Energy and Low Carbon Heat

First National Assessment of Potential Heat Network Zones

Baseline and Stringent assessment for Scotland using the LHEES Methodology (V03, August 2021)

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Scottish Government
Riaghaltas na h-Alba
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This document has been prepared by Buro Happold on behalf of Zero Waste Scotland for the Scottish Government.

Contents

Glossary

Abbreviations

Abbreviation	Description
BEIS	UK Government Department for Business, Energy and Industrial Strategy
FNA	First National Assessment of Potential Heat Network Zones (also referred to as Potential Heat Network Zones First National Assessment)
GIS	Geographic Information System
Ha	Hectares - there are 100 hectares in a square kilometre (km^2)
km^2	A square kilometre
LA	Local Authority
LDP	Local Development Plan
LHD	Linear Heat Density
LHEES	Local Heat and Energy Efficiency Strategy
NAEI	National Atmospheric Emissions Inventory
NCA	Opportunity areas for district heating networks in the UK: second National Comprehensive Assessment
SAP	Standard Assessment Procedure
SEPA	Scottish Environmental Protection Agency
UPRN	Unique Property Reference Number

Terms

Terms	Description
Anchor Load	Anchor loads are high heat demand buildings and key connections on a heat network that usually drive the economics of a project.
Baseline	The Baseline screening criteria provide the low-end requirements (in terms of linear heat density and minimum number of anchor loads) used in this study to identify potential heat network zones. See also Stringent.
Building	In most instances a building is defined as property which has a Unique Property Reference Number (UPRN). However, in some instances, properties are grouped under a Parent UPRN to identify the shared building that they are a part of (this is the case for properties in a block of flats or for units in a shopping mall but not, for example, for a semi-detached or terraced house). The properties which share a Parent UPRN are considered as a single building.
Home Analytics	Dataset provided by Energy Saving Trust which contains detailed data for domestic buildings informing key characteristics.
Heritage	This analysis considers three types of designations for identifying heritage properties, these are: 1. Listed properties 2. Properties within conservation areas 3. Properties within world heritage sites Also considered in the analysis are pre-1919 properties, as a proxy for traditional buildings
Linear heat density	Linear heat density (LHD) is a means of relating annual heat demand to a distance and is expressed as annual heat demand per meter of pipe. This metric is used within the methodology to cluster heat demands to highlight potential heat network opportunities. Details on how LHD is used in this study can be found in Section 2.2.1.
Mixed-tenure	Mixed-tenure properties are domestic buildings with a mix of domestic tenure types within, for example a mixture of owner occupied, private rented and social housing.
Mixed-use	Mixed-use buildings may be either a building which consists of a mix of domestic and non-domestic properties, or a building with varying non-domestic property types within it.
Non-Domestic Analytics	Dataset which provides detailed data for non-domestic buildings informing key characteristics. Previously Non-Domestic Buildings Energy Database.
Property	A structure or space that is used for domestic or non-domestic classes and is associated with a UPRN code. Properties can either be stand-alone (for example, a detached house), or alongside other properties, form part of a larger building (for example, a flat within a tenement building).
Stringent	The Stringent screening criteria uses a stricter set of criteria (in terms of linear heat density and minimum number of anchor loads) when analysing for potential heat network zones and is useful to compare results against that of the Baseline screening.

Executive summary

The First National Assessment of Potential Heat Network Zones (FNA) carries out an analysis to identify and characterise potential zones for heat networks in Scotland. The focus of the work is on potential zone identification through assessment of heat demand density, providing an initial, automated assessment using national datasets of the areas that are most suited to heat networks from a demand density perspective[1]. In identifying potential zones, the analysis does not take into account local development plan sites, existing heat networks and sources of waste or surplus or low carbon heat. This information will require local information that is not available in a uniform manner nationally. Additionally, the analysis does not consider the economic viability or the detailed technical or stakeholder related aspects of project opportunities within potential zones. Further detailed assessment would be required to understand if heat network projects within potential zones could offer heat to properties at a cost that is competitive against alternative options. It is emphasised that the potential zones identified, and the summaries of key characteristics reported within potential zones, should be considered in this context.

The Heat Networks (Scotland) Act[2] (known as "the Act" from this point on) defines a heat network as:

a) a district heat network, or

b) a communal heating system.

The focus of this assessment is on the district heat network scale, defined in the Act as "a network by which thermal energy is distributed from one or more sources of production to more than one building." The analysis used focuses on potential for fourth generation heat networks. It may be possible that some of the potential zones identified are also suitable for fifth generation heat networks. The analysis does not identify potential for fifth generation heat networks outside the potential zones identified.

[1] Note that local authorities have not sense-checked the outputs from the FNA – see further detail within the Executive Summary and Introduction sections of the report on how the results from the FNA have been shared with local authorities, for further consideration as part of LHEES

[2] Heat Networks (Scotland) Act 2021 (accessed 29/11/2021)

Potential heat network zones are identified using two levels of analysis providing more potential zones (Baseline Criteria) and fewer potential zones (Stringent Criteria). The former sets a lower threshold in terms of the distance between buildings with a large heat demand (called anchor loads) and numbers of these anchor loads, whilst the latter sets higher threshold resulting in fewer and smaller potential zones being identified.

Potential heat network zones are identified through a linear heat density (LHD) approach, drawing on the demand data from within the Scotland Heat Map. The approach calculates a connection distance for each building's heat demand, based on different LHD criteria. The two main LHD values used are 4,000 kWh/m/yr, known as the Baseline screening, and 8,000 kWh/m/yr, known as the Stringent screening (higher LHD values result in shorter connection distances and therefore provide a more stringent screening of potential). An additional 16,000 kWh/m/yr analysis is also carried out to give greater context to dense urban areas, but this not a primary focus of the assessment.

The analysis involves spatial consideration of heat demands in Scotland and the connection distances that result from the various LHD settings considered. Where the calculated connection distances from two heat demand points are sufficient to link these together, they form a potential heat network zone. Consideration is also given to the number of buildings with high heat demands, known as anchor loads (defined in this work as buildings with at least 500 MWh/yr heat demand in this analysis), which fall into potential zones identified by the LHD analysis. In identifying potential zones, a minimum of two anchor loads are required for Baseline screening and five for Stringent. It should be noted that a heat network could be based around one central heat load, or may not require any anchor loads in certain circumstances. Local authorities will have the opportunity to set different screening criteria, as appropriate to their geographies and circumstances, when developing LHEES.

The analysis identifies 647 potential zones (this is increased to 712 when potential zones are split by local authority boundaries) using the Baseline screening criteria, which contain a total heat demand of 25.7 TWh/yr. It is important to note this demand total is for every property within the potential zones identified and not all buildings will be suitable for connection to heat networks; 14.1 TWh/yr of the total comes from

anchor loads. The Stringent screening identifies 196 potential heat network zones (207 when potential zones are split by local authority boundaries), with a total demand from all buildings within the zones of 13.7 TWh/yr. Of this demand 9.3 TWh/yr comes from anchor loads. This represents 68% of the total demand within potential zones, whilst only 55% of demand comes from anchor loads in the Baseline screening.

Traditionally, district heat networks have focused on large anchor loads and the Stringent screening criteria identifies potential zones that are better aligned to this model (generally in denser urban areas). However, being a national analysis, it is also important to identify potential zones in more rural areas without the same concentrations of anchor loads. The geographic distribution of potential zones identified by the analysis is provided in Figure 0—1, where the differences in settings used to identify potential zones are evident in the outputs for rural areas.

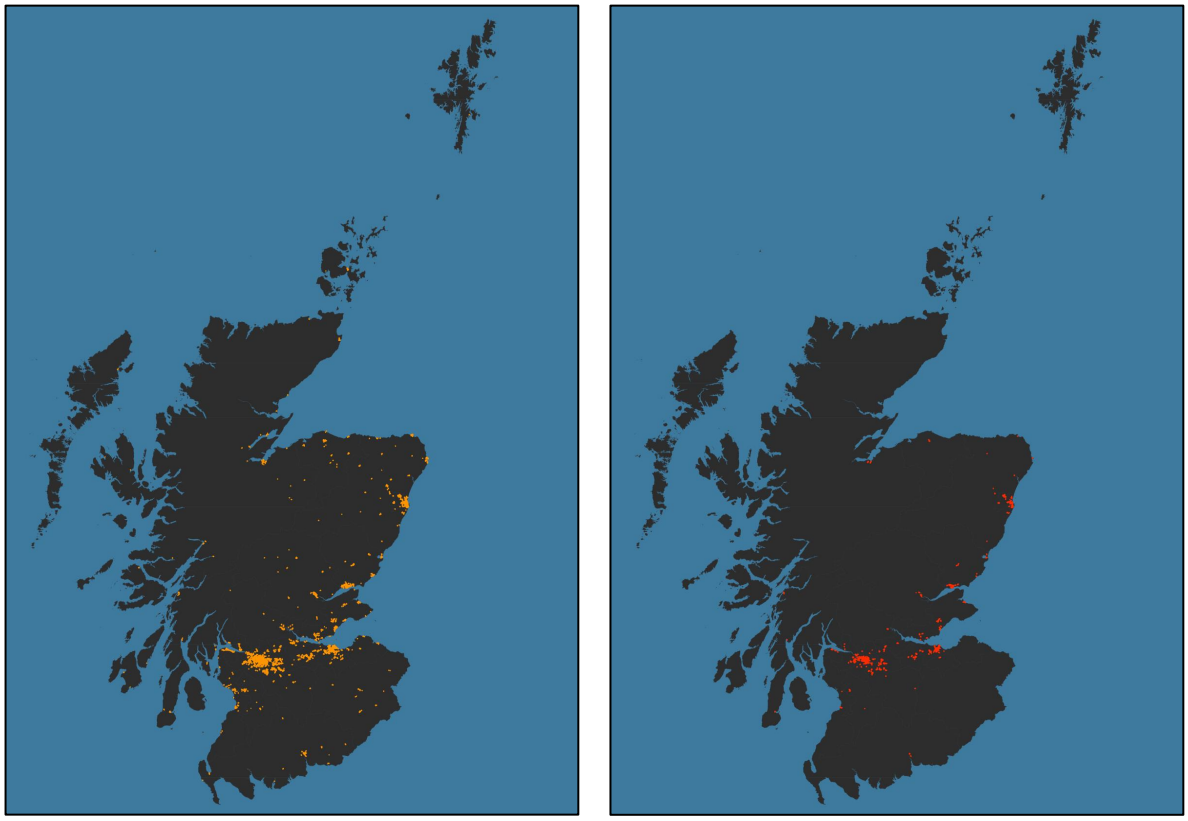


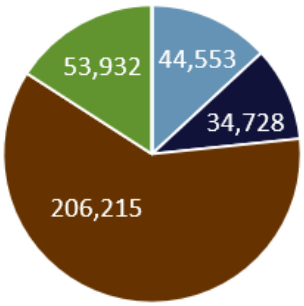
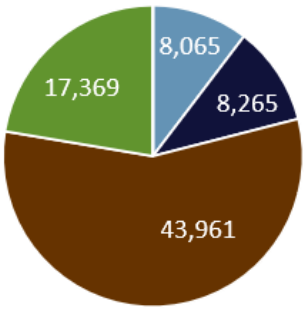
Figure 0—1 Potential heat network zones identified, the image on the left uses Baseline screening criteria and the image on the right Stringent. Larger copies of these images can be found in Figure 5—9 and Figure 5—8, respectively.

Potential heat network zones are focused in the central belt for both the Baseline and Stringent screening of potential zones; having 68% and 76% of the national total heat demand identified in potential heat network zones, respectively.

Although some potential zones are very small, and easier to view on the local authority maps provided alongside this document, the Baseline screening identifies at least one potential heat network zone in every local authority. Six local authorities have no potential zones identified with the Stringent screening criteria[3].

The defined potential zones have various characteristics reported and examined, some key domestic characteristics are summarised in Table 0—1.

Table 0—1 Summary of key domestic characteristics for properties in potential heat network zones.

Characteristic	Baseline screening	Stringent screening
Number of domestic properties	340,000	78,000
Domestic demand	7.1 TWh/yr	2.2 TWh/yr
Domestic properties by tenure ■ < 100 m^2 ■ 100 – 500 m^2 ■ 500 – 1000 m^2 ■ > 1000 m^2		
Households in fuel poverty	91,000 (approximately 26% of domestic properties) with 1.4 TWh/yr heat demand	18,000 (approximately 22% of domestic properties) with 0.4 TWh/yr heat demand
Households in extreme fuel poverty	44,000 (approximately 13% of domestic properties) with 0.8 TWh/yr heat demand	8,000 (approximately 10% of domestic properties) with 0.2 TWh/yr heat demand

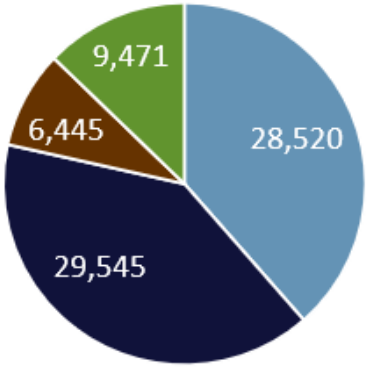
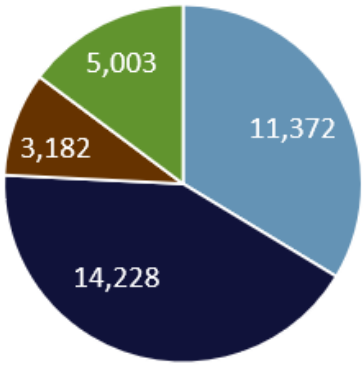
The domestic characteristics highlight the greater significance of domestic demand when Baseline screening is used. This extends to potential zones identified with

[3] These local authority areas are: Clackmannanshire, East Lothian, Na h-Eileanan Siar, Orkney Islands, Scottish Borders and Shetland Islands.

Baseline screening also having a greater prevalence of fuel poverty within households.

A similar summary for non-domestic properties is provided in Table 0—2.

Table 0—2 Summary of key non-domestic characteristics for properties in potential heat network zones.

Characteristic	Baseline screening	Stringent screening
Number of non-domestic properties	74,000	34,000
Non-domestic demand	17.6 TWh/yr	11.1 TWh/yr
Non-domestic properties by floor area < 100 m² 100 – 500 m² 500 – 1000 m² > 1000 m²		
Non-domestic demand totals by floor area	<100 m² – 2.0 TWh/yr, 100 m² to 500 m² – 2.6 TWh/yr 500 m² to 1000 m² – 1.5 TWh/yr >1000 m² – 11.6 TWh/yr	<100 m² – 1.1 TWh/yr 100 m² to 500 m² – 1.5 TWh/yr 500 m² to 1000 m² – 0.7 TWh/yr >1000 m² – 7.7 TWh/yr

Non-domestic total heat demand is dominated by the largest property group (those with floor areas greater than 1000 m²). This is the same for both Baseline and Stringent screening.

This report also compares the outputs of the FNA to the Opportunity areas for district heating networks in the UK: second National Comprehensive Assessment (NCA), undertaken for the whole of the UK by BEIS. The analytical approach to both assessments is similar, with the use of different levels of LHD to determine different levels of screening. The LHD values used in the NCA are similar, but not exact matches, to those used in the FNA. The main difference in the LHD approach taken between the two studies is the FNA puts a cap (250 m) on the maximum connection distance in the LHD model, whilst the NCA model has no cap, meaning extremely

large heat demand sites in the NCA can have connection distances of several kilometres. Other differences in approach include a minimum heat demand of 73 MWh/yr for connection to heat networks in the NCA, which although generally aligning to current practices screens out most domestic properties. Additionally, no minimum anchor load criteria are applied in the NCA.

The NCA analysis identified 17.3 TWh/yr in potential heat network zones using the screening criteria which most closely matches the Baseline screening in this study. This is a substantially lower value (8 TWh/yr lower) than the potential zones identified in the Baseline screening, with the difference mostly due to the minimum threshold demand for connection applied in the NCA. The values are more closely aligned for the equivalent of Stringent screening, 15.0 TWh/yr in the NCA compared to 13.7 TWh/yr in the FNA. This is despite only 9% of equivalent land area being covered in the FNA analysis – showing the value of limiting the LHD to help geographically focus potential heat network zones.

Alongside this report, a detailed set of summary data is provided in Excel files. These provide a detailed breakdown of property characteristics within potential zones for the following geographies:

- National – summaries for all of Scotland
- Cities – for each of Scotland seven cities
- Additional regions – for five additional regions: the central belt, central belt west, central belt east, the Clyde Mission area and the Lanarkshire towns
- Local authority – for each local authority and the largest potential heat network zone (determined by demand) in each local authority

A set of maps presenting the location and extent of potential heat network zones for these geographies is provided alongside the Excel files. There are approximately 150 maps provided in A3 high resolution PDFs. A full description of these outputs is provided in Section 3. The final output supplied is a set of Geographical Information System (GIS) files, showing the extent of the potential zones identified in this analysis.

Additionally, local authority specific outputs from this work have been packaged and shared with respective local authorities as part of the LHEES (Local Heat and Energy Efficiency Strategies) National Assessment activity. These outputs provide a high-

level and initial assessment at a national level – the LHEES process includes sense-checks that draw on the knowledge base of local authorities and will further consider how local factors could impact on potential zones identified by the FNA.

1 Introduction

The First National Assessment of Potential Heat Network Zones (FNA) carries out an initial, automated analysis to identify potential zones for heat networks in Scotland, based on heat demands captured within the Scotland Heat Map. The approach and outputs align to the current methodology for the identification of potential zones for Heat Networks that forms part of the LHEES (Local Heat and Energy Efficiency Strategies) Methodology V03 (August 2021) and was agreed with a Steering Group consisting of Scottish Government representation, with local authority input provided during the development of the LHEES methodology. This report details the base data and methodology used to inform and carry out the FNA, and provides a summary of the initial outputs which are generated through use of Baseline and Stringent criteria, and presented across a range of geographies. A high-level comparison of these outputs is made with the outputs generated from the 'Opportunity areas for district heating networks in the UK: second National Comprehensive Assessment (NCA)' report[4].

The focus of the work is on potential zone identification through assessment of heat demand density, providing an initial assessment of the areas that are most suited to heat networks from a demand density perspective. The analysis does not consider the economic viability or the detailed technical or stakeholder aspects of project opportunities within potential zones. Further detailed assessment is required to understand if heat network projects within potential zones could offer heat to properties at a cost that is competitive against alternative options. It is emphasised that the potential zones identified, and the summaries of key characteristics reported within potential zones, should be considered in this context.

Structure of this report

The work covered within this report is split into two main phases:

[4] Opportunity areas for district heating networks in the UK: second National Comprehensive Assessment

- Phase 1 – covers setup and approach. Within this report the main elements this covers are base data and a non-technical summary of the methodology used for the FNA.
- Phase 2 – this provides an overview of the outputs produced using the methodology in Phase 1. This includes a set of maps, descriptions, Geographical Information System (GIS) data and summary data tables. Phase 2 is split into: Phase 2A, which uses a Baseline set of potential zone identification criteria and; Phase 2B, which uses more Stringent criteria that help to focus the identification of potential zones in heat dense locations. Two sets of criteria are used in Phase 2B: Stringent and an additional set which is more stringent again.

Phase 1 is summarised within Section 2 of this report, whilst Phase 2 is detailed in Sections 3, 4 and 5.

