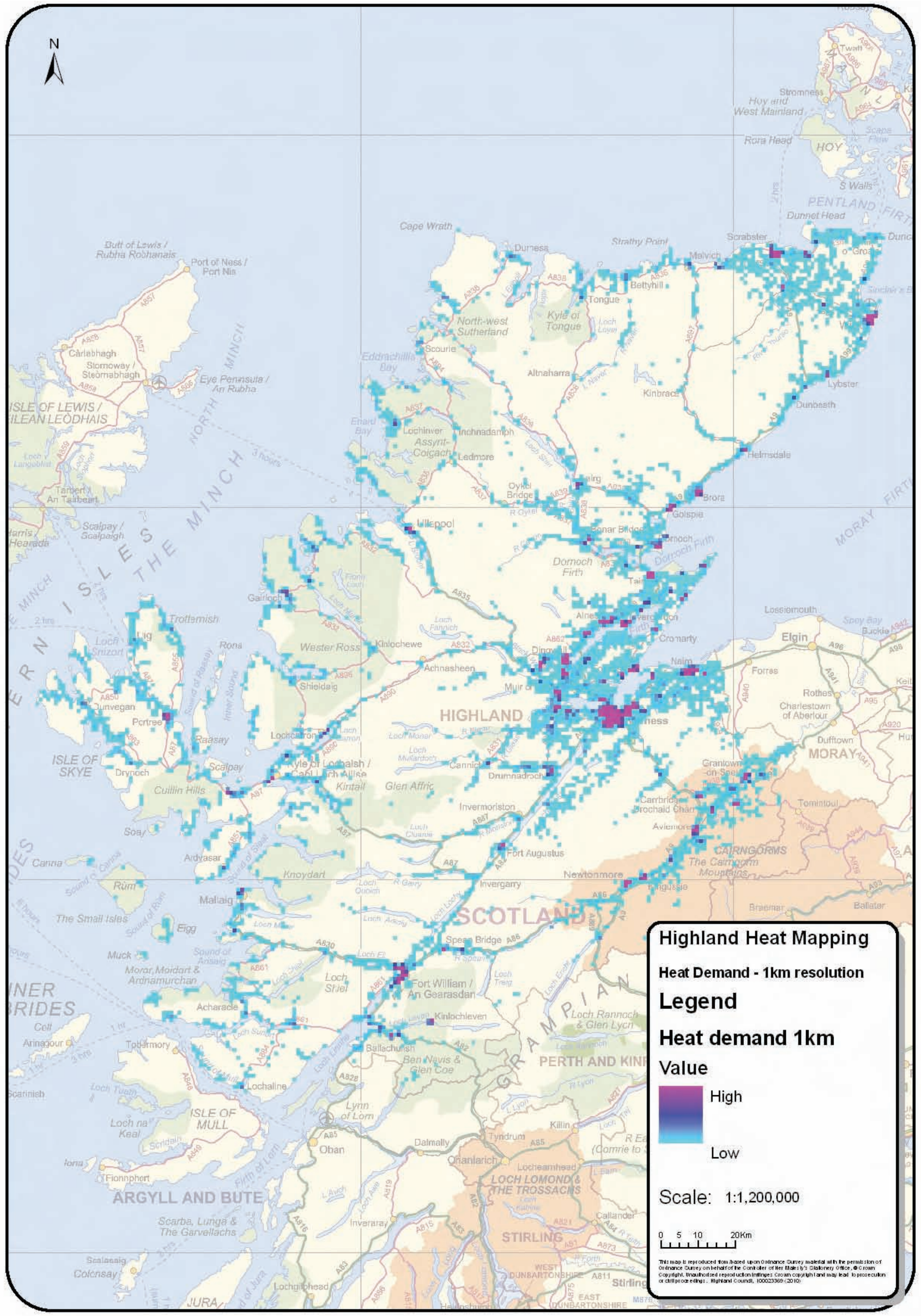
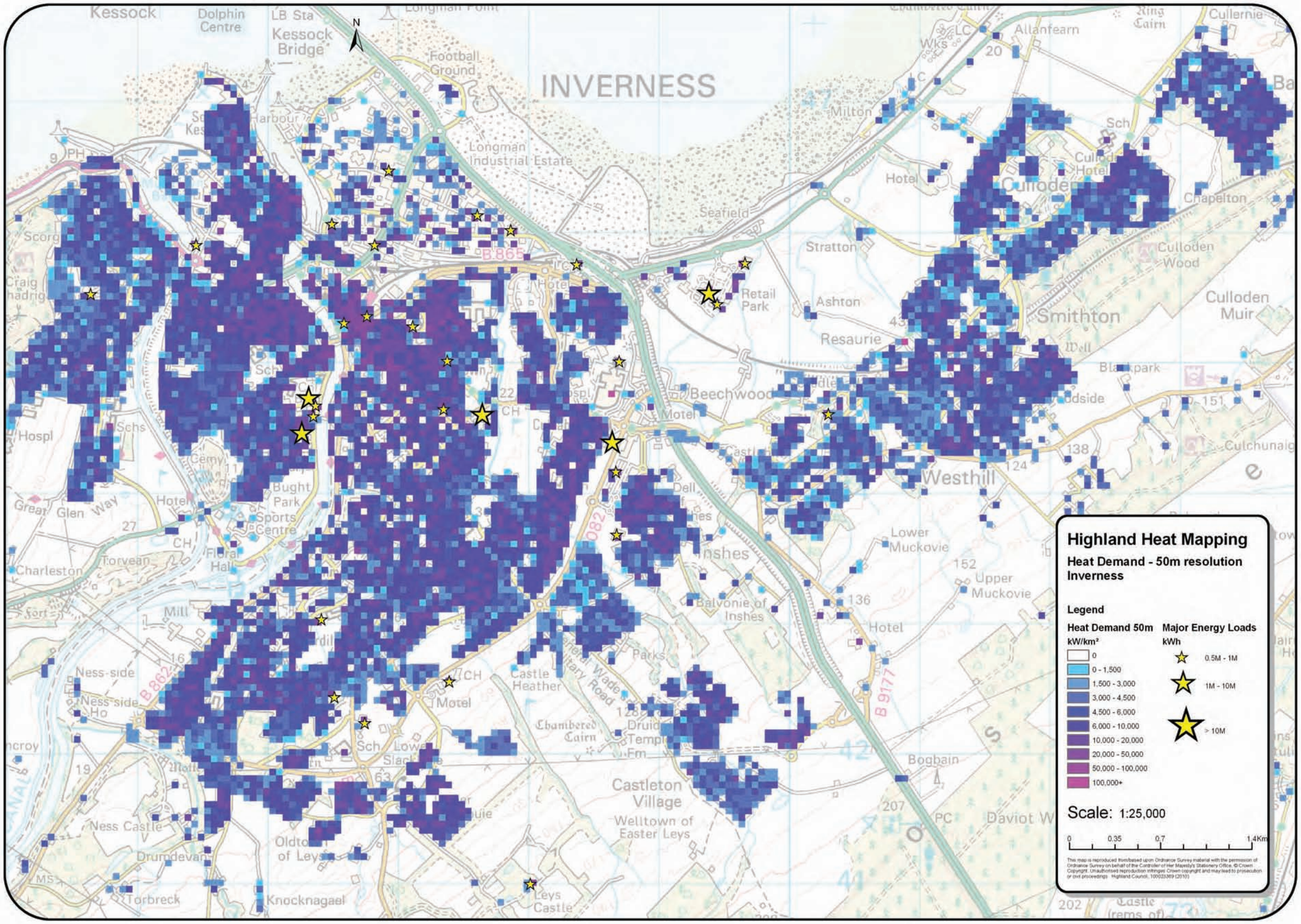


