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Heat mapping for district heating

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Abstract

If the UK wishes to decarbonise its energy supply, it should consider a wider uptake of district heating. Currently, district heating only accounts for 2% of the country's total heat supply. This paper considers the initial stages of designing a district heating network, the energy mapping in the local area, using a case study of Darley Dale, England. Energy mapping techniques are used to estimate the local area energy demand, a basis on which the district heating network design will rely on. The areas in the case study that are found to be profitable for possible district heating and where the rest of the district heating design work should focus on are Matlock, Bakewell and Darley Dale. The results of the mapping technique presented in this paper are found to agree with heat mapping work carried out by the UK Government. The agreement between the two mapping techniques shows that the mapping technique outlined in this paper is accurate enough for use.

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Keywords: District heating; energy mapping; heat demand; feasibility; geographical information services

1. Introduction

District heating (DH) is an alternative to the incumbent UK heating technologies of individual, natural gas fired, boilers. A district heating network (DHN) is comprised of three elements: a thermal energy generating unit (or units), the pipe network and substations that connect the network to the customer buildings [1]. The major advantage of district heating is that, through the economies of scale and supply, a DHN can utilize thermal energy sources that may not be economically viable on an individual scale. Examples of thermal energy sources that can be utilized by DH are: excess heat from industry, energy from waste incineration and combined heat and power [2]. In addition, DH is both flexible and secure and can use local thermal energy sources, providing money to the local economy [1].

In the UK, DH implementation is low, accounting for only 2% of the total countries energy supply [3]. A reason for the low implementation of DH is through the high costs of installation. The operation and installation of a DHN should be led by the local authority, who tend to lack in house engineering experience [4]. The lack of in house

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engineering experience means that local authorities must employ expensive engineering consultancies to assess the viability of a new network, a cost that in some cases may be prohibitive. A simple model of DH feasibility that can be utilized by a non-technical individual will allow for more potential DHNs to be considered and therefore for more DHNs to be installed. This paper investigates the initial stage of a simple model of DH feasibility, estimating the local area energy demand.

An estimation of the local area energy demand allows for a quick comparison to be made between the local area heat demand density and the minimum heat demand density, of 3 MW/ km^2, that the UK government advise for profitable DH [5]. The heat demand estimation is also used to identify possible anchor loads. Anchor loads are customers with a high, constant and stable heat demands that are vital to the business case of a new DHN and are used to determine the network route [6]. The heat demand estimation can be done using one of a variety of techniques: questionnaires, thermal imaging, remote sensing or geographical information services (GIS), otherwise called heat mapping [7]. Questionnaires are highly accurate for individual buildings but are only accurate across a large area if the response rate is high; the overall questionnaire process is time consuming and expensive [7]. Remote sensing and thermal imaging are both highly accurate and quick but are very expensive [7]. GIS mapping is widely used, proven to be affordable, quick and accurate [7-12].

The aim of this paper is to investigate the heat mapping process for district heating. Heat maps of the case study are generated and compared to existing maps to assess the accuracy of the heat mapping process.

2. Methodology

The heat mapping was done by combining techniques presented by the following sources: Parsons Brinckerhoff [13], the Chartered Institution of Building Services Engineers (CIBSE) [14], the Energy Information Administration (EIA) [15], the UK Energy Research Centre (UK ERC) [17] and Finney et al. [7]. The heat mapping was split into two areas: commercial heat mapping, to identify anchor loads and domestic heat mapping, to estimate the heat demand density.

The domestic heat mapping used the technique outlined by Finney et al. [7]. UK census data was obtained [17], giving the population density of the case study area. The population density was converted into energy and power density using the UK ERC study as well as several assumptions. It was assumed that: the average number of people living in a dwelling was 2.37, the average UK dwelling heat usage is 20.5 MWh per year and that the average UK dwelling was heated for 3,000 hours per year.

The commercial heat mapping used the techniques outlined by Parsons Brinckerhoff [13]. Googles Maps and Google Street View were used to identify the commercial buildings in the case study area, noting the following: building type, building location and total building floor area. The CIBSE energy benchmarks TM 46 [14] gave the typical fossil fuel energy use of archetype building categories (in kWh/ m^2). The EIA commercial buildings energy consumption study split the total energy use of archetype buildings into the individual uses. The UK ERC carbon trust advanced metering trial gave a ratio of energy to power usage for archetype buildings. Combing the three studies estimated the energy and power usage for heating purposes of archetype buildings in kWh/ m^2 and kW/ m^2. When combined with the total floor area noted of each building in the case study area, the estimated energy and power usage for each commercial building in the case study area were calculated.

