Interreg
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HeatNet NWE
European Regional Development Fund

Guide to Heat Mapping

Researched by	Checked by	Reviewed by	First Draft	Final Draft
Odile Lefrère, Cerema, with the contribution of Joseph Jebamalai, University of Gent, and Renée Heller, Amsterdam University of Applied Sciences	Audrey Pierre	Benoit Hofer Julien Joubert	May 2019	September 2019

Author(s): Odile Lefrère, Cerema
Email: odile.lefrere@cerema.fr
Phone: 33 (0) 20 49 61 22
Address: 44 ter rue Jean Bart CS 20275 59019 Lille Cedex

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About HeatNet NWE

This document has been developed as part of the HeatNet NWE project, which is part-funded through the Interreg NWE programme and aims to increase the uptake of 4DHC networks across North-West Europe. As part of this project, the partners are developing the HeatNet Model, which will help the public sector to begin implementing 4DHC networks, and the Transition Roadmaps, which will outline the partners' experience in developing six district heating pilots across North-West Europe. The HeatNet Guide to Financing is also currently being developed and will give a broad overview of the various sources available to finance district heating schemes.

For further information on these reports and on the HeatNet NWE project, please visit www.nweurope.eu/heatnet.

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Summary and Useful links

Heatmaps are valuable regarding the urban and energy planning of a geographical area; it helps locating energy sources and needs and connect them, designing infrastructures, plan the refurbishment in some areas.

Heatmapping consists in describing the need or resources for heating (or cooling) of a geographical area. A set of colour rendering allows revealing the needs or resources from the residential, tertiary, or industrial sector. The unit translated into colours is usually MWh/m²/year. Apart from the heating or cooling need, a set of different information can appear which are often very useful during the planning of a 4DHC project: waste treatment plants, data centres, hospitals, etc. This guide aims to provide useful resources and a methodology to create a heatmap for a 4DHC project.

The following table is a non-exhaustive list of databases, maps and datasets that can be used during the process of making a heatmap, for all NWE Countries.

EUROPEAN LEVEL	
• **Demand**	
Population density	Eurostat (regional level): https://ec.europa.eu/eurostat/data/database Geostat (local level): https://ec.europa.eu/eurostat/fr/web/gisco/geodata/reference-data/population-distribution-demography/geostat
Land use	Corine Land Cover: https://www.eea.europa.eu/data-and-maps/data/copernicus-land-monitoring-service-corine
Urban Atlas	Copernicus: https://land.copernicus.eu/local/urban-atlas/urban-atlas-2012
Heating and cooling degree-days	European Environment Agency: https://www.eea.europa.eu/data-and-maps/indicators/heating-degree-days
Temperatures	European Commission: https://re.jrc.ec.europa.eu/pvgis5/tmy.html
Energy consumption per building	ODYSEE database: http://www.indicators.odyssee-mure.eu/online-indicators.html
• **Supply**	
Forestry	European Forestry Inventory: https://www.efi.int/knowledge/maps/treespecies
Solar	European Commission – PVGis: http://re.jrc.ec.europa.eu/pvgis/countries/europe.htm
Data Centre	Data Center Map: https://www.datacentermap.com/
Geothermal	GEoDH project: https://map.mbfsz.gov.hu/geo_DH/
Industry	European Pollutant Release and Transfer Register: https://prtr.eea.europa.eu/#/home
• **Other statistics**	
Energy prices	DG Energy: https://ec.europa.eu/energy/en/data-analysis
European projects regarding heatmapping	Stratego: http://stratego-project.eu/pan-european-thermal-atlas/ Hotmaps: https://www.hotmaps-project.eu Planheat: http://planheat.eu/
BELGIUM	
• **Demand**	
Statistics	Statbel platform: https://statbel.fgov.be/en/themes/energy/energy-statistics-economic-sector-and-energy-source Fluvius : https://lokaal-bestuur.fluvius.be/nl/thema/nutsvoorzieningen/open-data Wallonia: https://energie.wallonie.be/fr/bilans-energetiques-wallons.html?IDC=6288
Public sector data	Belgian Government : https://data.gov.be/en
Temperature	https://www.geo.be/#!/catalog/details/RMI_DATASET_AWS_1HOUR?l=fr
• **Supply**	

Geothermal energy	https://energie.wallonie.be/fr/la-geothermie-profonde.html?IDC=6173
Solar	https://apps.energiesparen.be/zonnekaart
Forestry	http://iprfw.spw.wallonie.be/
FRANCE	
• **Demand**	
Statistics	National heatmap: http://reseaux-chaleur.cerema.fr/carte-nationale-de-chaleur-france Géoportail platform: https://www.geoportail.gouv.fr/ Local energy data: https://www.data.gouv.fr/fr/datasets/donnees-locales-denergie/ District heating: https://carto.viaseva.org/public/viaseva/map/
• **Supply**	
Geothermal energy	Géothermie perspectives: http://www.geothermie-perspectives.fr/cartographie
Solar	Calsol tool: http://ines.solaire.free.fr/gisesol.php
Forestry	IGN – Inventaire Forestier: https://inventaire-forestier.ign.fr/spip.php?article646
IRELAND	
• **Demand**	
General Statistics	Environmental indicators: https://www.cso.ie/en/releasesandpublications/ep/p-eii/eii2016/energy/
Heat Demand	SEAI GIS Suite: http://maps.seai.ie/giswiki/
• **Supply**	
Bioenergy, geothermal	SEAI GIS Suite: http://maps.seai.ie/giswiki/
Geothermal	DCCAE geological survey Ireland: https://www.gsi.ie/en-ie/data-and-maps/Pages/Geoenergy.aspx
NETHERLANDS	
• **Demand**	
General Statistics	Electricity and gas consumption: https://www.energieleveranciers.nl/netbeheerders/overzicht-netbeheerders Industry statistics: https://www.cbs.nl/nl-nl/economie/industrie-en-energie
• **Supply**	
Geothermal energy	Ministry of economic affairs : https://www.nlog.nl/en/geothermal-energy
Forestry	NFI6, Sixth Dutch Forest Inventory:): https://www.wur.nl/en/Research-Results/Research-Institutes/Environmental-Research/Projects/Dutch-Forest-Inventory.htm
UNITED KINGDOM	
• **Demand**	
General Statistics	England: sub-national consumption statistics: https://www.gov.uk/government/collections/sub-national-electricity-consumption-data Scotland: Scottish heatmap: http://heatmap.scotland.gov.uk/
• **Supply**	
Geothermal	England : British Geological Survey : https://www.bgs.ac.uk/research/energy/geothermal/ Scotland : https://www.gov.scot/policies/renewable-and-low-carbon-energy/geothermal-energy/
Forestry	NFI woodland map and resources: https://www.forestresearch.gov.uk/tools-and-resources/national-forest-inventory/about-the-nfi/

Introduction

Heating and cooling in buildings and industries accounts for half of the European Union’s energy consumption. To reduce greenhouse gases, reducing heating and cooling demand and developing renewable energy is necessary. However, making these changes efficient requires a good knowledge on energy demand.

Heatmaps have become a tool for decision makers and a source of information on local energy demand and supply in the recent decade. Most of the heatmaps give information on heat demand in the form of heat density, and on current supply sources. Some also combine this with potential studies of renewable or waste heat sources. This effective tool used by local or national authorities as well as urban planners led to a better energy planning at different scales. Locally, heat mapping is a key component, which has significant influence in district heating (DH) planning and decision-making process. A heatmap shows spatial distribution of heat demand (used for heating buildings or in industrial processes) in a given area. It is useful for analysing different scenarios regarding the buildings and to implement energy efficiency measures for the future. It is also extremely helpful for DH engineers to decide technical opportunity and feasibility as well as economic viability of a DH system.

This guide is one of the deliverables of the Interreg project HeatNet NWE. It aims to help local, regional and national authorities as well as energy planners to understand the use of such maps and the different methods available to create one. It focuses on the data, resources and good examples in North West Europe (NWE) countries and emphasizes on 4th generation District Heating and Cooling (4DHC) specificities regarding heat mapping.

Definition of heat mapping

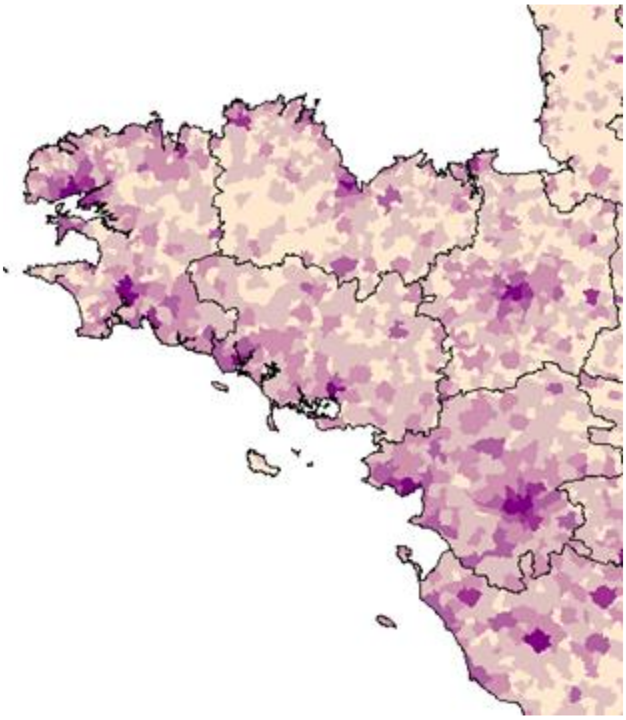

Figure 1: French national heatmap (Source: French Ministry of Ecological and Solidary Transition)

Heat mapping, and by extension, cool mapping, consists in describing the **need for heating and cooling of a geographical area**. On the map of the concerned area, thanks to a Geographic Information System (GIS), colours rendering make it possible to understand the importance and the **geographical variation of the heating and cooling demand**. Usually the unit translated into colours is Megawatt hour per square meter per year (and equivalent units).

The geographical area can be as vast as an entire country or the size of a neighbourhood depending of the purpose of the map. **The precision of such maps also depends on its purpose** but often the limitation comes from the precision and the availability of the data. The level of detail can vary from individual buildings to per square kilometre data.

The heating and cooling demand can also be sorted out by topics. Usually, it is possible to filter in order to visualize on the map only the demand of the residential sector, or the demand of the tertiary sector or the demand of the agricultural sector. Sometimes demands by use (e.g. space heating, domestic hot water, cooking) are separately displayed.

In addition to the colour rendering of heating and cooling demand, **a heatmap can also contain punctual information** such as energy sources (CHP, waste incineration plants, etc.), potential heat supply, but it is also possible to add any information which helps the purpose of the heatmap, for example any opportunity or constraint.

The heating and cooling demand can represent the past, the present or the future demand depending on the purpose and the data. It can also be a model based on hypothesis or based on real consumption data.

The creation of the heatmap involves the process of data gathering, data processing and visualization. **Gathering data is one of the first and most difficult processes in creating heatmaps.** Once the data is gathered, it has to be sorted and processed. It is always better to give some confidence value related to data accuracy. Then, data visualization is the final step in creating heatmaps.

What is the purpose of a heatmap?

Heat mapping is a way to visualise the need for heat and the localisation (or potential localisation) of heat sources. With this vision, it is then possible to better **connect the need and the sources** in order to reduce the cost of heat and the greenhouse gases emissions. Heat mapping is also a powerful tool to target the areas that require refurbishment in order to improve energy efficiency. Heatmaps can also help to investigate socio-economic difficulties such as fuel poverty.

Heatmap for Energy planning

With the need to develop renewable energies, local and regional authorities have become major actors in the energy transition. However, efficient and cost effective energy planning remains a tough exercise. Heatmap is a valuable tool they can use **to improve their energy planning**. By analysing a heatmap, energy planners can design infrastructure according to the demand. Some heatmaps even have geographic information on existing energy networks (electricity, gas, DHC) to simplify the process.

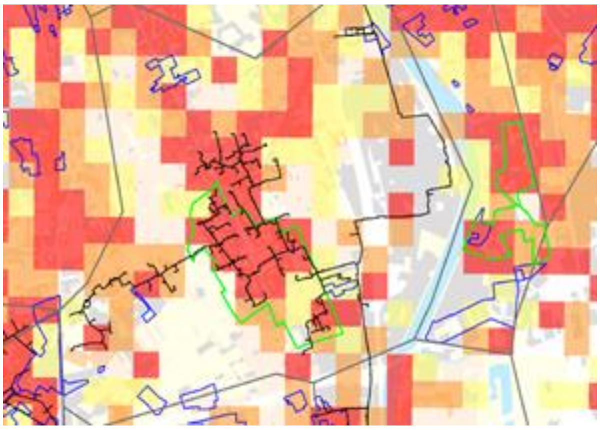

Figure 2: Heatmap of Paris with the District Heating network routing (Source: French national heatmap)

If a neighbourhood presents a high heat demand on a small geographical area, a district heating network can be a virtuous heating solution. Indeed, heat demand estimation is the first and foremost step in planning and designing of district heating and cooling (DHC) systems. If a local authority wants to plan the implementation of a large-scale district heating or the expansion of the gas network, a heatmap remains an efficient solution for a cost optimal and energy efficient planning.

Heatmap showing other data such as renewable energy potential, Combined Heat and Power (CHP), methanization units, and data centres can also impulse numerous synergies and the development of renewable energy, as well as heat recovery. Crossing the localisation and potential of renewable energy sources with the heat demand shows the specific potential of each area.

Heatmap for urban planning

With more and more decentralized energy production points, energy and urban planning tend to become more and more interlinked, thus a **heatmap can be used to improve urban planning**. For example, in an urban plan, using a heatmap to choose where to install new equipment can optimize both an existing DHC network and the equipment. The same goes with the extension of a city. Thanks to a heatmap, it is possible to place new urban development according to its purpose or the heat density in the area, in order to optimise both the urban project and the existing of future energy network, and to create opportunities to foster renewable energy.

For example, the City of Lille, France, adapted its plan for a new area when they studied how to switch from gas to renewables. The city decided to add a swimming pool and to extend the future green DH network toward the new urban development in order to limit its environmental impact.

Heatmaps can also be used to identify areas where the heat demand is high because of poor building thermal efficiency and **to fight fuel poverty** by targeting the most vulnerable areas. In addition to planning the refurbishment, studying the creation of a district heating can often help to fight fuel poverty thanks to competitive and stable energy prices.

What information is needed to create a heatmap?

Heat and cool global demand

The heat and cool demand is the annual energy demand in heating and cooling of buildings. It is best to distinguish **the heating demand and the cooling demand** since different installations are usually necessary to meet these. Yet, interactions between the two can improve the overall system.

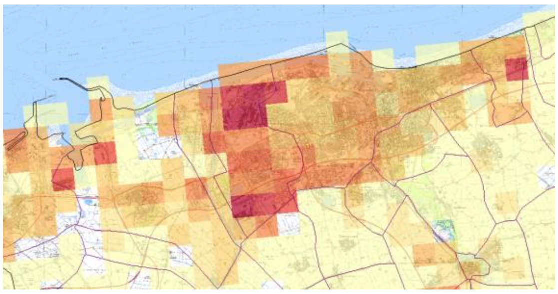

Figure 3: 1km² Heat demand density in the industry and agricultural sector around the city of Dunkirk (Source: French National Heatmap)

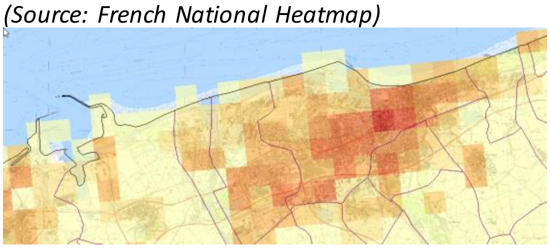

Figure 4: 1km² Heat demand density in the tertiary sector around the city of Dunkirk (Source: French National Heatmap)

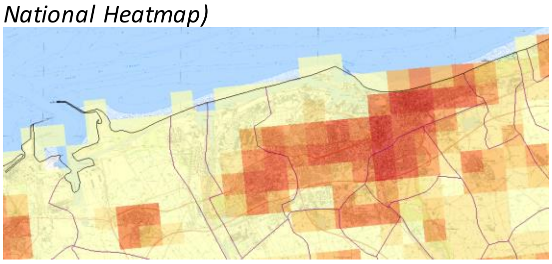

Figure 5: 1km² Heat demand density in the residential sector around the city of Dunkirk (Source: French National Heatmap)

The heating and cooling demand is also usually more useful when known for each sector: **residential, tertiary, agriculture, industry**. Indeed, those sectors often have specificities regarding cooling and heating demand and thus are more or less compatible with DHC. Besides, one of the benefit of DHC is that the diversity factor increases the efficiency of the overall heating system.