Figure 3.3 Heat Demand - Inverness



Heat Mapping - The Highland Council

Figure 3.4 Heat Demand - Fort William

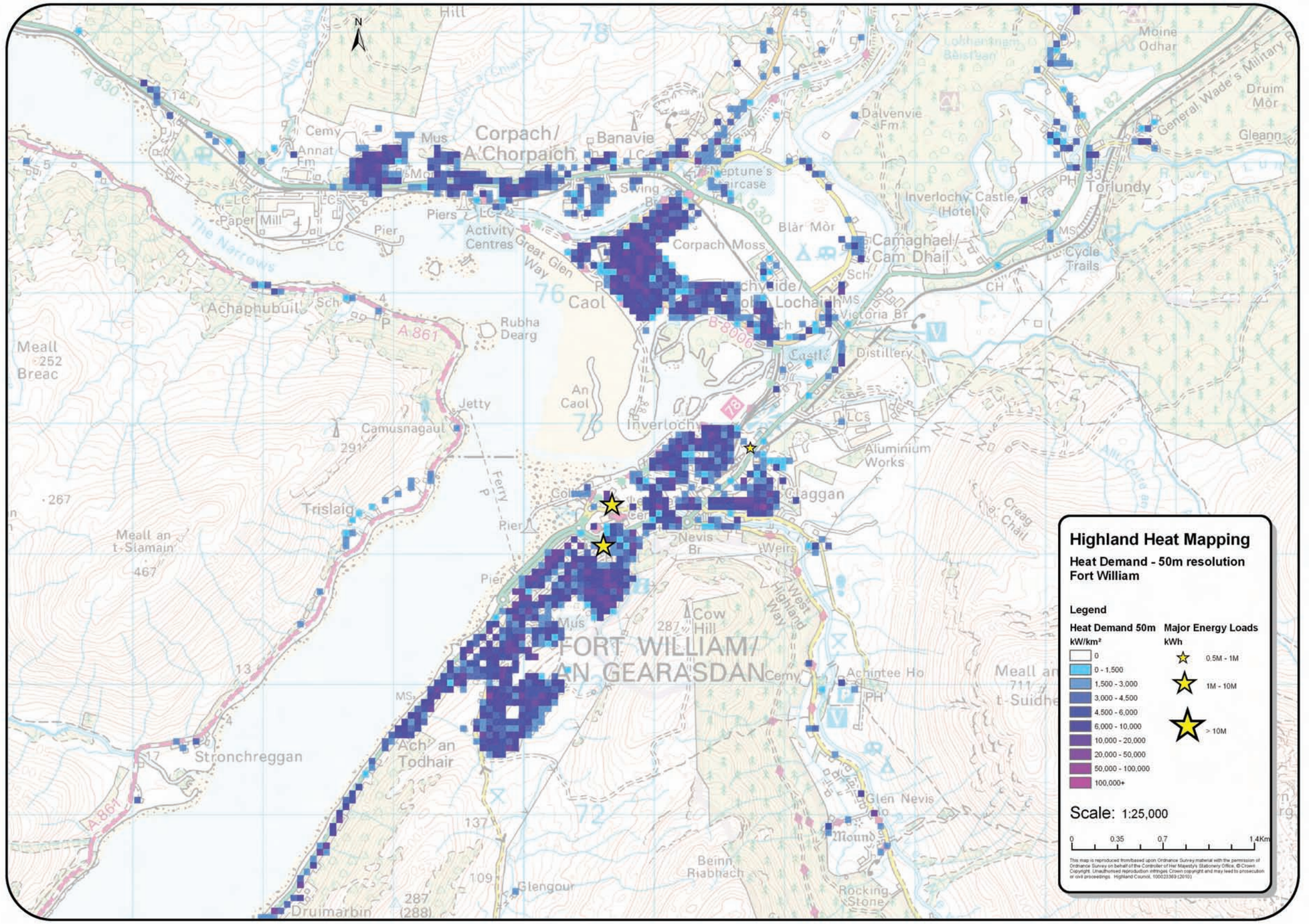


Figure 3.5 Heat Demand - Portree

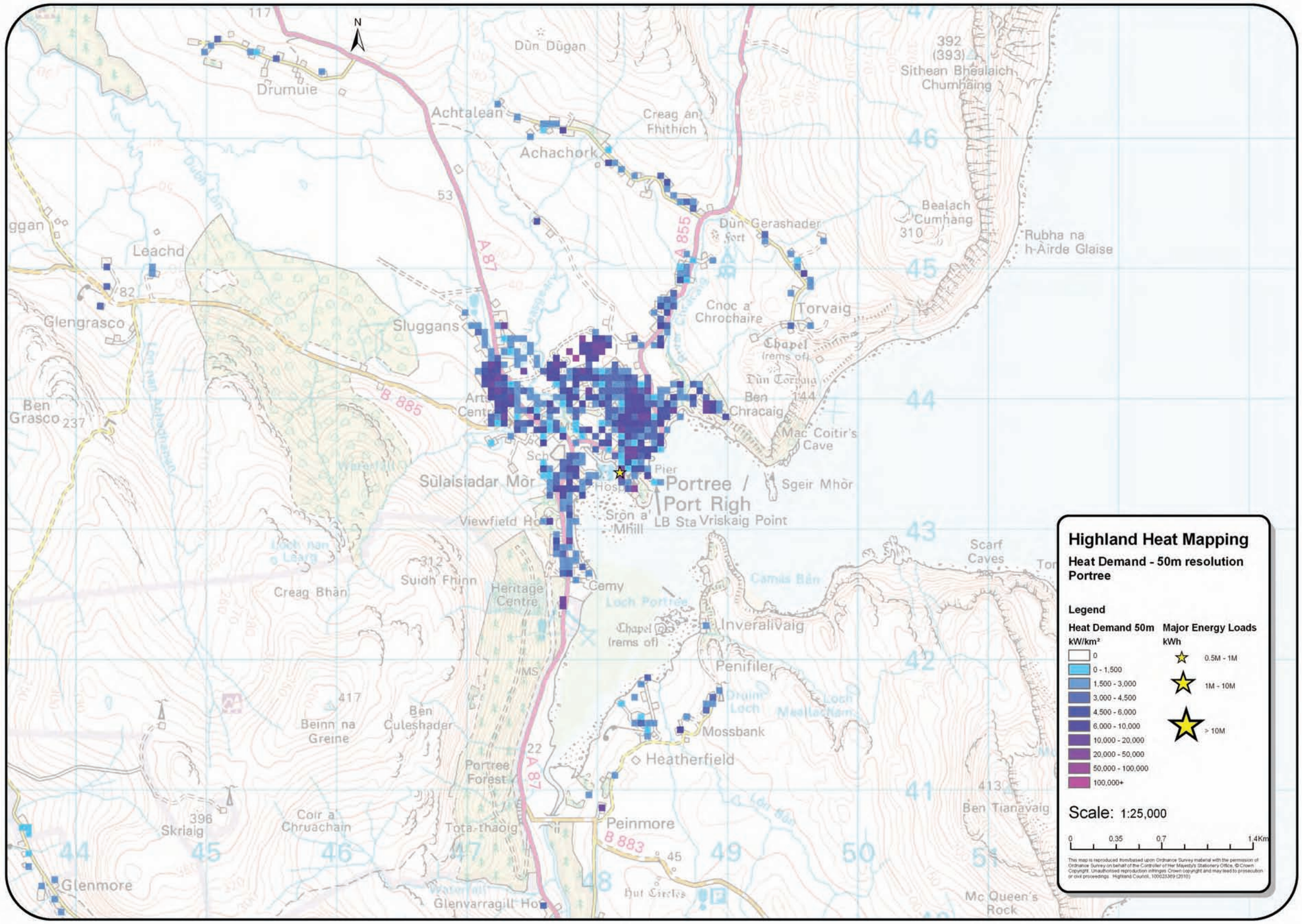


Figure 3.6 Heat Demand - Aviemore

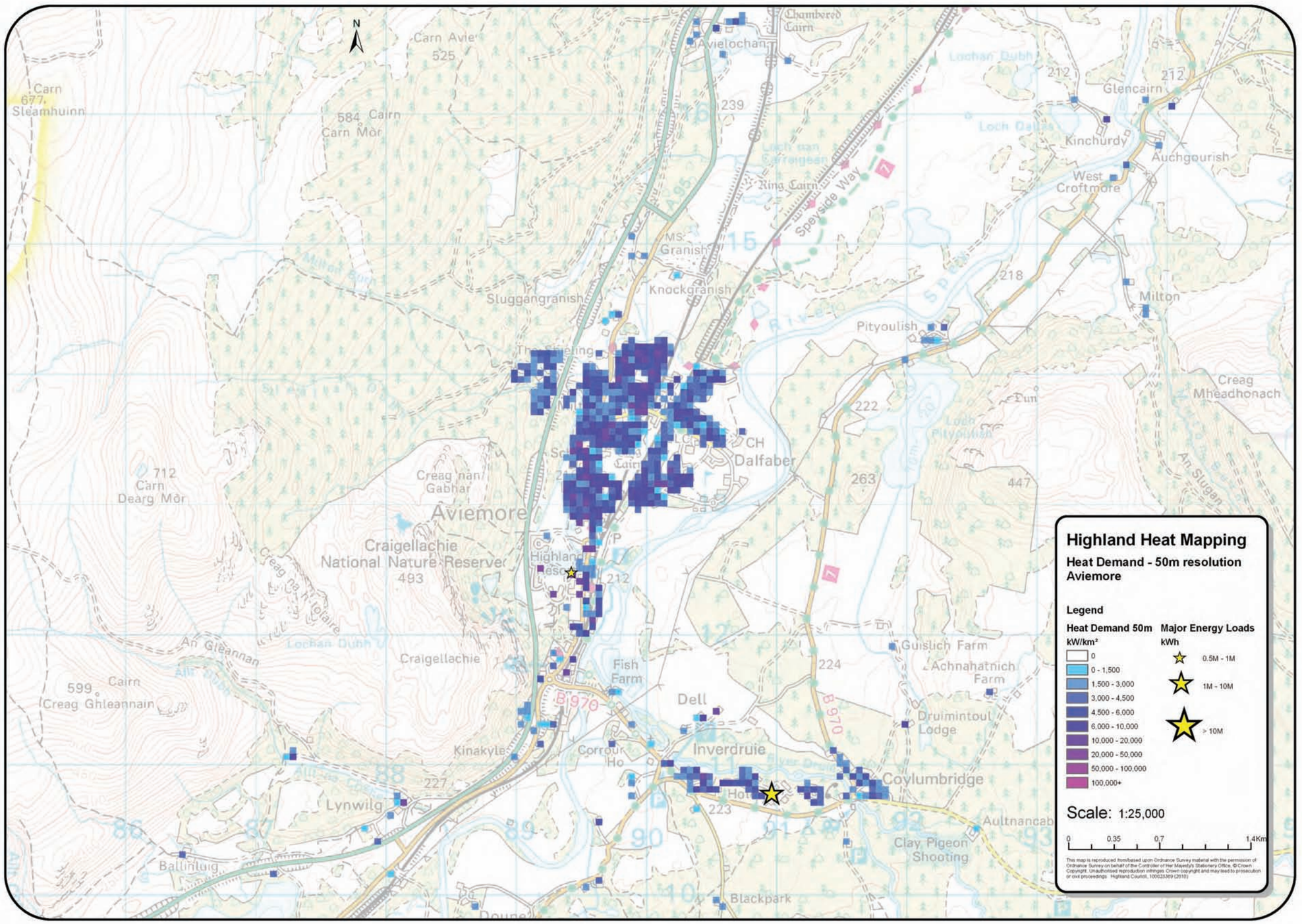
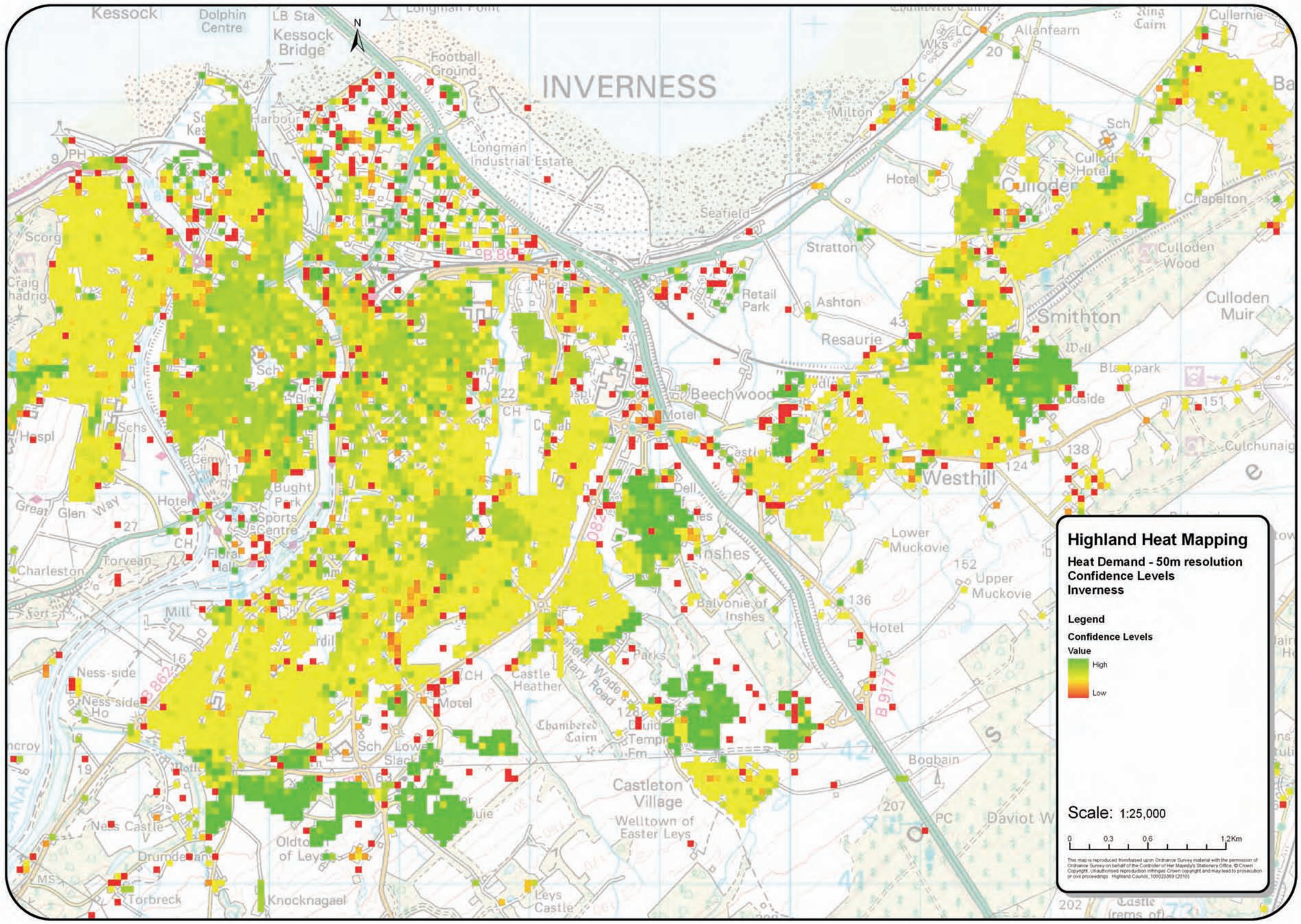
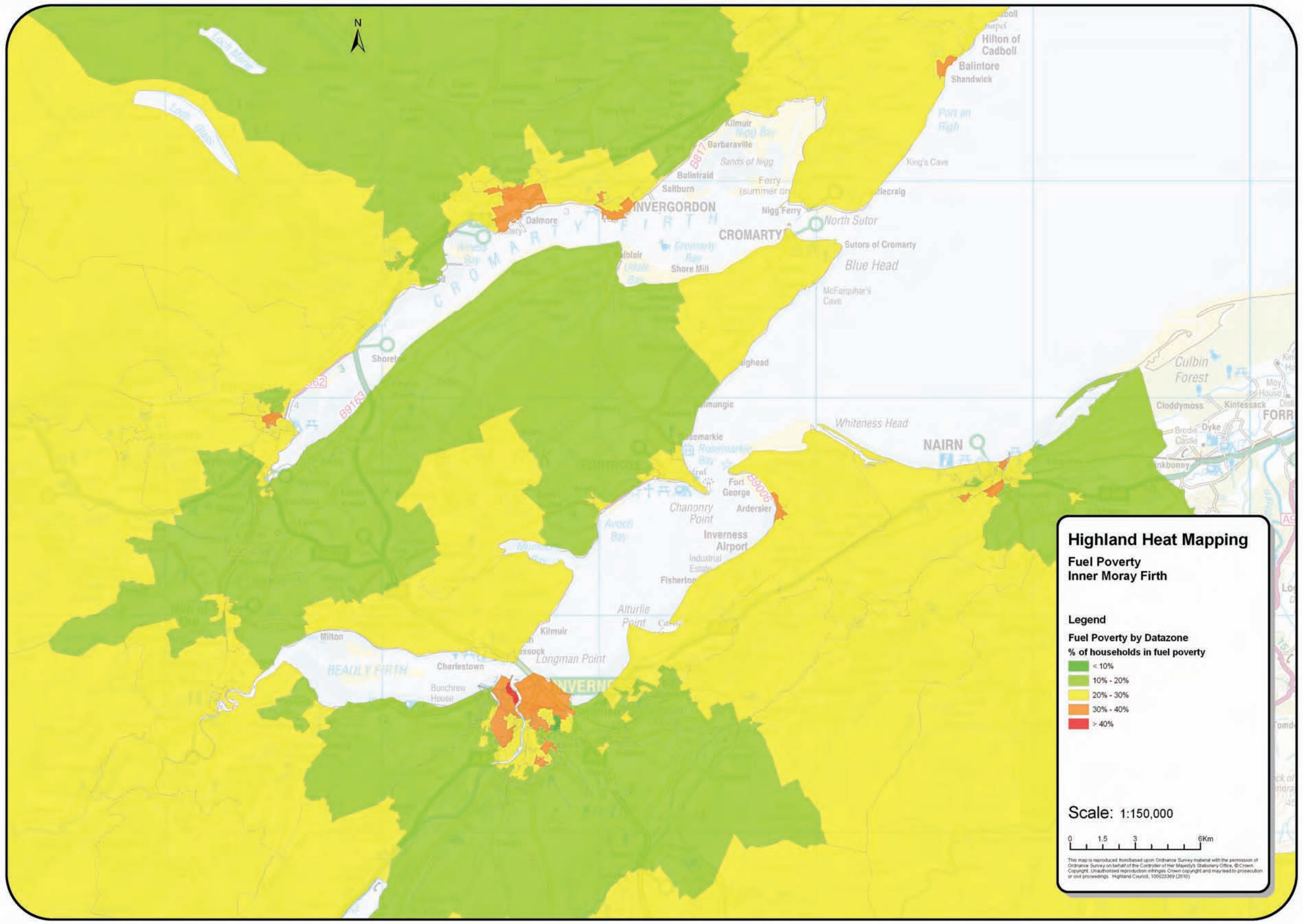