The methodology used relied on several assumptions and techniques that may bring inaccuracy into the work. Normally, an engineering study would strive to minimize and quantify any inaccuracies in the work. The purpose of heat mapping is not to accurately model the heat demand in the local area but to quickly estimate the heat demand in the area; therefore, inaccuracies could be tolerated. The validity of the work was assessed by comparing the results to that of similar work produced by the UK government [18].

3. Case study

The work in this paper was based around HJ Enthoven. HJ Enthoven are a lead-acid battery recycling plant located in Darley Dale, England who are interested in the possibility of a DHN in the local area to improve the efficiency of their process [19]. Heat mapping work was carried out for all towns that are within an 8 km radius of the HJ Enthoven site with a population of at least 1,000. The towns identified were: Darley Dale, Matlock, Rowsley, Bakewell, Youlgreave, Cromford and Matlock Bath.

4. Results

A domestic buildings heat map was generated for the towns of Darley Dale, Matlock, Rowsley, Bakewell, Youlgreave, Cromford and Matlock Bath as shown in Fig. 1.

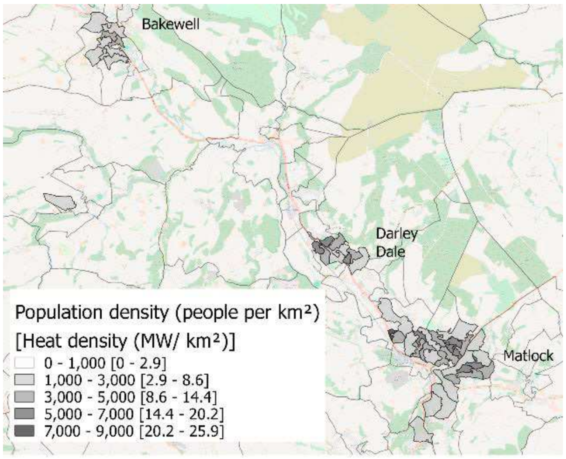

Fig. 1. Domestic heat users in the case study area.

Fig. 1 shows that the towns of Bakewell, Darley Dale and Matlock have large areas with heating power densities of greater than 3 MW/ km^2 and the towns of Rowsley, Youlgreave, Cromford and Matlock Bath do not. As only Bakewell, Darley Dale and Matlock have large areas with power densities higher than the profitable level advised by the UK government, the potential new DHN should be focused there and there only.

A commercial buildings heat map was generated for the towns of Darley Dale, Matlock, Rowsley, Bakewell, Youlgreave, Cromford and Matlock Bath as shown in Fig. 2.

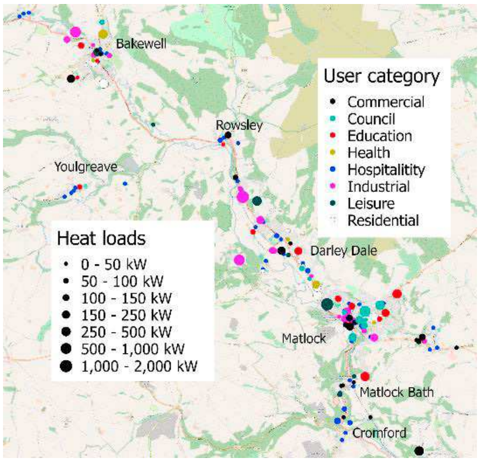

Fig. 2. Commercial heat users in the case study area.

Fig. 2 shows that the largest concentration of large commercial heat customers are found in Bakewell, Darley Dale and Matlock. The yearly energy use for heat, average power demand and peak power demands are shown in Table 1.

Table 1. Energy and power demand of the large commercial heat customers found in Bakewell, Darley Dale and Matlock.