Figure 3, Figure 4 and Figure 5 illustrate three heatmaps on the same sector (City of Dunkirk and its surroundings). It is possible to distinguish clearly the industrial area and the residential area. The combination of the three maps reveals the high density of the heat demand. However, two different kinds of installation (with potential synergies between them) might be necessary to meet the demand since the industrial sector and the residential sector often have different needs regarding heat quality.

The city of Dunkirk actually already possesses one of the rare district heating in France, or even in Europe, using industrial waste heat from a steel factory. Within its industrial port, other small district heating networks between industries also exist. These synergies were made possible thanks to the Port Authority initiative to create an "energy and solid flux map". Energy needs of each industrial as well as its input and output were mapped.

The **scale and precision** of a heatmap regarding the heating and cooling **demand is another important factor** for a successful heatmap but the "right" scale depends on the main purpose of the heatmap. Here are some examples of the accuracy required depending on the type of action needed:

- To approximately estimate the potential of major DHC deployment at a national level: local authority scale;
- To plan the long term strategy (10 years) for the deployment of renewable energy regionally: from local authority scale to 1km by 1km square;
- To plan the deployment of renewable energies and energy networks on the long term (10 years) in a city: from 1kmx1km to 200mx200m square;
- To plan the creation or extension of a DHC: from 200m x 200m square to building scale.

Figure 6, Figure 8and Figure 7 show heat maps at different scales, to illustrate the possible accuracy of heatmaps.

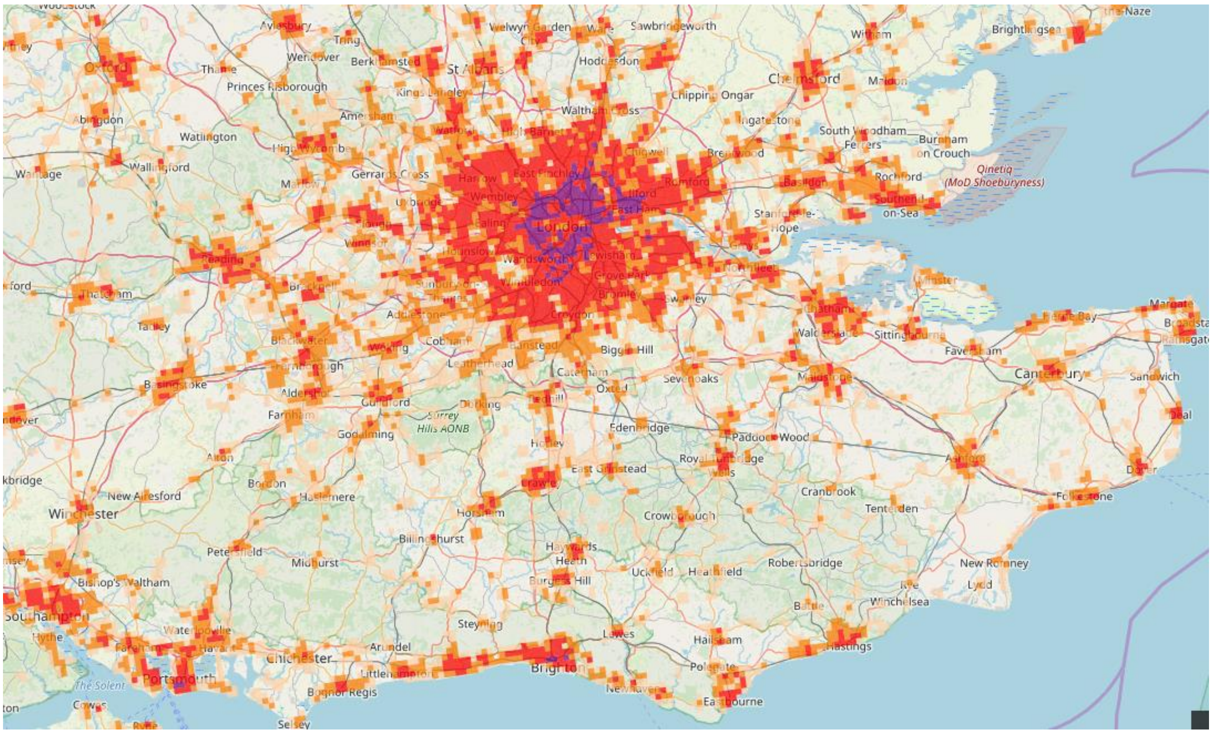

Figure 6: 1km² densities of calculated heat demand in south East England (source: Stratego)

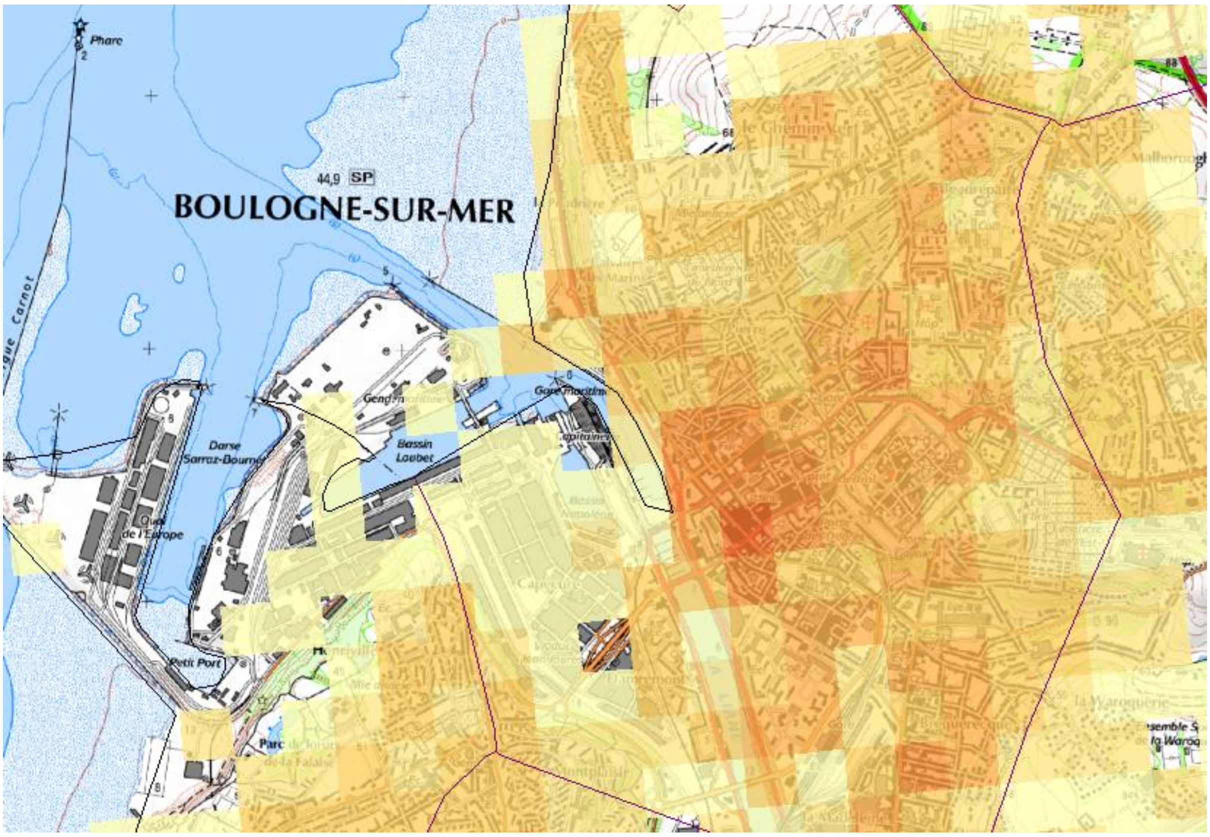

Figure 8: 200m² densities of heat demand for the residential sector in the city of Boulogne-Sur-Mer (source: French national heatmap)

Figure 7: Heat demand for residential properties at building scale in South Manchester (source: UK national heatmap)

Building energy consumption profile

Heat parameters in a building

When looking to create a DHC in an area, the heatmap requires more than just information on the global heating and cooling demand. As seen above, the ideal scale for the data is at the building level and at this scale, not only the global heat and cool demand is useful, but also its quantitative and qualitative aspects (**heat quality**).

Those aspects are:

- Building annual energy demand / floor area;
- Peak capacity / Power (Peak energy demand);
- Exterior temperature;
- Time profiles (User energy demand profiles);
- Building insulation;
- Type of heating/cooling system;
- Heat or Cool potential production.

The **building annual energy demand influences the calculation of energy density**, which in turn decides the feasibility of DHC systems. Peak power/capacity can be estimated from peak energy demand, which has influence on the investment cost. Indeed, this parameter has an effect on the power of the installations, the power of the back-up units, and the sizing of the pipes, which represent a large share of the investment for a DHC.

Users' energy demand profiles can be used to decrease the capacity **and increase the capacity utilization** (the same energy capacity/source can be used to heat up the office during daytime and nearby residential buildings during night time.) As a result, energy capacity can be decreased by **increasing the utilization factor**. Furthermore, energy-user demand profiles help to optimize the energy demand and supply. It also helps to predict the future energy demand and remains an essential part in planning and designing DHC systems.

The heat quality requirement of a building can be estimated knowing the temperature required and the insulation of the building. While well-insulated buildings require low-grade heat (low-temperature heat), poorly insulated buildings require high-grade heat (high-temperature heat). The heat quality requirement influences the possibilities to connect a building to a DHC. The type of heating system influences the heat quality requirement of a building and the possibilities to connect easily a building to a DHC.

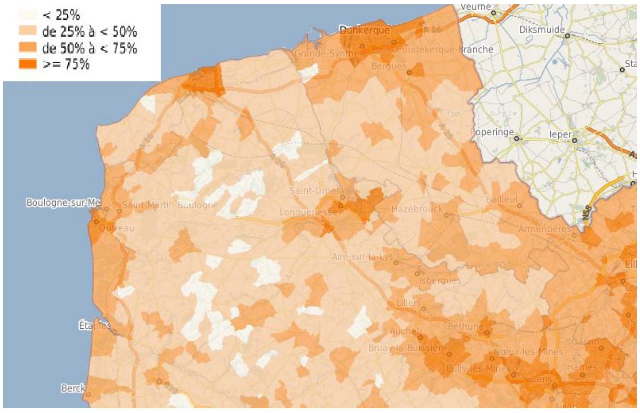

Figure 9: Share of dwellings heated with a collective boiler in the North of France (source: insee – CeremaData)

It is easier to convert to DHC a building already using a collective boiler than one with individual gas boilers. On the other hand, it is costly to convert a building with only electric heating systems.

Information on the type of heating system can be hard to find at a building level without a specific investigation and contacting the building owner or manager. Especially since to plan properly 4DHC, one needs information not only on the type of heating system but also on the type of heaters. However, data exists at a larger scale that still can be useful for energy planning (see Figure 9and Figure 10). At the city level, it is also possible to map the building already connected to an existing district heating.

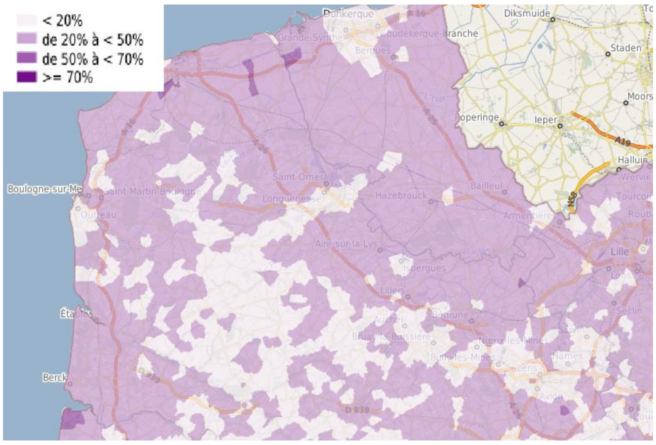

Figure 10: Share of dwellings heated with electric heaters in the North of France (source: insee - CeremaData)

Information on heat quality is even more important to plan 4DHC than to plan 3DHC. Indeed, the fourth generation DHC system has a unique aspect of heat balancing between heating and cooling. The traditional system involves the energy density mapping of heat sinks (only heat demand). **Heating and cooling demand should be mapped together spatially to identify the synergies** between them. For example, numerous hospitals have an enormous need for cooling and heating; with a classical system, the excess heat produced by the cooling system is simply wasted whereas synergies are easily achievable. The identification of matching/compatible nearby profiles further reduces the external energy supply, and therefore very useful for 4DHC planning and designing.

Mapping all the above factors will lead to a more efficient DH system planning and designing. With these elements, it is possible to plan the creation of a 4DHC but also the actions to undertake the transformation of a 3DHC to a 4DHC. Indeed, traditional DH systems operate at high temperatures, while the future generations of DHC are moving towards a decrease of the supply temperature. This is mainly because buildings are becoming more energy efficient by better insulation and other energy efficiency measures. Consequently, 4DHC systems also involve a temperature reduction. In order to connect with 4DHC systems, the buildings should be compliant with 4DHC standards (low energy buildings). And the poorly insulated buildings should be renovated with better insulation to make it energy efficient. **Mapping of energy demand with different building standards or insulation types would be helpful in 4DHC planning and designing.**

In 4DHC systems, the users can either tap heat from the network or/and deliver heat into the network. If they both use and provide energy to the network, they are called prosumers. It is beneficial to identify the potential prosumers and map them. These prosumers are easy to identify by type of activity since some activities naturally involve excess heat or cool production (data-centres, laundry building, underground station, fridge storage facilities, wastewater treatment facilities, etc.). Potential prosumers can also be identified in a heatmap, for example, by **mapping solar thermal rooftop potential**. Many maps, created and usually used for other purposes than energy planning can be helpful to localize these prosumers (see Figure 11 and Figure 12).

Figure 11: Map of data centre around Brussels (source: Data Centre Map)

Figure 12: Estimated rooftop solar potential, Oklahoma City (source: Google project Sunroof)

Buildings acting like anchor load

If it is complicated to know the heating profile of each buildings in an area, it is possible **to target some buildings thanks to their activities**. Indeed, some activities are known to transform a building into an "**anchor load**" for DHC. That means that the heating need is both massive and steady. A famous example of these "anchor load buildings" is the **hospital**. In addition the connection to a DHC is often easier because these buildings have a centralized heating system. Care facilities and retirement homes also possess a heating demand that stabilizes the district heating network. Other good profiles are leisure or sport installations, among which **swimming pools**. Universities, schools, and other **massive public buildings** are also interesting for DHC as well as social housing buildings. Those types of buildings are not only anchor loads but also potentially easier to convince because interested by a long-term solution offering a more stable price than fossil fuels. Malls and large commercial buildings can also be "anchor loads" often using both heat and cool, thus it is interesting to localize them on a heatmap.

Figure 13: Map of hospitals and care facilities in Paris (Source: Geoportail).

Mapping these anchor load buildings is an important step toward planning a DHC. For 4DHC, because cooling and heating are better linked, anchor load can also be offices buildings if they are new or recently refurbished.