Figure 3.7 Heat Demand Confidence - Inverness



Heat Mapping - The Highland Council

Figure 3.8 Fuel Poverty - Inner Moray Firth



3.2 Potential Heat Supply

Figure 3.9 illustrates the layers of information that have been identified relating to potential heat supply. These are a combination of point, line and polygon data sources which have been included because of their potential as a source of heat. All information relating to the locations of potential heat supply can be displayed at any user specified scale. Figure 3.9 illustrates this information at a Highland wide scale.

Distilleries have been included as potential heat sources as these can present an opportunity to access any surplus heat production. This type of heat source could be of interest when planning locations of potential district heating networks.

Locations of **existing fossil fuel suppliers** have been identified to provide an indication of where existing heat supply is sourced from. The type of fossil fuel supplied is provided as additional information within this layer.

Locations of **existing woodfuel suppliers** have been identified. Additional information relating to the products available from each location is also provided.

The location of **high pressure gas pipelines** are included in this theme. Whilst this does not identify which households are served, it does provide an indication of the general areas of gas supply.

Locations of **existing industrial heat production** have been identified. These could theoretically offer potential for wider heat supply. The Norbord plant in Dalcross is an example of this.

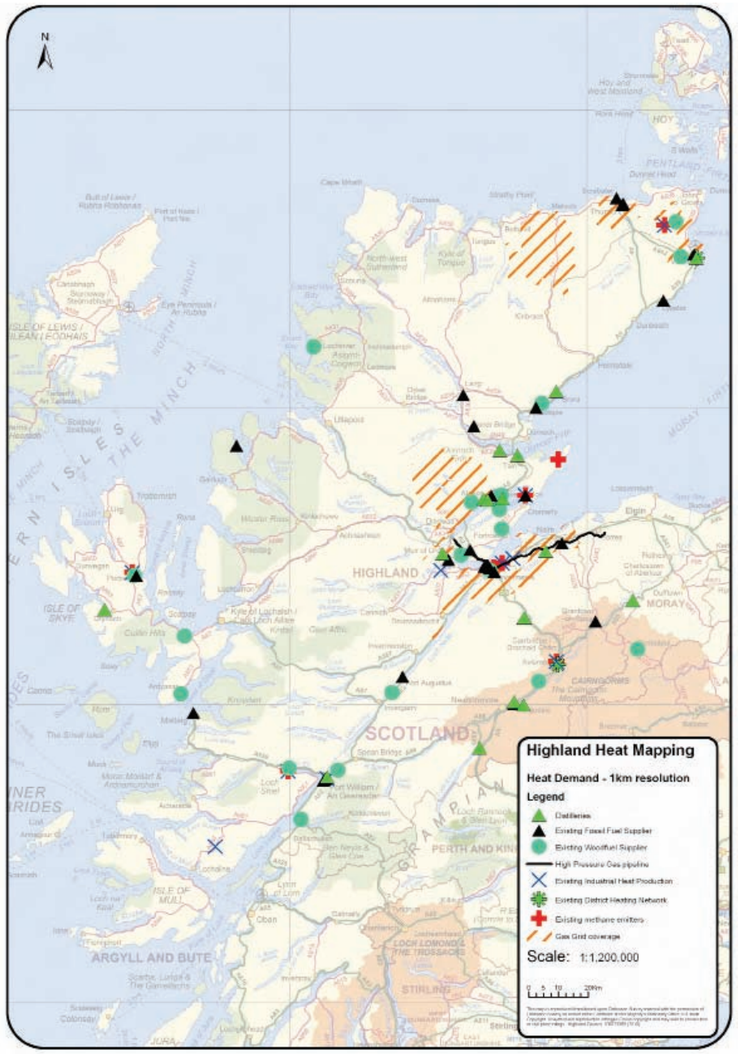
The locations of **existing district heating networks** within the Highlands have all been identified. Additional information relating to the energy value for each scheme has also been included.

Locations of **existing methane emitters** have been identified. These could offer potential supply opportunities for potential energy from waste schemes. These could also provide opportunities for low carbon heat.

Areas that are served by the **gas grid** have been identified. This is based upon access to the gas grid by datazone, showing all datazones that are wholly or partially served by the gas grid.

Feedback on the potential heat supply layers has identified that this is an area where there is scope to improve the quality of Information available in the future. This includes use of additional data sources such as the renewable heat database and the supply of additional attribute information relating to size and capacity of existing suppliers.

Figure 3.9 Potential Heat Supply



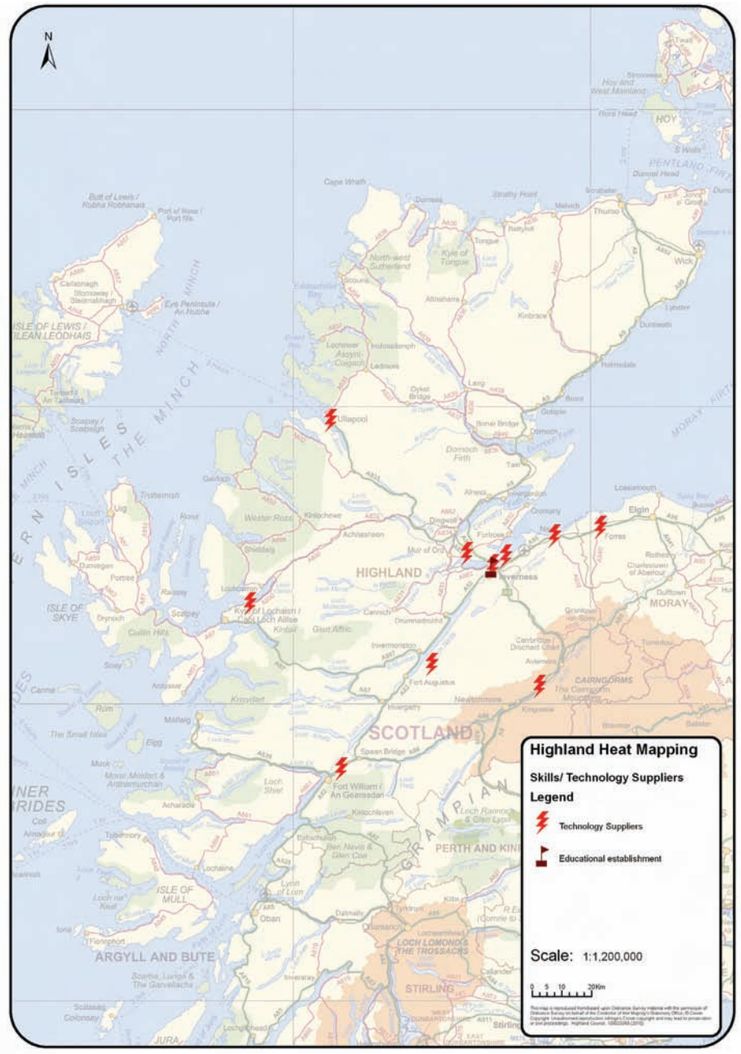
3.3 Skills/ Technology

Figure 3.10 illustrates the contents of the Skills/ Technology suppliers theme.