1.1 Background

Policy context

This work provides an initial, national assessment of heat network potential across Scotland. It is framed by two key policy drivers: the ongoing development of Local Heat and Energy Efficiency Strategies (LHEES) and the Heat Networks (Scotland) Act 2021 (the 2021 Act)[5]. Within this context the work aims to support the development of policy and regulations, including informing:

a) The Heat Networks Delivery Plan[6] (as detailed in the 2021 Act), published in March 2022 after public consultation[7] in 2021.
b) The local identification of potential zones for heat networks as part of LHEES.

The work may also support wider policy development.

As set out in the Heat in Buildings Strategy, the Scottish Government is undertaking an LHEES National Assessment, using the LHEES methodology developed with local authorities, and national datasets to carry out a Scotland-wide assessment of

[5] Heat Networks (Scotland) Act 2021
[6] Heat Networks Delivery Plan
[7] Draft Heat Networks Delivery Plan: Consultation Responses

the building stock and identify initial strategic heat decarbonisation zones. Each Scottish local authority has received combined outputs for their local authority area from both the LHEES National Assessment and the First National Assessment of Potential Heat Network Zones.

The Scottish Government is also currently providing funding to 14 local authorities to take the first steps in developing a full, local authority-wide strategy, testing the LHEES methodology and building on the outputs from the national assessments. Based on feedback from this testing, and a review to ensure that in following it local authorities can fulfil the requirement of the 2021 Act to consider whether one or more areas in its area is likely to be particularly suitable for a heat network, the Scottish Government will update the LHEES methodology as required.

It is worth highlighting that the LHEES process includes sense-checks that draw on the knowledge base of local authorities and will consider how local factors could impact on the potential zones identified by the FNA.

Potential next steps – as part of the wider LHEES work being undertaken

It may also be useful for follow-on activity to include the following which are not addressed in the scope of this report:

- consideration of current heat network development pipeline, where these projects are located relative to potential zones and the areas within the potential zones identified that could be catalyst sites for near-term development of heat networks.
- stakeholder engagement to capture wider heat network activity and; engagement with local authorities to test approaches, gather feedback and refresh outputs at a local level.
- the development, testing and use for national assessment of approaches to identify fifth generation heat networks and communal heating.

1.2 Project objectives

Fitting within the background described above there are four broad objectives for the FNA in terms of the Phase 1 and Phase 2 activity.

1. To provide the first national assessment of the size and location of potential zones for large heat networks (indicatively fourth generation[8]). In reference to the 2021 Scotland Heat Networks Act[9], this assessment focuses on the district heat network scale (as defined in Section 1(2) of the Heat Networks (Scotland) Act) and not on communal heating.
2. To provide at a national and local level information about key characteristics of buildings and households within these potential zones.
3. To feed in specific outputs from the analysis to the ongoing LHEES National Assessment project (GIS shapefiles of potential heat network zones from Phase 2A and 2B; maps, summary tables and an accompanying summary note are to be packaged and shared with local authorities).
4. To give an indication of the potential zones with greatest heat and anchor load density (Phase 2B).

[8] These potential zones for heat networks are determined using an adaptation to the LHEES Methodology (V03), which uses demand-led linear heat density analysis alongside consideration of anchor loads to determine potential zones. The potential zones show areas of high heat demand density at a strategic level from consideration of national datasets, prior to consideration of local factors by local authorities (as will be carried out in LHEES) and any site-level feasibility analysis that considers techno-economic appraisal and wider practical and non-technical factors. The LHEES Methodology (V03) considers potential only for fourth generation heat networks and does not include strategic identification of the potential for communal heating systems. Fourth generation heat networks here meaning approximately 65 degree systems, a lower temperature than third generation (<100 degrees), but still with heat generation in a central energy centre such as from using a water source heat pump. Fifth generation networks, such as ambient loops, operate at much lower temperatures again and feature building level heat generation equipment such as heat pumps to deliver heat at the required supply temperature. The Methodology identifies heat network potential zones irrespective of building ownership.

[9] Heat Networks (Scotland) Act 2021(accessed 29/11/2021)

2 Methodology

The approach taken by the FNA to address the objectives listed in Section 1.2 is summarised, in terms of data inputs, outputs and intermediate steps, in Figure 2—1. A summary of the data used within this analysis is provided in Section 2.1 and an overview of the approach in Section 2.2.

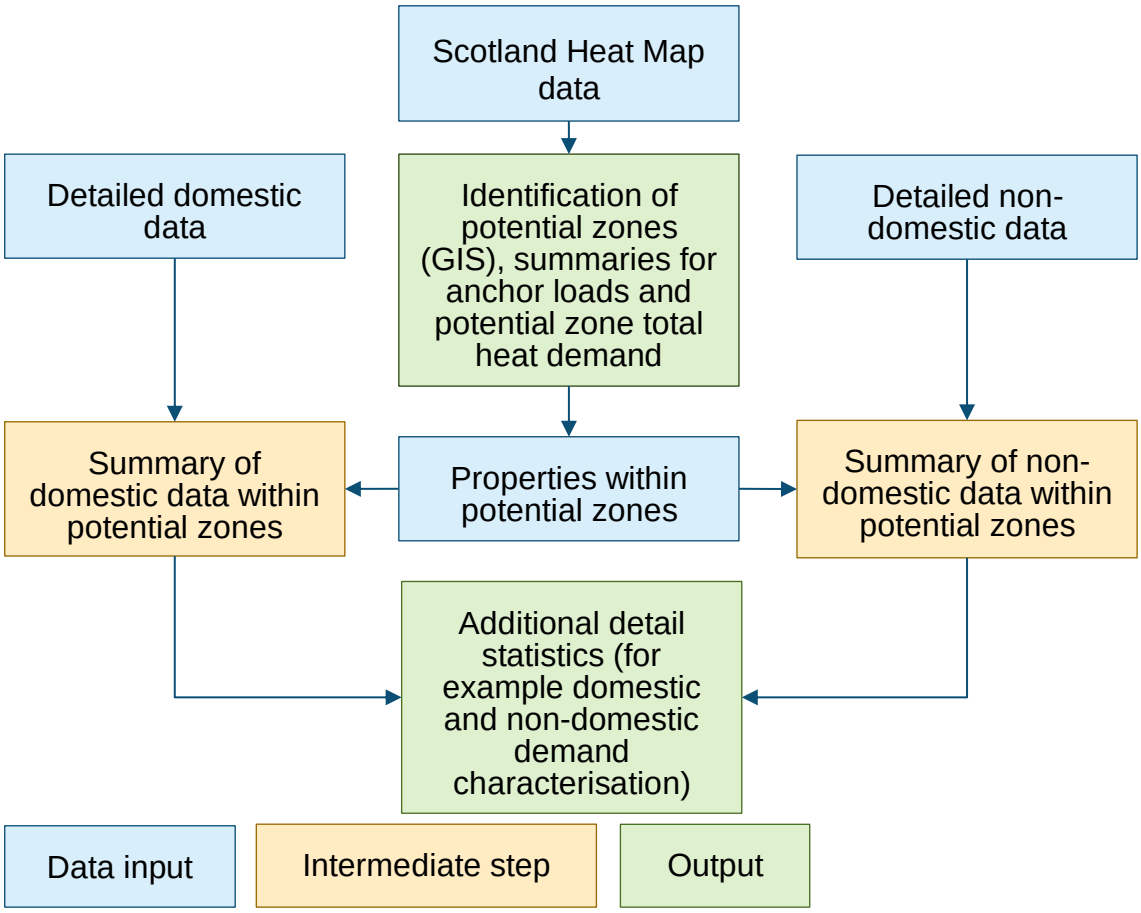


Figure 2—1 Summary of the data inputs and main phases for identifying potential heat network zones and main outputs.

2.1 Base data

Data for initial identification of potential zones for heat networks in the FNA was drawn from three key sources, summarised in Table 2—1. Further detail is provided in Section 2.1.1 on combining the base data to support the analysis.

Table 2—1 Summary of data sources, completeness, accuracy and use.

Source	Use	Completeness	Accuracy
Scotland Heat Map	1. Building level heat demand and locations for domestic and non-domestic, to inform potential zone identification analysis 2. Identification of potential low carbon or waste heat sources 3. Identification of existing heat networks	1. Good coverage of property-level demand data by UPRN 2. Contains some data layers that could support identification of potential low carbon or waste heat sources but not comprehensive 3. Incomplete dataset that identifies point sources but not connected properties	1. Generally higher confidence in local authority demands, lower confidence in other non-domestic demands which are mostly benchmarked by floor area. A note below addresses a fix to some issues with non-domestic heat demand data. 2. Mixed across data layers 3. Mixed
Home Analytics	Detailed data for domestic buildings informing key characteristics	Good coverage of property-level demand data by UPRN	Contains a mix of modelled and actual data. Accuracy suitable for strategic use across wider areas such as larger potential zones.
Non-Domestic Analytics	Detailed data for non-domestic buildings informing key characteristics	Good coverage by UPRN – significant levels of modelled data	Related to coverage, actual data limitations and specific fields in question, accuracy is variable.

Home Analytics data was provided for the whole of Scotland by the Energy Saving Trust. The Scotland Heat Map and Non-Domestic Analytics (previously Non-Domestic Buildings Energy Database) were provided by the Scottish Government. There are three key notes regarding the use of these datasets. The first is that the Non-Domestic Analytics is in early development stages and many of the fields contain significant percentages of modelled data. Work is being done to better understand these limitations, however the fields used to support the FNA analysis are areas with higher data confidence.

The second point relates primarily to non-domestic, property-level heat demand data within the Heat Map and a pre-analysis data cleaning exercise that was carried out before undertaking the FNA activity. The Heat Statistics and Energy Mapping team at Scottish Government identified approximately 30,000 heat demands which should be removed within the 2020 Scotland Heat Map dataset. Although relatively few demand points as a percentage of the national total, these are significant in terms of the analysis outputs as many of the removed heat demands were larger demand values which could be classified as anchor heat loads (definition provided in bullet point below – see section 2.2.1 for more detail):

- Anchor loads are high heat demand properties and key connections which may aid in driving the economics of a potential heat network. In this work anchor loads have a heat demand of at least 500 MWh/yr.

The removal of these demands is either due to duplication of heat demands at functional sites or due to issues with the Basic Land and Property Unit (BLPU) codes. It is anticipated that an equivalent cleaning approach will be adopted in the next version of the Scotland Heat Map, however, this should be clarified with the Heat Statistics and Energy Mapping team at Scottish Government.

The third point is that data in Home Analytics on fuel poverty is used to inform this analysis and is expected to continue to improve over the period 2021-2023, with updates to the modelling method and change to ensure fully compatible with all elements of the new fuel poverty definition.

2.1.1 Combining the base data

UPRN stands for unique property reference number and is a key piece of information for joining datasets together for analysis. UPRNs are noted in relation to each of the base datasets in Table 2—**1**. Each property in Scotland has a UPRN which means data can be matched from the different datasets based on this field to support the analysis.

UPRN values are used to link and then add the key characteristics from the Home Analytics and Non-Domestic Analytics to the Scotland Heat Map demand points. This information is:

- tenure type,
- 8-fold classification of settlement type (these are Large Urban Area, Other Urban Area, Accessible Small Town, Remote Small Town, Very Remote Small Town, Accessible Rural, Remote Rural, and Very Remote Rural)[10],
- non-domestic property type (these are Restaurants and Cafes, Retail and Financial Services, General Industrial, Storage or Distribution, Offices and Workshops, Residential Institutions and Spaces, General Assembly, Non-residential Institutions, and Other),
- commercial building floor area.

Some issues with duplications and missing parameters resulted from combining 3 datasets to support this analysis; these are discussed later in Section 2.2.4.

2.2 Non-technical summary of approach

This non-technical summary provides an overview of key criteria and approaches taken within the FNA analysis. For a more technical and detailed methodology, the "LHEES Stage 4: Generation of Initial Delivery Level Areas. Heat Networks – Generation of Potential Zones (V03)" document should be referred to.[11]

2.2.1 Criteria used to define potential zones

The basis of the analytical approach to potential heat network zone identification in the FNA is the buffering of heat demand properties using a metric known as linear heat density (LHD)[12]. Using LHD in strategic analysis gives a proxy for the connectable distance from a building, this is undertaken by dividing the annual heat demand of the property by the LHD benchmark figure utilised. The "buffering" approach sweeps this connectable distance (radius) around a potential heat load point to create a circular buffer, and where buffers overlap, these form potential zones where other criteria are also met. It should be noted that the buffer radius is capped to 250 meters to avoid very large heat demands indicating connection

[10] Definitions can be found at: Scottish Government Urban Rural Classification 2016
[11] This guidance document has been provided to local authorities but has not been published.
[12] Linear heat density is a means of relating heat demand to distance. For a heat network, it is defined as the total annual heat demand of connected buildings per meter of distribution pipework to these connections.

viability over unrealistic distances. A visual representation of LHD 'buffering' and connection distances for three example heat loads is presented in Figure 2—2. The visualisation presents that the first two properties would be viable connections to each other due to their LHD 'buffers' overlapping, while the third property is not viable for connection.

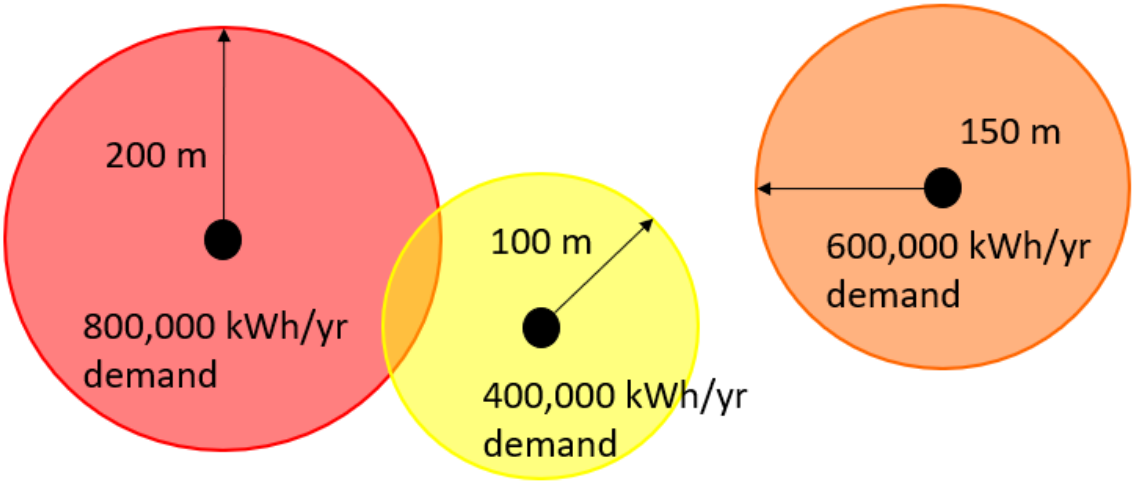


Figure 2—2 Example for LHD buffering utilising the Baseline 4,000 kWh/yr/m benchmark, with the three central points representing heat demand points

For low carbon heat networks in the UK, there are no standard figures for LHD that provide a threshold guide to the economic viability of a heat network, with many of the established LHD benchmarks being based on networks with natural gas combined heat and power plants (CHP) – these networks present different economics to those powered by low carbon technologies such as heat pumps[13]. Given the lack of standard figures to base the analysis upon, the FNA considers a range of LHD values. Two different levels of LHD are primarily used, aligning to a Baseline (Phase 2A) and Stringent (Phase 2B) assessment of potential heat network zones, whose results are also compared against each other. A third, supplementary LHD screening level (16,000 LHD) is also included, with no comparison made between the results of this screening level and the previous two utilised.

[13] One of the main drivers behind the economics of gas CHP supplied heat networks is the benefit gained by generation and use of electricity onsite (whilst also making use of the heat from this process). The historic and current difference in unit price between gas and electricity results in relatively cheap onsite electricity from gas CHP, when compared to the costs of importing electricity from the grid. These benefits are not available to low carbon heat supplied heat networks supplied by heat pumps or surplus / waste heat.

More detailed local analysis would be required to establish tenability of heat networks, likely requiring a level of feasibility assessment to consider connection scenarios, the most suitable low carbon heat supply technology and the economics of the opportunity, including an early estimate of heat supply costs. The LHD values used within the FNA analysis build on those used in similar studies[14].

As well as LHD, the minimum number of anchor loads is the other key consideration that makes up the Baseline and Stringent assessment criteria. LHD regions are then selected for analysis if a threshold of anchor loads within the 'buffered' region is met. Anchor loads are high heat demand properties and key connections on a heat network that usually drive project economics – a core group of anchor loads is often needed to create a heat network opportunity. For the FNA, anchor loads are classified as heat demands of over 500 MWh/yr, in line with many UK studies[15]. These criteria for each screening level are summarised in Table 2—2.

In the Baseline screening, a minimum of 2 anchor loads is used, however it should be noted that a heat network could be based around one central heat load, or may not require any anchor loads in certain circumstances, for example the supply of surplus heat to a housing estate or new development site. Networks that aren't identified as potential zones could still be viable and could be considered as project opportunities at a local level. The use of more stringent screening criteria could be one way to focus early activity on the most strategically important potential heat network zones. A local authority will have the opportunity to set different LHD and anchor load screening criteria, as appropriate to their geographies and circumstances, when developing an LHEES.

[14] Local Heat and Energy Efficiency Strategies (LHEES): phase 1 pilots - technical evaluation: Local Heat and Energy Efficiency Strategies (LHEES): phase 1 pilots - technical evaluation

[15] These studies tend to be based in London – which due to the high number of opportunities has the most significant concentration of heat networks in the UK. Lewisham Council - Making Lewisham carbon neutral by 2030: our climate emergency declaration – see "energy masterplan".

Table 2—2 Different levels of screening criteria used in the FNA.

Screening level	Linear heat density	Anchor loads
Baseline	4,000 kWh/m/yr – this is an industry standard figure for strategic analysis of heat network potential, reflected in other national studies[16]; however it is not based on an understanding of low carbon heat supplied networks operating in Scotland or the UK	Minimum of 2 anchor loads required – this is relatively few compared to the Stringent assessment in order to capture opportunities in rural areas
Stringent	8,000 kWh/m/yr – doubling the Baseline helps identify the more heat dense potential zones in urban areas. It also aligns to more Stringent screening measures adopted in other studies[17]	Minimum of 5 anchor loads required
16,000 LHD	16,000 kWh/m/yr – doubling of the Stringent screening level, used to further interrogate the more heat dense potential zones within urban areas.	Minimum of 5 anchor loads required

In the Stringent screening criteria, 5 anchor loads are used as a minimum. It should be noted a heat network would not necessarily require this many anchor loads to be successful. The FNA analysis identifies potential zones rather than specific networks, as such, more detailed analysis of a potential zone may highlight several small networks to be more appropriate than one large network.

The third LHD 16,000 kWh/m/yr[18] is also used in the FNA alongside the same minimum of 5 anchor loads requirement as the Stringent screening criteria. This is to provide further context and definition, particularly in high heat demand urban areas, where the larger scale heat network opportunities are located.

[16] For example, Local Heat and Energy Efficiency Strategies (LHEES): phase 1 pilots - technical evaluation
[17] For example, Green Heat in Greenspaces - Scotland
[18] This 16,000 kWh/m/yr aligns to the Green Heat in Greenspaces - Scotland study.

The greater the LHD benchmark utilised the smaller the ‘buffered’ connectable distance (radius) around a potential heat load point due to the heat demand of the property being divided by a greater benchmark figure.