New development areas or major renovation

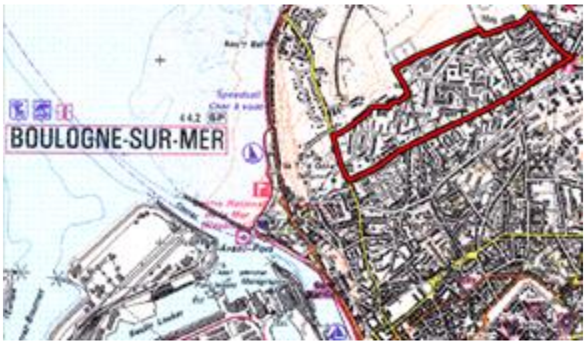

Figure 14: District under an urban renewal convention with the French government in the city of Boulogne-sur-Mer

Local authorities are often informed of new development areas and their potential for residential, commercial or industrial buildings construction. The same goes with urban renewal projects and major renovation of public buildings. Mapping this information allows a much better heat planning at the city level.

Indeed, **new development areas and major urban renewal are real opportunities to implement a DHC**, especially a 4DHC. Figure 14 shows the parameter of a vast plan of urban renewal in the city of Boulogne-Sur-Mer. The city, in partnership with its main social landlord, started to discuss the opportunity of building a 4DHC after the signature of the urban renewal convention with the French government.

Existing energy networks

Figure 15: Map of low-pressure gaz pipelines in the city centre of Huddersfield, UK (Source: Athanasios Angelis Dimakis)

To avoid waste of public money and to enhance the possibilities, **mapping the existing energy networks (gas, electricity, DHC)** is always a good option. Where a gas network already exists, it might be more difficult to build a successful DHC (and vice-versa). Even when a network is more advantageous (financially and/or environmentally) than another, due to contract constraint or fear of change, some building owners might not choose what the local authority expects.

Technical characteristics can also be useful such as temperature (to estimate if conversion to 4DHC is feasible), pressure levels or age of the pipes (to anticipate refurbishment and opportunity for a project).

With 4DHC, there is another advantage to mapping the existing networks. **4DHC systems can integrate thermal grid with other energy grids like electricity grid** or gas grid to make the global system more efficient. If the electricity grid is coupled with the thermal grid, the thermal grid can act as a buffer/load balancing which gives flexibility to both electricity and thermal grids. In order to achieve this feat, mapping of electricity demand, electricity grid and surplus electricity is an essential component going towards sustainable 4DHC systems. Mapping of other grids like gas will also be helpful moving towards designing future energy grids.

Energy sources or potential sources

The heat supply mapping is as important as heat demand mapping. **The heat supply mapping involves mapping of all nearby potential sources to satisfy the demand (in addition to mapping prosumers)**. Low-temperature waste heat is widely available in many cities. In order to ensure that it is properly used, it needs to be mapped clearly.

Indeed, since the transport of heat is costly and reduces the energy efficiency of the system**, it is important to link closely the heating or cooling production with the heating or cooling demand**. Similar to heat demand, several data are needed from the heat supply side for planning district heating systems. Both quantitative and qualitative information are important:

- Capacity (MW);
- Energy availability (MWh/year);
- Supply profile;
- Heat grade (utilization temperature).

The heat sources should be easily accessible and as close as possible to the demand. The heat availability/supply profiles are as important as heat demand profiles. Ideally, the heat demand profiles should match perfectly with heat supply profile. **Storage plays a main role in rectifying the mismatch**. The selection of storage type depends on the mismatch type - daily, seasonal, peak time etc.

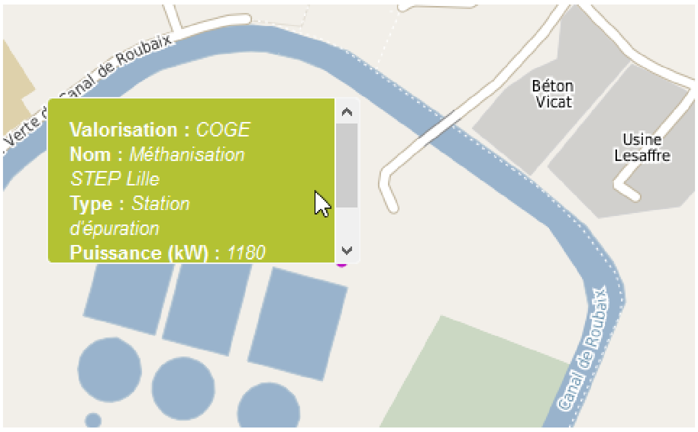

Figure 16: Map of renewable energy centre (CHP, Waste incineration plant, methanization unit) in France with data on type of activity, power and owner (Source: CeremaData)

Usually, information regarding energy sources is a punctual information with metadata such as :

- CHP (power, heat production, electricity production, fuel used, etc.);
- Thermal plant (power, electricity production, number of hours of utilisation per year, etc.);
- Methanization farm (power, biogas production, heat production, electricity production, owner name, availability, etc.);
- Waste incineration plant (tonnage, availability, hours of utilisation per year).

Energy intensive industries or crematoriums can also be potential energy sources. The mapping of boilers, large heat pumps and solar installations is also relevant since they can be connected to a DHC as back up or additional sources. In 4DHC systems, one of the main objectives is to increase the low-grade waste heat utilization and integrate more renewable energy sources. In order to achieve that, the supply temperature of 4DHC system is limited to 50 – 60°C. This will open up the possibility of utilizing waste heat (with or without heat pumps) from most of the local industries:

- Data centres,
- Waste water management plants,
- Bakeries,
- Sewage network,
- Condenser heat from refrigeration systems or large chillers,
- Supermarket,
- Underground transport system
- etc.,

Since the low supply temperature can help to integrate many possible buildings, mapping them is very crucial for planning 4DHC systems.

Renewable energies such as geothermal potential, thermal solar potential, biomass potential, etc. are also relevant to be associated with a heatmap to plan a 4DHC. Indeed, prioritizing energy sources regarding their availability and their proximity to the area of the future project is one of the keys to a successful 4DHC.

Figure 17: Data centre Map in London (source: Data Centre Map)

Mapping barriers and constraints

To go deeper in the planning of a DHC and 4DHC, it can be interesting to also add on the heatmap the barriers and constraints. **These barriers and constraints can be natural or artificial**, but also legal due to local urban legislation or environmental laws.

The natural barriers that usually complicate DHC implementation are:

- River crossings;
- Flood risk;
- Forest or reserved areas.

The artificial barriers that usually complicate DHC implementation are:

- Railway crossings;
- High traffic road crossings;

The barriers caused by environmental or urban laws are:

- Prevention plan for air pollution with zoning;
- Law on land use;
- Law on maximum height of building and building architecture constraints.

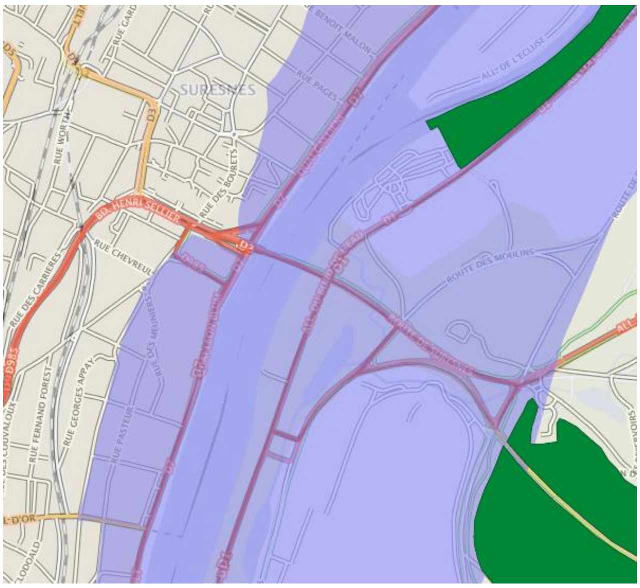

Figure 18: Map of natural and artificial barriers in Paris surroundings - railways in grey, roads in red and yellow, flood risk area in blue and natural reserved area in green (source: Geoportail).

The last three points can be problematic regarding the construction of energy centres.

If some of these barriers are hard to find and to map, other can be easily found (see Figure 18).

The **different categories of information mentioned above should be implemented using separate layers** for a better utilization and comprehension of the heatmap.

Data collection

If no one questions the advantages to have a heatmap, most local authorities or project holders face **many difficulties to collect the data at a local level.** To create a heatmap, real data is always better but harder to find and it demands time to process. Finding hypothesis-based data or creating data is less accurate but can be easier and less costly depending on the country policy. The legislative background regarding energy data in each country is an important aspect to analyse before choosing between real or hypothetical data. This part aims to help collecting or modelling data in order to create a heatmap.

Legislative and policy aspects regarding energy data in NWE countries

Energy data can be a sensitive subject for some actors and in most countries; laws provide a framework for energy data management and confidentiality.

In most countries**, individual data remains protected**. Regarding energy data, it is also the case especially in the industrial sector where data on energy consumption can easily give information on the industrial activity on site to competing companies. However, with the open-data trend and the need to plan energy more and more cleverly and locally, **energy data has become more and more open**. Open access to energy data is governed by privacy laws (data in general including smart meters). In Belgium, France, the Netherlands and the UK this means that some data sets on energy consumption are available on an aggregated level like postal code (Netherlands, UK) or street (Belgium), or 200x200m squares (France), but none on the individual house level.

Before starting a heatmap, to avoid any legal issue, it is important to know where your country stands regarding energy data and confidentiality.

European Level

At the European level, with the regulation (EC) 1099/2008 and then its modification brought by the regulation (EC) 431/2014, **national energy data is already gathered and available on the Eurostat website**[1]. Aware of the importance of having precise energy data to success in the energy transition, the European Union went further with the European directive on energy efficiency 2012/27/UE that led to the creation of **national heatmap in EU countries**. Lot of national authorities chose to make this heatmap public.

In addition, since 2011, public sector bodies are required to report their energy use annually (EU Energy Efficiency Regulations). The EU directive INSPIRE 2007 also aims to create more open-data platforms and

[1] https://ec.europa.eu/eurostat/web/energy/data

geoportals to support community environmental policies. Most of those geoportals map useful information to create a heatmap.

Other national policies made it more or less difficult to access energy data. Below are some examples of policies in NWE countries.

France

France published its national heatmap and all the data associated in 2015 but energy data remained a complicated topic until a major law on energy transition adopted in 2016, which facilitated the access to energy data. Indeed, **the multiple energy network administrators have now an obligation to make some data publicly available**. Those data concern the production, transport and consumption of electricity, gas, oil, heat and cool. By 2020, **this data must be available for the local authorities at the building level** but not in open-access. With the massive deployment in France of smart meters for electricity, gas and DHC, the quantity and quality of the data might only improve with time.

Regarding data on DHC, France made it compulsory for medium and large DHC (more than 2 MW) to answer a national survey annually. This survey made it possible to have data on DHC prices, energy mix, heat delivered and other useful information. However, the result of the survey isn't public. The Ministry of energy compiles the data at a regional or a national level.

Regarding DHC planning, the French government made it mandatory to census DHC systems and integrate them into the master plan for energy and climate at a regional level. At local level, the local authorities that possess an old DHC have to design a 10-year-scheme to develop their DHC in their energy and climate masterplan.

United Kingdom

The UK national heatmap is now offline but the department for Business, Energy and Industrial Strategy (BEIS) publishes regularly **sub-national consumption statistics associated with a methodology and a guidance booklet** to use these data[2]. Those data are based on actual and estimate data and at LSOA (Lower Layer Super Output Area, around 1.500 residents) or MSOA (Middle Layer Super Output Area, around 5,000 residents) level. A renewable energy-planning database is also open source and tracks the progress of renewable energy projects[3].

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[2] BEIS sub national consumption statistics methodology: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/771895/Sub-national_Methology_and_Guidance_Booklet_2018.pdf

[3] Link toward the Renewable energy planning database: https://data.gov.uk/dataset/a5b0ed13-c960-49ce-b1f6-3a6bbe0db1b7/renewable-energy-planning-database-repd

Scotland

The Scottish government's Heat Policy Statement insists on spatial planning to develop district heating.

The Scottish Planning Policy (SPP) of 2014 has made decarbonisation of heat a national priority for the planning system and is the main pathway through which the Scottish Government's heat policies are promoted in planning. The SPP states that Local Development Plans should use heat mapping to identify the potential for co-locating developments with a high heat demand with sources of heat supply.

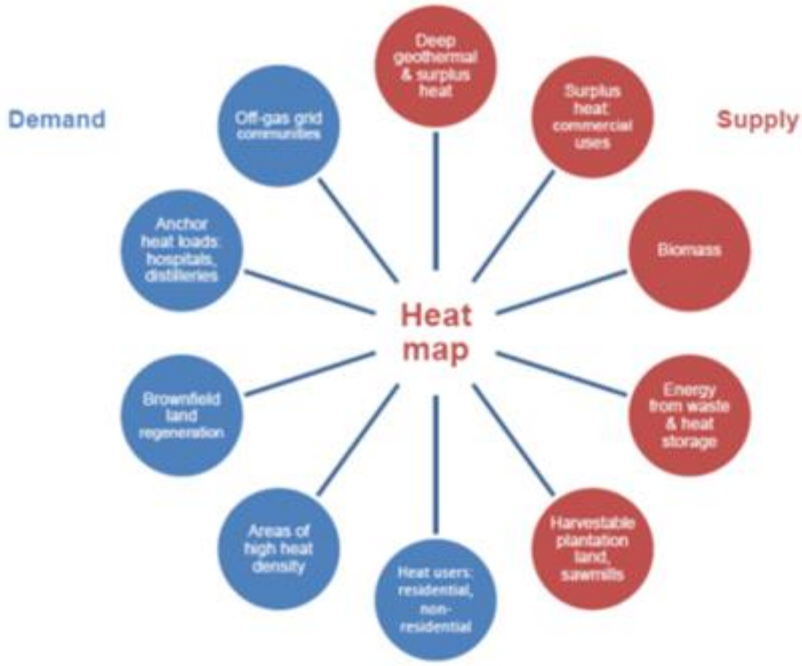

Figure 19: Potential heatmapping component (Source: Planning and Heat)

Sources of heat supply may include:

- Harvestable woodlands;
- Sawmills producing biomass;
- Biogas production site;
- Heat recoverable from mine waters, aquifers and other bodies of water;
- Heat storage systems;
- Geothermal heat;
- Developments producing unused excess heat.

Sources of heat demand may include:

- High density developments;
- Communities off the gas grid;
- Fuel-poor areas;
- Anchor developments such as schools, hospitals and leisure centres; and
- Heat intensive industries.

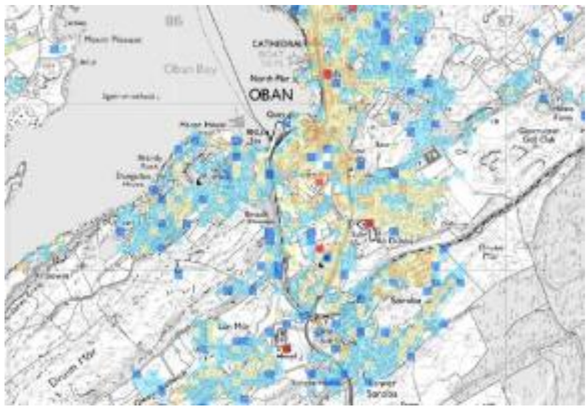

Figure 20: Scottish heatmap sample (Source: Scotland Heat Map)

SPP also states that Local Development Plans should support the development of heat networks in as many locations as possible. Initially, this includes supporting the development of carbon-based fuel powered heat networks if they can be converted to run on renewable or low carbon sources of fuel in the future. Local Development Plans should also identify where heat networks, heat storages and energy centres exist. They should identify where these may be appropriate and include policies for their implementation. **Local Development Plans may include policies to require new development to include infrastructure for immediate or future connection to heat networks**. This includes safeguarding pipework to the curtilage of development and within development sites.

The Scottish Government wrote a note on heat mapping called "Planning and Heat"[4] to help local authorities and has made its national heatmap public (http://heatmap.scotland.gov.uk/) as well as the entire manual and methodology used[5].