Locations of **technology suppliers** have been sourced from the Microgeneration Certification Scheme (MCS). This layer also includes information about the types of technology that each supplier deals in, including low carbon heat technologies.

Educational establishments offering renewable energy related courses have also been identified. The names of the available courses has also been supplied for each establishment.

Figure 3.10 Skills and Technology Suppliers



3.4 Opportunities and Constraints

The final theme relates to opportunities and constraints relating to a range of other criteria including ecological designations, flood risk, forest and woodland strategy and local planning site allocations for future development.

Figure 3.11 illustrates some of the constraints included within this theme relating to natural heritage designations and flood risk.

Figure 3.11 Natural heritage and flooding constraints

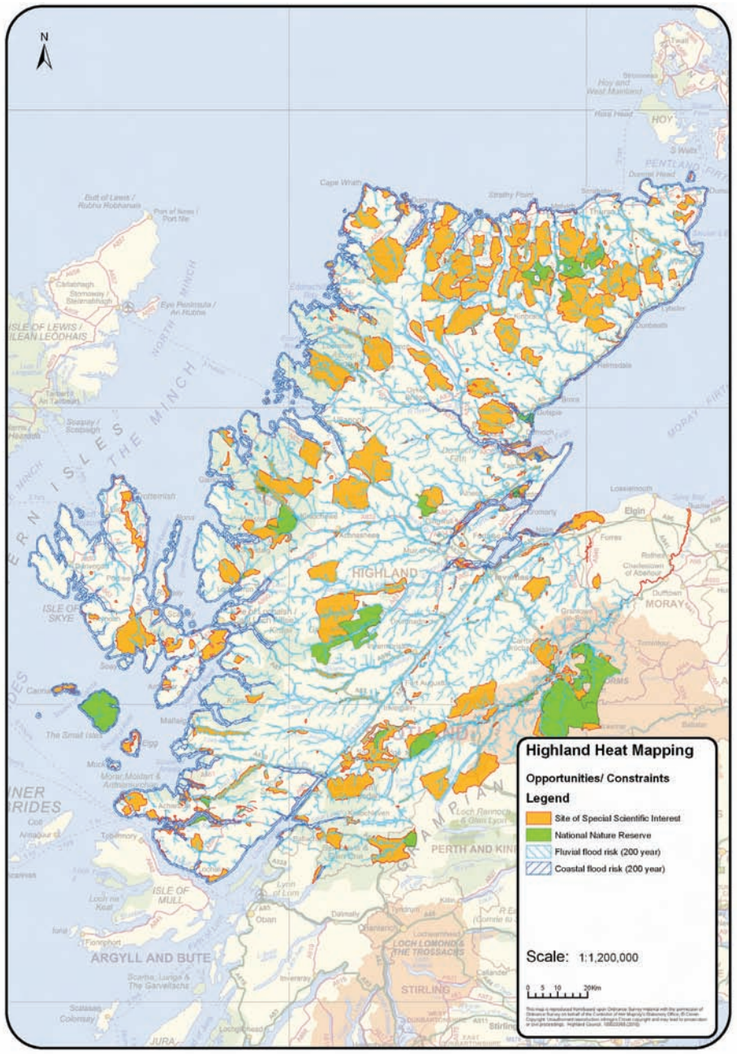


Figure 3.12 illustrates information relating to potential renewable heat opportunities (sites identified for development) in relation to existing heat demand levels. The Highland Forest and Woodland Strategy is also included within this theme as a potential opportunity layer. This is illustrated in Figure 3.13.

Figure 3.12 Local Development Plan opportunities

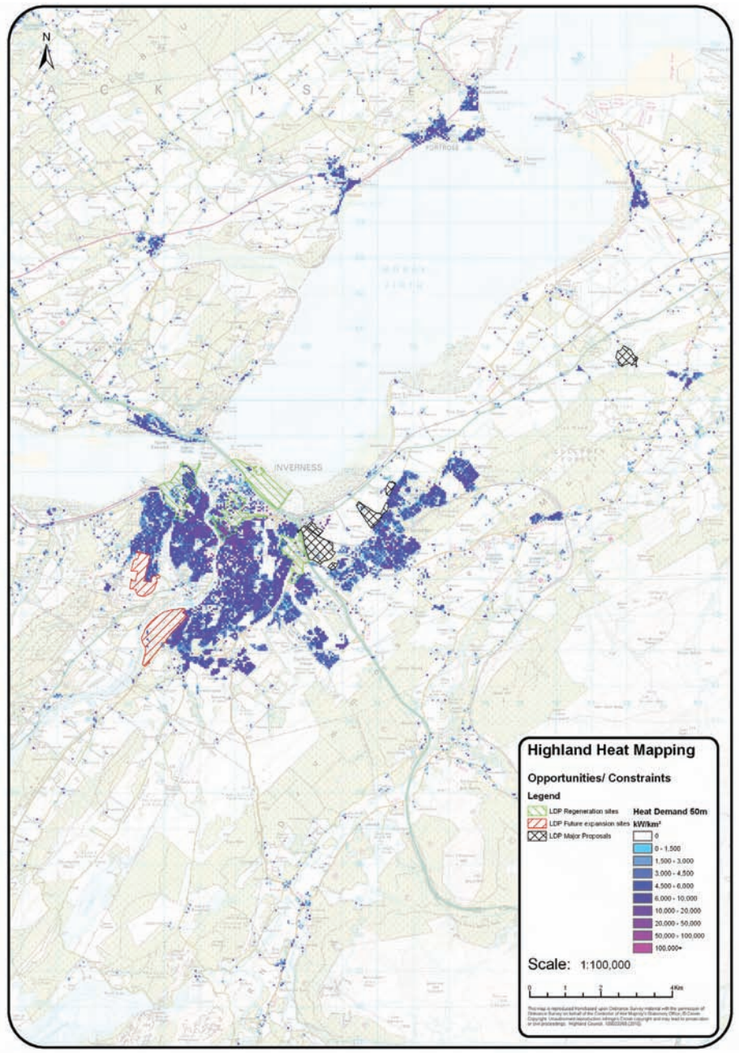
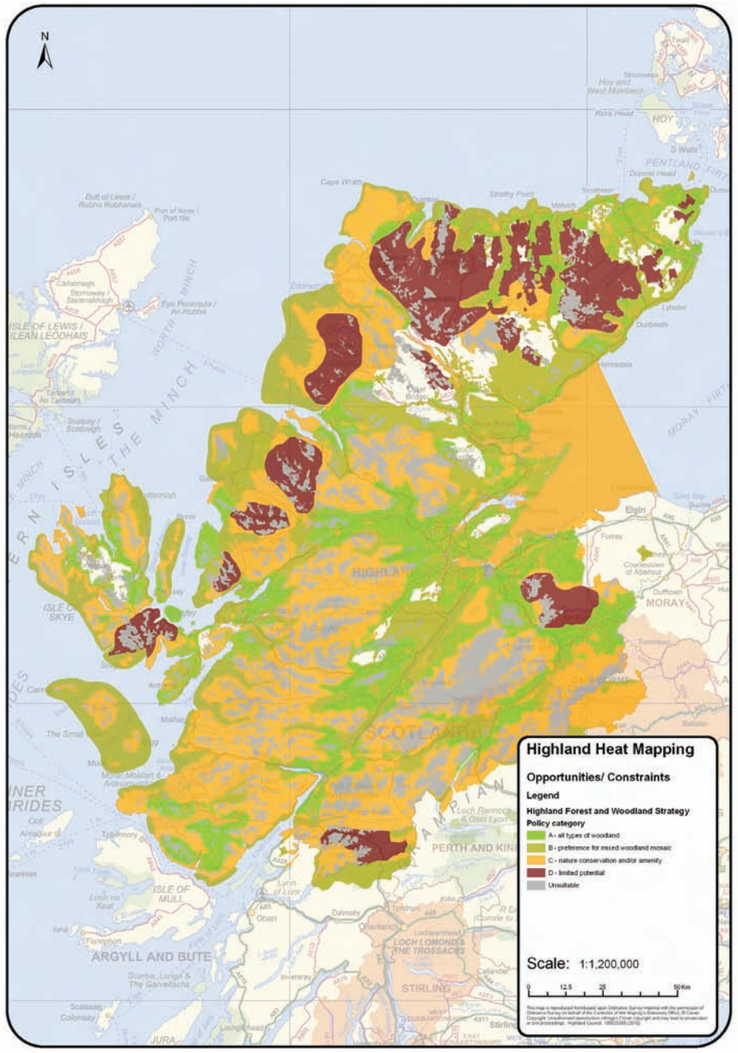


Figure 3.13 Highland Forest and Woodland Strategy



4.0 GIS Tools

In order to realise the full potential of the Heat Map it was identified at an early stage that there was a need to build some GIS functionality which could help to address some of the key questions that people may wish to interrogate the map for. For example, a planner may wish to understand how a new development might affect the level of heat demand in a neighbourhood whilst also identifying the locations of any existing potential heat supply within a specified distance.

The functionality that has been developed was identified during the user requirements analysis and was shaped by a wide range of stakeholders.

The tools that have been developed are:

- Scenario Development Tool
- Development Proposals – Proximity Summary
- Search Tool – Areas of Heat Demand
- Search Tool – Skills/ Suppliers/ Knowledge
- Postcode Reporting

Each tool has been developed using ArcGIS ModelBuilder. ModelBuilder is an application within ArcGIS which can be used to create, edit, and manage models. Models are workflows that string together sequences of spatial analysis tools, feeding the output of one tool into another tool as input. Using ModelBuilder is an effective way of streamlining frequently carried out tasks in a consistent and efficient manner. ModelBuilder is a visual programming language for ArcGIS but is quite accessible to GIS specialists with knowledge and experience of ArcGIS.