2.2.2 Potential zone identification

A detailed summary of the precise analysis steps (including GIS processes) required to produce the outputs generated within this assessment are provided in the “LHEES Stage 4: Generation of Initial Delivery Level Areas. Heat Networks – Generation of Potential Zones (V03)” document. This Section provides an overview of the method for potential zone identification followed in the FNA, as summarised in Figure 2—3. An equivalent approach is followed for the 16,000 kWh/m/yr assessment with a minimum of 5 anchor loads.

A 250 meter restriction is included in the buffering process to prevent large heat demands causing unworkably large buffers (suggesting connection viability across whole towns or cities). It also reduces the undue leverage that large heat demands (with a low confidence level) can have upon results. It should be noted that if analysing supply generation (for example a large waste heat resource) rather than demand, then the removal of this 250 meter buffer restriction could be appropriate.

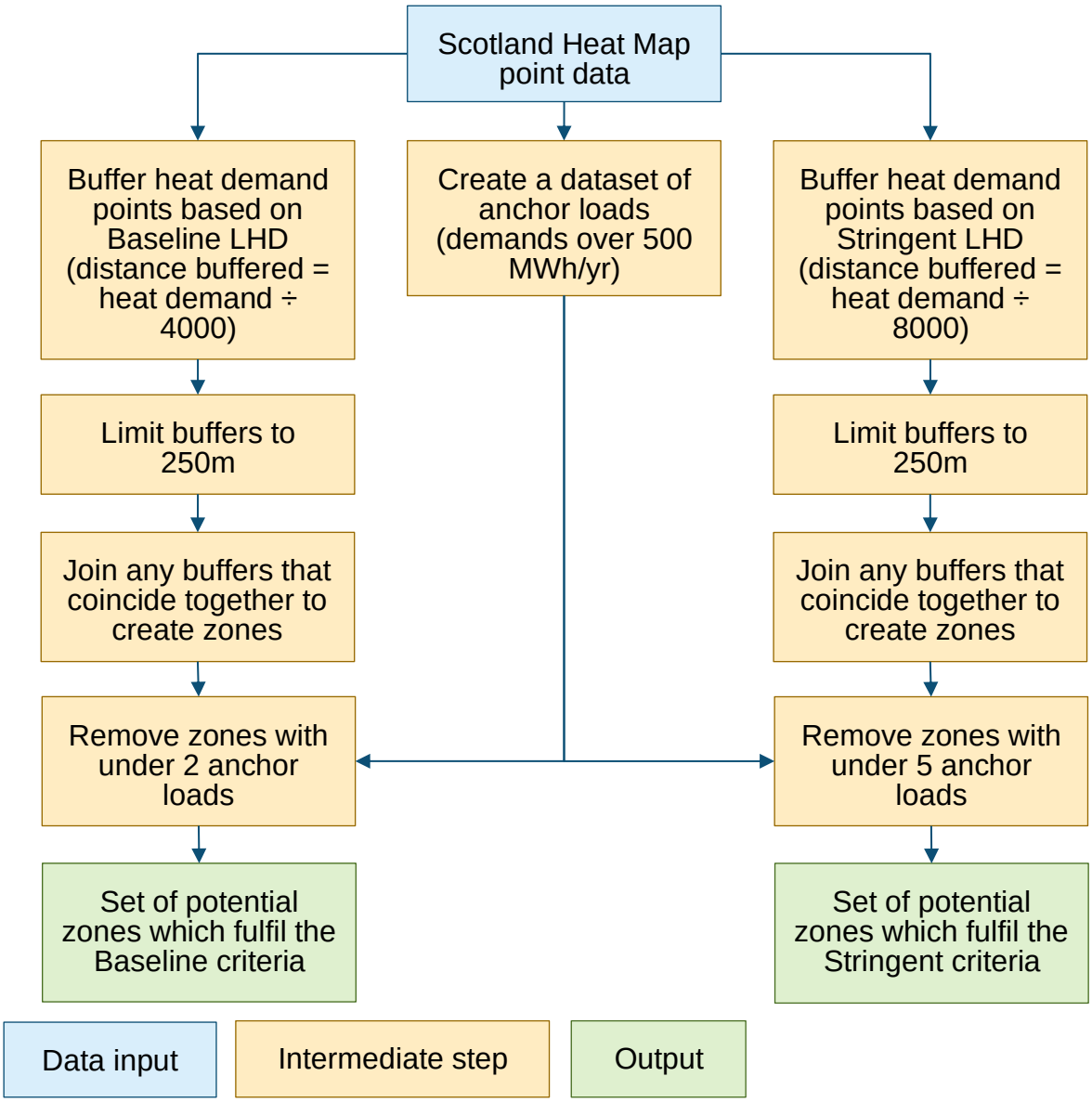


Figure 2—3 Flow chart summarising approach to potential heat network zone identification in the FNA.

Once the potential heat network zones are generated, they can be examined within the context of other key factors, notably:

- **Existing heat networks** – uses the dataset within the Scotland Heat Map. This is a set of point data and is incomplete, so at a local authority level, local knowledge will be an important cross-check of these data. Existing heat networks are considered the priority additional data for display on maps.
- **Low carbon heat supply opportunities** – there is not a single data source that can be used to understand potential low carbon heat supply opportunities at a strategic level. A low carbon heat supply opportunity is

heat which may be extracted for utilisation using low carbon technology, either from waste heat recovery or from the physical geography of the area. Multiple sources can be drawn on, discussed in detail in the LHEES guidance document, these include supply points from the Scotland Heat Map (which is the main data displayed in maps in this assessment), NAEI data which could identify industry that is likely to have large process heat demands (and therefore potential waste heat that could be utilised) and substations, as well as geological information and waterbodies to highlight good heat pump potential.

A comprehensive Scotland wide dataset could assist with future national analysis as well as assisting local authorities with their individual requirements within LHEES and the 2021 Act. This would initially focus on readily available sources i.e. waste sites, waterbodies, green space, geology, large substations, existing point data within the Scotland Heat Map. Other datasets are less readily available are sewer networks and uniform waste heat information from large energy consumers (NAEI data helps identify some but is not definitive). Integration of a dataset like that outlined in *Potential sources of waste heat for heat networks in Scotland*[19] published by ClimateXChange in 2020 would provide a useful starting point for the latter dataset.

The LHEES guidance is being updated to provide a more definitive list of potential data sources (focusing on open source information) to consider for low carbon heat supply opportunities, which will help provide a more definitive approach to collating these data sources.

- **Local Development Plan (LDP) sites** – it is anticipated that local authorities will use their own data to bring in LDP sites. In this instance Improvement Service is the preferred centralised source for national modelling. Displaying too much data on maps, reducing clarity, means LDP sites are not included in the map outputs of the FNA; however, consideration of this information will be important at a local level as new demands of sufficient density can present promising opportunities for the development of heat networks that

[19] Potential sources of waste heat for heat networks in Scotland

are not identified as potential zones by this work. This is demonstrated, for example, by the heat network project for the new Shawfair town[20].

Full details of how this information can be displayed and data sources is provided in Section 3.4 of the "LHEES Stage 4: Generation of Initial Delivery Level Areas. Heat Networks – Generation of Potential Zones (V03)" document.

2.2.2.1 Largest potential heat network zones

Each local authority has been provided with a map and summary information for the largest potential heat network zone in the local authority, as well as a GeoPackage ArcMap file with a layer outlining all identified potential heat network zones. The largest zone being defined as that with the greatest heat demand identified within it. These zones are clipped to local authority boundaries, which means the boundary line between local authorities will form the new potential zone boundary for local authority outputs, where there had previously been overlap of potential zones from one local authority to another in results presented at a national level. If a potential zone crosses a local authority boundary, the heat demand for the zone is proportioned by the zone area (m^2) within each of the local authorities, this process is illustrated in Figure 2—4.

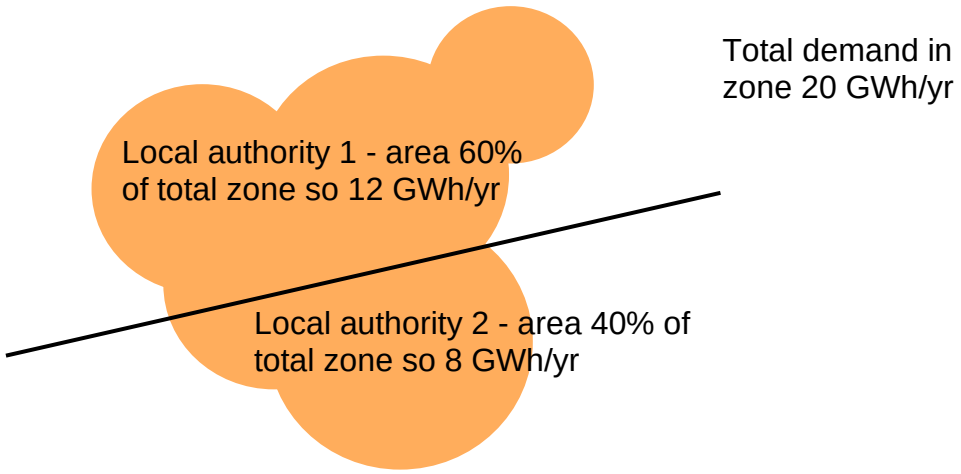


Figure 2—4 Illustration of apportioning of demand in zones which cross local authority boundaries. The orange area represents the potential heat network zone and the black line the local authority boundary.

[20] This potential heat network has not been identified through the FNA methodology, however, it is a significant project. See: Midlothian Council and Vattenfall set up green energy services company

2.2.3 Generation of summary statistics

Note that the process to generate the majority of the summary statistics provided as part of the FNA is not part of the LHEES Methodology documented in “LHEES Stage 4: Generation of Initial Delivery Level Areas. Heat Networks – Generation of Potential Zones (V03)”.

A key set of statistics are generated in the FNA based on all demands which fall within potential heat network zones – the reporting parameters were established through engagement with the Steering Group. A full list of parameters is included in the Potential Heat Network Zones First National Assessment, Summary Tables Excel file appended to this report (FNA Summary Tables). The Scotland Heat Map data is used to provide heat demands whilst the Home Analytics provides other details for domestic properties and the Non-Domestic Analytics provides other information for non-domestic buildings.

Factors examined include total heat demand, number of properties, building tenure, scale of domestic buildings and urban or rural classifications. Most factors are self-explanatory, with key characteristics drawn out in captions for maps produced alongside this report and in Sections 4 and 5.

One factor which requires detail of how it is represented is fuel poverty. Within Home Analytics, a field reports the percentage likelihood of fuel poverty and a separate field reports percentage likelihood of extreme fuel poverty. Two key parameters are examined in the FNA in the context of both fuel poverty and extreme fuel poverty, with the approach taken as outlined below.

- **Number of households** – this is assessed by multiplying each domestic property by the fuel poverty % likelihood figure and then aggregating the count to the desired spatial level. For example, a 60% likelihood for one household and another with a 90% likelihood would combine for a total count of 1.5 households, that is (1 household x 0.6) plus + (1 household x 0.9), making a total of 1.5 households.
- **Heat demand from these households** – this calculation focuses on apportioning the heat demand in a manner that aligns with the household count. This is assessed by multiplying the heat demand for a property by the

percentage likelihood of fuel poverty and aggregating the totals. So, in the example above, if the household with 60% likelihood had an annual demand of 8,000 kWh and the 90% likelihood household 12,000 kWh, the heat demand associated with the household count above is calculated as 4,800 kWh (8000 x 0.6) plus 10,800 kWh (12000 x 0.9), making a total of 15,600 kWh.

Selected summary statistics for each potential heat network zone identified are provided in a GIS file, using both the Baseline and Stringent criteria (an additional set of data generated using a 16,000 kWh/m/yr LHD are also provided). In the 'Potential Heat Network Zones First National Assessment, Summary Tables' Excel file, the full set of summary statistic information is provided at the following resolutions:

- National level
- For each city area (Glasgow, Edinburgh, Aberdeen, Dundee, Perth, Inverness and Stirling)[21]
- For five different additional areas (the Mission Clyde area, the Central Belt, the Eastern Central Belt, the Western Central Belt, and the Lanarkshire towns)
- For each local authority
- For the largest potential zone within each local authority (determined by total heat demand)

2.2.4 Analysis limitations

The limitations of the analysis tend to stem from data quality, most notably for non-domestic demands which have direct influence on the generation of potential zones, but also for existing heat networks, which could inform how potential zones relate to operational networks. The building assessment reports, as envisaged by the 2021 Act, may provide a route to better understanding of non-domestic demands and their potential to connect to heat networks in future. The existing heat networks data used is incomplete and is in point format rather than detailing network layouts, which creates challenges in understanding the extent of existing networks and how these

[21] These are taken from the National Records of Scotland dataset National Records of Scotland: Settlements and Localities Dataset

relate to potential zones. A key consideration for further analysis here is to identify those properties within potential zones that are already connected to a heat network.

It should also be noted that a national level assessment run solely using national datasets is not able to take advantage of local knowledge and information that could influence the identification of potential zones. Local input is recognised as something which needs to be addressed within LHEES, and there are steps within the "LHEES Stage 4: Generation of Initial Delivery Level Areas. Heat Networks – Generation of Potential Zones (V03)" guidance to incorporate local knowledge and sense-checks in the identification of potential zones. This local engagement with the outputs is vital to realise the maximum value of the First National Assessment of Potential Heat Network Zones.

The analysis considers all demands within an identified zone as a potential connection for a heat network. Within the BEIS second National Comprehensive Assessment (NCA) for heat network opportunities[22] a threshold value of 73 MWh/yr is considered the minimum for heat network connection provided within the NCA report. This has meant that a very high percentage of domestic properties will be screened out. This report assumes the inclusion of all demands within a zone to connect to a heat network. This is likely to be an overestimate, as in practice not all buildings are likely to connect.

2.2.4.1 Data mixing

The analysis uses data from the Scotland Heat Map as a basis but cleans and adds data using both Home Analytics and the Non-Domestic Analytics. Particularly in the case of the latter, some data appears in the Scotland Heat Map but not in the Non-Domestic Analytics data. Data from both sources is required to complete the analysis which means some data may not be captured. To minimise this issue potential zones are identified using the Scotland Heat Map data, avoiding missing out potential properties. Potential zone overall demands and anchor loads are analysed using the Scotland Heat Map data. However, statistics for precise domestic and non-domestic or mixed tenure/mixed use information require a demand to appear in either Home Analytics or the Non-Domestic Analytics as well as the Scotland Heat Map dataset.

[22] Opportunity areas for district heating networks in the UK: second National Comprehensive Assessment

This means demands statistics may not always precisely align to the total for potential zones.

This approach was taken in part due to another issue when using the Home Analytics and Non-Domestic Analytics - some properties are duplicated, for example, they appear as both a domestic property and a non-domestic property at UPRN level. To reduce the impact of this issue, domestic heat demands are reported for these points using the Home Analytics data[23], whilst for non-domestic demands the value taken is the Scotland Heat Map demand for that UPRN minus the domestic heat demand. In instances when this would result in a negative heat demand, the non-domestic demand is assumed to equal zero.

Any demands in the Scotland Heat Map which do not have a UPRN in the Home Analytics or Non-Domestic Analytics are still included but not attributed as either domestic or non-domestic demands. This means in summary tables domestic and non-domestic demands will not always add up to the total demand identified. These demands without a non-domestic or domestic label are included in the summary statistics as unattributed heat demand and a number of unattributed properties.

Local authorities carrying out the analysis required for heat networks in the LHEES guidance will not be impacted to such an extent by these issues. The LHEES guidance relies almost entirely on the Scotland Heat Map data, the only exception is any quantification of fuel poverty. This will require the use of Home Analytics data but as it is not trying to capture all demands there will not be the same issues as in this national assessment, which includes greater depth of non-domestic analysis.

2.2.4.2 Potential zones that cross local authority boundaries

In this work multiple potential zones are identified that cross local authority boundary lines. In these instances, potential zones are split and are reported separately for each local authority. The number of anchor loads and demand which falls within a specific local authority is then reported in the local authority level data. This can lead to potential zones being reported that do not fulfil criteria at a local authority level. For example, using the Stringent criteria, one potential zone may have four anchor loads in one local authority and three in another. This means the numbers reported at a

[23] This is only for the analysis looking at domestic properties and mixed use, mixed tenure analysis.

local authority level may not meet the requirements but the potential zone itself does. This is more a factor to be aware of at different reporting levels, than a shortcoming of the analysis.

For local identification and consideration of collaboration opportunities, border zone references are highlighted within the summary tables at a local authority level, can be seen visually as clipped areas within the static output maps provided and can be more closely interrogated using the GIS outputs from the work. Such potential zones present opportunities for collaborative working should any actions be taken forward to progress these.

2.2.5 Comparison to the Opportunity areas for district heating networks (NCA) report.

Alongside this analysis, a UK-wide assessment of heat network potential has been published[24]. The NCA ran multiple LHD scenarios. The LHD values were arrived at based on the economic viability of different heat sources[25]. This source-specific approach varies from the approach taken by the FNA, which focuses on demand to define potential heat network zones. Once the demand-based analysis is carried out in the FNA, potential heat sources are examined in the context of potential heat network zones.

Added to the NCA model is another set of variables which focus on network costs and the heat margin[26]. The LHD values used in the NCA analysis were provided by Arup who carried out the NCA analysis for BEIS. The three core LHD values in the NCA are:

- Low – 2,919 kWh/m/yr
- Medium – 6,607 kWh/m/yr
- High – 18,684 kWh/m/yr

[24] https://www.gov.uk/government/publications/opportunity-areas-for-district-heating-networks-in-the-uk-second-national-comprehensive-assessment

[25] These heat sources include consideration of waste heat opportunities and location specific technologies such as water source heat pumps, however, the majority of heat comes from location agnostic technologies (such as air source heat pumps).

[26] The heat margin is the difference in the cost of heat purchased by the heat network operator and the sale price to the customer.

These values integrate consideration of factors including heat purchase price/heat supply and pipe costs for the network.

The low and medium levels used in the NCA are similar but lower than the Baseline and Stringent LHD values used within the FNA, however, they are broadly analogous. Another difference in the respective approaches is the lack of minimum anchor load requirements or a limit on LHD buffer size in the NCA in the identification of opportunities or potential zones. It should also be noted that the NCA analysis excludes any buildings with a heat demand of less than 73 MWh/yr due to economic viability of connection. Whilst such screening is not unusual for heat network feasibility studies, small loads are not excluded in the FNA. A summary of some of the key characteristics of the two approaches is provided in Figure 2—3.

Table 2—3 Summary of the differences between FNA and NCA (in the central scenario) parameters

Analysis	LHD settings	Anchor loads	Demand filter
FNA	4,000, 8,000 and 16,000 kWh/m/yr used. Adds a 250 m limit to LHD buffer	Defined as a minimum of 500 MWh/y building demand, with a minimum of two for Baseline and three for Stringent and 16,000	No demand filter at a building level
NCA	2,919, 6,607 and 18,684 kWh/m/yr used (in central scenario)	Equivalent value is 73 MWh/yr for a building, requires at least three such loads	Minimum building demand filter of 73 MWh/yr

In general, the two approaches are broadly similar but there are differences in approach that will result in a different set of outputs. The resolution of the NCA outputs which were available and different threshold criteria mean comparisons within this report have a national focus. Factors which are compared in this report are demand, distribution of potential heat network zones across Scotland, and total coverage of potential heat network zones in Scotland.