Ireland

The government launched a national smart metering programme in order to encourage energy efficiency. Smart meters also allows to support renewable and micro generation and improve knowledge on energy data. **The Sustainable Energy Authority of Ireland (SEAI) has developed tools to assist spatial planners** in defining the spatial energy landscape of the future. One of such spatial planning tool is the SEAI methodology for Local Authority Renewable Energy Strategies (LARES)[6].

The LARES methodology aims at facilitating consistency of approach in the development of renewable energy sources, and to assist local authorities in developing robust, co-ordinated and sustainable strategies in accordance with national and European obligations. The methodology also aims at addressing common issues encountered with RE resources, technologies and projects.

The methodology provides an outline LARES structure and detailed guidance for planning authority staff on the execution of each of the steps to complete a LARES**. It also details the primary sources of information and data**, relevant stakeholder organisations and land use interactions for renewable energy developments.

Under its Sustainable Energy Communities programme, the SEAI has also funded several local authorities and communities to develop their local Sustainable Energy Action Plans (SEAPs). After funding the development of South Dublin County Council's SEAP in 2013, SEAI provided a grant to the Council in 2014 to carry out energy demand mapping to inform its LARES and to provide a basis for incorporating the SEAP within the County Development Plan. **The City of Dublin Energy Management Agency (CODEMA) assisted in developing the methods to be applied to energy mapping** and have since applied these to energy mapping for Dublin City Council and are carrying out similar exercises for Fingal and Dun Laoghaire Rathdown Councils.

SEAI has fostered the development of tools to facilitate spatially based energy analyses and has recently revamped its online Geographical Information System (GIS) to facilitate planners who engage with spatial energy strategies and plans. The new online SEAI Energy GIS allows the SEAI renewable energy resource atlas datasets to be utilised within the user GIS environment (http://maps.seai.ie/giswiki/).

[4] To read the full note: https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2013/06/heat-demands-planning-advice/documents/817906cc-fcce-4865-946f-6995038020eb/817906cc-fcce-4865-946f-6995038020eb/govscot%3Adocument

[5] Scotland Heatmap manual and user guide: https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2018/11/scotland-heat-map-documents/documents/scotlands-heat-map-user-guidance/2.1-manual/2.1-manual/govscot%3Adocument

[6] Methodology for Local Authority Renewable Energy Strategies: https://www.seai.ie/resources/publications/Methodology-for-Local-Authority-Renewable-Energy-Strategies.pdf

Belgium

By transposition of the European directive 20136/37/UE, the Belgian law on the use of public sector information was promoted by the Belgian Government in 2016. It allows anyone to use and distribute freely any data published by the public sector. All the data is gathered on the platform (https://data.gov.be/en).

Also, the Belgian DG Energy provides energy statistics sorted by economic sector and energy sources on the Statbel platform. The data is available to all in the format of metadata and tables.

Netherlands

In the Netherlands, the data is openly available for each postal code (via https://www.energieleveranciers.nl/netbeheerders/overzicht-netbeheerders), on a yearly basis. The data regards electricity and gas consumption.

Also, the Dutch transmission and distribution system operators cooperated in order to create the Energie Data Services Nederland (ESDN), an energy data hub. The purpose of this hub is to facilitate the Dutch energy market, but the platform evolved and offers a client interface to access personal data.

From generic data to modelling

If the heatmaps already available are not relevant for the aimed purposes, and the creation of a heatmap is necessary, it is often possible to estimate the heat demand and supply using and combining different data sets. For example, in Flanders, to estimate the energy demand for the private service sector, the government used statistical data such as the average energy consumption per employee in the service sector. The total energy consumption of the sector for Flanders was multiplied by a generic 85% efficiency factor and divided by the number of employees in this sector. Then, using this ratio of consumption per employee, they computed the consumption of office and service buildings based on staff number.

Using average and statistics can lead to good heat mapping but should at least be differentiated according to the sectors. Then, according to extra data available (age or height of the building, local meteorological data, etc.) adjustment toward more accuracy is always possible.

The different hypotheses to make depend on the type of data available and the precision required. Generally, **it is better to underestimate rather than overestimate heat demand** for the planning of a DHC. Whatever the hypothesis chosen, it is important to document the methodology applied during the mapping process. It makes it easier to update information or improve the methodology in case better statistical data become available.

Numerous European and national information sources are available (often freely) to estimate the heat demand. Usually the precision is limited but with hypothesis and cross-referring data, a general heatmap can be created.

Furthermore, the EU has financed projects on heat mapping.

One of them is **Stratego** (http://stratego-project.eu/pan-european-thermal-atlas/). Stratego created a Pan-European Thermal Atlas[7] through an interactive map (see Figure 21, Figure 22 and Figure 23), which gives some thermal resources available in a region as well as thermal demand at 1km² resolution.

Another European project is **Hotmaps** (https://www.hotmaps-project.eu). Hotmaps data and toolbox allow public authorities to identify, analyse, model and map resources and solutions to supply energy needs within their territory of responsibility in a resource and cost efficient way. It integrates estimations of hourly and yearly load profiles and calculation modules; and allows users to import their own datasets. A default dataset (heat demand, heat sources) is provided for users which don't have data.

The **PlanHeat** project (http://planheat.eu/) is a similar project as Hotmaps, although the tool is in a format of a QGIS plugin whereas the Hotmaps tool is an online tool. Both offer similar features.

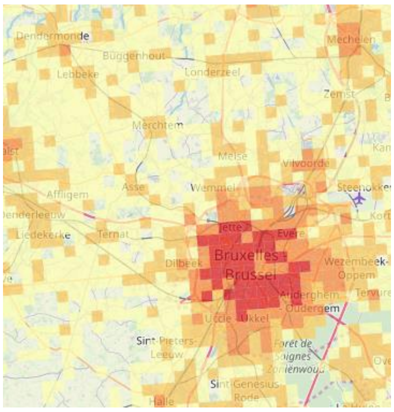

Figure 21: Heat demand 1km² resolution in Brussels area (Source: Stratego)

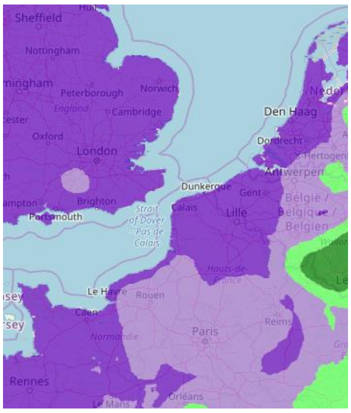

Figure 22: Wood resource in around the North sea channel (Source: Stratego)

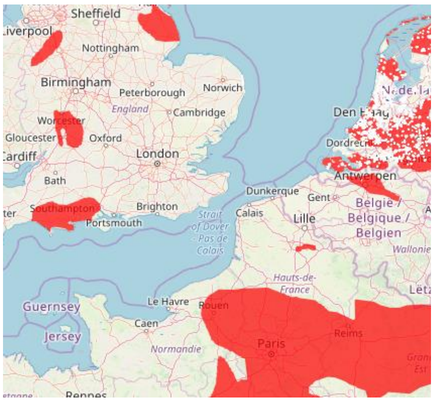

Figure 23: Geothermal sources compatible with DH around the North sea channel (Source: Stratego)

Here is the list of data usually used to estimate and map heat demand:

Based on land use - Corine Land Cover and Copernicus

Thanks to the knowledge of land use, it is possible to estimate roughly the heating demand per sector, with a ratio demand per square meter, according to the activity. Information on land use are produced at the European level through Corine Land Cover (CLC): https://www.eea.europa.eu/data-and-maps/data/copernicus-land-monitoring-service-corine . This map and data were updated in 2018 and provide information on the biophysical characteristics of the Earth Surface (using mainly satellite information). The CLC nomenclature is hierarchical including three levels of thematic detail in five major groups (artificial surfaces, agricultural areas, forest, wetlands, and water bodies) as shown in Figure 25.

Using the same idea, the European Environment Agency created an **Urban Atlas** in 2012 (https://land.copernicus.eu/local/urban-atlas/urban-atlas-2012) that improves the precision of the CLC for the urban areas (see Figure 26) and that can be very helpful to estimate the heat demand. A map of building height (see Figure 24) can also greatly help to evaluate heat density (https://land.copernicus.eu/local/urban-atlas/building-height-2012?tab=mapview) at a more precise level, using the ratio of heat demand per square meter. Unfortunately, the data exists only for major cities so far.

[7] To access the interactive map: https://heatroadmap.eu/peta4/

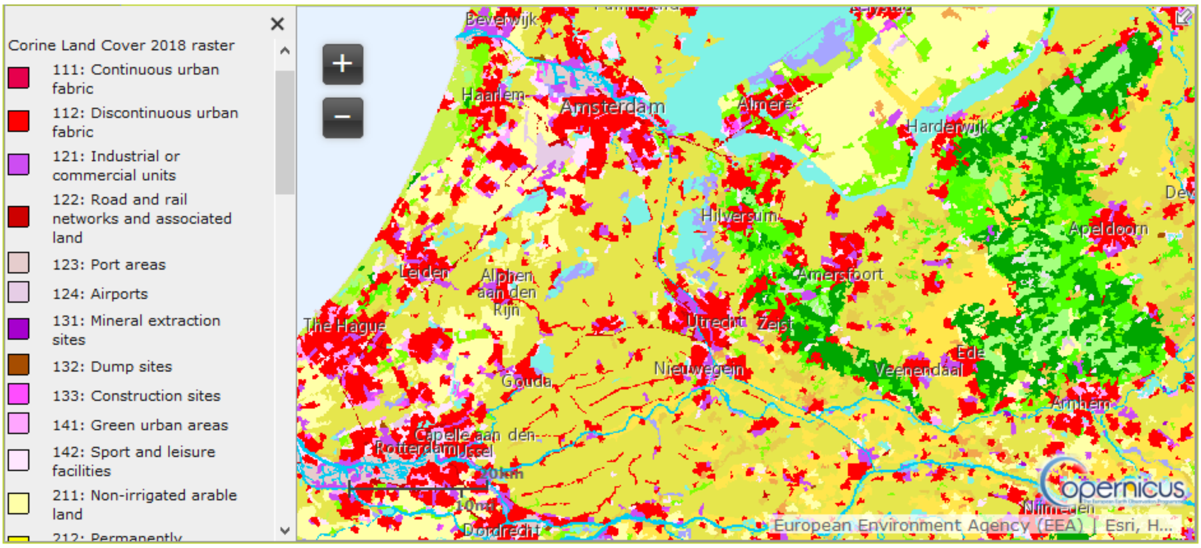

Figure 25: Corine Land Cover map view around Amsterdam (source: European Environment Agency, Copernicus)

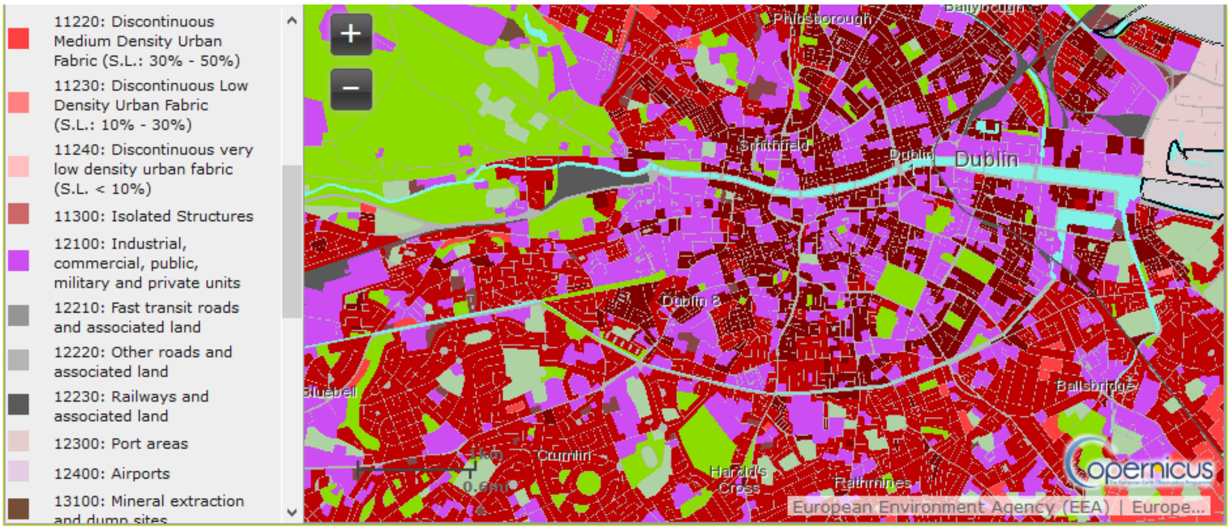

Figure 26: Urban Atlas 2012 Map view of Dublin (source: European Environment Agency, Copernicus)

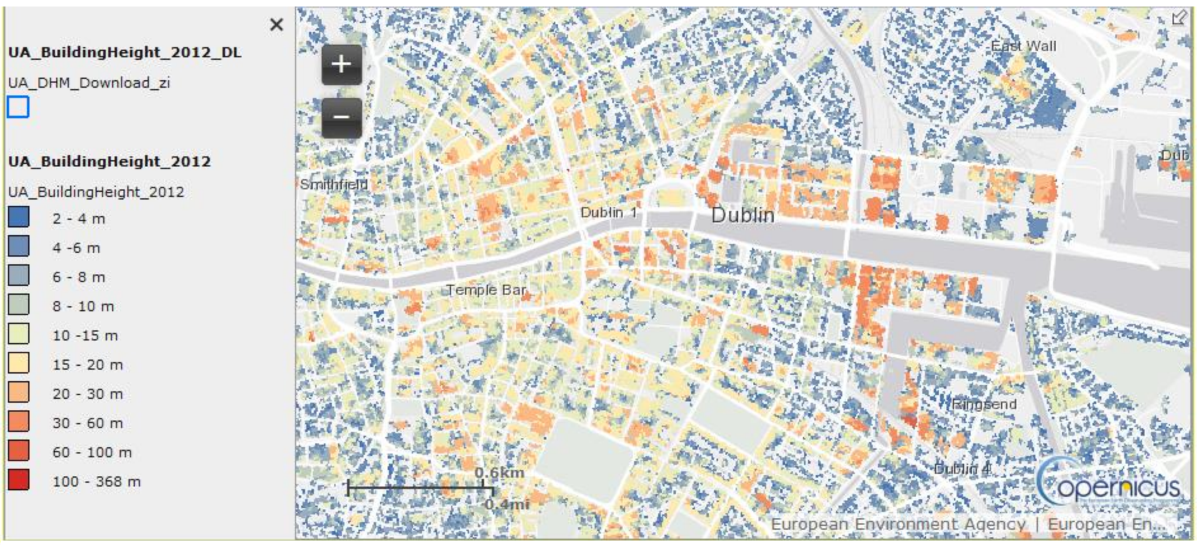

Figure 24: Building Height in Dublin (source: European Environment Agency, Copernicus)

Based on population and demographic data

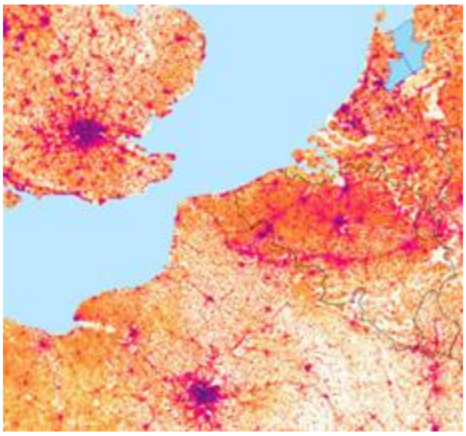

Figure 27: Geostat 2011 - Map view (Source: EFG, Eurostat)

Data on population density can also be useful to estimate the heat demand, using a ratio on consumption per inhabitant. **The Eurostat website** (https://ec.europa.eu/eurostat/data/database) provides data on population but the data is available only at a regional level and not at the city or neighbourhood level. The **Geostat** project provides data on population density on a 1km x 1km grid, which is much more useful for the creation of a heatmap. (https://ec.europa.eu/eurostat/fr/web/gisco/geodata/reference-data/population-distribution-demography/geostat).