Highland Council staff have been heavily involved in the development of these tools and have gained a good understanding of the tools and how they have been constructed. This expertise should prove to be invaluable in the future as new functionality is identified through continued use and application of the Heat Map across the Council's core business areas.

The tools have been developed for use by trained GIS professionals.

Each tool is described in more detail in the following sections.

4.1 Scenario Development Tool

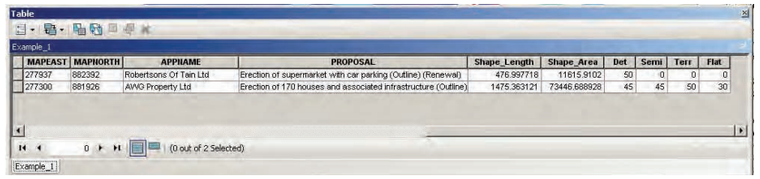
Purpose

To update the heat map with heat demand values for new or proposed developments. This allows the user to understand the impact that a new development will make on heat demand in a particular location.

Inputs

The tool requires the user to provide a boundary for the development and specify the type of development. For residential developments there are four types that can be used (Detached, Semi-detached, Terraced, Flat) and for industrial/ commercial development an additional 29 types relating to the CIBSE benchmarks that have been used in the heat demand calculations. Figure 4.1 illustrates the required format for the input information.

Figure 4.1 Input table for residential development



Applications

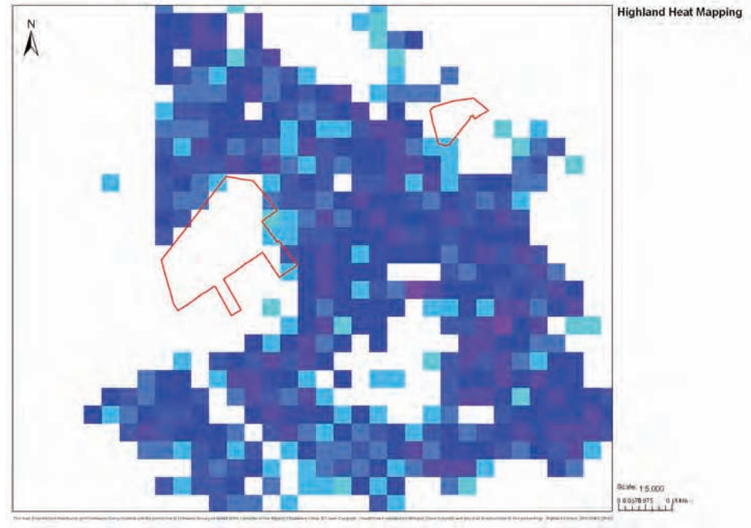
This tool has been designed to be used specifically for assessing the impact of planning applications or testing potential development plan allocations.

Outputs

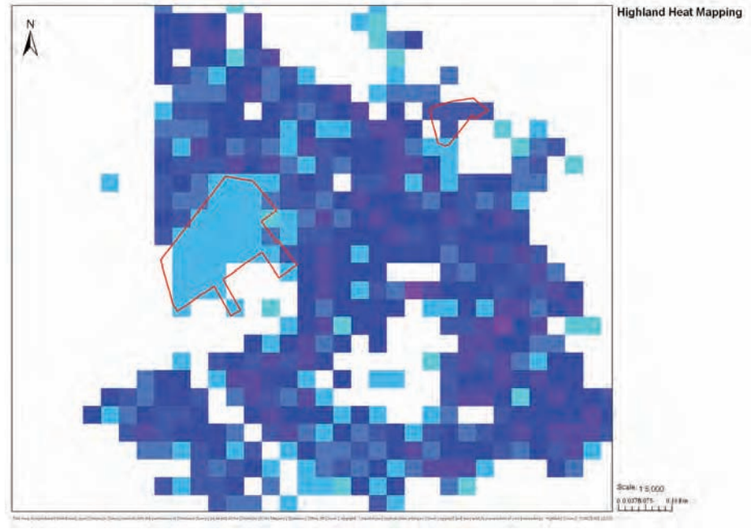
Figure 4.2 illustrates a typical before and after scenario where two separate proposals are planned (one for retail and one for housing), indicated by the red line boundary. The spatial accuracy of the outputs will depend on the level of detail available regarding the development. This example shows a planning application boundary but does not include the detail of where the different property units will be located. In this instance it is only possible to make an assumption that the heat demand would be spread consistently across the whole site. Where more information exists, (e.g. in a masterplan) each development block could be modelled to give a more realistic impression of potential heat demand across the whole site. The tool also offers an option for the user to input more detailed information as points, if this is available. This will provide the user with a more detailed output which will reflect more closely the impact on heat demand of different types of development.

Figure 4.2 Scenario Development - Before and After

Before



After



4.2 Development Proposals - Proximity Summary

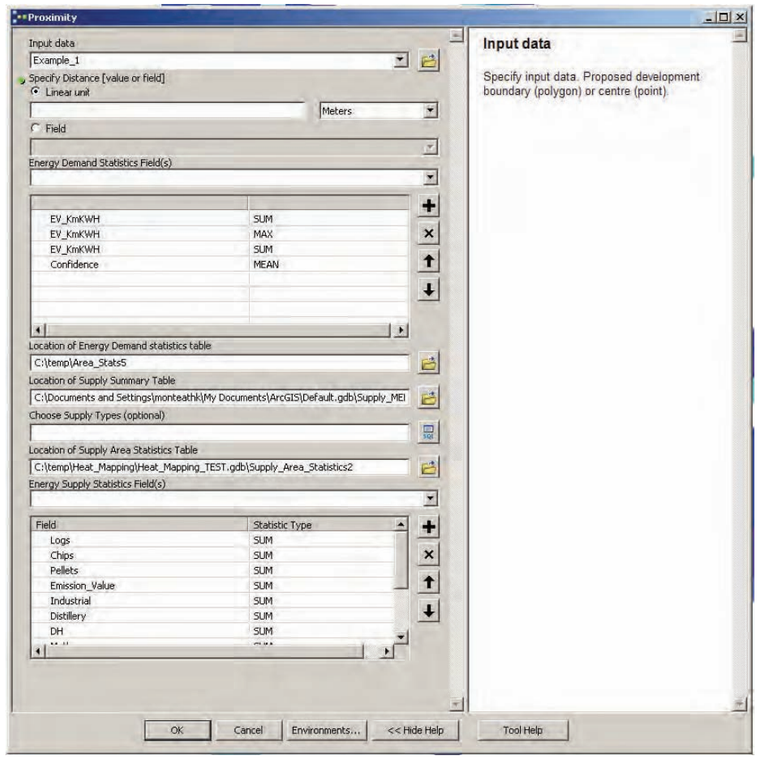
Purpose

To summarise the heat demand and potential heat supply within a user specified location. This can be from a specific point location or from the boundary of a development proposal.

Inputs

The tool requires the user to provide a location (either a point or a boundary dataset) and specify a search distance within which they would like statistics for, relating to heat demand and potential heat supply. The user also has the option of narrowing down the results by specifying the type of supply they are interested in. If this option is not chosen, the default will list all types of supply. Figure 4.3 illustrates the tool dialog box through which the user is prompted for their inputs.

Figure 4.3 Tool dialog box



Applications

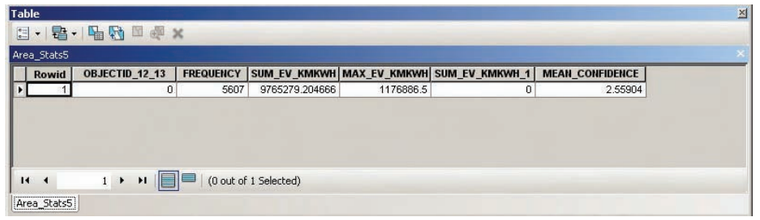
This tool has been designed for assessing development proposals. This differs from the previous tool in that it provides the user with a summary of the existing heat demand and supply within a specified area of influence of the development. These statistics can be used to highlight where there are existing areas of high demand and potential supply that could be suitable for renewable heat.

Outputs

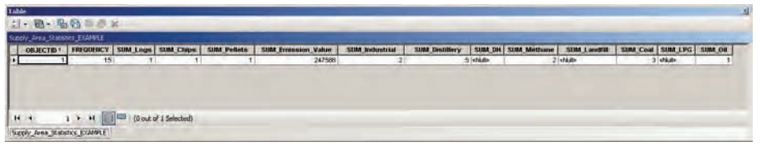
Figure 4.4 illustrates the typical outputs produced from this tool. The outputs are in tabular form and consist of three tables. The information provided within the tables gives the user a summary of the overall heat demand and overall potential heat supply within the search area. It also provides the user with an additional breakdown of all potential heat supply sources within the area of search and the potential supply associated with these. Due to the format in which the outputs are provided these can be easily incorporated into other applications.

Figure 4.4 Tool outputs

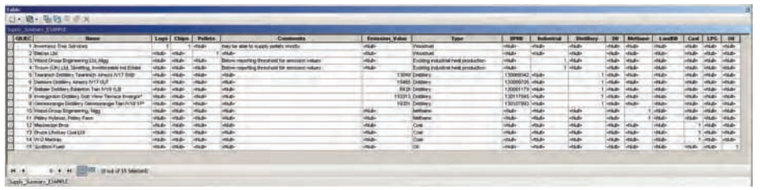
Heat Demand Summary



Potential Heat Supply Summary



Heat Supply Sources Listing



4.3 Search - Areas of High/ Low Heat Demand

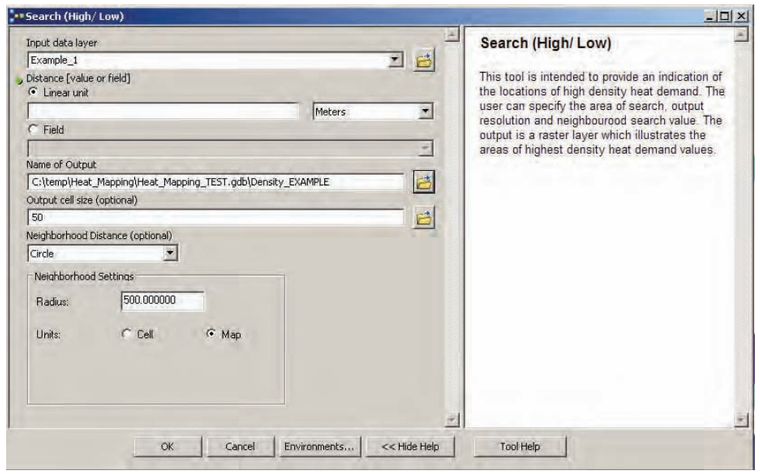
Purpose

To identify significant clusters of heat demand within a user specified location. This tool helps the user to visualise and highlight existing clusters of high heat demand for further investigation with regards to renewable heat opportunities. The outputs produced using this tool differ significantly from the Heat Map itself as heat demand is being calculated on a neighbourhood basis (i.e. each cell and its neighbouring cells) as opposed to each individual cell in isolation. The tool can also be used on previous scenario development tool outputs to predict whether new developments are likely to form part of significant clusters of heat demand where there may be opportunities to investigate renewable heat opportunities.