3 Summary of outputs by geography

This section details the FNA outputs which accompany this report. These are broken down by the two output types:

1) maps with accompanying summary information and;
2) data held in Excel tables.

These outputs are summarised for the four main geographies considered in the FNA: national, additional regions, Scottish cities and local authority.

3.1 Map outputs

The map packs contain high resolution A3 maps in PDF format – suitable for printing for use at workshops. The high resolution of these maps means files are large, approximately 50 MB each, thus it is suggested that only required maps are downloaded rather than the entire map pack.

The three main types of map are:

- Point based – these summarise potential heat network zones as points. Points are shown at the centre of each potential zone, with points having different colours to represent the total heat demand within the potential heat network zone.
- Area based – these show the outline of the potential heat network zones identified. They often group Baseline and Stringent criteria on the same map and in some instances also show potential zones generated using a 16,000 kWh/m/yr LHD radius and a minimum of five anchor loads, to add further context to the most demand dense potential zones.
- Detailed maps – these include similar outputs to the area-based maps but are overlaid with other key additional information. This can include anchor loads (heat demands greater than 500 MWh/yr), existing heat networks, and potential heat sources.

Alongside these maps, a summary of the potential heat network zones covered by the map is provided, this draws out key information from the summary Excel tables.

The majority of maps are for local authority areas so the above three key types of map are illustrated using examples for local authority outputs, with the first example being the point map type in Figure 3—1.

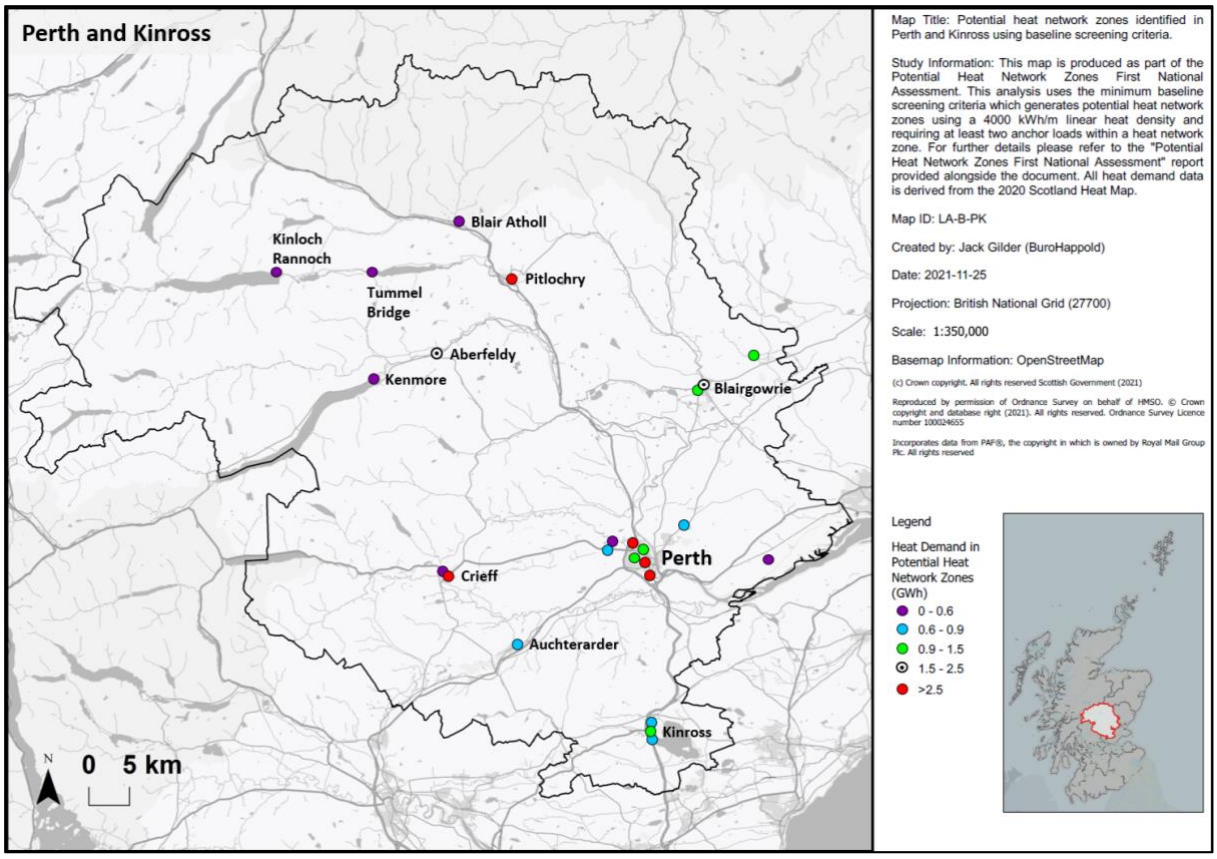


Figure 3—1 Example map output at a local authority level for point-based data[27].

Figure 3—1 shows the central point of heat demands or potential heat network zones but does not define the spatial extent of them. For larger geographic areas this is useful as precise locations of potential zones may be hard to see, as they will be very small compared to the relative geographic area.

At smaller spatial scales, such as more urban local authorities, potential zones can be better represented as precise areas on maps rather than points. An example of an area map is provided in Figure 3—2.

[27] The text in this image will not be legible. A high resolution version of this map with legible text has been provided to the relevant Local Authority.

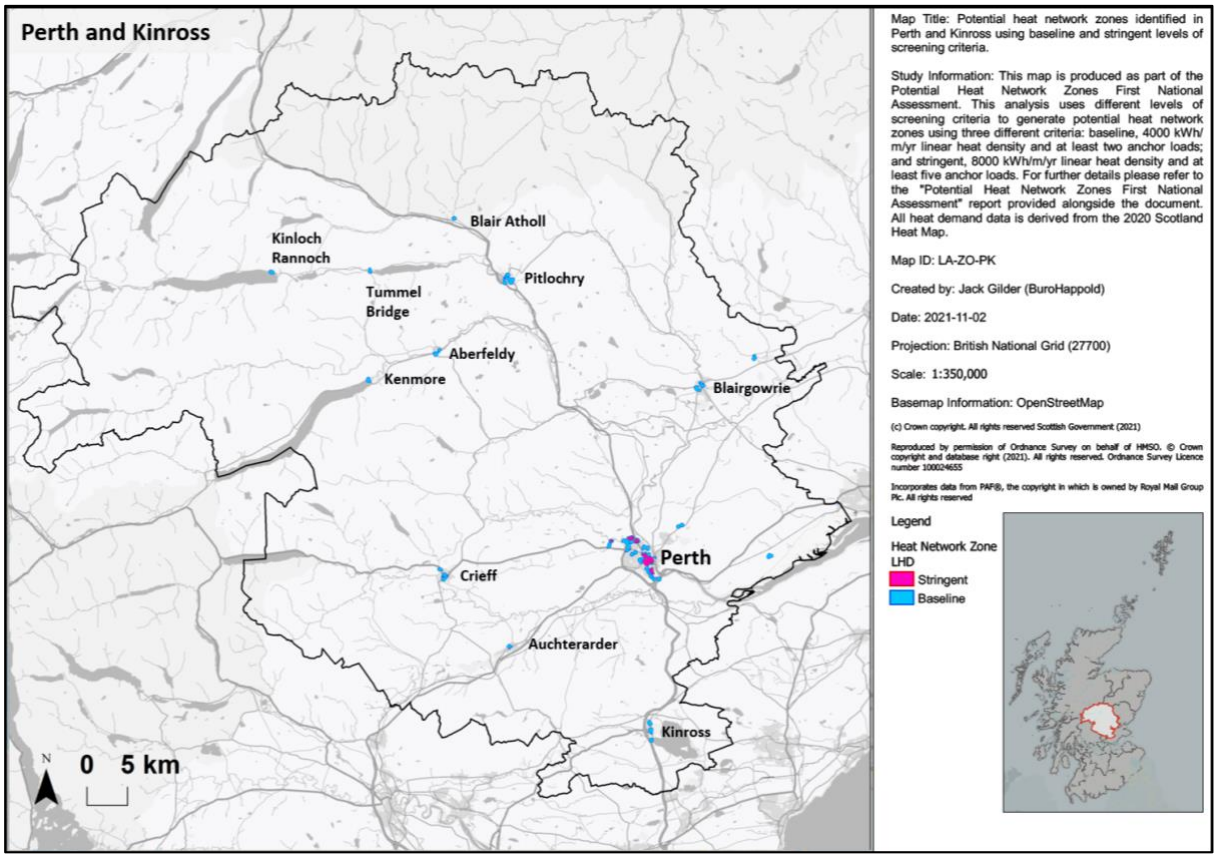


Figure 3—2 Example map output at a local authority level for potential zone areas[28].

This style of map is more suited to smaller, more urban, local authorities than rural ones like the example in Figure 3—2 for Perth and Kinross. However, they are produced in high resolution so it is possible to zoom into specific areas to give an indication of zone extent, see Figure 3—3 for an example.

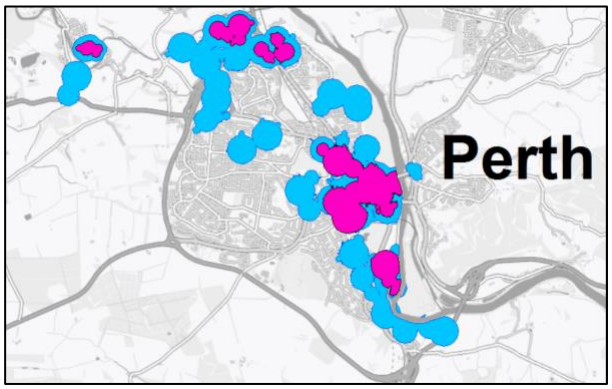


Figure 3—3 Zoomed in section from the potential zone areas map, showing the extent of potential heat network zones in Perth.

[28] The text in this image will not be legible. A high resolution version of this map with legible text has been provided to the relevant Local Authority.

In some instances, the map outputs focus on more granular areas than a local authority. These maps typically show a specific potential zone, where it is also useful to bring in additional detail, for example on anchor loads, nearby existing heat networks or potential heat sources. An example of this detailed map type is provided in Figure 3—4.

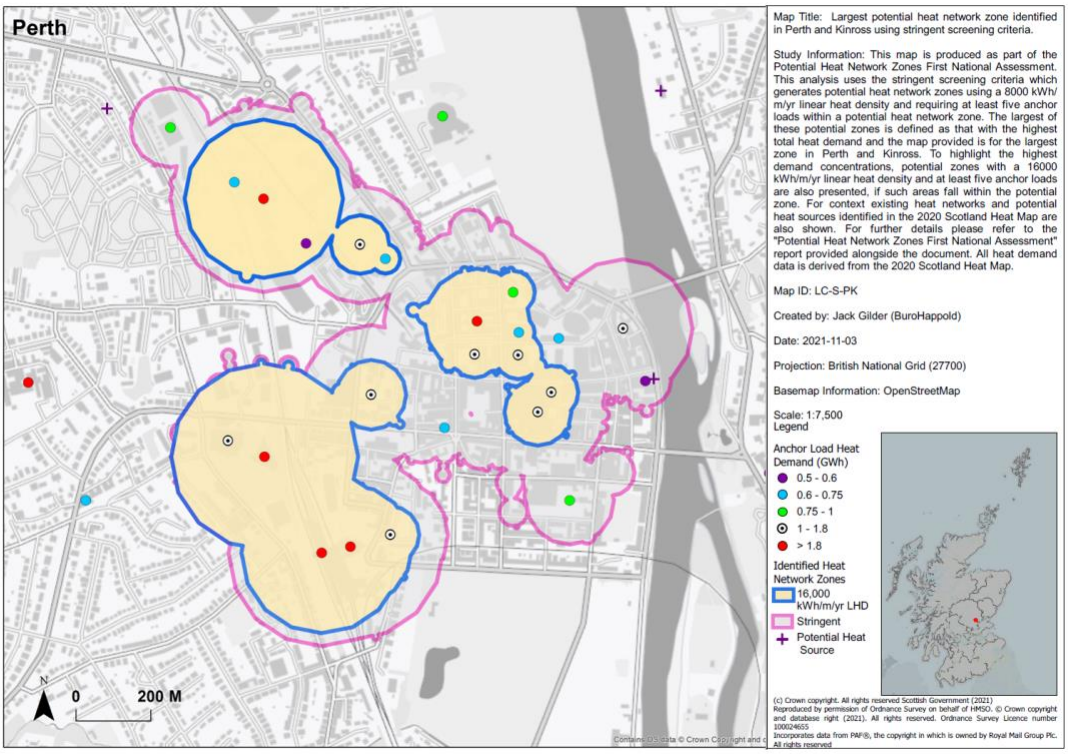


Figure 3—4 Example map output for the largest potential heat network zone identified in a local authority[29].

Showing information like anchor loads on these detailed maps can help inform strategy. Anchor loads provide a backbone of key connection points for a potential network, which will often drive a network's economics. The existing heat networks and potential heat sources are some of the other key considerations in any opportunity identification or zoning process. The base GIS data is not provided with this report but is available on request. It is suggested that a local authority, after review and local sense-check of the outputs, could incorporate further information, such as local development plan outlines and potential low carbon heat sources. This information is not included in these map packs as presenting too much information

[29] The text in this image will not be legible. A high resolution version of this map with legible text has been provided to the relevant Local Authority.

on a printed map can result in them being overly complicated to interpret, instead it is suggested such information would be better viewed dynamically within GIS software.

3.1.1 Map codes

The FNA analysis has nearly 200 associated map outputs. A set of codes have been generated for ease of identification and comparison. These are tabulated in Table 3—3, and follow a few simple rules, provided in Table 3—1.

Table 3—1 FNA analysis map code identification

Code	Identification
B	Baseline screening criteria.
S	Stringent screening criteria.
LA	Local authority geographic scale.
Nat	National geographic scale.
SC	Scottish city geographic scale.
AA	Additional area / region of interest geographic area.
ZO	Zone outlines. These maps show the potential heat network zone areas precisely.
LC	Largest cluster. This equates to the largest potential heat network zone by total heat demand identified in a local authority.

The IDs and description of national level maps are provided in Table 3—2.

Table 3—2 Summary of map ID codes and content at a national level.

Map ID	Map content
Nat-1B	The centroid of each potential heat network zone identified in Scotland using the Baseline screening criteria. Points are graduated by colour to indicate demand.
Nat-1S	The centroid of each potential heat network zone identified in Scotland using the Stringent screening criteria. Points are graduated by colour to indicate demand.
Nat-2B	The total heat demand in potential heat network zones identified using the Baseline screening criteria summed to local authority level.
Nat-2S	The total heat demand in potential heat network zones identified using the Stringent screening criteria summed to local authority level.

The additional regions of Scotland only have one map produced per region and the five codes used are:

- AA-CB (for the whole central belt region),
- AA-CBE (for the eastern area of the central belt),
- AA-CBW (for the western area of the central belt),
- AA-CM (for the Clyde Mission area[30]),
- AA-LT (for the Lanarkshire towns).

These maps show the areas covered by the potential heat network zones identified using the Baseline and Stringent screening criteria.

The Scottish cities also only have one map generated, these seven maps have the following codes:

- SC-AB (for Aberdeen),
- SC-DU (for Dundee),
- SC-ED (for Edinburgh),
- SC-GL (for Glasgow),
- SC-IN (for Inverness),
- SC-PE (for Perth),
- SC-ST (for Stirling).

These maps contain a high level of information, showing the area of potential heat network zones using the Baseline, Stringent and 16,000 LHD screening criteria. Additionally, point level information is also provided for potential heat sources, existing heat networks and anchor loads (these are colour coded to indicate scale of heat demand).

For each local authority (LA) area there are 4 maps provided. With 32 local authorities this provides a total of 128 LA maps. The four different map outputs comprise three covering the whole local authority and one the largest (by heat demand) potential heat network zone in the local authority. These are detailed in Table 3—3, map codes in the table use XX to represent the unique two letter local authority code – these two letter codes are detailed in Table 3—4.

[30] Further analysis of opportunities in the Clyde Mission area is included in the Clyde Mission: Energy Masterplan - Clyde Mission: Energy Masterplan

Table 3—3 ID and content of the 4 maps generated for each local authority.

Map ID	Map content
LA-B-XX	The centroid of each potential heat network zone identified in the LA using the Baseline screening criteria. Points are graduated by colour and size to indicate demand.
LA-S-XX	The centroid of each potential heat network zone identified in the LA using the Stringent screening criteria. Points are graduated by colour and size to indicate demand.
LA-ZO-XX	The area covered by potential heat network zones identified using both the Baseline and Stringent screening criteria. For some more rural LAs this map will be of limited use given the relative size of potential heat network zones compare to the LA as a whole.
LC-S-XX or LC-B-XX	The LC-S-XX map shows the largest (by demand) potential heat network zone identified in the LA using the Stringent screening criteria. For context, potential zones identified using the 16,000 LHD screening criteria (to identify the highest demand density areas) are also displayed, as are three sets of point data: potential heat sources, existing heat networks and anchor loads (graduated by colour). In some LAs there are no potential heat network zones identified using the Stringent screening criteria, in these instances the largest potential heat network zone (by demand) identified using the Baseline screening criteria is shown along with the point data.

Table 3—4 Two letter codes used for each local authority (LA) in map IDs.

LA code	LA name	LA code	LA name
AC	Aberdeen City	In	Inverclyde
Ab	Aberdeenshire	Mi	Midlothian
An	Angus	Mo	Moray
Ar	Argyll and Bute	NS	Na h-Eileanan Siar
CE	City of Edinburgh	NA	North Ayrshire
Cl	Clackmannanshire	NL	North Lanarkshire
DG	Dumfries and Galloway	Or	Orkney Islands
DC	Dundee City	PK	Perth and Kinross
EA	East Ayrshire	Re	Renfrewshire
ED	East Dunbartonshire	SB	Scottish Borders
EL	East Lothian	SI	Shetland Islands
ER	East Renfrewshire	SA	South Ayrshire
Fl	Falkirk	SL	South Lanarkshire
Fi	Fife	St	Stirling
GC	Glasgow City	WD	West Dunbartonshire
Hi	Highland	WL	West Lothian

3.2 Summary Excel tables

The Excel summary information allows key details for potential heat network zone characterisation to be extracted at different geographic scales. Four different Excel workbooks are appended to this report, representing the four main geographic scales:

1. FNA Summary Table – National
2. FNA Summary Table – Additional Areas
3. FNA Summary Table – Cities
4. FNA Summary Table – Local Authorities

The Scottish Government has access to all spatial scales. Each local authority has been given the table containing information for their area.

The first three workbooks all contain a cover sheet and four data tabs:

- Combined – this contains a copy of statistics for potential heat network zones identified using the Baseline and Stringent screening criteria for each geographic area and compares the two (Stringent - Baseline), to allow any differences to be highlighted.
- Baseline – contains statistics for potential heat network zones identified using the Baseline screening criteria.
- Stringent - contains statistics for potential heat network zones identified using the Stringent screening criteria.
- 16,000 LHD - contains statistics for potential heat network zones identified using a 16,000 kWh/m/yr LHD and a minimum of five anchor loads screening criteria.

In front of each tab name is also a description of the geographic scale (for example National, Additional Area and City).