It is also possible through these statistics to have the evolution of the population for the past years. This **knowledge on the trend of the population made it possible to estimate future population** and thus create hypothesis regarding the future demand (hypothesis that must be combined with the evolution of the buildings insulation and performance and the renewal rate of the building stock).

Meteorological data

- Heating and cooling degree-days: https://www.eea.europa.eu/data-and-maps/indicators/heating-degree-days

Heating degree-days (HDDs) and cooling degree-days (CDDs) are proxies for the energy demand needed to heat or cool, respectively, a home or a business. Both variables are derived from measurements of outside air temperature. The heating and cooling requirements for a given structure at a specific location are considered, to some degree, proportional to the number of HDDs and CDDs at that location.

- Min and max temperatures: http://re.jrc.ec.europa.eu/pvgis5/tmy.html

Other meteorological data can also be found on national websites of NWE countries. For example, the following websites provide hourly observations of weather stations for Belgium:

  - https://www.geo.be/#!/catalog/details/RMI_DATASET_AWS_1HOUR?l=fr
  - https://opendata.meteo.be/

Consumption for space heating

The **ODYSSEE database**, created by the ODYSSEE-MURE project, aims at providing data on energy efficiency policies and motoring of the energy efficiency trends. The database provides the average heating consumption per dwelling or per square meter for households at national level: http://www.indicators.odyssee-mure.eu/online-indicators.html

It is also possible to estimate heating consumption thanks to the diagnosis of energy performance that are mandatory in many cases and in many countries.

Thermographic data –knowing the level of insulation

Heat loss due to poor insulation can be easily detected through thermographic imaging. Numerous cities have used it to raise awareness among their citizens and get them to improve the insulation of their roofs. These thermographic maps are well spread in Belgium for example (Ghent, Antwerp, Brussels, etc.). They can be used in heatmaps to spot areas to be refurbished or on the contrary to spot buildings suitable for 4DHC.

From historical data to modelling

To create a high quality local heatmap**, using real historical consumption data is the most accurate**, but also the most difficult to undertake. Real data can be collected thanks to different sources:

- Historical meter reading;
- Energy bill;
- Smart metering;
- Energy performance certificates;
- Energy labels (Passiv'haus, Minergie as a matter of example);
- Customer specific estimates.

Dialogue with building owners or managers is one of the best ways to obtain the information needed. Through dialogue, questions regarding peak loads, current state of the boiler(s), etc. are also possible.

Hopefully, national or regional data about heat demands are often available for free and for everyone through regional or national observatories. Other organisations can provide data on demand (free or not). These data can be a start or a way to know where to look further.

It is important to check the accuracy of the existing data and its quality. Data can be useful even if not perfect but it is important to understand the limits of the data in order to better apprehend the limit of the actions that can be engaged thanks to the heatmap.

The main sources to use for energy data are listed and detailed in the following paragraphs.

At the European level

The European Commission provides numerous data and analysis regarding the energy market (https://ec.europa.eu/energy/en/data-analysis). Prices, statistics and energy market scenarios for 2030 and 2050 are also available on the commission website. Through Eurostat (https://ec.europa.eu/eurostat/fr/data/database), it is also possible to find raw data with metadata and explanations. Eurostat allows to download the data in different format for free. Eurostat publishes data on numerous topics and not only on energy and on environment. Data on economy, transport, industry, social indicator can also bring useful indicators or help to find useful hypothesis for a heatmap. However, these two sources are often at a national level or regional level. To have more precise data, other sources are needed.

Energy consumption

As already mentioned in the paragraph on policy aspects of NWE countries regarding energy data, a lot of effort was made by governments to make energy data more available and improve energy planning. Here is a list of the official government data regarding energy in NWE countries.

- United Kingdom:
  - https://www.gov.uk/government/organisations/department-for-business-energy-and-industrial-strategy/about/statistics
- France: Geoportail and Via Seva and other local heatmap:
  - https://www.data.gouv.fr/fr/datasets/donnees-locales-denergie/
  - https://carto.viaseva.org/public/viaseva/map/
  - https://www.observatoire-des-reseaux.fr/cartographie/
  - https://opendata.reseaux-energies.fr/pages/accueil/
  - https://www.agenceore.fr/
  - https://www.enedis.fr/consommation-electrique-par-secteur-dactivite
- Belgium:
  - National level : https://statbel.fgov.be/en/themes/energy/energy-statistics-economic-sector-and-energy-source
  - https://lokaal-bestuur.fluvius.be/nl/thema/nutsvoorzieningen/open-data
  - https://walstat.iweps.be/walstat-catalogue.php?theme_id=16
  - https://energie.wallonie.be/fr/bilans-energetiques-wallons.html?IDC=6288
- Ireland:
  - https://www.cso.ie/en/releasesandpublications/ep/p-eii/eii2016/energy/
- Netherland:
  - https://www.cbs.nl/nl-nl/economie/industrie-en-energie
  - https://www.energieleveranciers.nl/netbeheerders/overzicht-netbeheerders

Usually, existing data were not created for heat mapping purposes, thus, the cleaning and checking of the data is necessary and takes time. Hopefully, with the big data and the numerous open data projects, future data will become more and more standardised and easy to use.

Energy infrastructures and network

In some countries, energy networks can be already mapped and data freely accessible (for example in France). Otherwise, grid operators have all the information required but can be reluctant to give them or can use a format for the data that is difficult to include in a mapping tool.

Industrial and unconventional energy sources

Information on industrial plants is available on the European Commission website: https://prtr.eea.europa.eu/#/home. This map only concerns industrial activities that release pollution. Energy sector, waste and water management, paper and wood production processing and chemical industries are thus included. It is possible to choose the industrial activity of your choice or the economic sector using NACE system.

Another potential source of information is the website IndustryAbout (https://www.industryabout.com/industrial-maps) which maps industries in several activities.

Figure 28: Industrial plants around the city Antwerp (Belgium) (Source: European Pollutant Release and Transfer Register)

For smaller installations, an interactive map showing various completed renewable energy projects was created within the framework of the IEE project Repowermap: https://www.repowermap.org/. It is not an exhaustive map but many projects are presented and can be sorted out by type of energy. Another source for 4DHC is data centres, and an open access free map exists (also non-exhaustive): https://www.datacentermap.com/.

An easy option is to use the data already treated by European projects, which directly provide energy consumption and excess heat potential of industrial sites, like the PanEuropean Thermal Atlas[8] and the Hotmaps toolbox[9] (this one providing load curves). The PanEuropean Thermal Atlas also provides data regarding excess heat of metro stations and wastewater treatment plants from the European ReUseHeat project[10].

Heat extraction from sewage is trickier at the street level but local authorities often have data on their own networks. Sewage pipes with a diameter of at least 1 meter located very close from a heat demand area are the best candidates to map. Some cities, like Antwerp in Belgium have mapped the potential of heat from sewage pipes.

Geothermal potential

Geothermal potential for deep geothermal energy has already been mapped in Europe through the GEoDH project (http://geodh.eu/). The map is available here: https://map.mbfsz.gov.hu/geo_DH/ and indicates the existing district heating networks and the existing deep geothermal installations (see Figure 29). This map made by GeoDH has also been included into the PanEuropean Thermal Atlas and the Hotmaps tool. Another European Project called ThermoMap has mapped the very shallow geothermal potential (first 10 meters deep) in terms of heat conductivity[11]. National resources on geothermal energy, including maps with potential for deep geothermal energy and for heat pumps with information regarding regulatory constraints also exists in numerous countries around NWE Europe:

- France – géothermie perspective: http://www.geothermie-perspectives.fr/cartographie

[8] https://heatroadmap.eu/peta4/
[9] https://www.hotmaps-project.eu/
[10] https://www.reuseheat.eu/
[11] http://geoweb2.sbg.ac.at/thermomap/

- England – British Geological Survey : https://www.bgs.ac.uk/research/energy/geothermal/
- Scotland – Scottish Government: https://www.gov.scot/policies/renewable-and-low-carbon-energy/geothermal-energy/
- Belgium – énergie Wallonie: https://energie.wallonie.be/fr/la-geothermie-profonde.html?IDC=6173
- Ireland – DCCAE geological survey Ireland: https://dcenr.maps.arcgis.com/apps/webappviewer/index.html?id=9ee46bee08de41278b90a991d60c0b9e and https://data.gov.ie/dataset/geothermal-modelled-subsurface-temperatures-1000m-depth
- Netherland - Dutch ministry of Economic affairs : https://www.nlog.nl/en/geothermal-energy

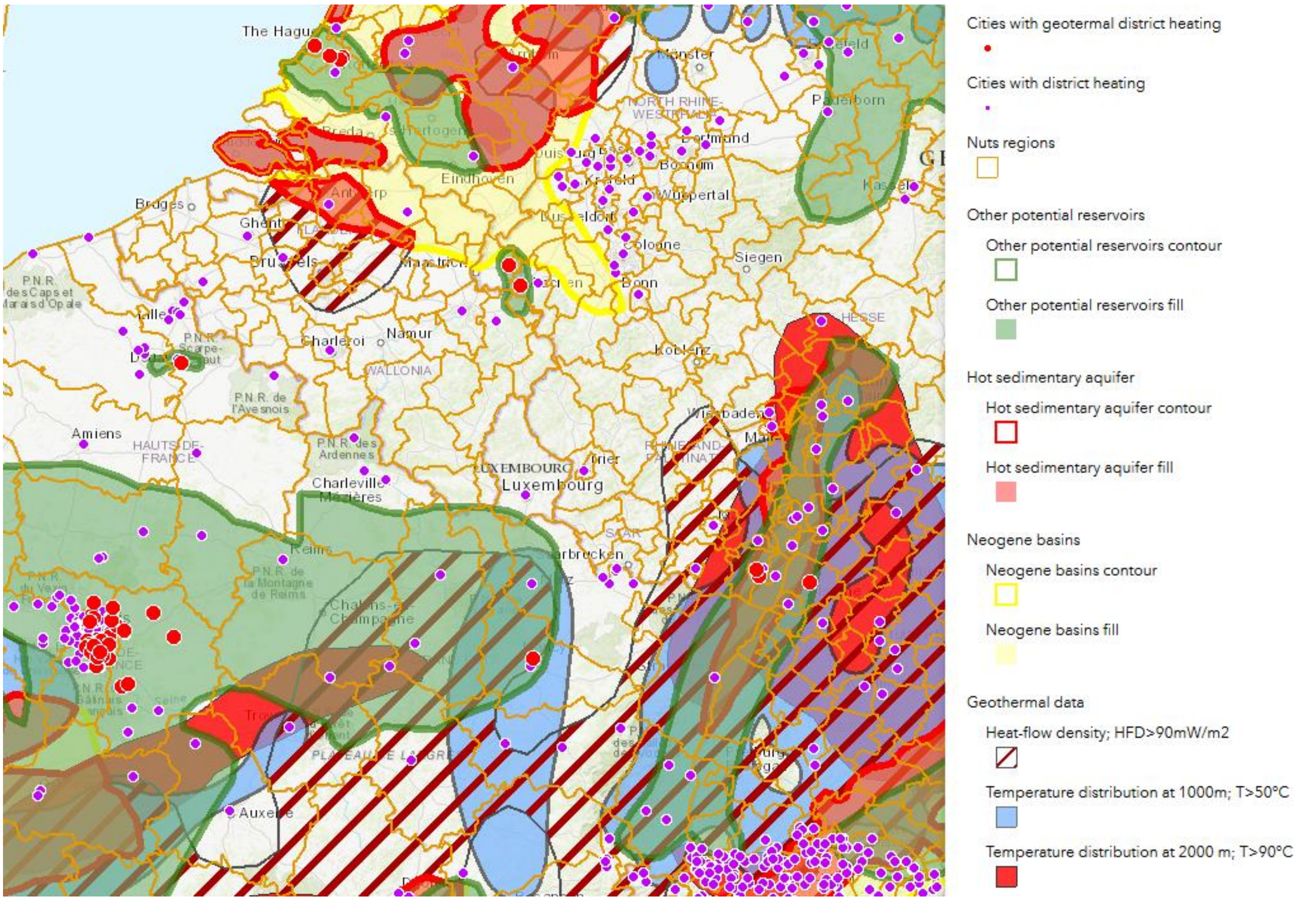

Figure 29: Geothermal resources and existing installations (source: GeoDH)

It is also important not to forget the energy potential from water bodies (hydrothermal energy). Rivers, lakes, seas and other water bodies are well known and easy to map even if getting their temperatures (during winter time and summer time) can be more complicated.

Biomass and biogas potential

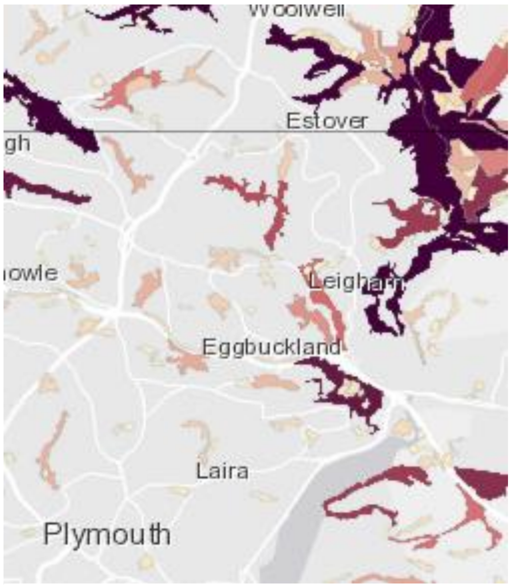

Figure 30: Wood Inventory around Plymouth (Source: Forestry Commission open data)

Biogas and biomass potentials can be estimated by mapping the agricultural areas, the forest areas and the wastewater treatment plants, as well as the organic municipal waste treatment plants and landfills.

Using the Corine Land Cover database, it is possible to work on the potential of biomass and biogas. Indeed, hypothesis like 1 hectare for a boiler of 2kW or around 5000 kWh/tonne of wood are easy to apply. The European projects mentioned above also estimate the energy potential of biomass and biogas through different sources (livestock effluents, forest and agricultural residues, etc.).

To go further and estimate more precisely the potential, it is important to have the detail of the trees (at least distinguishing hardwood and softwood trees) and cultures on site and to know the percentage of forest and agriculture land that already produces biomass and biogas.

European resources on forestry exist, like the European Forestry Inventory, which also produces maps (https://www.efi.int/knowledge/maps/treespecies). In several countries, regional master plans on biomass energy have already been done as well as surveys on wood use. National database also exist in numerous NWE countries:

- UK – the NFI woodland map and resources: https://www.forestresearch.gov.uk/tools-and-resources/national-forest-inventory/about-the-nfi/
- France – IGN inventaire forestier : https://inventaire-forestier.ign.fr/spip.php?article646
- Belgium – Inventaire Permanent des Ressources Forestières de Wallonie: http://iprfw.spw.wallonie.be/
- Netherland – Sixth Dutch Forest Inventory (NFI6): https://www.wur.nl/en/Research-Results/Research-Institutes/Environmental-Research/Projects/Dutch-Forest-Inventory.htm
- Ireland – Ministry of agriculture : https://www.agriculture.gov.ie/forestservice/forestservicegeneralinformation/foreststatisticsandmapping/forestmapviewer/geoportal/

Solar thermal potential

To map the solar thermal potential the main important factor is the global irradiation. Several maps are available:

- PVGis – European commission (free): http://re.jrc.ec.europa.eu/pvgis/countries/europe.htm
- Global Solar Atlas (free): https://globalsolaratlas.info
- Solargis (free samples, otherwise from 500 to 3600€/yr) : https://solargis.com/maps-and-gis-data/overview/

The European projects mentioned earlier (Hotmaps, PlanHeat) also map solar energy potential.

In addition to global irradiation, available maps of roof space can also be a way to investigate further the solar thermal potential of a city. If some projects such as the Google project Sunroof (https://www.google.com/get/sunroof#p=0) are currently working on solar energy potential of buildings, it is often limited to PV panels. Numerous cities or states are already starting solar potential maps (often open source) using roof potential (see Figure 31). The City of Auckland has even added an economic assessment and solar installation specifications to its Rooftop Solar Energy Potential (http://solarpower.cer.auckland.ac.nz/). In NWE, Zonatlas has mapped several cities in the Netherlands considering the rooftop potential (see Figure 32).