Location	Annual energy use for heating (*MWh*)	Average power demand for heating (*MW*)	Peak power demand for heating (*MW*)
Matlock	24,000	7.4	25
Darley Dale	4,100	1.6	4.8
Bakewell	9,000	2.8	7.4

Table 1 and Fig. 2 show that, from an industrial heat user perspective, the focus of a new district heating network should be on Bakewell, Matlock and Darley Dale. Table 1 and Fig. 2 support the findings of Fig. 1 proving that the design should be on Bakewell, Matlock and Darley Dale. It is worth noting that the work done thus far does not prove that a DHN would be profitable for HJ Enthoven but that it is worth further consideration.

Once the methodology outlined in this paper has been generated, repeating the work for a different case study would be very quick and is simple enough that the work could be done by a non-technical individual at a local authority. The quick and simple methodology would allow a local authority to assess their own potential for a new DHN without having to employ and pay an engineering consultancy. Making the assessment quicker and cheaper will encourage more local authorities to assess the feasibility of DHNs in their locale, encouraging more DHNs to be assessed and therefore more DHNs to be installed.

Before the heat mapping methodology is sent out for use by local authorities, it would be prudent to assess the accuracy of the methodology. The UK government publish a CHP development map that shows the energy density of the country. The UK CHP development is shown and compared to the heat mapping produced in Fig. 3.

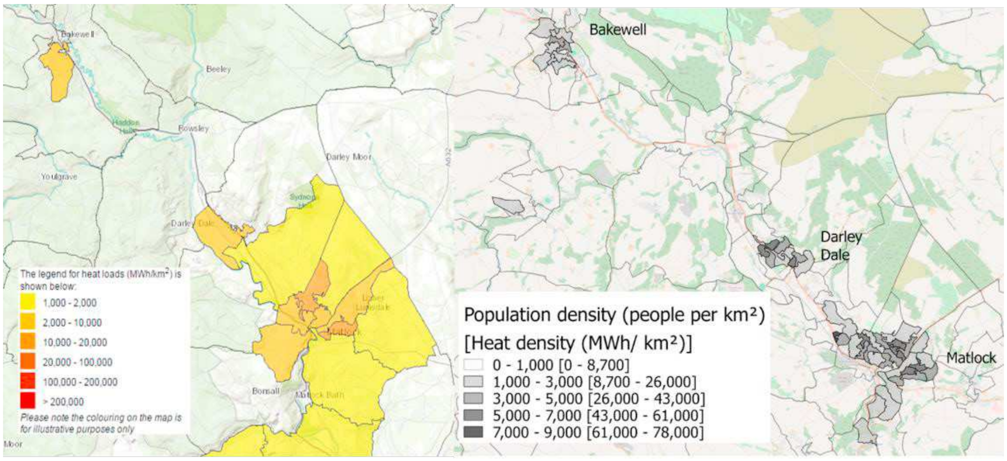

Fig. 3. (a) UK CHP development map (b) Domestic heat users in the case study area.

In Fig. 3, the energy density needed for profitable DH is roughly 9 MWh/ km^2. The UK CHP development map shows, similarly to Fig. 1 that the areas of profitable DH are located exclusively in Matlock, Bakewell and Darley Dale. The agreement between the new mapping technique and the established mapping technique developed by the government proves that, for the purposes of heat demand assessment, the heat mapping technique presented in this paper is accurate enough for use.

5. Conclusion

Commercial and domestic heat demand assessment is carried out using GIS heat mapping techniques as presented by Parsons Brinckerhoff and Finney et al., using HJ Enthoven as a case study. The domestic heat demand assessment found that the only areas in the case study with a heat power density large enough to be considered profitable for DH by the UK Government is Matlock, Bakewell and Darley Dale. The commercial heat demand assessment found that the areas of Matlock, Bakewell and Darley Dale have large concentrations of large commercial heat customers which can act as anchor loads for the DHN. When combining the two types of assessment, it is shown that future design work for the case study DHN should focus on the areas of Matlock, Bakewell and Darley Dale. The heat mapping methodology developed in this paper is compared to existing mapping methodology generated by the UK Government. The UK Government heat mapping also finds that the only areas in the case study with a sufficient heat demand density to be profitable for DH is Bakewell, Matlock and Darley Dale. The agreement between the two mapping techniques shows that the mapping technique presented in this paper is suitable for future heat demand assessment.

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