In the local authority Excel workbook, the cover sheet and the standard four tabs are included as is an additional tab labelled Highest Heat Demand Zone. This provides the statistics for the largest (by heat demand) potential heat network zone identified in each local authority. As standard these statistics are derived using a potential heat network zone identified using the Stringent screening criteria. However, in some local authorities there are no potential zones identified using the Stringent criteria, in these cases the Baseline criteria is used instead (a note of this is provided in the Excel workbook).

Sections 3.2.1 to 3.2.10 provide a copy of the Excel table format. These tables are populated with numbers for the whole of Scotland, whilst the information will change, the layout will remain the same for each different geography. Where appropriate, information is provided in the underlying source data that informs the data reported, these are:

- The Scotland Heat Map for the majority of information (heat demand figures, additional information such as waste heat sources, number of properties and buildings, anchor load information)
- Home Analytics version 3.7 for domestic information (fuel poverty information, heritage property indicators – including pre 1919 construction, tenure, rural/urban classification). The fields used are listed in Table 3-5.
- Non-Domestic Analytics (previously Non-Domestic Buildings Energy Database) for non-domestic information (floor area information, use type/class,

pre 1919 construction, rural/urban classification). The fields used are listed in Table 3-5.

Table 3—5 Dataset variables referenced in Home Analytics and the Non-Domestic Analytics (previously Non-Domestic Buildings Energy Database).

Home Analytics	Non-Domestic Analytics (previously Non-Domestic Buildings Energy Database)
8-fold urban/rural classification	8-fold urban/rural classification
Extreme Fuel Poverty Probability	Floor Area
Fuel Poverty Probability	Heat Demand
Heat Demand	Property Age
Listed Building Grade	Property Class
Mixed Tenure	Property Type
Property Age	
Property Tenure	

3.2.1 Summary sections

The summary sections refer to four different main sets of data, these are displayed in the bold text in Figure 3-5 (on the following page).

The “Phase” refers to the analysis criteria used to identify potential zones, this is either:

- Baseline screening (Phase 2A) which is for potential heat network zones identified using the Baseline screening criteria.
- Stringent screening (Phase 2B) which is for potential heat network zones identified using the Stringent screening criteria.
- Screening comparison (Phase 2B vs 2A) this subtracts the values from the potential zones identified using the Baseline screening from the zones identified using the Stringent screening approach, presenting the difference in results between the two screening criteria. This therefore presents results in negative values within the summary tables due to fewer zones and number of properties identified using the Stringent screening criteria.

Phase	Geographical Area	Map Reference Code
Baseline screening (*Phase 2A*)	Scotland	Nat-1B

Summary Statistics			
Zone Summary		Characteristic Summary	
No. zones identified	712	No. domestic properties (within heat network zones)	339,428
Zone area (Ha)	44,426	No. non-domestic properties (within heat network zones)	73,981
Total heat demand (GWh)	25,673	No. mixed tenure properties	101,318
No. properties	421,115	No. mixed use properties	4,359
No. anchor loads	5,486	No. heritage properties	95,204
% of heat from anchor loads	55%	No. fuel poverty households	90,662
		No. pre-1919 properties	126,576
		Unattributed heat demand (GWh)	920
		No. unattributed properties	7,706

Figure 3—5 Copy of summary sections from FNA Summary Table – National Excel document.

The “Geographical Area” refers to the location for which potential heat network zones are summarised in the table. For “FNA Summary Table – National” this will be Scotland; “FNA Summary Table – Additional Areas” will be one of the additional areas or regions examined (for example Lanarkshire towns); “FNA Summary Table – Cities” will be one of Scotland’s seven cities (for example Inverness); and “FNA Summary Table – Local Authorities” will be one of the local authority areas in Scotland (for example Argyll and Bute).

For the summary of the largest potential zone by heat demand provided for each local authority, “Zone ID” replaces “Geographical Area” and details a unique zone ID that aligns to the naming used in the GIS outputs. The convention being two letters to signify the local authority, a unique number for the potential zone (this does not differentiate between local authority so all are unique) and a code to signify if it is Baseline (B) or Stringent (St1). For example, a cluster code for Angus could be An-529-B and for the City of Edinburgh CE-168-St1.

The “Map Reference Code” refers to the map within the accompanying map pack which is most suited to examine alongside the data contained in the table.

The final “Summary Statistics” contains information which was determined by the Steering Group to best summarise the potential heat network zones in each geography. These are split into two main groups:

- Zone Summary – examines the headline figures, such as the number of potential zones identified and the total heat demand.
- Characteristic Summary – presents an overview of the demand within potential heat network zones, such as the number of households in fuel poverty.

3.2.2 Zones across LAs

Some potential zones cross multiple authority areas, which means demand will not be entirely attributed to one local authority. The summary table provides a count of these and the percentage contribution (in terms of count) such potential zones make to the total for the geographic area. A copy of this section of the table is provided in Figure 3—6.

Zones across LAs	
No. zones crossing LA boundaries	% of total zones
30	4%

Figure 3—6 Copy of part of the table showing potential heat network zones in the summary table which cross multiple local authorities, taken from FNA Summary Table – National Excel document.

With the local authority level information an additional column is added to the table, which provides an ID code for the potential heat network zone which falls across a local authority boundary. These potential zones can be examined using this reference through the GIS data which will accompany this report.

3.2.3 Domestic properties

Many different characteristics are examined for domestic properties, for all of these both a precise count and an equivalent percentage is provided. This examines the number of domestic properties, the heat demand for these properties, the number of properties which fit into different settlement classifications (using the Scottish Government 8-fold urban rural classification) with count and heat demand values,

and tenure classifications both with count and heat demand. A copy of the relevant section of the summary table is provided in Figure 3—7.

Number of properties	% of total properties*	Heat load (GWh)	% of heat demand*
339,428	81%	7,118	28%

Domestic Properties				
Domestic Classification	Domestic urban/rural count	% of domestic properties*	Domestic urban/rural heat demand (GWh)	% of domestic heat demand*
Large Urban Area	176,333	52.0%	4,545.0	63.9%
Other Urban Area	116,197	34.2%	1,763.4	24.8%
Accessible Small Town	19,941	5.9%	320.8	4.5%
Remote Small Town	10,089	3.0%	179.6	2.5%
Very Remote Small Town	5,400	1.6%	104.7	1.5%
Accessible Rural	6,577	1.9%	112.2	1.6%
Remote Rural	3,273	1.0%	63.2	0.9%
Very Remote Rural	1,618	0.5%	28.9	0.4%
Total	**339,428**	**100.0%**	**7,117.8**	**100.0%**

Domestic Tenure	Domestic tenures property count	% of domestic properties*	Domestic tenures heat demand (GWh)	% of domestic heat demand*
Local Authority	44,553	13.1%	667.0	9.4%
Housing Association	34,728	10.2%	724.9	10.2%
Owner Occupied	206,215	60.8%	4,446.8	62.5%
Privately Rented	53,932	15.9%	1,279.1	18.0%
Unknown	-	0.0%	-	0.0%
Total	**339,428**	**100.0%**	**7,117.8**	**100.0%**

Figure 3—7 Copy of the part of the table of the domestic properties which fall within potential heat network zones, taken from FNA Summary Table – National Excel document.

3.2.4 *Non-domestic properties*

Many different characteristics are examined for non-domestic properties, for all of these both a precise count and an equivalent percentage is provided. This examines the number of non-domestic properties, the heat demand for these properties, the number of properties which fit into different settlement classifications (using the Scottish Government 8-fold urban rural classification) with count and heat demand values, key non-domestic property use classes[31] with count and heat demand values, and property type, which is taken from a field in Non-Domestic Analytics (previously Non-Domestic Buildings Energy Database) – again this has both a count and heat demand value. A copy of the relevant section of the summary table is provided in Figure 3—8 (below).

Non-Domestic Properties			
Number of properties	% of total properties*	Heat load (GWh)	% of heat demand*
73,981	18%	17,634	69%

Non-Domestic Properties				
Non-Domestic Classification	Non-domestic urban/rural count	% of non-domestic properties*	Non-domestic urban/rural heat demand (GWh)	% of non-domestic heat demand*
Large Urban Area	37,784	51.1%	7,809.3	44.3%
Other Urban Area	25,227	34.1%	6,686.6	37.9%
Accessible Small Town	3,678	5.0%	443.5	2.5%
Remote Small Town	2,486	3.4%	376.7	2.1%
Very Remote Small Town	2,087	2.8%	261.2	1.5%
Accessible Rural	1,274	1.7%	1,522.0	8.6%
Remote Rural	833	1.1%	396.4	2.2%
Very Remote Rural	612	0.8%	138.7	0.8%
Total	**73,981**	**100.0%**	**17,634.4**	**100.0%**

[31] As defined in The Town and Country Planning (Use Classes) (Scotland) Order 1997. Details of classes available at: The Town and Country Planning (Use Classes) (Scotland) Order 1997

Non-Domestic Properties				
Non-Domestic Property Class	Non-domestic property class count	% of non-domestic properties*	Non-domestic property class heat demand (GWh)	% of non-domestic heat demand*
Class 1-3	39,163	52.9%	3,675.8	20.8%
Class 4-6	23,599	31.9%	7,205.7	40.9%
Class 7-9	3,778	5.1%	3,319.2	18.8%
Class 10-11	7,127	9.6%	3,313.6	18.8%
Other	314	0.4%	120.2	0.7%
Total	**73,981**	**100.0%**	**17,634.4**	**100.0%**

Non-Domestic Properties				
Non-Domestic Property Type	Non-domestic property type count	% of non-domestic properties*	Non-domestic property type heat demand (GWh)	% of non-domestic heat demand*
Restaurants and Cafes	6,833	9.2%	469.8	2.7%
Retail and Financial Services	32,330	43.7%	3,205.9	18.2%
General Industrial, Storage or Distribution	5,960	8.1%	2,886.8	16.4%
Offices and Workshops	17,639	23.8%	4,318.8	24.5%
Hotels	2,522	3.4%	2,179.8	12.4%
Residential Institutions and Spaces	1,256	1.7%	1,139.4	6.5%
General Assembly	1,613	2.2%	1,390.9	7.9%
Non-residential Institutions	5,514	7.5%	1,922.7	10.9%
Other	314	0.4%	120.2	0.7%
Total	**73,981**	**100.0%**	**17,634.4**	**100.0%**

Figure 3—8 Copy of part of the table of the non-domestic properties which fall within potential heat network zones, taken from FNA Summary Table – National Excel document.

3.2.5 Mixed-tenure and mixed-use

The mixed-tenure elements of the analysis examine buildings which contain multiple domestic properties with different tenures. This provides a count, what percentage of total domestic properties come from mixed-tenure properties, the total heat demand

from mixed-tenure properties and how this compares as a percentage to the total heat demand from domestic properties. If a property is classified as mixed-tenure or not is captured by a field included within the Home Analytics dataset.

Mixed-use examines buildings with multiple non-domestic properties (this is classed as “Non-domestic only”) and buildings with a mix of non-domestic and domestic properties (classed as “Mixed”). Within these two groups a property count, a percentage of total heat demands (or properties) mixed-use properties make up of the total properties within the potential heat network zones, the total demand from these properties and what percentage of total demand within the potential heat network zones this equates to. A “Mixed” mixed-use property was identified by if the parent UPRN associated to a property was present in both the Home Analytics and Non-Domestic Analytics datasets. A “Non-Domestic” mixed-use property however was identified if the parent UPRN associated to the property firstly wasn’t present in Home Analytics and the “property types” associated to the parent UPRN were greater than 1.

A copy of the relevant section of the summary table is provided in Figure 3-9.

Mixed-tenure and mixed-use buildings				
Building / property typology classification	Mixed-tenure property count	Mixed-tenure % of domestic properties*	Mixed-tenure heat demand (GWh)	Mixed-tenure % of domestic heat demand*
Domestic only	101,318	29.2%	3,009.7	37.4%
Non-domestic only	-	-	-	-
Mixed	-	-	-	-
Total	-	-	-	-

Mixed-tenure and mixed-use buildings			
Mixed-use property count	Mixed-use % of all properties*	Mixed-use heat demand (GWh)	Mixed-use % of heat demand*
-	-	-	-
1,957	0.5%	3,909.4	15.2%
2,402	0.6%	114.6	0.4%
4,359	**1.0%**	**4,024.0**	**15.7%**

Figure 3—9 Copy of part of the table of the mixed-tenure and mixed-use properties which fall within potential heat network zones, taken from FNA Summary Table – National Excel document.

3.2.6 *Heritage Properties*

This heritage properties section uses three specific designations to provide information about buildings with heritage designation, these are:

- Listed properties (information is only available for domestic properties)
- Properties within conservation areas
- Properties within world heritage sites

The table also provides information as to the number of properties which have at least one of these characteristics, as they are not mutually exclusive. Again, the characteristics examined are: the number of properties, percentage of properties compared to the potential zone/zones as a whole, the heat demand from designated heritage properties and the percentage of demand this is, compared to the total for the potential zone/zones. A copy of the information is provided in Figure 3—10.

Heritage Properties				
Heritage type	No. properties	% of properties*	Heritage property heat demand (GWh)	% of heat demand*
Listed property (domestic only)	21,540	6.2%	759.7	9.5%
Within conserv. areas	92,830	22.0%	6,403.2	24.9%
Within world heritage sites	10,131	2.4%	631.24	2.5%
Either one of three criteria	**95,204**	**22.6%**	**6,496.5**	**25.3%**

Figure 3—10 Copy of part of the table of the heritage properties which fall within potential heat network zones, taken from FNA Summary Table – National Excel document.

This is not an exhaustive list and further proxies are examined in Section 3.2.9.

3.2.7 *Non-domestic Property Area*

Non-domestic property area information is provided in four key categories: < 100 m^2, 100 - 500 m^2, 500 - 1000 m^2 and > 1000 m^2. Again, characteristics examined are: the number of properties, percentage of properties compared to the potential zone/zones as a whole, the heat demand from non-domestic properties with different floor areas and the percentage of demand this is, compared to the total for the potential zone/zones. A copy of this part of the table is provided in Figure 3—11.

Non-Domestic Property Area				
Floor area (m^2)	No. of properties	% of non-domestic properties*	Heat demand (GWh/yr)	% of non-domestic heat demand*
< 100 m2	28,520	38.6%	1,955.1	11.1%
100 - 500 m2	29,545	39.9%	2,639.9	15.0%
500 - 1000 m2	6,445	8.7%	1,450.8	8.2%
> 1000 m2	9,471	12.8%	11,588.6	65.7%
Total	**73,981**	**100.0%**	**17,634.4**	**100.0%**

Figure 3—11 Copy of part of the table of the non-domestic property area which fall within potential heat network zones, taken from FNA Summary Table – National Excel document.

3.2.8 Fuel Poverty

A summary of the estimated prevalence of fuel poverty within different potential heat network zones is also provided. This examines both fuel poverty and extreme fuel poverty using Home Analytics data. Data in Home Analytics on fuel poverty is expected to continue to improve over the period 2021-2023, with updates to the modelling method and change to ensure fully compatible with all elements of the new fuel poverty definition. The four standard characteristics are provided: number of properties, percentage of properties compared to the potential zone/zones as a whole, the heat demand from fuel poor households and the percentage of demand this is, compared to the total for the potential zone/zones. The approach undertaken to calculate these values was presented previously within Section 2.2.3. A copy of the relevant part of the table is provided in Figure 3—12.

Fuel Poverty				
Estimated number of domestic properties classified as their householders living under:	No. properties	% of domestic properties*	Heat demand (GWh)	% of heat demand*
Fuel poverty (fuel bill >10% income after housing)	90,662	26.1%	1,378.5	17.1%
Extreme fuel poverty (fuel bill >20% income after housing)	44,106	12.7%	782.6	9.7%

Figure 3—12 Copy of part of the table of the characteristics of households in fuel poverty which fall within potential heat network zones, taken from FNA Summary Table – National Excel document.

3.2.9 *Built before 1919*

Properties constructed before 1919 are examined in the table as a proxy for undesignated heritage properties. These are useful to examine alongside the heritage properties identified within Section 3.2.6 utilising three different heritage designations as there are likely to be similarities between the properties which fall into these two groups. Like designated heritage properties, these properties are of interest due to their construction type and the implications this has for demand characteristics and sensitivities to changes such as extensive retrofit. Again, the four standard characteristics are provided: number of properties, percentage of properties compared to the potential zone/zones as a whole, the heat demand of properties built before 1919 and the percentage of demand this is, compared to the total for the potential zone/zones. A copy of the relevant part of the table is provided in Figure 3—13.

Built before 1919				
Built before 1919	No. properties	% of properties*	Heat demand (GWh/yr)	% of heat demand*
Domestic pre-1919	86,792	25.0%	2,977.1	37.0%
Non-domestic pre-1919	39,784	53.8%	5,502.6	31.2%
Total	**126,576**	**30.1%**	**8,479.8**	**33.0%**

Figure 3—13 Copy of part of the table of the characteristics of properties built pre-1919 within potential heat network zones, taken from FNA Summary Table – National Excel document.

3.2.10 *Demand losses*

The final factor covered within the summary table are losses through transmission and distribution in a heat network. These are assumed to be 10% of the total demand within a potential heat network zone, to give an initial indicative figure[32]. Once the heat loss figure is calculated it is added to the total heat demand within the potential heat network zone, to give the total heat generation which would be required to supply the potential heat network zone. Demand losses are an important consideration in relation to the targets set out within the Heat Networks (Scotland)

[32] CIBSE CP1 Heat Networks: Code of Practice for the UK (2020)

Act, which are set in terms of heat supplied as opposed to being set in the context of the demand of connected properties, meaning demand losses need to be factored in.

A copy of this part of the table is provided in Figure 3—14.

Demand Losses	
Supply type	Heat supply (GWh/yr)
Total load demand	25,672.5
Anchor load demand	14,074.9
Distribution losses	2,567.3
Total demand	**28,239.8**

Figure 3—14 Copy of the part of the table of the demand losses summary within potential heat network zones, taken from FNA Summary Table – National Excel document.

4 Summary analysis – Baseline criteria

This Section details the key trends and outputs from the First National Assessment of Potential Heat Network Zones using the Baseline screening criteria (a linear heat density of 4,000 kWh/m/yr and at least two anchor loads). This is not an exhaustive analysis and is focused at the national level primarily.

4.1 Characterisation of demands - Baseline

The Baseline screening criteria identifies 647 potential heat network zones (712 if split by local authority boundaries). These cover 44,426 Ha with approximately 25.7 TWh of heat demand within potential heat network zones (55% or 14.1 TWh/yr comes from anchor loads – some of which are likely to already be connected to heat networks). This is approximately 32% of the Scottish total of approximately 79 TWh/yr heat demand in 2020[33] (this value is a national figure from a different source; the total for the Scotland Heat Map is 62 TWh/yr, differences are due in part to factors like consideration of process heat being greater in the national data rather than point level data in the Scotland Heat Map). However, it should be noted that whilst a property falls within a potential zone it may not be viable for connection; this demand total is merely to establish the upper band of demand within potential zones to consider.

421,000 different demand properties fall within these Baseline potential zones, with 18% being non-domestic and the remaining 81% domestic, the remaining 1% was unattributed loads. A breakdown of these 340,000 domestic properties by tenure is provided in Figure 4—1.