Should one want to create his own solar rooftop potential map, the city of Bristol made its methodology public as an example[12].

It is also possible to use PV panels in DHC (for the heat pumps or auxiliary equipment for example) instead of thermal solar if another heat source is better.

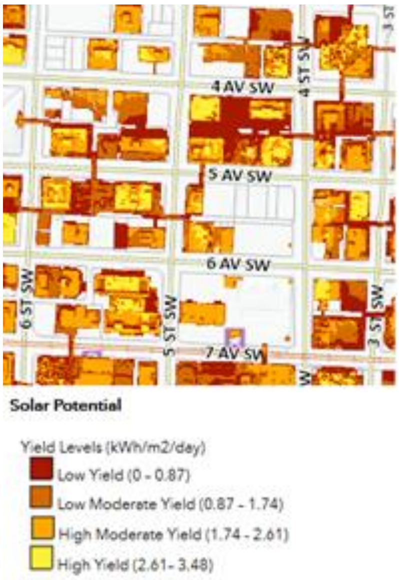

Figure 31: Solar potential Map of Calgary (Source: City of Calgary)

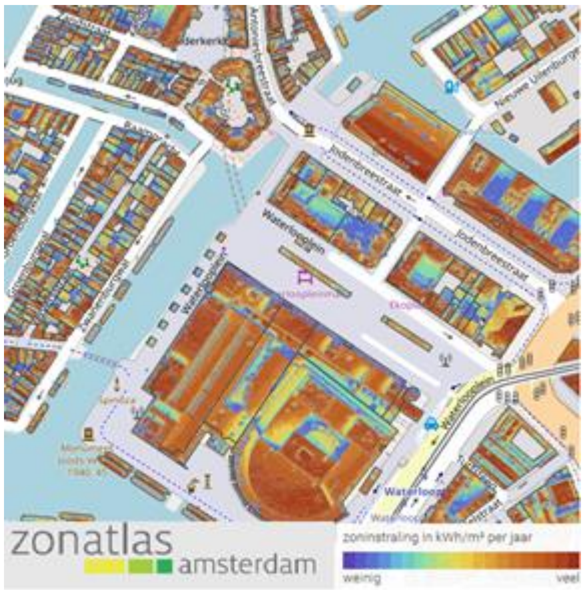

Figure 32: Solar potential in Amsterdam (Source: Zonatlas)

In Flanders, a map can be used to view the roofs that are relevant for implanting solar panels: https://apps.energiesparen.be/zonnekaart (see Figure 33).

12 Bristol Sunshine – technique and outputs: https://www.bristol.gov.uk/documents/20182/33776/5+Bristol+Sunshine+-+An+Analysis+of+Rooftop+Solar+Mapping.pdf/49941f3f-f524-4c0e-9dcf-bbf1559f75ea

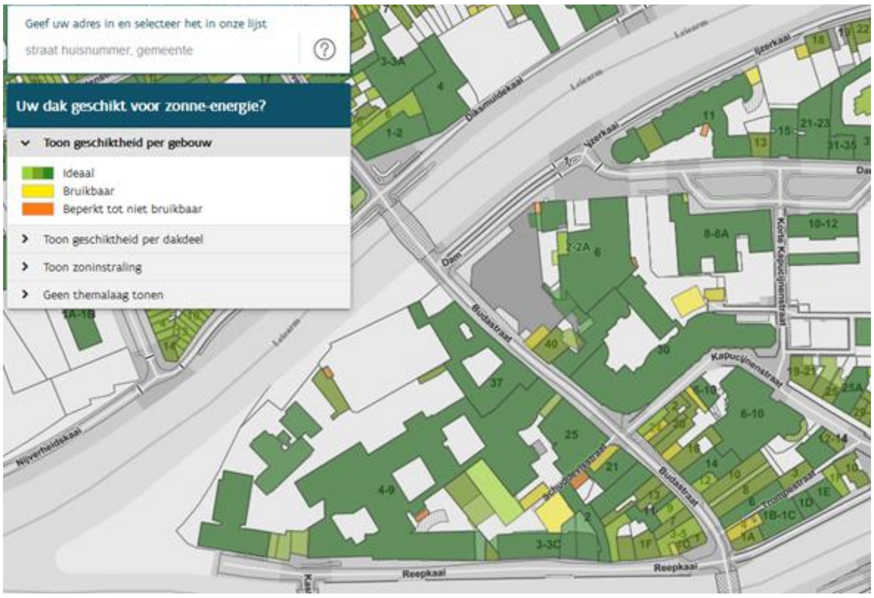

Figure 33: Map showing the relevance of solar panels per building in Kortrijk (Source: Energiesparen)

What to do with the heatmap?

At a National or regional level

In addition to improving energy planning, heatmapping at a national or regional level can help to plan the deployment of DHC networks. Firstly by making it possible **to calculate the potential of deployment of district heating and cooling** and secondly by **identifying the most promising areas** and adapt the legislation or subsidies.

To calculate the potential of deployment, numerous methods exist depending on the heatmap. For example, if the national heatmap is made with 200 square meters of heat density, it is possible to choose a minimum acceptable heat density and add up all squares that are above this minimum in order to roughly estimate the overall maximum potential of district heating at the national or regional level.

The minimum heat density for a square of 200m² must be chosen in order to have a financially viable district heating. Regarding the current policy and existing DHC projects, the limit in terms of heat density by linear meter of district heating is often known in NWE countries. For example, in France, this limit is usually set at 1.5 MWh per linear meter; the International Energy Agency recommends a value superior to 1.8 MWh per linear meter. Therefore the hypothesis to build a district heating of 300 linear meters in a 200 m² area is quite credible if the heat consumption is superior to 450 MWh (300m x 1.5MWh/m). Of course because not all buildings can connect to the DHC, it is wise to choose a minimum heat consumption higher than 450 MWh especially if there is not a lot of incentives to connect to a DHC in the country or if there are a lot of electric heaters in the considered area.

Once again, it is possible to choose hypothesis such as considering than no more than half of the buildings could connect and thus add only squares where heat density is higher than 900 MWh. If the idea is to calculate the immediate potential, some **hypothesis must be made according to the current legislation and incentives** but someone can also **estimate the potential of a new legislation or incentives by choosing new hypothesis**.

A heatmap can also be used to detect high potential cities where no district heating has been built yet. For example, with a national heatmap, sorting out cities with more than 10,000 inhabitants without district heating becomes possible. Listing the areas with a major waste heat source and a district heating nearby or without district heating at all is also a good use of a national heatmap. Offering financial help or technical help to these high potential cities is a good way to improve the deployment of DHC in a country or a region.

At a local level

One of the main purpose of a heatmap at a city scale is to identify sustainable heating and cooling potential projects. By crossing high heat density areas and potential sources, it is possible to start analysing a DHC project. Many cities have already traced potential district heating that would be financially viable thanks to a heatmap (with or without considering the heat sources).

The next part illustrates what is possible to do thanks to a heatmap at local level with the valuable input from the pilots of HeatNet NWE, namely South Dublin City Council and Plymouth City Council.

Feedbacks from pilots

HeatNet NWE helped six District Heating and Cooling projects to go forward 4DHC. All of the six project developers used a heatmap at one point or another in their schemes. Here is illustrated how two of them used heatmapping during the process of developing a 4DHC.

South Dublin, heatmapping for a global energy policy at a county scale:

Figure 34: South Dublin City Council

South Dublin County Council (SDCC) is the third largest local authority in Ireland with a population of 265,000 inhabitants and 90,000 households, 6,000 businesses covering an area of 223 square kilometres. SDCC has already gained expertise in the area of cross-departmental energy planning through the participation in the Leadership for Energy and Action Planning[13] project and the Spatial Planning and Energy for Communities In All Landscapes project[14].

In 2015, the South Dublin County Council asked Dublin's energy agency (Codema) to achieve a Spatial Energy Demand Analysis[15] (SEDA) in order to understand energy needs, and how energy efficiency and renewable energies can respond to the challenge of energy transition.

The energy data for the commercial, residential and municipal sectors had been already gathered using the EU Covenant of Mayors and sustainable energy action plan (SEAP) methodologies. These methodologies had been refined to generate a range of energy information: energy demand, heat density and energy costs.

[13] For more information on the LEAP project: https://leaps-eu.org/
[14] For more information on the SPECIAL project: http://www.special-eu.org/
[15] Full report of the analysis available here : http://www.codema.ie/images/uploads/docs/South_Dublin_Spatial_Energy_Demand_Analysis_Final.pdf

Codema used several data sources including Central Statistics Office (CSO), Valuation Office, Sustainable Energy Authority of Ireland (SEAI), Building Energy Rating (BER) datasets and of course energy data from SDCC owned buildings and facilities.

Five mains sets of data were created for each of the three sectors: total energy use, total heat demand, total electricity use, total fossil fuel use, estimated total annual energy costs. The geographical breakdown into "small areas" is used for spatially visualising the energy data. A "small area" is an area of population comprising between 50 and 200 dwellings (the lowest level in Ireland for the compilation of statistics). This geographical breakdown results into "small areas" of various sizes and makes it more difficult to compare total energy demand between areas. Here energy density must be used to make this comparison (see Figure 35 and Figure 37). The total energy demand can also be analysed in conjunction with the map showing the location and energy demand of each commercial and municipal building (Figure 36). The analysis of Figure 35, Figure 37 and Figure 36 easily leads to identifying high priority areas for DHC that require further investigation (energy use in terms of heat and electricity demands).

The high priority areas are, if close enough, grouped together and the type of activities are listed to see if the mix of buildings uses is favourable to a DHC. Then Codema searched for other anchor loads nearby. Once this phase achieved, a feasibility study for the deployment of DHC on selected areas started.

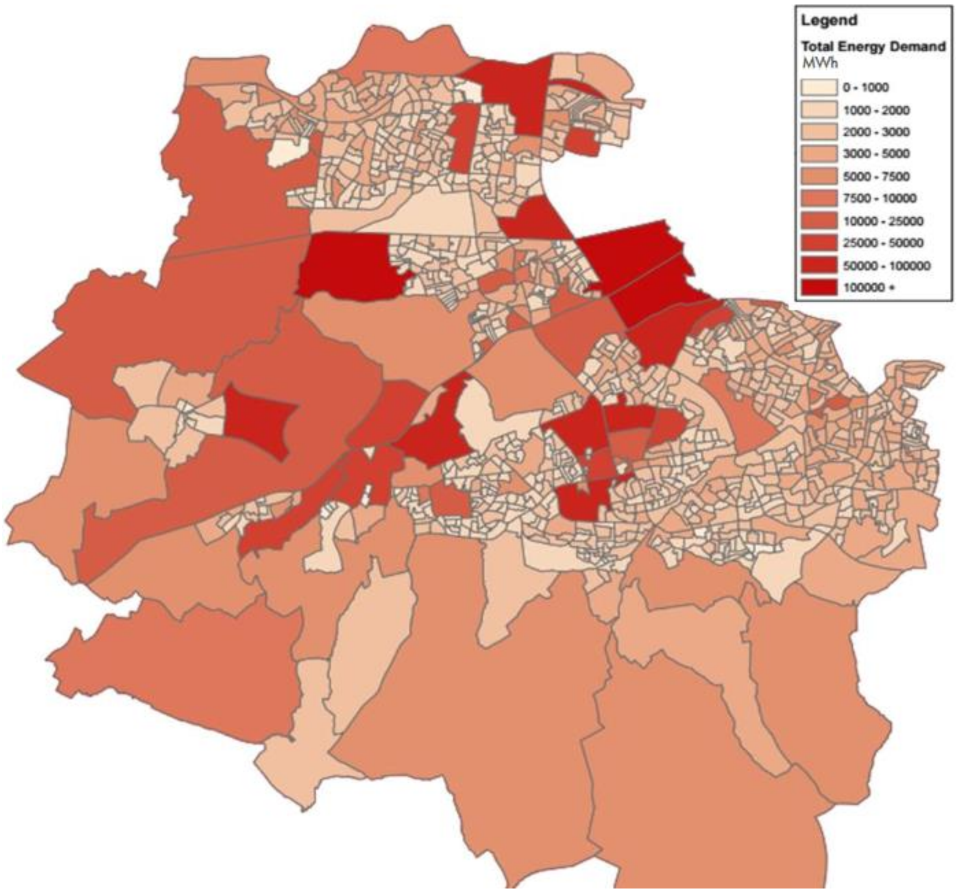

Figure 35: Total Energy Demand (MWh) Map in South Dublin County (SDC) (source: Codema, SEDA)

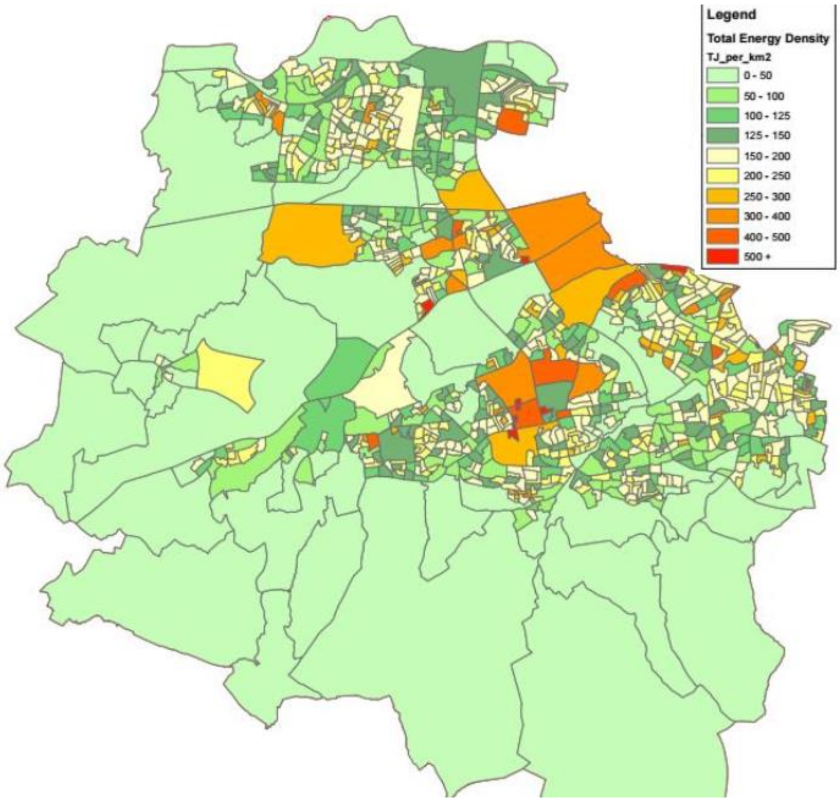

Figure 37: Energy Demand Density (TJ/km²) Map in SDC (source: Codema, SEDA)

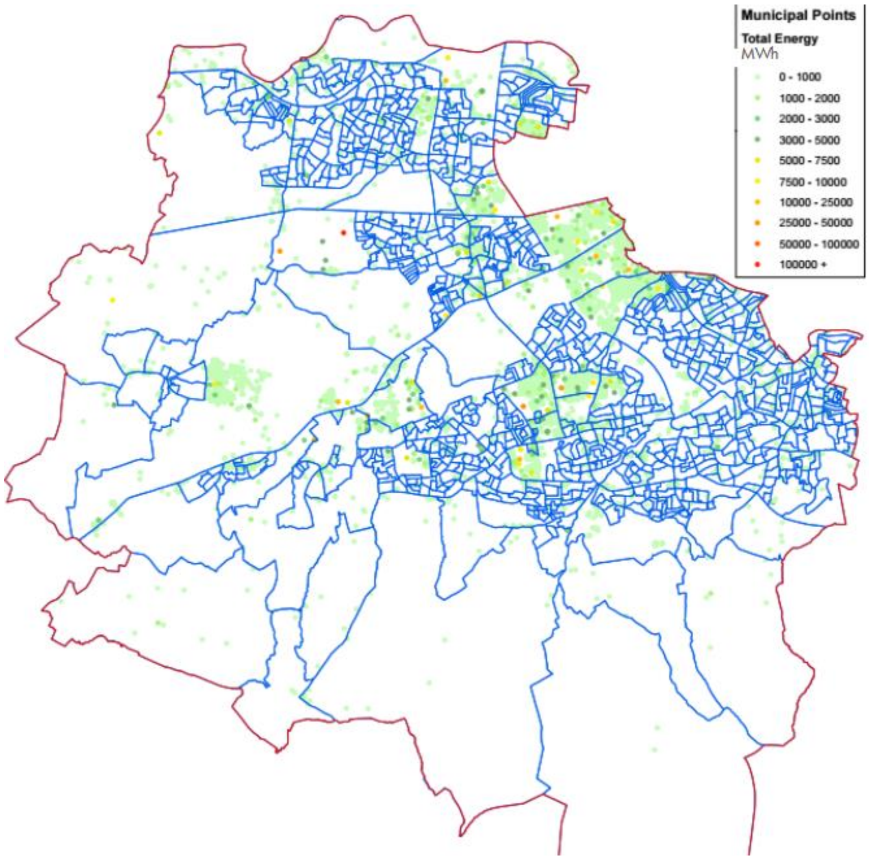

Figure 36: Energy use (MWh) and location of each commercial and municipal building (Source: Codema, SEDA)

The residential sector analysis was the easiest and most detailed part. In order to attach a location to the dwellings, the Central Statistics Office formulated special tabulations, which showed the number of each housing type and the period in which each was built within each “small area”. However, like in numerous countries in the EU, data protection law requires to “hide” data when the breakdown could possibly allow identification of individual households (less than 2% of the dwellings for the SDCC). Then, using the application of actual BER data, it is possible to find an average energy profile for the entire housing stock in the SDCC region. However, no actual energy consumption data (bills, metered consumptions) were available. Regarding the cost of energy, Codema used fuel mix from BER data and prices from SEAI Cost Comparison Prices for Domestic Fuels to calculate the energy costs for residential energy user in each “small area”.