Inputs

The tool requires the user to provide a location (either a point or a boundary) and to specify a search distance which indicates how far from the input location the user is interested. The user is also required to provide a threshold distance to indicate the spatial influence of existing heat demand sources. This threshold signifies the neighbourhood in which the heat demand might exert an influence (e.g. the user may have a certain size/ scale of scheme in mind which would dictate the distance that existing heat demand may have an influence over). Figure 4.5 illustrates the tool dialog and the inputs required from the user.

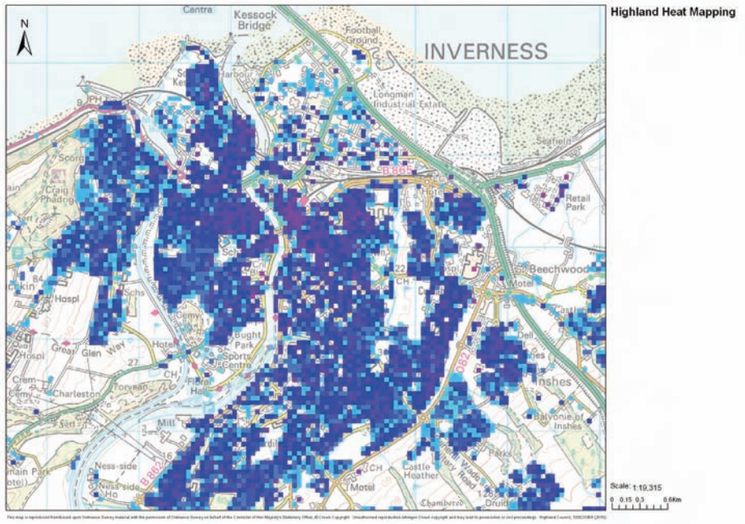
Figure 4.5 Tool dialog



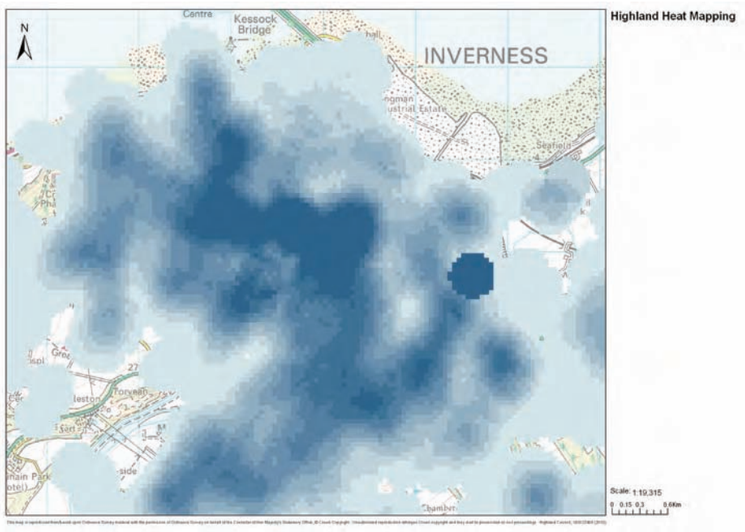
Output
The output from this tool is a density map created using the user specified parameters in the model. Figure 4.6 shows an example of the heat map and the output from this tool for the same area. This clearly illustrates why it is important to analyse heat demand across a neighbourhood as opposed to on a cell by cell basis.

Figure 4.6 Heat Demand compared to Heat Density

Heat Demand



Heat Density

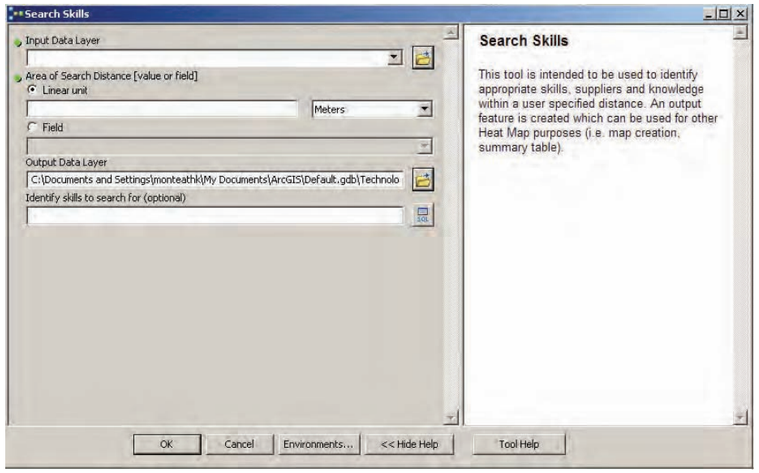


4.4 Search - Skills/ Technology Suppliers

Purpose
To identify the existing skill base within a user specified distance of any location. An output data layer is produced which can be utilised in other Heat Map processes.

Inputs
The user is required to provide an input location (point, line or polygon) and an area of search radius. The user also has the option to specify which types of technology to search for. The default will search for all types. Technology types that can be searched for include Air Source Heat Pumps, Heat Pumps, Hydro, Micro CHP, Wind, Biomass, Solar/ Thermal, Ground Source Heat Pumps and Solar (Photovoltaic). Figure 4.7 is an illustration of the dialog box for this tool.

Figure 4.7 Tool dialog box



Outputs
The output is a data layer containing a selection of features extracted from the skills database using the user specified parameters. Figure 4.8 shows a typical example of the tabular results of this analysis.

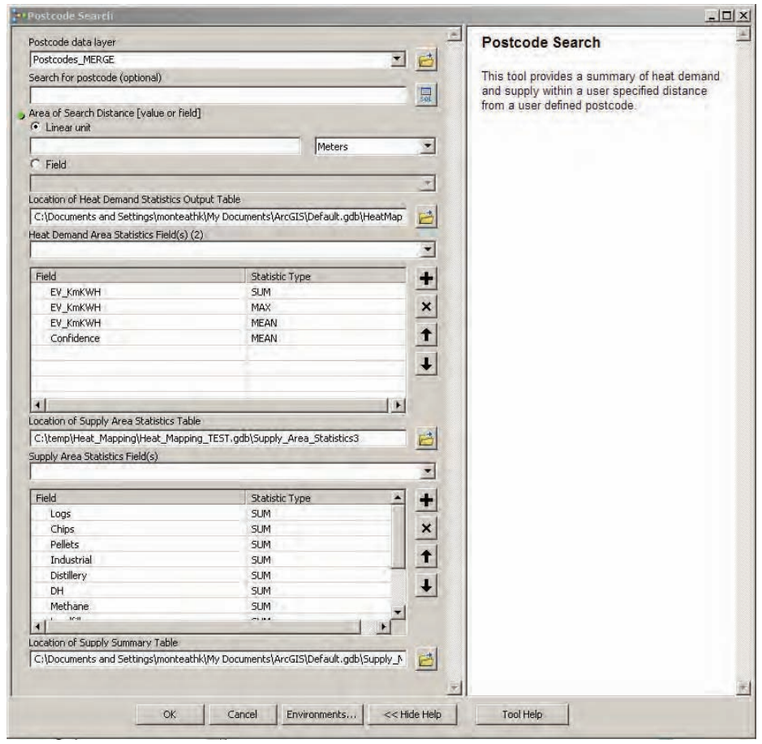
Figure 4.8 Skills search output

4.5 Postcode Reporting

Purpose
To allow users to search for potential heat supply and heat demand using postcode locations. This tool could be enhanced to incorporate a skills/ technology search as well if this was thought to be useful.

Inputs
The tool requires a minimum of two inputs from the user, a postcode and a search radius for the report. The user can also optionally specify the types of summary statistics that they require for both heat demand and potential heat supply. If these options are not taken then the default option will provide the user with some standard statistics. Figure 4.9 is an illustration of the dialog box for this tool.

Figure 4.9 Tool dialog box



Outputs
The outputs derived from this tool will take exactly the same form as those described in the Proximity tool (i.e. three output tables containing summary statistics for heat demand, potential heat supply and a summary of potential supply locations).

4.6 Functionality not developed

As a result of the User Requirements analysis, a list of desired tools were developed for further investigation. These include all the tools discussed in the previous sections. There were however two areas of functionality where the results of our investigations indicated that there would be little value in creating a bespoke tool. These were:

- Appropriate Energy - a model to identify most suitable technology according to location
- Locational Adjustment - functionality to provide an adjustment based upon location and temperature

The reasons that tools have not been developed for these is summarised in the following sections.

4.6.1 Appropriate Energy

The purpose of this functionality was to indicate to users which technology was best suited according to location. Our investigation of this topic however lead us to the conclusion that, a) this would be extremely difficult with no guarantee that the results would be either useful or accurate and b) unsuitable for development of a tool, but perhaps may be possible as a one-off layer in the future. Our thoughts on the different factors that would help to define the suitability of locations for different technologies are recorded below.

General

In general, a stronger financial case can be made for renewable heating systems for locations off the mains gas network.

Biomass heating / CHP

- There are no reasons for blanket exclusions in any areas.
- Everywhere in the Highlands is potentially within economic delivery range of wood pellet suppliers (although not necessarily wood chip).
- Although many properties will not have space for an installation, the idea is that this could be situated remotely, serving a group of properties. i.e. District Heating.
- Air quality is an issue to be tackled on a case by case basis. There are no Air Quality Management Areas in the Highlands.
- Liquid bio-fuels – such as biodiesel – are assumed to be more appropriately used as transport fuel.

Solar Water Heating

- Solar water heating, by its nature, is suited to separate systems on individual buildings, so not a huge overlap with the heat demand map.
- Much more important than the general location within the Highlands (and associated solar resource) is a group of site specific issues such as: roof pitch and orientation; shading; hot water demand; counterfactual (existing or alternative hot water system).
- Solar thermal is useful in a range of contexts. Best example would be swimming pools. Hotels and dwellings also good. Not for process energy in industry though, as this usually needs more than low grade heat.
- Solar thermal technology can be used to provide supplementary space heating (and there is reckoned to be a stronger case for this in the Highlands than almost anywhere else because of the long heating season), although this is not commonly done in practice and is unlikely to be supported by the Renewable Heat Incentive.

Heat Pumps

- Ground, water or air can be used as heat source. Hence it is difficult to apply blanket constraints. Noise can be an issue for air source heat pumps (ASHP), and space is often an issue for GSHP, but through the use of boreholes it can be possible to install GSHP even in tight locations.
- Significant quantities of grid electricity are required to run the pump.
- Heat pumps are difficult to justify from an environmental and economic perspective at locations which are on the mains gas network. A recent Energy Saving Trust study showed that a high proportion of installations have higher carbon emissions than a conventional gas central heating system: such installations would also have higher capital and operating costs.