[33] Scottish Energy Statistics Hub Share of renewable heat of non-electrical heat demand: 2008-2020

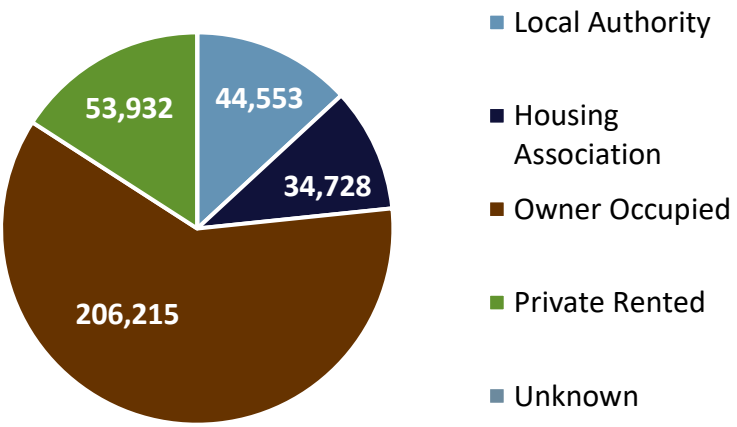


Figure 4—1 Pie chart of the domestic tenure within potential heat network zones. Property counts are provided for the relevant segments.

Owner occupied is the largest overall share of properties falling within the Baseline potential zones at 61%, matching the national percentage of properties for this tenure. The private rented sector averages 13% of properties nationally, and 16% of domestic properties that fall within potential heat network zones are of this tenure. This is significant as the private rented sector has historically been perceived as the hardest to engage with in regard to uptake of low carbon technology.

Domestic demand by tenure broadly matches the split seen by property count. Local authority ownership makes up 9.4% of domestic heat demand (667 GWh/yr), housing association 10.2% of domestic heat demand (725 GWh/yr), owner occupied 62.4% of domestic demand (4,447 GWh/yr) and privately rented the remaining 18% (1,279 GWh/yr).

Although making up the vast majority of the property counts for Baseline potential zones, domestic properties falling within potential zones only make up approximately 28% (7.1 TWh) of the heat demand share. This is lower than the 43% share of national heat demand, with the lower proportion due to residential areas being far away from major anchor loads and thus falling outside the buffers around the anchor loads that define potential zones.

The 74,000 non-domestic heat demands that fall within Baseline potential heat network zones make up the remaining 69% approximately (17.6 TWh) of heat demand falling within potential zones (domestic and non-domestic load percentage

do not add up to 100 due to the Scotland Heat Map data not aligning precisely to the detailed domestic and non-domestic datasets) and have been characterised by building size (using floor area). The breakdown of these in terms of property count by floor area category is provided in Figure 4—2.

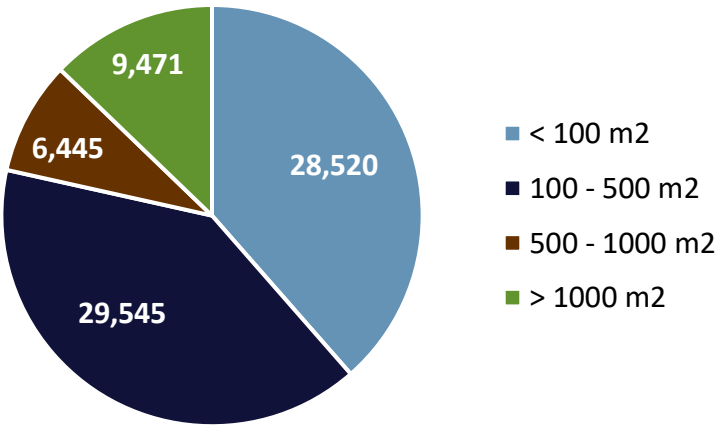


Figure 4—2 Pie chart of the count of non-domestic properties of different building sizes.

Although relatively low in count (9,471), the largest non-domestic buildings (by floor area, > 1000 m^2) do have a large share (65.7%) of the total non-domestic demand relating to 11,589 GWh/yr (see Figure 4—3).

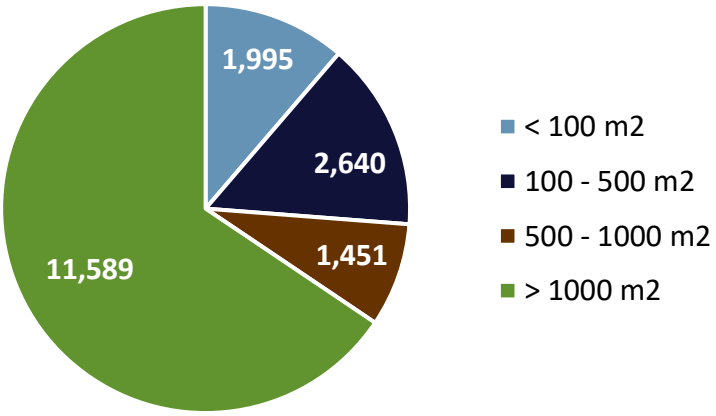


Figure 4—3 Pie chart of the non-domestic heat demand (GWh/yr) in potential heat network zones by building size.

The relatively high proportion of these large buildings is to be expected, as by being larger they will tend to have a higher heat demand. Furthermore, this larger demand means they are more likely to be anchor loads and thus have a greater likelihood of being within a potential heat network zone.

In some situations, buildings will contain multiple properties, which can be a mix of domestic and non-domestic, multiple types of non-domestic use and multiple domestic tenure types. In these instances, there will be specific considerations and opportunities in connecting a building to a heat network. At a national level there are approximately 106,000 (25%) such properties within potential heat network zones identified with the Baseline criteria, with a total heat demand of 7 TWh or approximately 28% of the total demand identified within Baseline potential heat network zones.

95,000 properties (23%) within Baseline potential heat network zones have some form of heritage designation (within the heritage property section of this methodology, the three groups of building designation are considered: listed buildings, within a conservation area, and within a world heritage site), these have a total demand of approximately 6.5 TWh or 25% of total demand identified within Baseline potential heat network zones. Properties built pre-1919, which can act as a proxy for heritage buildings without designation, make up approximately 8.5 TWh (approximately 3 TWh domestic and 5.5 TWh non-domestic) of heat demand within potential zones from 127,000 total properties (approximately 69% of which are domestic). It should be noted that there will be properties which are counted both within the designated heritage status measures and the pre-1919 heritage building proxy, so these values should not be aggregated.

In some instances, potential heat network zones fall within multiple local authority boundaries. In such cases, to realise the maximum potential of these opportunities, local authorities will need to coordinate consideration of these. Such cross-boundary potential zones would not be identified if a local authority were to carry out this analysis, as the national data would not be available. A total of 30 potential zones fall within two or more local authority areas with the Baseline criteria. This is approximately 4% of the total potential heat network zones identified.

The final characteristic considered is fuel poverty. This can add considerable sensitivity to how a potential heat network is taken forward. Within the potential heat network zones identified at the Baseline criteria, an estimate of 26.1% of total domestic properties are households in fuel poverty (approximately 91 thousand households and 1,400 GWh/yr heat demand) and 12.7% of households in extreme fuel poverty (approximately 44 thousand households and 800 GWh/yr heat demand).

4.2 Characterisation of geographic distribution - Baseline

Potential heat network zones are focused, as would be expected, in the more urban areas of Scotland – especially within the central belt. This is shown in Figure 4—4, which maps the potential heat network zones identified across Scotland, a full A3 version of this image can be found in the map pack (under the map ID Nat-1B).

In analysis of the central belt area, it contained approximately 68% of the national demand in potential heat network zones identified using the Baseline criteria, despite covering only approximately 9% of the land mass of Scotland.

Other than the central belt there is a general focus of potential zones being around the coastline, matching the general trend for urban development in such areas. It should be emphasised at this point that some demands are not captured within the Scotland Heat Map (e.g. process heat loads) or are very isolated from other demands. This can result in some areas where you would expect to see a potential zone not being flagged. In these instances when local authorities review their own opportunities local knowledge will be key to overcoming such information gaps.

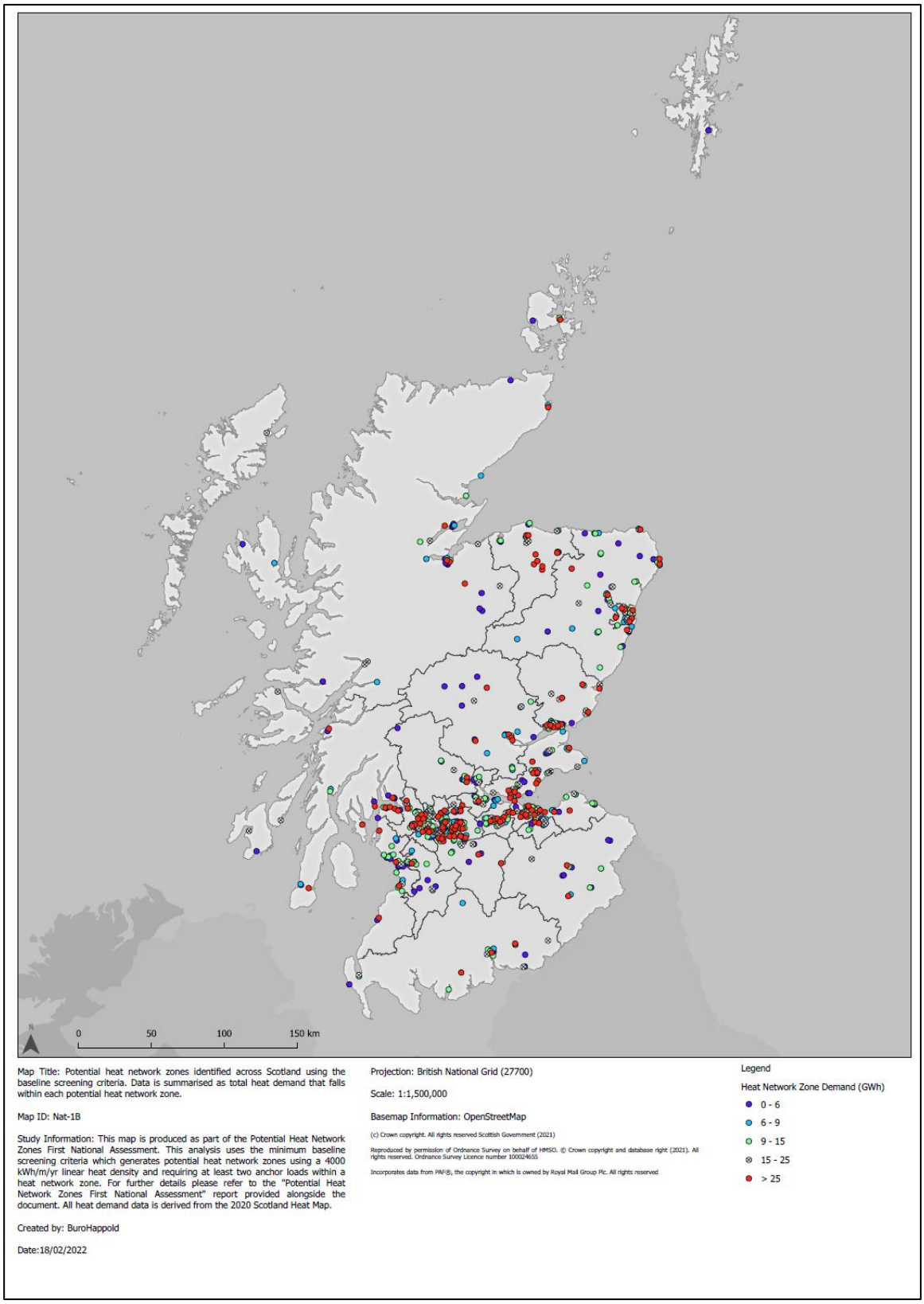


Figure 4—4 Potential heat network zones across Scotland, identified using the Baseline criteria.[34].

[34] The text in this image will not be legible. A high resolution version of this map with legible text is available in map Nat-1B in the accompanying map pack.

These point-based heat network zones can be attributed to the different local authority areas within Scotland, as presented in Figure 4—5 (see map ID Nat-2B in the map pack).

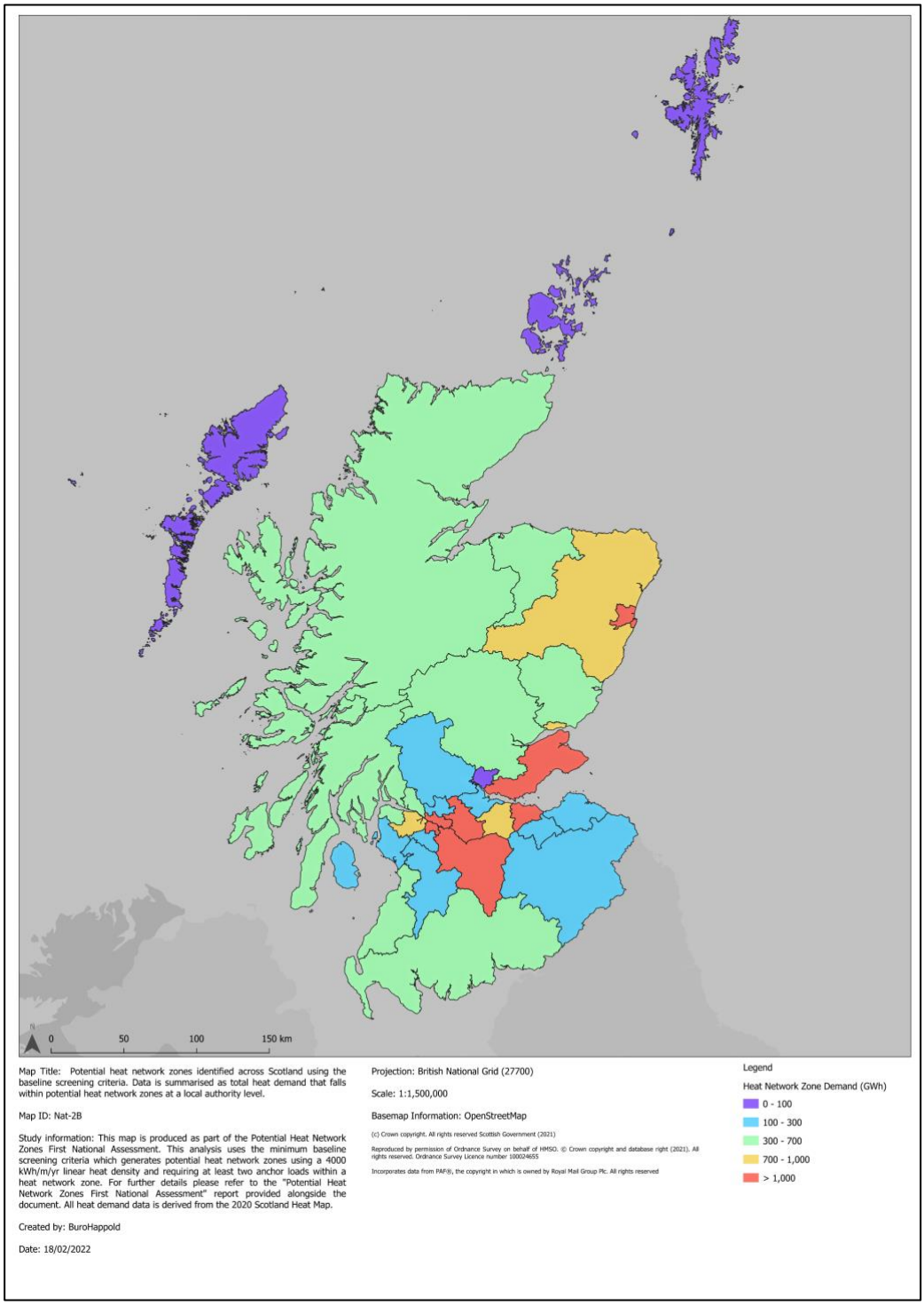


Figure 4—5 Potential heat network zones across Scotland, identified using the Baseline criteria and aggregated to local authority level.[35].

[35] The text in this image will not be legible. A high resolution version of this map with legible text is available in map Nat-2B in the accompanying map pack.

Figure 4—5 highlights that rural areas without large towns and cities often have less heat network potential, notably local authority areas which are entirely made up of islands. These island areas tend to have far lower populations so the total demand available for potential heat network zones will be lower.

A more detailed analysis is also possible, with demands being reported in the context of their rural/urban classification. The breakdown of demands for heat network zones according to the Baseline classification is shown in Figure 4—6[36].

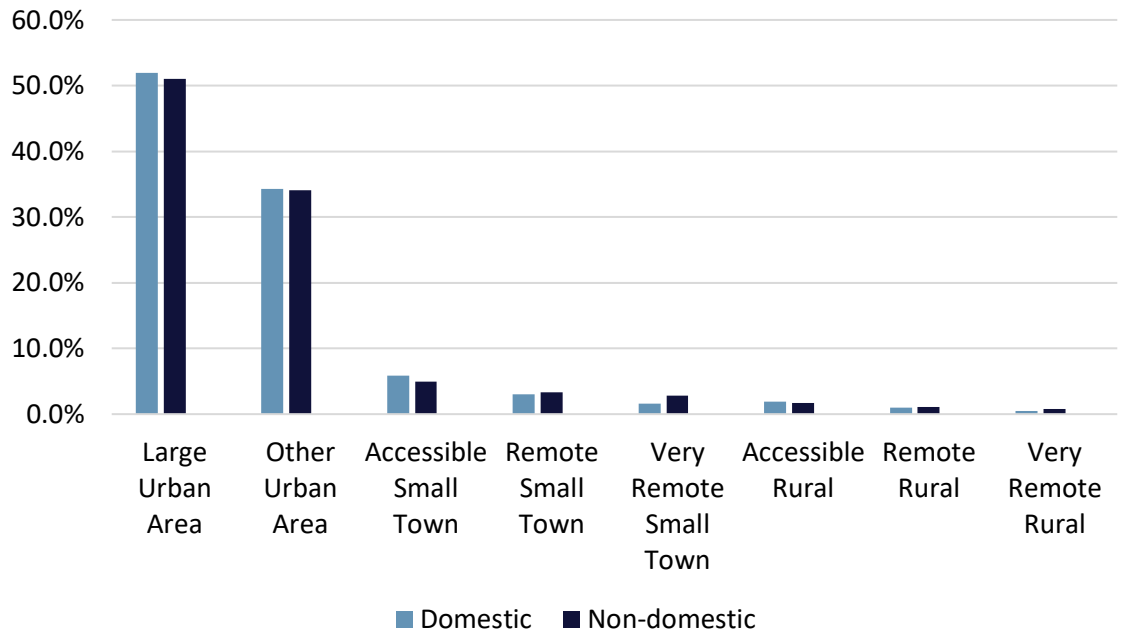


Figure 4—6 Percentage of properties (split by domestic and non-domestic categories) which fall within different rural/urban classifications in potential heat network zone identified using Baseline criteria.

The influence of being in a more urban area is large for both domestic and non-domestic properties but greater for domestic than non-domestic properties. This is in part due to potential heat network zones being identified using a linear heat density approach. This means that larger demands (which will more often be non-domestic) determine the extent of potential heat network zones and thus fall within them, this will have a greater impact on percentage of demand share in more sparsely developed areas.

[36] Scottish Government Urban Rural Classification 2016

5 Summary analysis – Stringent criteria

This Section details the key trends and outputs from the First National Assessment of Potential Heat Network Zones using the Stringent screening criteria (a linear heat density of 8,000 kWh/m/yr and at least five anchor loads). This is not an exhaustive analysis and is focused at the national level primarily.

At the end of this Section a comparison with the NCA analysis is presented. This comparison is carried out here as the NCA analysis better aligns to the stringent methodology than the Baseline. However, some material is presented from the Baseline analysis to aid the comparison.