For the commercial sector, the openly available sources regarding energy information in Ireland are scarce. Codema used data form the UK’s Chartered Institution of Building Services Engineers (CIBSE), which, through audits, was able to establish an average energy use per metre-squared floor area for each commercial activity type. Then, Codema used data on floor area and localisation of the commercial buildings by activities from the Valuation Office. This work led Codema to identify a large industrial pharmaceutical plant and a large data-centre in the same area as well as a hospital in a high density commercial area.

For the municipal sector, thanks to the EU directive on Energy Efficiency, Codema had access to real energy data for the 141 SDCC’s buildings. The biggest energy users are the leisure centres in Tallaght, the stadium, the civic center, theatre and offices.

For the projections into the future, even with higher building energy ratings standards for new homes, considering past job/population ratio and population projections the report assumes an increase of the energy demand. To identify areas of potential for low carbon district heating, a heat density analysis has been undertaken. Areas above 250 TJ/km² are identified in this analysis as priority areas[16].

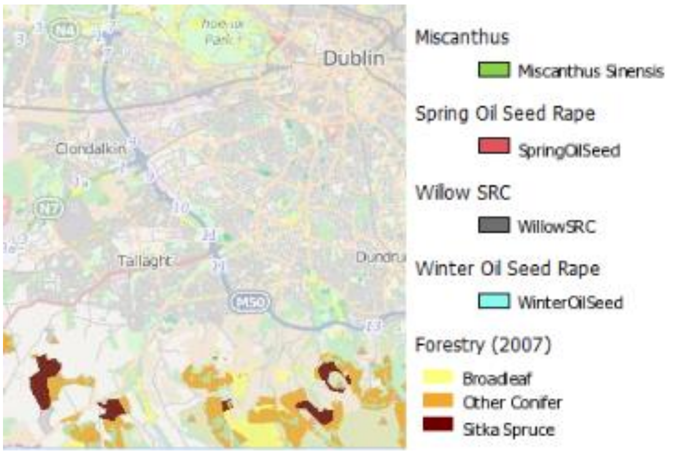

Figure 38: Bioenergy sources close to SDC (Source: SEAI bioEnergy Mapping system)

Another important phase of the SEDA and the heatmaps was the research of energy sources. Codema looked into bioenergy and geothermal energy potential thanks to existing national resources (see Figure 38 and Figure 39). Waste heat potential sources have also been explored thanks to energy data for commercial sector collected for this SEPA.

The SEDA included also a map of barriers and constraints on the SDC area with major roads, canals, rails (see Figure 40).

[16] This figure of 250TJ/km² must be adapted to every country according to their energy prices and their fiscalities on fossil fuel. For example, in Denmark, 150TJ/km² is used instead of 250 TJ/km².

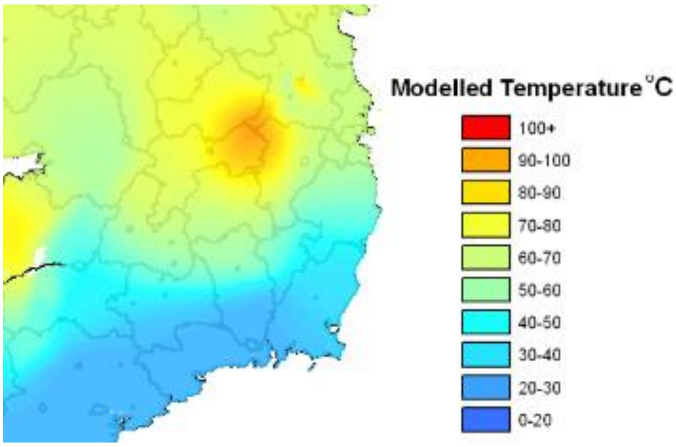

Figure 39: Geothermal Temperature at 2500m (source: SEAI Geothermal Mapping System)

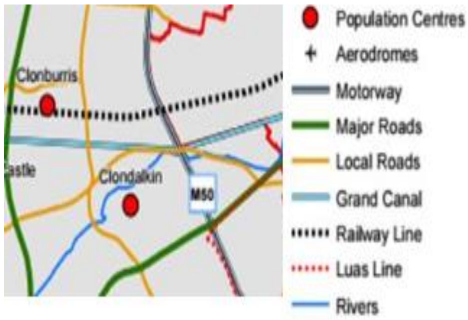

Figure 40: Barriers and constraints in SDC area (Source: SEDA, Codema)

The methodology used by Codema and described above is of course summarized and simplified, the full report explains the hypothesis taken and how to handle the problems of non-uniformed data when using multiple data sources.

Through this analysis, the area of the Tallaght-Springfield district, close to Tallaght town centre was outlined as the top priority area for the building of a DHC. It is indeed an area of high commercial, residential and municipal activities with anchor loads such as the Tallaght hospital. A feasibility study has been carried out then, which also identified a new development area. This feasibility study leading to the creation of the South Dublin pilot using waste heat from a data centre has been carried out thanks to this heatmap analysis. The feasibility study then has resulted into the project shown in Figure 40.

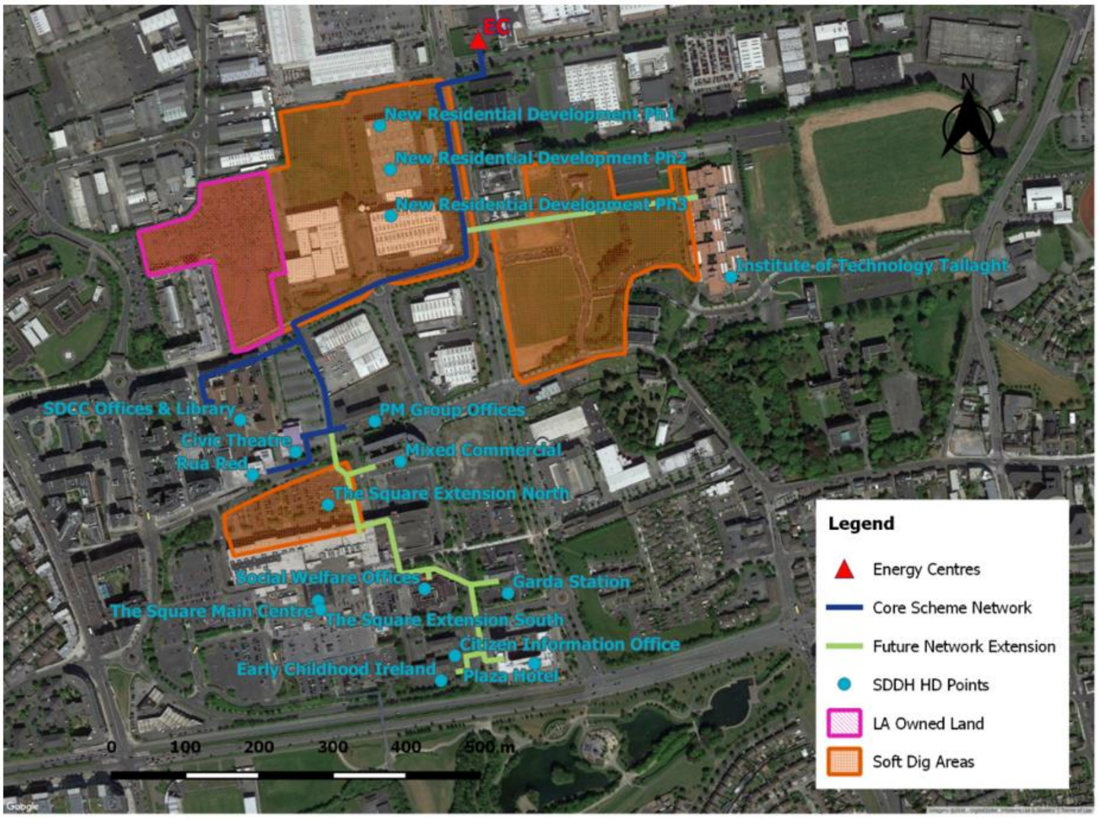

Figure 41: South Dublin scheme for the new 4DHC

Plymouth, heatmap to develop a 4DHC in the city centre

Plymouth City Council (PCC), as a part of its Energy Masterplan, decided in 2016 to undertake a heat mapping[17] and to study the potential of district heating deployment in the wider Cultural Quarter and in the City Center area. The City decided to commission BuroHappold (BH), an engineering firm, to conduct this study.

Figure 42: PCC's several steps toward DHC

The first step to create their heatmap was of course the data review and demand assessment. BH used:

- Actual annual heat loads from PCC for council owned properties where possible;
- Floor area to apply, through an appropriate benchmark, estimated heat loads;
- Heat demands estimated for future buildings using benchmarks based on no. of units and retail floor area:
    - Figures for buildings from Plymouth City Council and Planning documents;
    - Annual heat benchmarks estimated for Residential units using Part L 2013 SAP models and retail/commercial areas using BH studies.

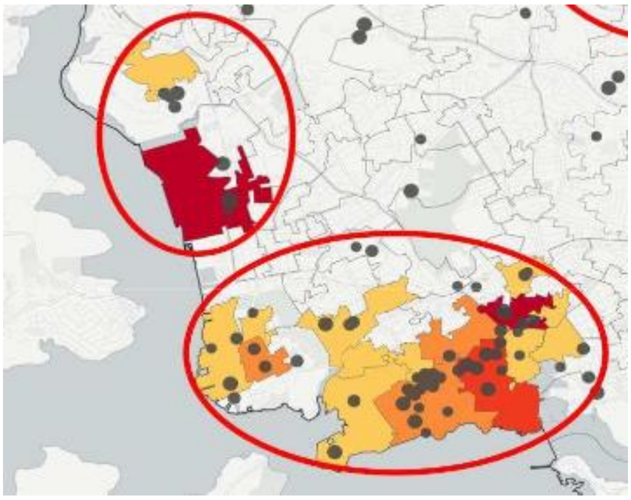

Figure 43: Plot of Heat Demand in Plymouth by LSOA with anchor point loads (source: Plymouth City wide energy strategy, BH)

Several sources of data has been used: Valuation Office Agency data, Display Energy certificates dataset, basic land and property unit data, electronic property information mapping service, previous energy studies conducted in Plymouth area, etc. This demand assessment led firstly to Figure 44 then Figure 43 where the Lower Layer Super Output Areas (LSOA[18]) were used and then Figure 46, a focus on the more promising areas.

This technique of zooming a heatmap and adding more and more data is very efficient to define a more and more realistic project, from the idea, to the feasibility study.

[17] The full reports is available here : https://www.plymouth.gov.uk/sites/default/files/PlymouthDistrictHeatingWP3WiderCQCityCentreConnectionsHeatMappingEnergyMasterplan.pdf
https://www.plymouth.gov.uk/sites/default/files/PlymouthCityWideEnergyStrategy.pdf

[18] LSOA stands for Lower Layer Super Output Areas; they are areas in which more than 3,000 people or 1,200 households were counted according to the 2011 census performed by the Office for National Statistics in England.

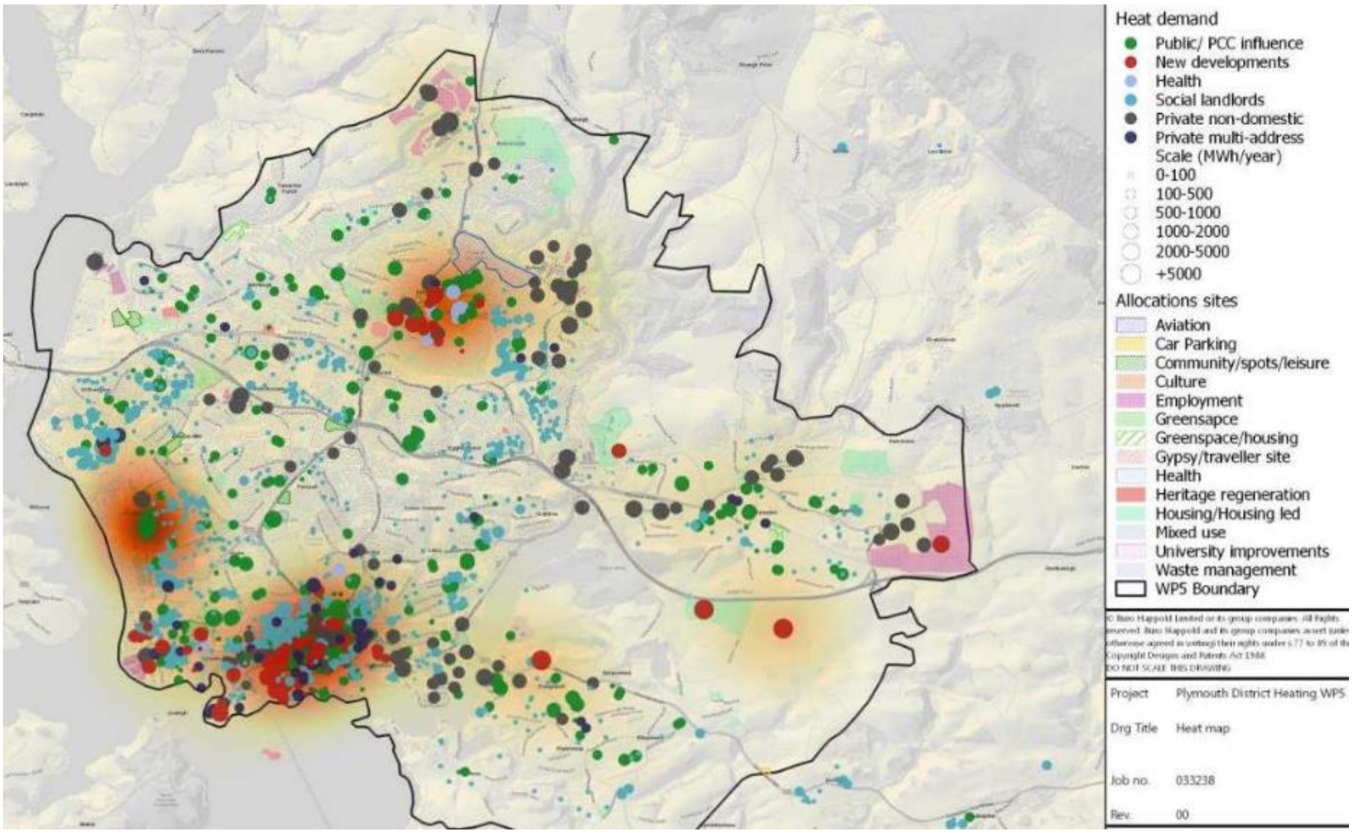

Figure 44 : Heatmap of all data collected (source: Plymouth City Wide Energy Strategy, BH)

PCC and BH also realized a heat sources and constraints map (Figure 45) showing all the industrial installations, the incineration plants, the data centre and the power stations as well as major road, rail tracks, river and streams, conservation areas, etc. This constraints map also shows green areas owned by PCC.