Deep Geothermal

- BGS information would be required to determine suitable locations. This is available but at a cost.

Landfills

- Landfill gas (LFG), which typically consists primarily of methane and carbon dioxide, is emitted during the operating life of a landfill and for many years subsequently.
- LFG is usually managed and either flared off or utilised in some way (typically in a gas engine).
- LFG utilisation can be highly profitable, although whether the investment is justified depends on the quality and quantity of LFG being produced, and likely to be produced in the future.
- Heavy heat users and new developments near to landfill sites should find out about the status of LFG management at the site.

Waste to Energy

- This is relevant to planned municipal solid waste and/or Commercial and Industrial waste treatment plants.
- New incinerator plants, gasifiers, anaerobic digesters (AD) etc. A wide range of technologies are currently being tried out around the UK.
- Waste facilities can produce energy in a range of forms including electricity, heat, solid fuel (for use in incinerators/ gasifiers/cement kilns) or gas.
- Heat will often be available but this is not guaranteed. An example where heat would not be available is an AD plant where the biogas is collected for use off-site (e.g. as road fuel).
- Siting guidelines for waste to energy schemes are outside the scope. The map invites waste planners to look at their proposals for waste developments in a new light.

Agricultural Anaerobic Digestion

- This is incentivised by the Feed-in Tariff (FIT), although there is concern that the incentives are insufficient as only two facilities in the UK have registered to date.
- Potentially smaller scale. Reliant on energy crops and agricultural wastes, but may also use various commercial & industrial waste streams.
- Siting guidelines are out of scope, and difficult to identify the type of farms which might be applicable.

Wind to Heat

- A niche area, as wind to heat schemes are generally favoured for individual buildings in isolated areas.

District Heating

- Already referred to above. But an extra point to note is that it could run off a variety of fuels in addition to biomass. E.g. waste, biogas, landfill gas, and could be heat only or CHP.

4.6.2 Locational Adjustment

A point was made at the workshop about the effect of location on temperature across the Highlands and the knock-on effect that this has on heat demand. Degree data across Scotland was investigated but it was quite difficult to define a robust pattern, as there are probably not enough weather stations with comparable data. Some sample figures for “heating degree days” for various stations are shown below (ECI Oxford based on Met office data).
Aviemore – 3222, Edinburgh 2562, Glasgow 2641, Loch Glascarnoch 3375, Tulloch Bridge 3179, Wick 2780

The three higher figures can be discounted as this is an altitude effect rather than a lat/long effect. Edinburgh/Glasgow figures are too close to discern the significance of a longitude effect. Edinburgh/ Wick figures could, perhaps, be used to calibrate the latitude effect. Note, though, that the range in the Highlands would be not much more than 50% of the difference between these. This would give a central figure of around 2720, with + or – about 3% based on latitude variation. Whilst this could be applied it is likely that altitude and aspect will be more significant than latitude alone. This would require further research to determine the accuracy and value of such an adjustment.

5.0 Next Steps

Whilst the development and implementation of a methodology for heat mapping in the Highlands is a significant achievement, in many ways it is only the start. The Heat Map of the Highlands provides for the first time a detailed picture of heat demand, potential supply, skills and technology providers and potential opportunities and constraints related to renewable heat. The design of the map provides users with a wealth of analytical options using the in-built functionality of GIS as well as providing access to a range of bespoke renewable heat related tools.

This does however merely provide a baseline albeit one that provides the platform to direct and target future renewable heat opportunities in a coherent and consistent manner. In order to ensure that the maximum value is gained from the Heat Map it will be important to address some key issues which will be factors in the impact that the Heat Map will make:

- Provision of Heat Map outputs and services
- Future development and updating of the Heat Map
- Development of Heat Maps for other locations

5.1 Provision of Heat Map Outputs and Services

The Heat Map has been developed for Highland Council and for the sole use of Highland Council staff. There is currently no mechanism to allow other stakeholders to view and interrogate the contents of the Heat Map or indeed access any of the GIS tools.

This is quite an important issue as a number of stakeholders have participated in the project and have willingly provided both their views and in some cases their data to the project. The project has considerably raised the profile of heat mapping in Scotland and has created a sense of anticipation amongst potential users. It is therefore important that this opportunity is not lost and that stakeholders will be able to access outputs from the Heat Map in some form.

In the short-term, we would recommend that Highland Council develop a protocol for dealing with stakeholder requests for information relating to the Heat Map. This will define:

- Main contact for requests
- Nature of requests that will be complied with
- Timescales for dealing with each request
- Who requests will be accepted from
- Outputs that will be provided

It will also be necessary for the Council to consider how and who this information will be communicated to. Like many organisations at present, the Council are experiencing increasing pressure upon their staff resources and this should be taken into account when considering how these services will be publicised.

In the medium term, we recommend that the Council should seek to make the Heat Map more widely available using the internet. Ideally this would provide access to the Heat Map layers through a Web GIS application which could be accessed from the Highland Council website. This is a method that is used by many Councils already to disseminate their spatial data.

5.2 Future Development and Updating of the Heat Map

It has already been stated that the Heat Map provides a detailed baseline of information relating to renewable heat opportunities. Unfortunately the baseline will only ever be as up to date as the information contained in it. It is therefore essential that the data that makes up the Heat Map is updated regularly. It has always been anticipated that the Heat Map will be dynamic and will evolve over time to reflect the changes taking place on the ground in the Highlands. Over time the Heat Map will be able to provide information on relevant trends and also the impacts that renewable heat installations have made to communities across the Highlands.

This will not happen automatically, and therefore will require some effort. The required effort however, is expected to be far less than the effects of not updating the map regularly over a long period.

The Heat Map has been constructed from a large number of data sources and organisations. A decision was taken during the design of the map to ensure that there was a high degree of confidence for all key datasets, that they would be updated by the data owners at regular intervals. It is important for the future maintenance of the Heat Map that the Highland Council maintain a regular dialogue with each of the data providers. Agreement should be sought on such issues as:

- frequency of updates
- key contacts
- data limitations/ restrictions on use
- data format

A good relationship with data providers will help to ensure that updated information is received regularly, in a correct format and that the information is handled correctly. Providing data providers with information about the benefits of the Heat Map and how it contributes to the Council's objectives can help to improve engagement with providers. It is also important that data providers are given credit for the role their organisations have played.

The two key datasets used in the construction of the Heat Map are the CAG and the Highland Assessors valuation data. The CAG is updated continuously and is available within the Council at any time. The Highland Assessors valuation data is also updated regularly, but is more difficult to access as it is held by another organisation. In an ideal world the Heat Map would use the most up to date information from both data providers, in effect providing a new version of the map every day or even more frequently.

Given the need to request this data from the Highland Assessor, it would not be feasible or indeed desirable to request the data so frequently. As a priority, Highland Council should continue dialogue with the Highland Assessors to agree a suitable update frequency for this information. This will depend on a number of factors, but ideally if the information was provided either quarterly or bi-annually this would be a significant step forward.

The Heat Map is only as good as the information that it is constructed from. We are aware of some weaknesses relating to some of the data sources and these have been discussed elsewhere. This has been captured for every record in the information relating to the confidence level of the heat demand calculation. Efforts should be made over time to work with data providers to iron out any issues relating to accuracy, completeness or consistency of data. This will help to steadily improve the quality of the map from good to excellent over the coming years.

5.3 Development of Heat Maps for other locations

This project has been carried out as a pilot project on behalf of Scottish Government. A key driver behind the methodology that has been developed is that it could be used for any other Scottish local authority. The methodology has achieved this by ensuring that nationally consistent information has been used wherever possible, and for all key data sources and calculations.

This means that the methodology could be easily applied to any other Council at any time in the future. It is expected that some Councils will have access to a range of slightly different data sources than others and these may help to improve the accuracy of the map further in these locations.

One major issue relating to the delivery of this project was the ability to gain access to the Highland Assessors valuation data. As it was a pilot project, it was felt that it was worth a delay in programme to determine whether this information could be accessed and if so how useful it would be. Although this decision resulted in a delay to the programme, it has contributed enormously to delivering a much more detailed and accurate picture of heat demand than was previously thought possible.

If other authorities are to be encouraged to develop their own Heat Maps, it may make more sense to attempt to create maps by assessor area. There are 14 assessors which cover all 32 Councils in Scotland, with each assessor covering more than one Council. By targeting clusters of Councils according to assessor area it would be possible to carry out the mapping more efficiently as contact would only have to be made once with each assessor. It would also be fairly straightforward to run the projects based upon a steering group consisting of one representative from each Council, one from the Assessor and one from Scottish Government. This would ensure that delivery of future maps is achieved in the most resource efficient manner.

Pre-workshop questionnaires

The purpose of the questionnaire was to gather information about each of the stakeholders' existing knowledge of heat mapping and its potential applications, their aspirations for the project and any other relevant information that could either bring value to the project or could be considered to be a potential issue or challenge. The questionnaire was distributed to over 30 people using the online application Survey Monkey with a total of 14 responses received. A summary of the main answers for each question can be seen in the table below.

Summary of questionnaire responses

Question	Summary of responses
Q1. Have you used a Heat Map previously?	21% - Yes, 79% - No
Q2. If you answered Yes to the previous question, please give details of where and for what purpose you used a heat map.	Identify potential micro district heating clusters. Identify high heat load businesses. As part of the FREDS group, the original heat map was commissioned to see if the concept was useful.
Q3. Can you describe your interest in a heat map for Highland?	The responses to this question were fairly varied in nature. Responses can be grouped into the following broad themes: Strategic - people were keen to understand how the map would help to meet renewable energy targets for Scotland and how the study might lead to a standardised national approach. Planning - a number of responses related to the expectation that the map could help to inform the planning process by highlighting and targeting renewable heat development in the most appropriate locations. Technical - relating to how the map would be constructed and also how it could direct different types of technologies to different locations.
Q4. Please list any benefits that you envisage a Heat Map for Highland will bring to your organisation?	The benefits that stakeholders perceived the map providing were many and varied. These included emission reductions and energy conservation, matching of potential resources with demand, an evidence base to promote the renewable heat agenda, better targeting of funding, proactive tool for leading development and monitoring of progress towards national targets for renewable heat.
Q5. Does your organisation hold any information that could add value to a Heat Map of Highland? Please list all that apply.	Various data sources were identified ranging from strategy documents, to databases of renewable projects.
Q6. Do you have any concerns or issues about the production of a Heat Map for Highland?	The main issues and concerns raised included concern about the specification of the outputs, maintenance and update of the map and how the map may be used/ interepreted by others.
Q7. What are your aspirations for the workshop?	The vast majority of attendees wished to gain a better understanding of heat mapping, its outputs and its benefits.