5.1 Characterisation of demands - Stringent

The Stringent screening criteria identifies approximately 13.7 TWh of heat demand (68% or 9.3 TWh/yr comes from anchor loads – some of which are likely to already be connected to heat networks). These fall within 196 potential heat network zones (207 if split by local authority), covering 14,500 Ha. This is a large percentage of the Scottish total heat demand of approximately 79 TWh/yr (approximately 17%). However, it should be noted that whilst a property falls within a zone it may not be viable for connection, this demand total is merely to establish the upper band of demand to consider.

Approximately 115,000 different properties fall within Stringent potential zones, with 29% being non-domestic (contributing 11 TWh of annual demand) and the remaining 68% domestic (contributing 2.2 TWh of annual demand). This represents a shift towards a greater non-domestic share than with the Baseline criteria. This shift is due to a greater reliance on anchor loads (which tend to be non-domestic) and high LHD values meaning potential zones are less likely to extend into residential areas.

A breakdown of the total number of domestic properties (77,660) by tenure is provided in Figure 5—1.

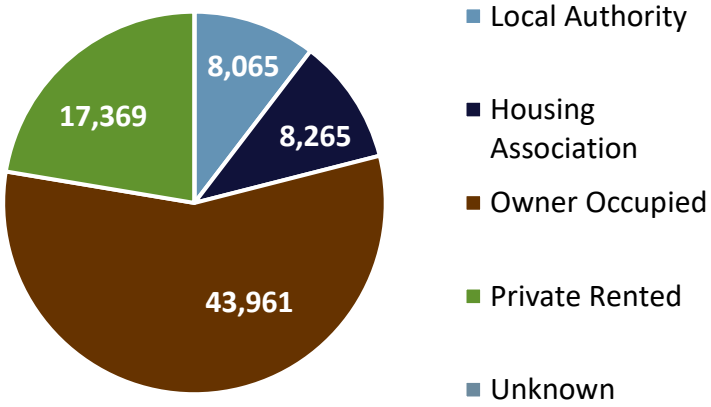


Figure 5—1 Pie chart of domestic tenure count within potential heat network zones identified using Stringent criteria.

The domestic tenure figures for potential zones identified using the Stringent criteria show an even stronger shift towards private rented from owner occupied compared, than with the Baseline screening. The percentage of private rented and owner-occupied properties for the Baseline screening was 15.9% and 60.8% respectively while these changed to 22.4% and 56.6% respectively for the Stringent screening criteria.

Domestic demand by tenure broadly matches the split seen by property count. Local authority ownership makes up 10.4% of domestic heat demand (166 GWh/yr), housing association 10.6% of domestic heat demand (238 GWh/yr), owner occupied 56.6% of domestic demand (1,228 GWh/yr) and privately rented the remaining 22.4% (523 GWh/yr).

The 34,000 non-domestic demands have been characterised by building size (using floor area); counts of properties are provided in Figure 5—2.

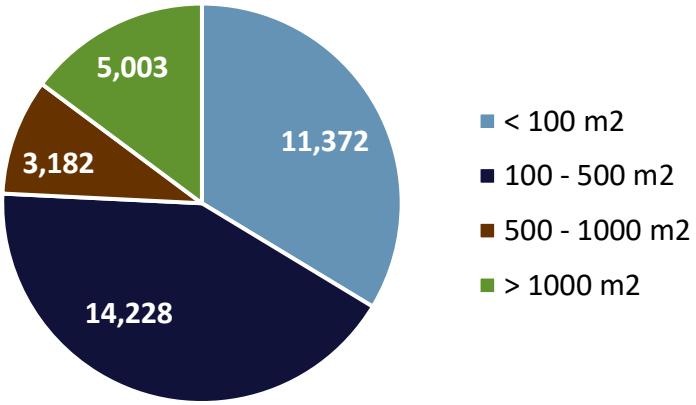


Figure 5—2 Pie chart of the count of non-domestic properties of different building sizes within potential heat network zones using Stringent criteria.

Although relatively low in number (5,003) the largest non-domestic buildings (> 1000 m^2) do have a large share (69.7%) of the total non-domestic demand relating to 7,719 GWh/yr (see Figure 5—3).

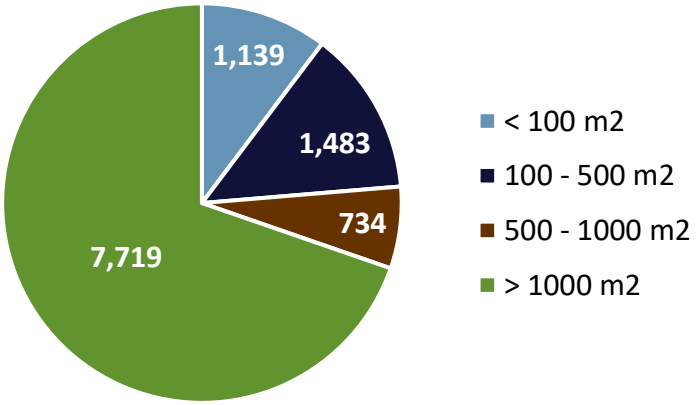


Figure 5—3 Pie chart of the non-domestic heat demand (GWh/yr) in potential heat network zones (identified using Stringent criteria) by building size.

The non-domestic trends are in broad keeping with those seen when using the Baseline criteria.

In some situations, buildings will contain multiple properties, which can be a mix of domestic and non-domestic, multiple types of non-domestic use and multiple domestic tenure types. In these instances, there will be specific considerations and opportunities in connecting a building to a heat network. At a national level there are

37,000 (32%) such buildings within Stringent potential heat network zones, with a total heat demand of 4.5 TWh (33% of demand). This higher level of demand from these shared buildings is reflective of town and city centres.

40,000 properties (35%) within Stringent potential heat network zones have some form of heritage designation (within the heritage property section of this methodology the three groups for heritage designation considered are listed, within a conservation area or within a world heritage site), these have a total demand of 4 TWh. Properties built pre-1919, which can act as a proxy for heritage buildings, make up 4.6 TWh (1.2 TWh domestic and 3.4 TWh non-domestic) of heat demand within Stringent potential zones from 46,000 total properties (60% of which are domestic). It should be noted that there will be properties which are counted both within the designated heritage status measures and the pre-1919 heritage building proxy, so these values should not be aggregated.

The final characteristic considered is fuel poverty. This can add considerable sensitivity to how a potential heat network is taken forward. Within potential heat network zones identified using the Stringent criteria, 21.8% of total households are in fuel poverty (approximately 18 thousand households and approximately 400 GWh/yr heat demand) and 10.1% within extreme fuel poverty (approximately 8 thousand households and approximately 200 GWh/yr heat demand).

5.2 Characterisation of geographic distribution - Stringent

There is an even greater focus of potential heat network zones identified within the central belt when using the more Stringent screening criteria. This is due to the requirement for higher demand density in the potential zone identified using the Stringent criteria, which causes a greater focus on more urban areas. This is shown in Figure 5—4, which maps the potential heat network zones identified across Scotland. A full A3 version of this image can be found in the map pack (under the map ID Nat-1S).

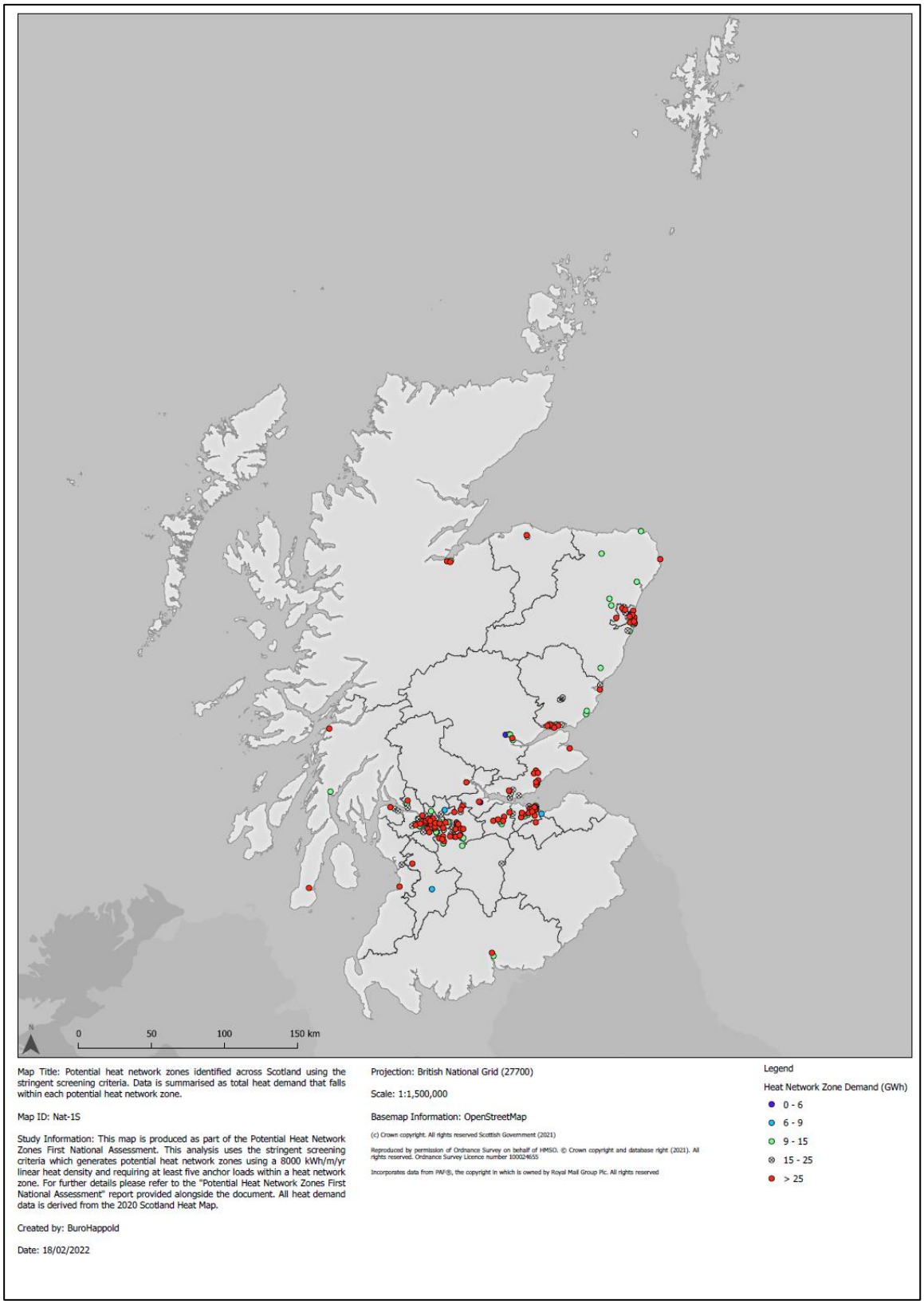


Figure 5—4 Potential heat network zones across Scotland, identified using the Stringent criteria.[37].

[37] The text in this image will not be legible. A high resolution version of this map with legible text is available in map Nat-1S in the accompanying map pack.

These point-based heat network zones can be attributed to the different local authority areas within Scotland, as presented in Figure 5—5 (see map ID Nat-2S in the map pack).

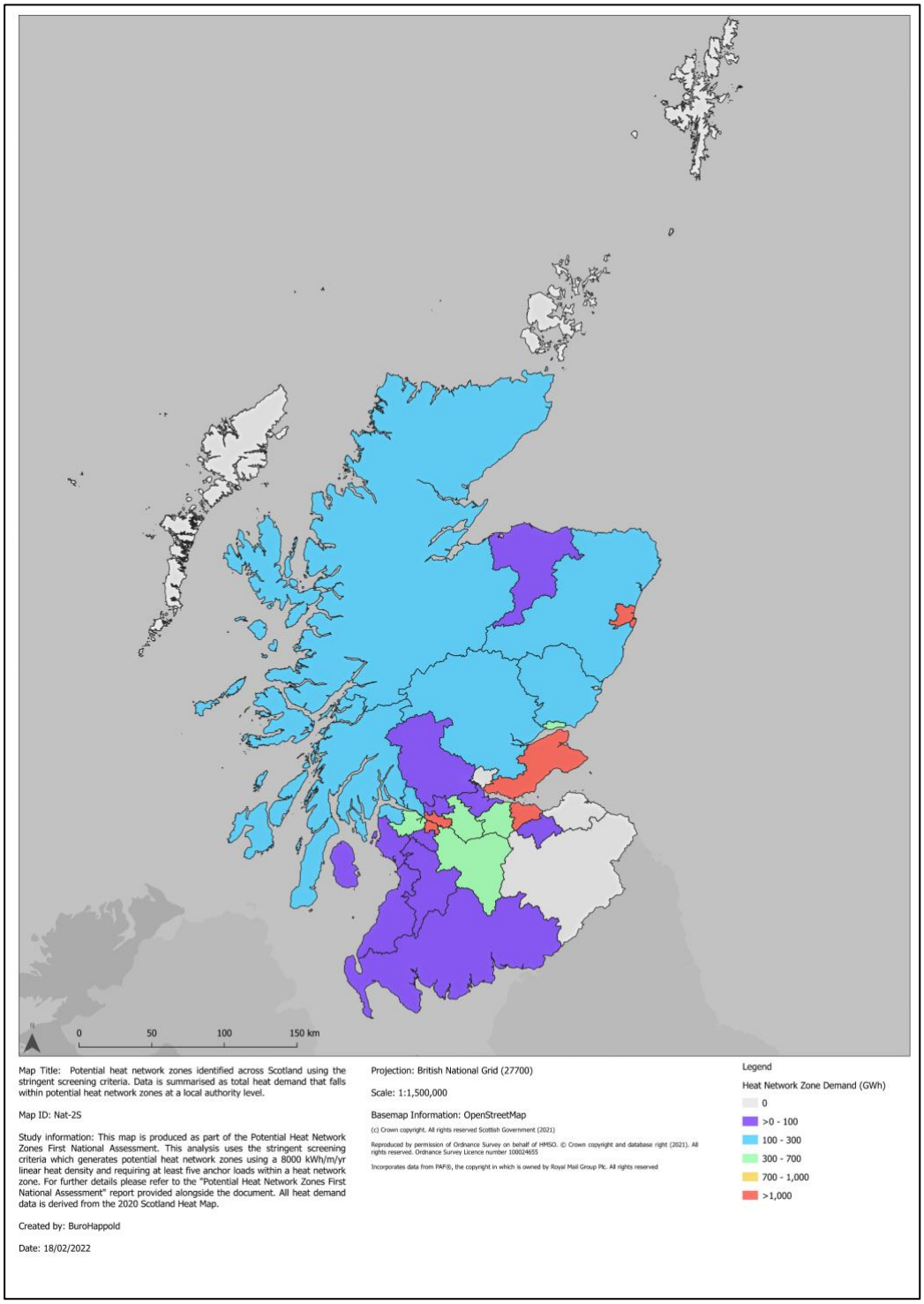


Figure 5—5 Potential heat network zones across Scotland, identified using the Stringent criteria and aggregated to local authority level.[38].

[38] The text in this image will not be legible. A high resolution version of this map with legible text is available in map Nat-2S in the accompanying map pack.

Figure 5—5 highlights that rural areas without large towns and cities often have less heat network potential, notably local authority areas which are entirely made up of islands. These island areas tend to have far lower populations, so the total demand available for potential heat network zones will be lower.

5.3 Baseline and Stringent comparison

Some comparisons have been made between the Baseline and Stringent potential heat network zones in Sections 5.1 and 5.2. This section pulls out some additional comparisons, focusing on the summary statistics elements of the Excel Summary Tables.

In both the Baseline and Stringent potential zones, anchor loads represent the majority of heat demand, 55% and 68% respectively. The greater dominance of anchor loads in the potential zones identified using Stringent screening criteria is to be expected, given the requirement for five anchor loads as opposed to two. This also reflects that Stringent screening highlights potential zones which are more traditionally the focus of heat networks, where a number of high demands are located in very close proximity.

This focus on larger loads is also seen when comparing the number of properties and the total demand. The Baseline potential heat network zones have an average demand per property of approximately 70 MW/a compared to approximately 120 MW/a for properties identified in potential zones using the Stringent criteria.

Fuel poverty is more prevalent in potential heat network zones identified using the Baseline screening criteria (26.1% of households) than the national average of 24.6%, whilst the zones identified using the Stringent criteria fall below the national average with 21.8% of households in fuel poverty. One potential reason being a greater level of affluence in the centre of urban areas which dominate the potential zones identified with Stringent criteria. Although analysis of other factors, such as energy efficiency levels, would be important to give greater context to the reasons for this difference in fuel poverty levels.

The Stringent criteria identifies potential zones with a higher level of heritage properties, compared to those identified with the Baseline criteria. With 35% of

properties being heritage designated and 40% pre-1919 in potential zones identified using Stringent criteria, compared to 23% and 30% for Baseline. Again, this is characteristic of the older centres of large urban areas which are the focus of the most heat dense potential zones.

The final comparison examines local authority level data, with demand falling within potential heat network zones being examined for both the Baseline and Stringent screening criteria. This analysis shows that the four local authorities with the largest heat demands in potential zones identified using the Baseline screening (Glasgow City, Fife, City of Edinburgh and Aberdeen City) also observe the highest demands for the Stringent Screening. As well as this, these four local authorities also present the four smallest percentage changes in relation to the heat demand difference of the Baseline screening compared to the Stringent screening, with an average % drop of 33% while the dataset average was 63% (for local authorities which had heat demand zones present under both screening scenarios). However, the local authorities with the sixth to tenth highest total heat demands show an average of a 50% reduction, and eleventh to fifteenth a 79% reduction, whilst the twenty-eighth to thirty-second average a 96% reduction.

This shows the importance of including a lower threshold for screening some areas for potential heat network zones, as otherwise all or most potential zones will be screened out. However, for the local authorities with more potential, having a more Stringent screening still retains a large percentage of total demand but helps focus on the more demand dense areas. This is illustrated by the area covered by potential heat network zones reducing by an average of 59%, when switching from Baseline to Stringent screening for the five local authority areas with the highest heat demand in potential heat network zones.

Figure 5—6 details the demand breakdown in potential heat network zones by local authority for both the Baseline and Stringent screening criteria.