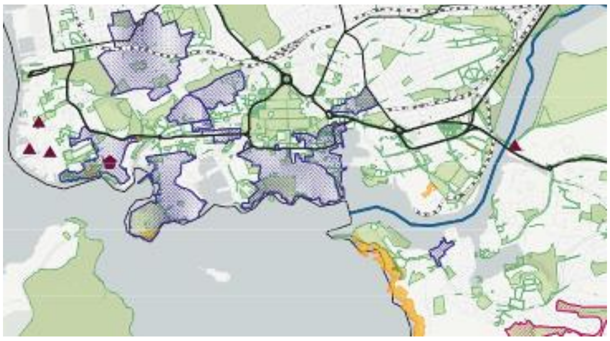

Figure 45: Extract of the Heat sources and constraints Map (source: Plymouth City Wide District Energy Strategy, BH)

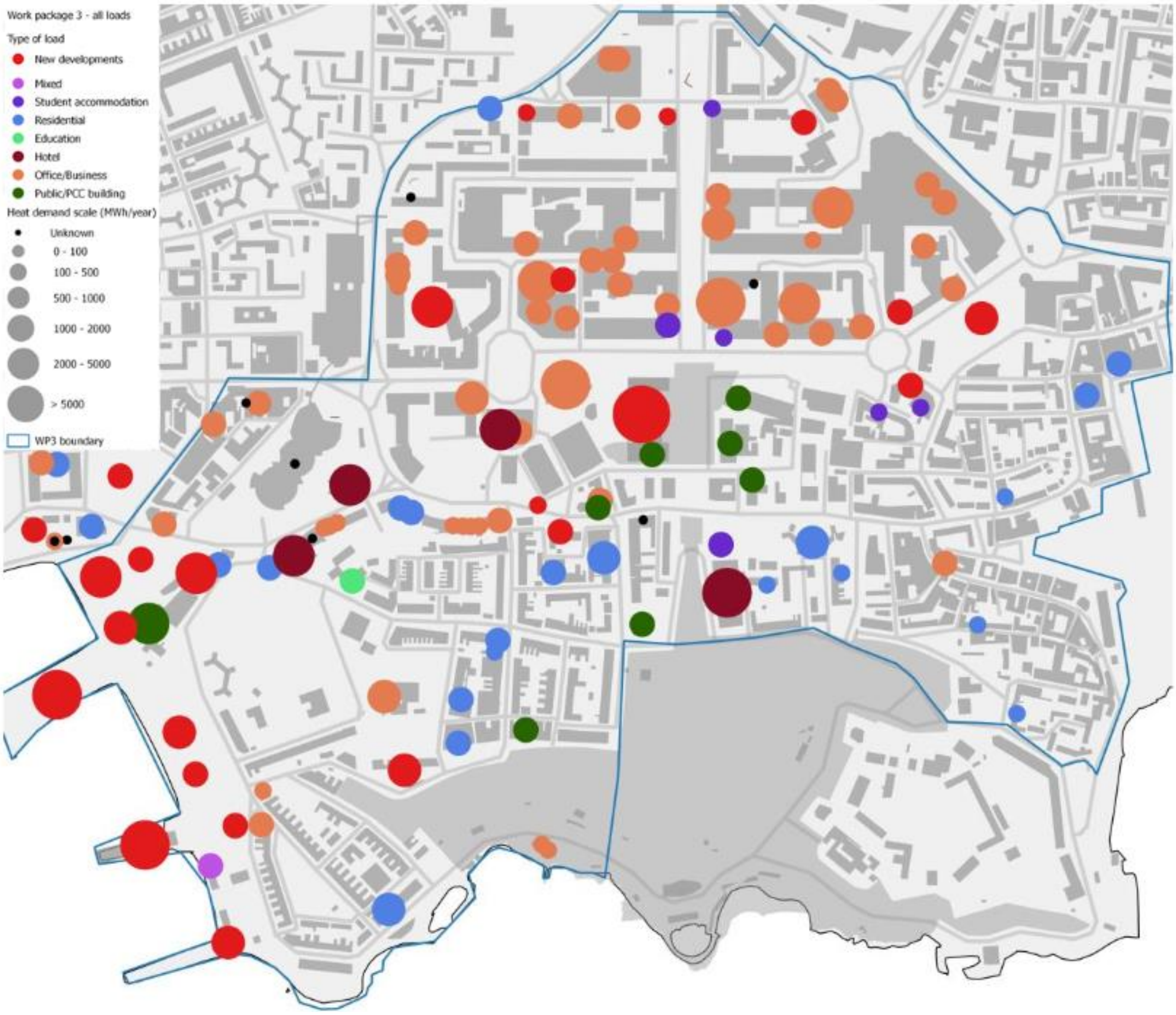

Figure 46: Heat Loads per buildings and activities (source: Heat mapping and Energy Masterplan, BH)

Then the buildings were grouped into tiers to prioritize likely DH connection viability using information on typology, ownership and heat demand. Large loads, communal central heating system, single ownership with PCC control were highly prioritized whereas small loads in the private sector were less prioritized. This step led to a new and more precise map (Figure 47) displaying where a DH network could be implemented.

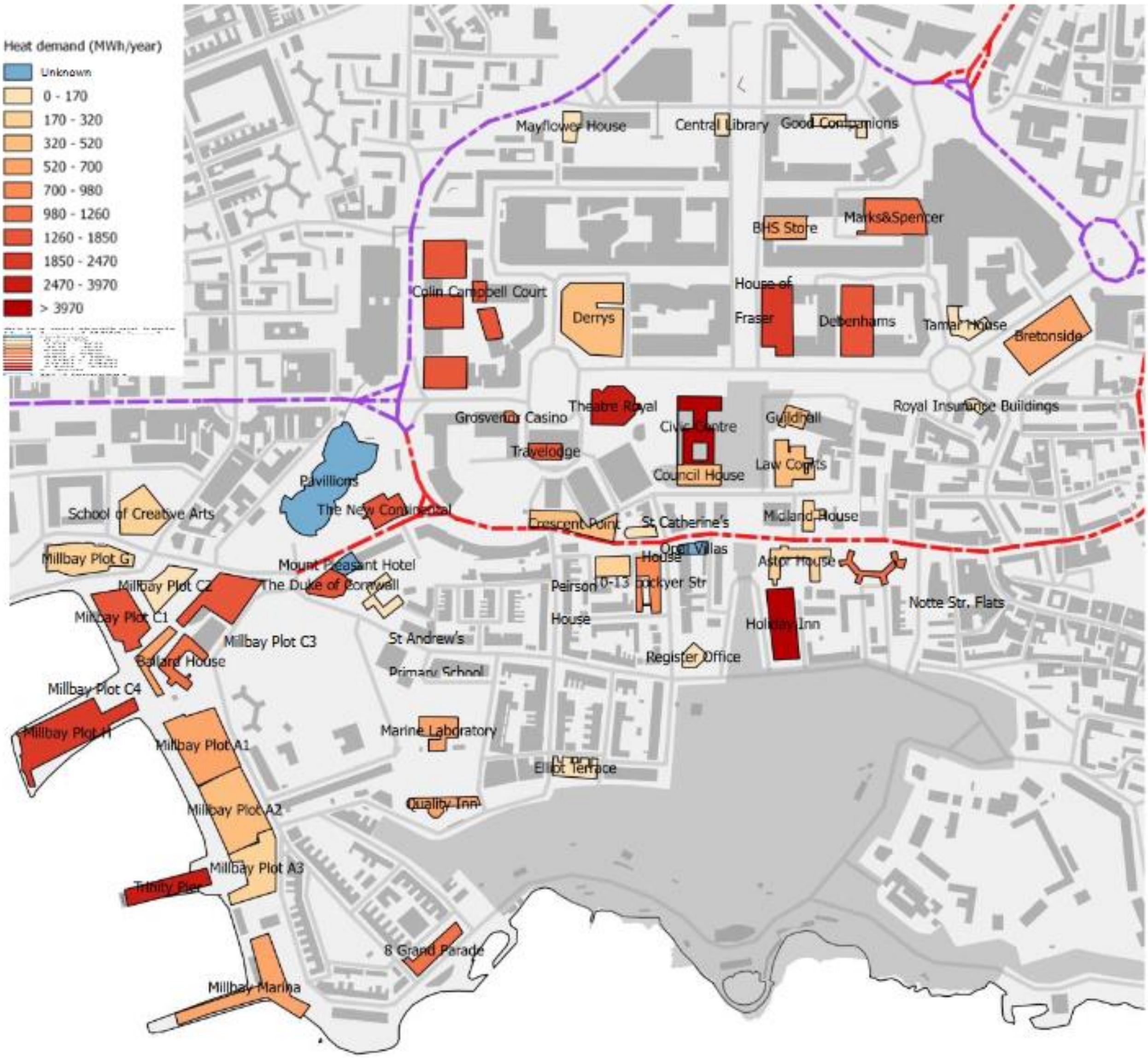

Figure 47: Significant loads and DH friendly building mapping (source: Heat mapping and Energy Masterplan, BH)

Once this precise heatmap was achieved, BH tried to group the buildings into clusters that would allow the deployment of a DHC with a heat density of 1.8MWh/m/yr minimum. For each cluster, potential phasing, information on heating system and demand of every building and PCC influence on the building owner were looked into. Existing networks and future new deployments were also studied and led to phasing a potential project. Figure 48 shows what HB has done with the most promising cluster: the civic centre scheme. On this map, information on annual consumption and peak load are indicated as well as the location of existing boilers and the potential localisation of the new energy centre. The network with the diameters of the pipes is also visible. For each phase, total heat demand, network length and heat line density are known. The Heat line density goes from 20 MWh/m/yr during the 1st phase to 11 MWH/m/yr by the end of the 3rd phase.

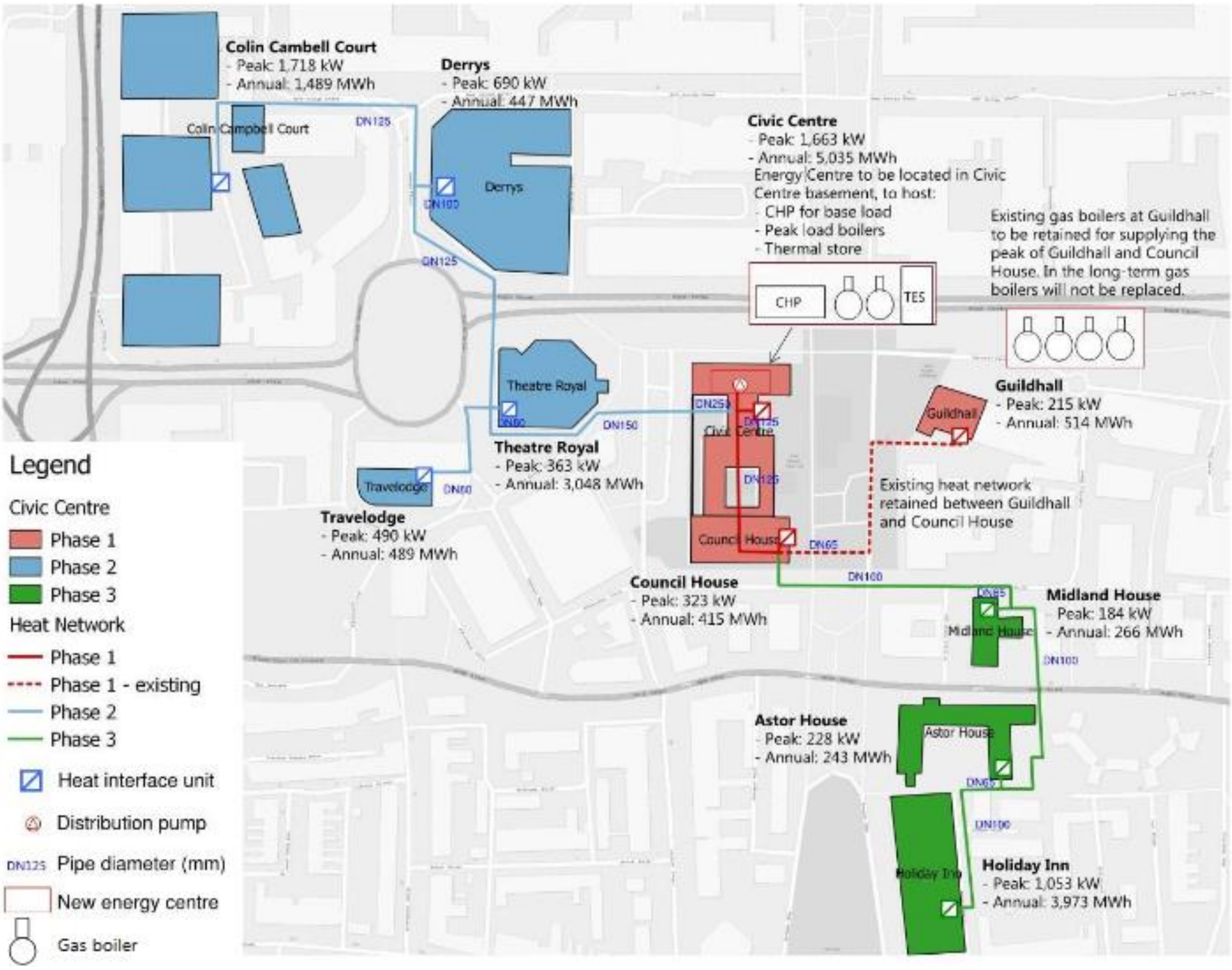

Figure 48: Civic Center scheme (source: Heat mapping and Energy Masterplan, BH)

Figure 49: Geological feature in Plymouth (Source: Geological Resources Assessment, Genius Energy Lab)

BH also achieved a technical and economical analysis and completed this feasibility study, but Plymouth City Council decided to go further and did some research on 4DHC best practices in the UK and in Europe. The aim was for PCC to clarify the main approaches on building a 4DHC in the UK context. It led PCC to develop the first "Low Temperature Building Zone" where all new and deep-retrofit buildings must have a heating system designed at less than 60°C. PCC is considering Grants or offset costs to help existing buildings to move to lower temperatures (under 60°C). To follow those first reflections Plymouth has also decided to achieve a geological resources assessment in order to choose a more sustainable energy on the Civic Centre scheme than a gas CHP (see Figure 49). This map of the resources led PCC to choose a geothermal resource for their DHC.

Conclusion

Heat maps are powerful tools, both at the national and regional or local scale. At the national level, it allows to identify and prioritize development areas for a number of different projects, for instance renewables energies or developing a local supply chain. At the regional or local level, it allows to reconnect energy and urban planning, to tap local resources and to improve the building stock by decarbonising it.

The data required to make such heat maps comes from a number of different studies and sources. As was highlighted in the report, many different European projects and studies have gathered data at national scales regarding population density, industrial activities, and renewable resources such as forestry or geothermal activity. Such data can be used in the process of making a heatmap, but regarding local 4DHC planning, it must be associated with local data, for instance building heating systems, local infrastructures and specificities.

The compilation of existing studies and local data allows to develop heatmaps as decision-making tools for energy and urban planning; and so it represents an important step during the process of developing a 4DHC.

Resources

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