Stakeholder Workshop

The responses gained from the questionnaire were extremely valuable in preparing for the stakeholder workshop. They helped to identify the level of current knowledge and the level of expectation of stakeholders. The information gathered during this process was used in the design and development of the stakeholder event, which was held on 14th January 2010 at the Highland Archive and Registration Centre in Inverness.

It was obvious from the questionnaire responses that the majority of people attending the workshop had little or no previous experience of heat mapping and were looking for the workshop to help improve their understanding and awareness. This played a large part in shaping the format and content of the workshop. This lack of prior knowledge also presented a challenge when trying to develop an understanding of the aspirations of different organisations for the Heat Map.

The event was run as a half day session split into the following sections:

- Presentation by AECOM – Project Definition
- Presentation by AECOM - What is a Heat Map?
- Breakout Session 1 – What information should a Heat Map include?
- Breakout Session 2 – How would you use a Heat Map?

A total of 22 people attended the workshop representing 10 organisations. For the breakout sessions these were split into 2 groups, each lead by AECOM. The aim of each breakout session was to gain feedback on the information that a Heat Map should include and how different organisations would anticipate using the map. This took the form of a number of questions which each group were tasked with discussing and then providing feedback to the main group at the end of each session.

The questions posed were:

Breakout Session 1 - What information should a heat map include?

Q1. What information would make the heat map relevant to your organisation?

Q2. What information does your organisation hold that could help in the development of a heat map?

Q3. Are there any other data sources you are aware of that would add value to a heat map?

Feedback received from this session was fairly broad in range with a number of additional information sources being cited as being of potential value. These were all considered with respect to data consistency and

access to data, and a number of these data sources were included in the map specification. These included oil and LPG use, fuel poverty data, population forecasts, planning constraints, landslip database, flood risk, distilleries, indicative forestry strategy and planning applications.

This session also identified a number of potential data sources for investigation which could be of value to the process. A number of these were investigated further after the workshop. Key factors in the assessment of potential data sources were the quality, consistency, coverage and accessibility of each data source.

Breakout Session 2 – How would you use a Heat Map?

Q1. How would your organisation use a heat map? List specific tasks.

Q2. In what format would you require any outputs?

Q3. Do you currently have access to this type of information, and if so, in what form?

The second breakout session was more difficult to get focused feedback on as most people had only just learnt about what a Heat Map is and what it might include. This made it difficult for people to comment fully on how this might be used within their organisation. Despite this issue, some useful feedback did emerge. In particular the top priority applications of the Heat Map were:

- Identification of new development proposals in close proximity to existing settlements
- Make available to wider community/ organisations
- Influence policy by treating region as a whole and identifying optimum locations on a Highland wide basis
- Identification of optimum locations for development

In addition it was also noted that it would be important to make the Heat Map outputs accessible to as wide an audience as possible and not just as a GIS layer. Different audiences will inevitably have different needs and it is therefore essential to try and meet as many of these as possible where appropriate.

Workshop Follow-up

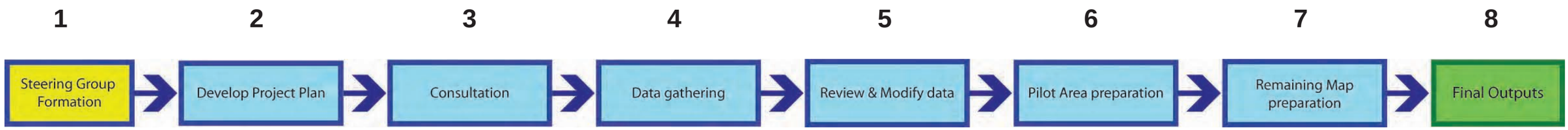
A summary of the workshop proceedings was prepared and circulated to the Steering Group and additional comments sought. Follow-up discussions were then entered into regarding many of the additional data sources that were identified during the workshop. Once these discussions had taken place, a specification was prepared and submitted to the steering group for approval. Feedback from the steering group was then received and used to refine the specification.

The outcome of the user requirements phase was the development of a specification which outlined the data that the map should be based on, and the analysis and functionality of the GIS tools.

Heat Demand Theme		
Name	Source	Status
Energy consumption by datazone	DECC	Sourced - used for validation
Proposed new development	THC	Sourced
Residential data	General Registers Office for Scotland (GROS)	Sourced - not required
Assessors valuation data	The Highland Assessor	Sourced - after a long delay, but ultimately a fundamental data source
Existing public building energy loads	THC & NHS Highland	Sourced - important sources of good quality information
Land use data		Not required due to methodology refinement
Rural Fuel Poverty Indicator	Energy Action Scotland	Sourced - included in the heat demand theme
Oil and LPG use	Various suppliers	Collection of this data was difficult due to commercial sensitivities. A limited amount of information was acquired which was insufficient for use in the Heat Map.
Distilleries, Manufacturers, Industrial premises and Retail building locations	THC, Scotchwhisky. net	Sourced - mainly from THC Corporate Address Gazetteer (CAG)
Scottish House Condition Survey	Scottish Government	Sourced - used in heat demand calculations
Energy benchmarks	Chartered Institution of Building Services Engineers (CIBSE)	Sourced - CIBSE TM46: 2008

Potential Heat Supply Theme		
Waste production & existing landfill sites	THC & Scottish Pollutant Release Inventory (SPRI)	Sourced - included as a layer in the Potential Heat Supply theme
Existing industrial heat production	SPRI	Sourced - included as a layer in the Potential Heat Supply theme
Woody biomass production capacity	usewoodfuel scotland	Sourced - included as a layer in the Potential Heat Supply theme
Potential medium/ deep geothermal capacity	British Geological Survey (BGS)	Not included due to cost/ access to data.
Gas grid	Scotia Gas & Energy Action Scotland	Sourced - location of high pressure gas pipelines and datazones with full or partial access to the gas grid.
Existing District Heating & CHP systems	Local knowledge	Sourced - included as a layer in the Potential Heat Supply theme
Existing fossil fuel suppliers	Trade directory	Sourced - included as a layer in the Potential Heat Supply theme
Skills and Technology Theme		
Locations of trades people/ services		Sourced
Educational establishments offering related training	Web search	Sourced
Renewable technology suppliers	MCS	Sourced
Renewable technology facilities	MCS	Sourced

Opportunities and Constraints Theme		
Designated sites	SNH	Sourced - SSSI and NNR's. Additional designations could be added if required.
Existing Local Development Plans	THC	Not included due to relevance of much of the data. There may however be a case for including some elements of the LDP.
A96 Corridor Development Framework	THC	Sourced - some information relating to regeneration and expansion sites for this location have been included within this theme.
Flood risk mapping	SEPA	Sourced - coastal and fluvial 200 year flood event locations.
Landslip database	BGS	Not included due to cost.
Distilleries	THC CAG	Included as part of the Potential Heat Supply layer
Licensing information forestry		Not available.
Location of windfarms		Could be added in the future, but not included at this stage as it was not regarded as core information.
Indicative Forestry Strategy	THC	Sourced - THC Woodland and Forestry Strategy included is in this theme.
Population growth forecasts	GROS	Not included due to resolution of output data (local authority).
Context		
Base mapping	Ordnance Survey	Sourced - Miniscale, 1:250,000 and 1:50,000 mapping products.



The workflow diagram at the top of this page identifies each of the key stages required in the production of a Heat Map. A more detailed explanantion of each stage is given in the text below. This template is intended as a step by step outline for local authorities to use when developing a Heat Map.

Stage 1 - Steering Group Formation
A steering group should be formed which will have responsibility for directing the project as well as raising awareness of the project and its outputs throughout the organisation.

The steering group should consist of at least the following members:
- Planning (Council)
- GIS (Council)
- Assessor data representative

In addition it would also be useful to have representation from the following departments:
- Housing and property (Council)
- Waste management (Council)

The steering group should meet at regular intervals throughout the project, coinciding with the production of the project deliverables.

Stage 2 - Develop Project Plan
It is the responsibility of the Steering Group to ensure that a Project Plan is developed which will describe how the Heat Map will be successfully delivered. At a minimum the Project Plan should contain the following elements:

- Proposed programme for all phases
- Details of the project team, roles and responsibilities
- Communication strategy
- Risk Log
- Quality review strategy

Stage 3 - Consultation
As Heat Mapping is a relatively unknown concept, it will be important to raise awareness of Heat Mapping and its potential applications both within the organisation preparing the Heat Map and within other relevant local organisations. Key stakeholders should be engaged from the outset and should remain involved throughout the project lifecycle. The consultation approach should be detailed in the Communication Strategy which forms part of the Project Plan. In addition to raising awareness of the Heat Map and its potential application, the consultation should be used to garner information from stakeholders on potentially useful data sources.

Stage 4 - Data Gathering
On completion of the initial stakeholder consultation a list of proposed data sources should be drawn up which will be used to develop the Heat Map. All data sources should then be requested from the source organisations. Metadata should also be sought for all data received using the UK GEMINI metadata standard.

Stage 5 - Review and Modify data
On receipt, all data should be reviewed for completeness and accuracy. All metadata should also be reviewed and any restrictions relating to use should be observed. Clarification should be sought from the data provider where necessary.

The original data supply should then be copied and manipulated where necessary to prepare it for use in the Heat Map.

Stage 6 - Pilot Area preparation
It is always useful for a project of this nature where the outputs cover a large geographical area to test the methodology on a small pilot area. Whilst the methodology has already been tested during the Highland Heat Mapping project there is considerable value in continuing to prepare a pilot area for each Heat Mapping project. The reasons for this are twofold. Firstly, every geographic area will have its own nuances which will inevitably throw up different types of issues that may not have been already addressed in other areas. The pilot map gives an opportunity for these to be addressed at an early stage in the project before it is too late. Secondly, and perhaps even more importantly the production of a pilot map provides the steering group with an early output of an area they are familiar with which they can interrogate. This helps to improve the understanding of the steering group of the strengths and limitations of the map and will aid them when raising awareness of the Heat Map within their organisation.

The pilot process consists of two stages:
- Map preparation
- Map Review and feedback

The map is prepared for a pilot area which should be agreed with the steering group in advance. This should be an area that members of the steering group are familiar with and it should be large enough to contain a range of different urban and rural characteristics typical of the overall study area.

On completion of the pilot area, the steering group should review the results and provide feedback to the project team. This could range from clarification on certain issues to identification of additional useful information or refinements to the methodology. Any refinements to the methodology must be agreed with the steering group.

Stage 7 - Remaining Map preparation
Once the pilot area has been reviewed and any issues resolved the Heat Map can be prepared for the remainder of the study area. This will incorporate any refinements identified during the previous phase.

Stage 8 - Final Outputs
All final outputs should be reviewed by the steering group, including all map data, any reports and any GIS tools if specified as part of the map.

Final outputs should also include any training which may be necessary for potential users of the Heat Map, including training materials. This should be identified as part of the Project Plan.

This Section will be completed by THC at a later date.