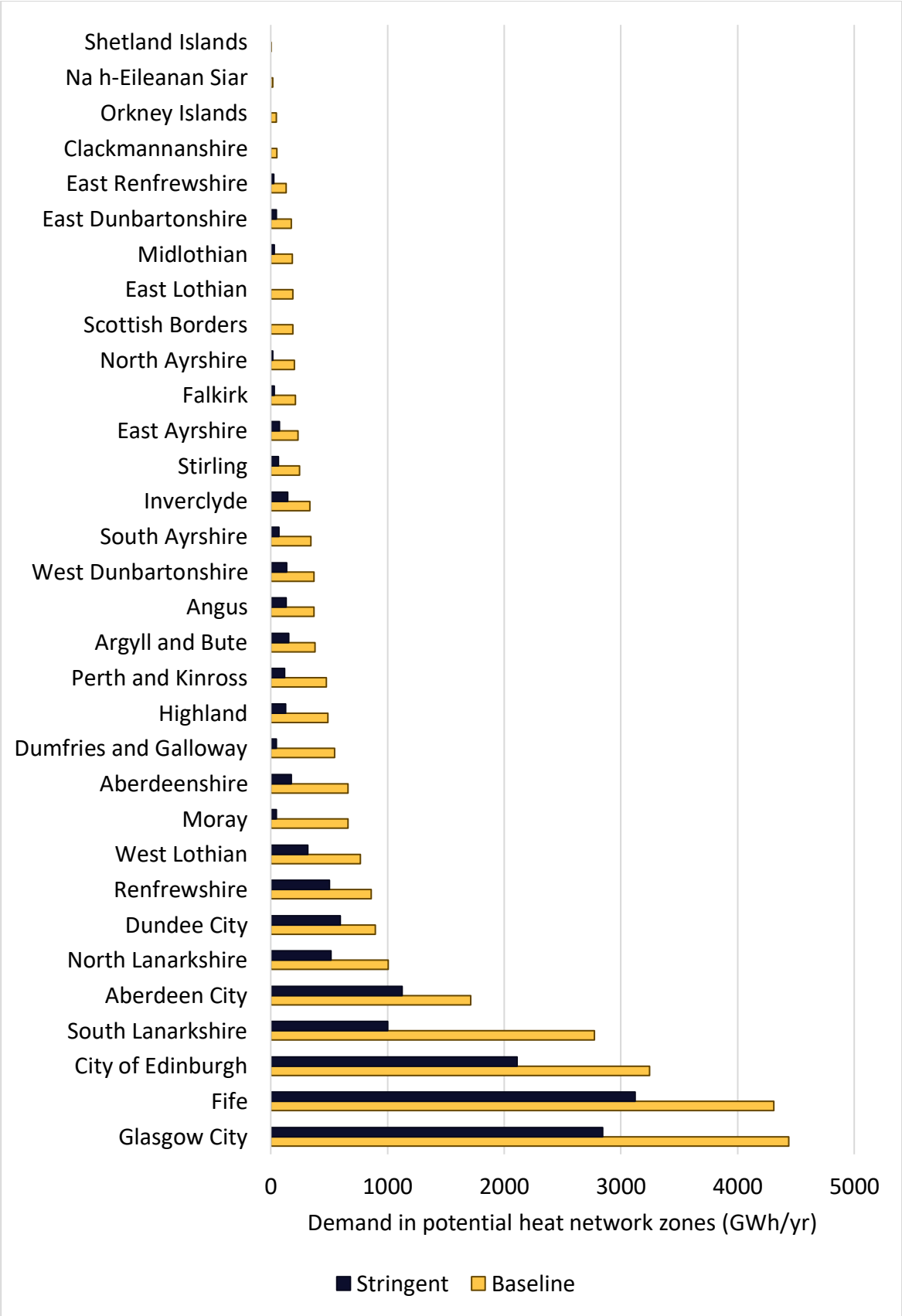


Figure 5—6 Demand in potential heat network zones for each local authority, for both Baseline and Stringent screening criteria.

5.4 Opportunity areas (NCA) comparison

The headline figure identified within the NCA for potential heat network demand in Scotland is 15.0 TWh (this is based on using the NCA medium LHD scenario), compared to 13.7 TWh as the total demand within potential zones using the Stringent criteria in the FNA. The values are relatively close, with differences due to the higher LHD requirement in this study (6,607 kWh/m/yr in the NCA compared to 8,000 kWh/m/yr for the Stringent criteria), the higher number of anchor loads compared to the NCA (the NCA only required more than two buildings to connect) and no limit on the LHD buffer size in the NCA analysis. These factors combine to cause a higher demand identified in potential heat network zones in the NCA, more than offsetting the loss in heat demand in potential zones from the screening out of buildings with a heat demand of under 73 MWh/yr.

In terms of geographic distribution of potential heat network zones, there is broad alignment with the outputs from the NCA (see Figure 5—7) and this FNA work (see Figure 5—8) in term of potential zone location but a disparity in terms of spatial extent. For reference the NCA covers an area of 1,620 km^2 and FNA approximately 150 km^2 using Stringent criteria and 450 km^2 using Baseline criteria, whilst the area of Scotland is 77,910 km^2.

The immediate visual difference when comparing the NCA with the FNA national map outputs is the land coverage of potential heat network zones. The FNA, when using Stringent criteria, covers 9% of the area covered by the medium LHD value for the NCA. The unconstrained linear heat density buffer used in the NCA analysis, compared to the 250 m limit applied in the FNA analysis, is the key contributing factor to the difference in land area of potential zones between the scenarios compared here.

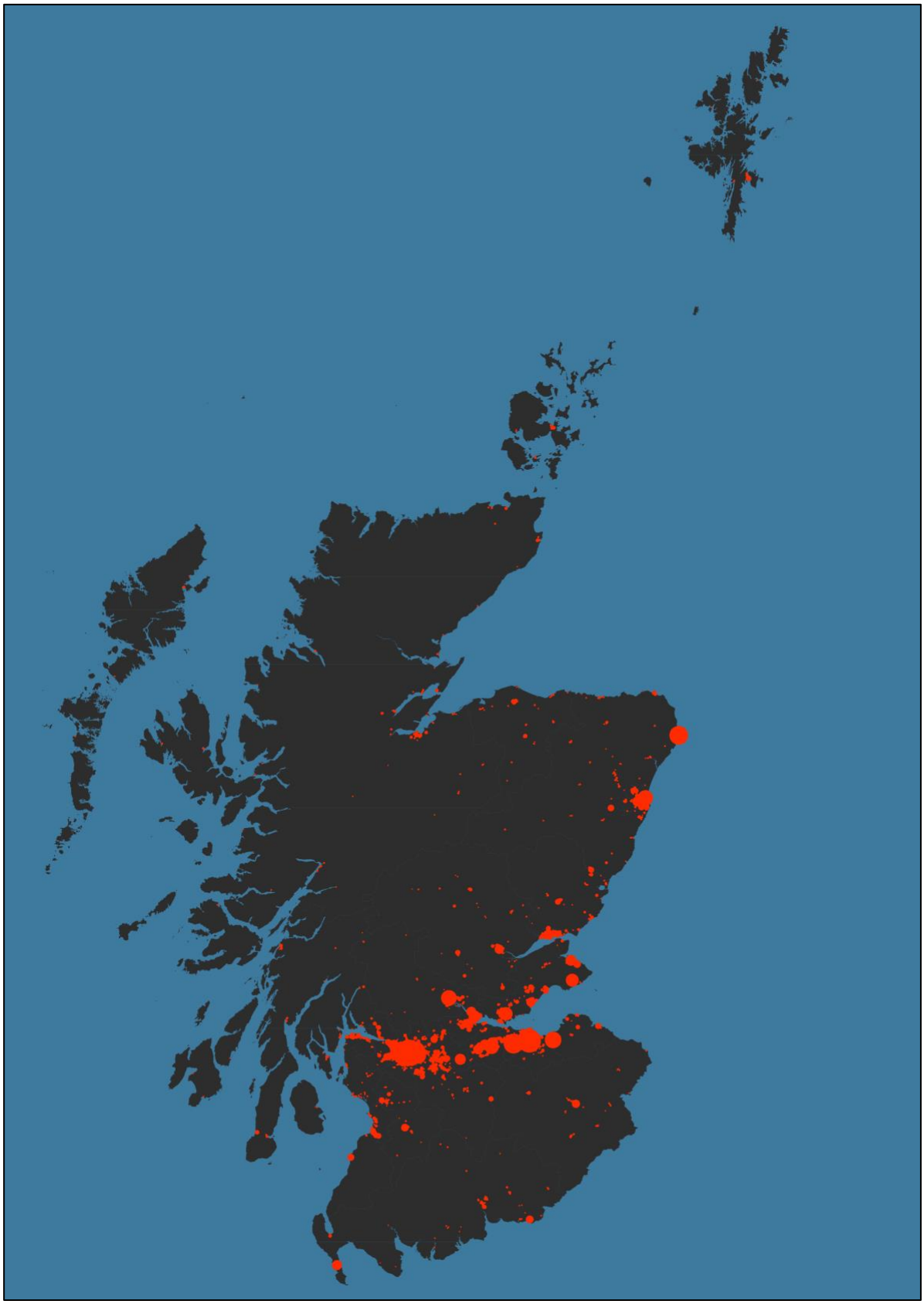


Figure 5—7 A map showing distribution of heat network zones identified across Scotland in the NCA analysis. Image is created from the medium LHD value defined in the NCA.

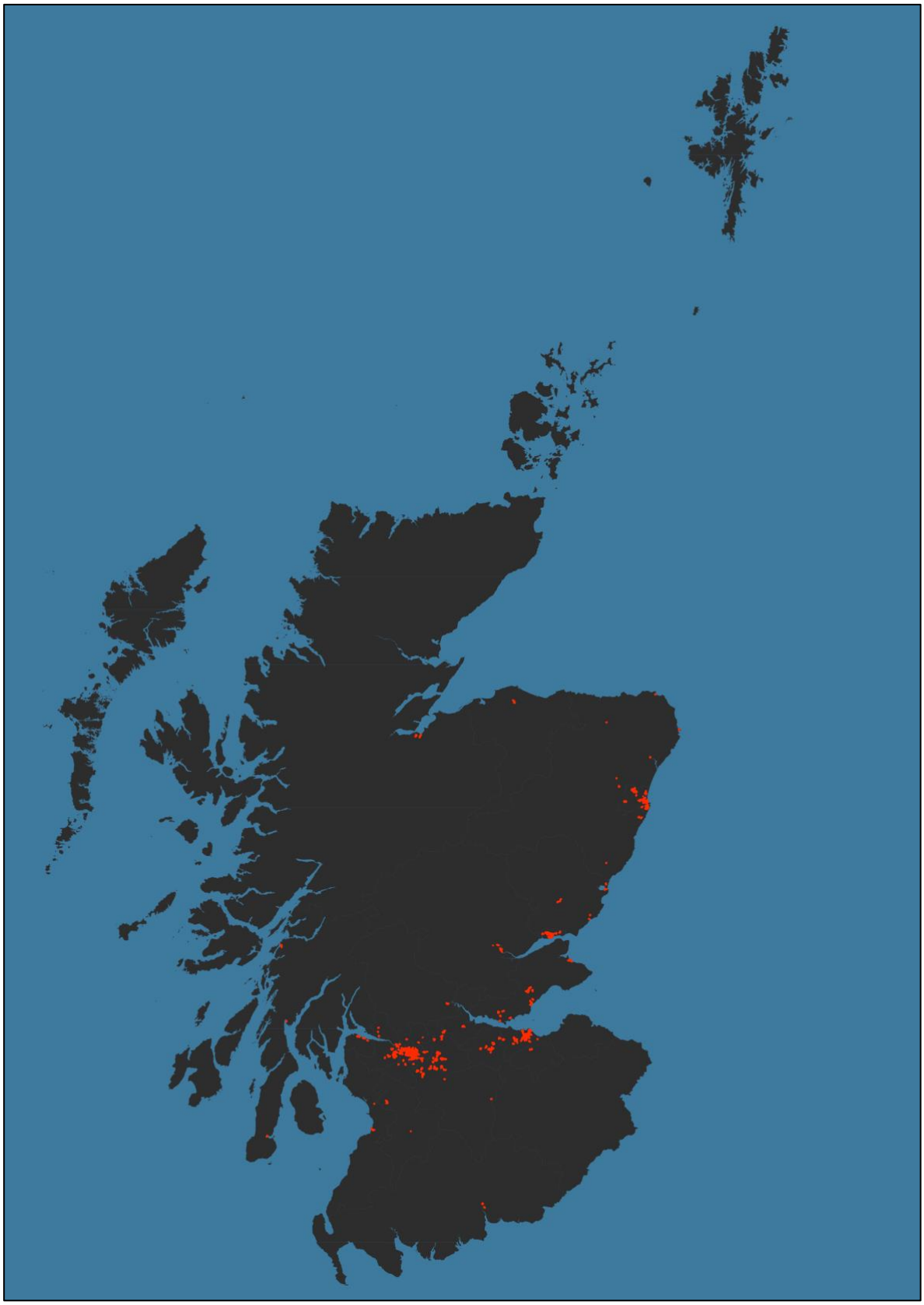


Figure 5—8 A map showing the potential heat network zones identified across Scotland in the FNA using the Stringent screening criteria.

In both analyses, the central belt area is highlighted as a focus for potential heat network zones. However, there are differences in other areas between the 2 sets of outputs, one being the lack of potential heat network zones identified in island locations in Figure 5—8 (FNA) compared Figure 5—7 (NCA). The lack of identification of potential zones in island areas in the FNA is due to the five anchor load requirement in the Stringent analysis; the density of properties fulfilling this requirement do not occur in the island environments. This is why the geographic distribution of potential heat network zones in the NCA looks more similar to that created using the Baseline screening (see Figure 5—9), where a minimum of only 2 anchor loads is required to identify a potential zone[39]. There are, however, still differences between the NCA outputs and the Baseline outputs, due to the slight variation in approaches. The most significant example of this is the Baseline screening identifies a cluster in Irvine on the Ayrshire coast, opposite Arran, which does not appear in the NCA outputs displayed in Figure 5—7.

There are clear benefits in carrying out analysis using both a Stringent and Baseline set of screening criteria. With Stringent criteria only, some key zones will be missed in rural areas, however, using just Baseline criteria, in some dense urban areas, it will be impossible to differentiate the most promising areas. The latter point is illustrated in Figure 5—9, with near-whole urban local authority areas being covered by potential zones.

It should be noted that although the output maps look similar, the demand in potential heat network zones identified using the Baseline criteria is substantially higher than that in the NCA, with 25.7 TWh of demand being identified within potential zones in the FNA compared to the demand identified using the low LHD of the NCA of 17.3 TWh. The NCA being lower primarily due to the exclusion of all heat demands below a threshold of 73 MWh/yr.

[39] Please note that as the map gives precise geographic extent of potential zones, and LHD buffers are limited to 250 m for buildings, rural areas may require zooming in to compare potential zone existence with the NCA outputs.

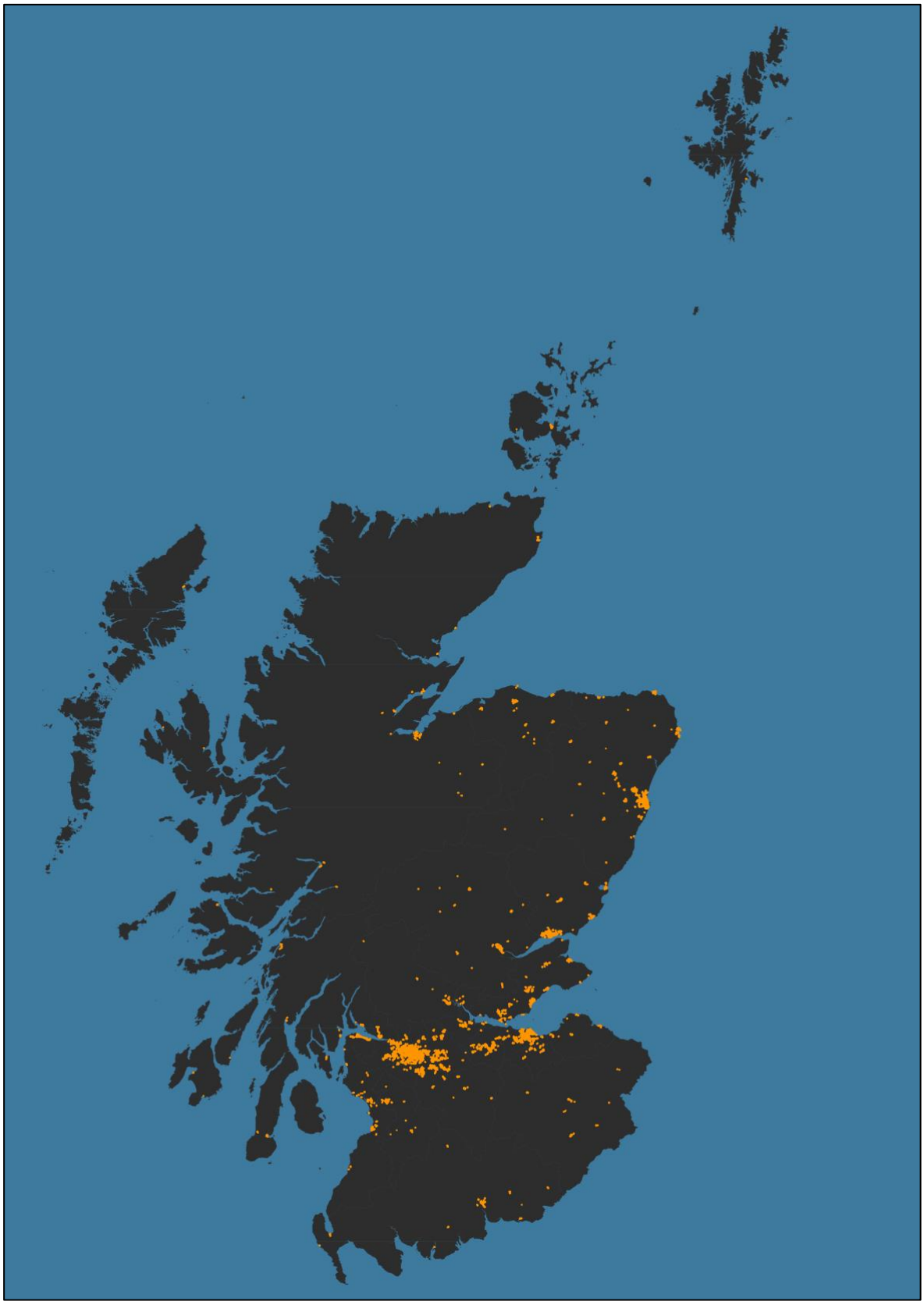


Figure 5—9 A map showing the outlines of potential heat network zones, identified using the Baseline screening criteria.

6 Concluding remarks and next steps

The FNA has used national datasets to carry out a first-pass assessment to identify areas that might be suited to heat network development from a heat demand density perspective. The analysis used different settings to identify potential zones, giving a range of outputs that might be appropriate for different local authority geographies. Substantial heat demand is identified in potential heat network zones using both the Baseline (25.7 TWh/yr) and Stringent (13.7 TWh/yr) criteria. These totals include all heat demands falling within potential zones – the total heat demands within potential zones if only anchor loads are considered are 14.1 TWh/yr for Baseline and 9.3 TWh/yr for Stringent. The analysis does not consider economic factors, detailed technical factors or the stakeholder related aspects of heat network project development within potential zones – significant further work is therefore required to establish the viability of project development within the potential zones identified by the FNA.

The FNA is framed by two key policy drivers: the ongoing development of Local Heat and Energy Efficiency Strategies (LHEES) and the Heat Networks (Scotland) Act 2021 (the 2021 Act). Within this context the work aimed to support the development of policy and regulations, including informing the Heat Networks Delivery Plan (as detailed in the 2021 Act) and the local identification of potential zones for heat networks as part of LHEES. The work may also be used to support wider policy development.

Regarding LHEES, the local authority specific analysis provided by the FNA (and shared with local authorities as part of the LHEES National Assessment outputs) is intended to support local authorities to work towards their requirements within LHEES in regard to heat networks. The LHEES process includes local consideration of potential zones outputs, bringing in local knowledge to sense-check anchor loads and other factors such as local development plan sites, existing heat network connections within potential zones and other requirements as set out in the 2021 Act, refreshing the outputs as required.

This work has also informed updates to the LHEES process, and these will feed-in to ongoing development of the LHEES methodology.

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