Integrated Hotmaps and THERMOS User Guide

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1 Introduction

The European Commission has identified heating and cooling (H&C) as one of the key action points to achieve the sustainability goals set for the next decades, specifically with regards to fossil fuel reduction and greenhouse gas emission targets. This is reflected in the amendment of the Energy Efficiency Directive (EED) stating: “Member States shall encourage regional and local authorities to prepare local heating and cooling plans at least in municipalities having a total population higher than 50.000”.

The Act!onHeat project aims to aid municipalities to improve their strategic H&C planning and to ensure this translates into tangible decarbonisation measures, such as district heating and cooling (DHC) networks. To do so, the project will use the THERMOS and Hotmaps tools, developed in previous H2020 projects, which provide several options for the identification, definition and optimisation of local decarbonisation measures.

- Hotmaps is aimed at supporting the planning process of the H&C sector at local, regional and national level. Hotmaps supports the analysis of various H&C demand reduction, resource potentials and supply and options for defined regions. It supports identification of areas with relevant potential for district H&C solutions and allows for the development of region wide future H&C scenarios.
- THERMOS focuses on the planning and optimization of local low carbon district heating or cooling networks. It supports analysis on the implementation of new networks in areas with potential, as well as expansion of existing networks and the optimization of the heat supply.

Both tools can provide several options with regards to low carbon supply solutions and their economic feasibility and can be used separately to provide relevant results. However, a methodology for their integrated use has been developed in order to maximize benefits to Act!onHeat participants and increase the project’s impact. This document aims to describe the integrated complementary use of both tools using a simplified approach. It provides an overview of the process and links to relevant information where a more detailed explanation can be found.

The content of this document should be considered a first approach to the integration of both tools and may evolve based on the users’ needs as well as additional synergies found between the tools as the project progresses.

2 Act!OnHeat Integrated Use

Hotmaps and THERMOS are two powerful open source tools designed for heating and cooling planning. These can be used individually, but there are remarkable potentials for an integrated use of both tools, as they focus on different areas, levels of details and research questions. The following are a non-exhaustive list of options for carrying out an integrated use of both tools:

- Use Hotmaps for the identification of suitable areas for DHC networks deployment and develop an in-depth analysis using THERMOS
- Use THERMOS to analyse feasible H&C network solutions for a defined area and do a detailed network supply dispatch analysis with Hotmaps
- Use Hotmaps to analyse geolocated resource potentials as an input to the detailed feasibility studies with THERMOS

This version of the document focuses on the first described option for the integrated use of both tools: the identification of priority areas for DHC with Hotmaps and the definition and analysis of detailed feasibility of different network solutions in THERMOS. It is based on the following **use case** describing the situation of the assessor:

"I know that district heating might be interesting for several areas in the city I need to analyse. I need to come up with a first idea of a concrete district heating project, but I do not know where to start the analysis. Which region(s) should I have a more detailed look at?"

The following **¡Error! No se encuentra el origen de la referencia.** shows the major steps in this integrated use process that are further described in the subsequent chapters.

Figure 2.1 - Steps in the integrated use of Hotmaps and THERMOS for the definition of concrete DHC feasibility analyses

The description of the integrated use is based on a case study performed for the city of San Sebastian in Spain. The described approach is hereby based solely on publicly available data.

2.1 Heat demand estimation

2.1.1 Identification of the working area

Based on the overall area that should be analysed for finding priority areas for district heating , a specific working region is to be identified.

The selection of the initial working area can be identified as follows:

- Select the entire municipality or the entire LAU2 region
- Specific areas (extending to a collection of buildings) as based on interest or commitments

of the local community can also be identified and selected. The selection of such sub-LAU 2 regions is also permitted by both the tools

For the case study of San Sebastian included below, the entire LAU2 region was selected.

2.1.2 Estimation of the demand associated with the building stock

2.1.2.1 Status Quo: Identifying common sourced demand data

When elaborating a thermal network optimisation solution, a fundamental ingredient is the annual and peak demand associated with each building candidate. These values could be estimated using the THERMOS tool based on the data available to it. THERMOS will always use the best available estimate by choosing, in order of preference, from user provided data, benchmarks or the integrated 3D and 2D shape-based regression models. However, in some cases that lack relevant parameters, the Hotmaps estimation is more accurate.

It is useful to understand the full process followed by the THERMOS tool because by appreciating it, a user can figure out which data is needed and can prioritise its retrieval. This process can be found in the THERMOS Replication Guide.

As for the Act!onHeat integrated use, the most relevant parameters that achieve a more accurate heat demand model in THERMOS are:

- **GIS files** – For the development of an accurate THERMOS feasibility study it is compulsory to have an accurate representation of the desired area in GIS format for both buildings and paths. Based on previous experience, the most efficient way to carry out this task would be first to identify if there are GIS files that have been previously generated for the relevant area that could be used. In case there are no existing GIS files, the user should check OpenStreetMap (OSM) to see if its data coverage sufficiently matches the reality of the location for subsequent analysis. If it does, THERMOS should be used to automatically generate a heat demand map based on OSM data. If it doesn't, the possibility of generating GIS files to represent buildings and paths using another source (e.g. CAD, Maps, etc.) should be considered – these can then be uploaded to THERMOS. Methodologies to carry out this last process will be developed during the collaboration agreement set up phase of the application procedure.
- **Real demand data/Benchmark ratios** – Once the geographic information has been sourced, the basic building heat demand estimation undertaken by THERMOS using the 2D model can be enhanced by using additional data. The most accurate method to do this is based on use of real heat demand data or benchmark ratios based on floor area.
- **LIDAR[1] layer/building height data** – In case the aforementioned real demand data or benchark ratios cannot be obtained, the next option would be to perform a 3D model estimation based on the LIDAR layer for the area or the building heights, which then allows building volume and surface area to be considered. If this data is not available, a 2D estimation will be carried out based on the ground area (footprint) of the depicted polygon.

The process that users should follow in order to obtain their demand characterisation is explained in Figure 2.2, which also depicts the hierarchy of the estimation performed on the right hand side.

[1] Laser Imaging Detection and Ranging

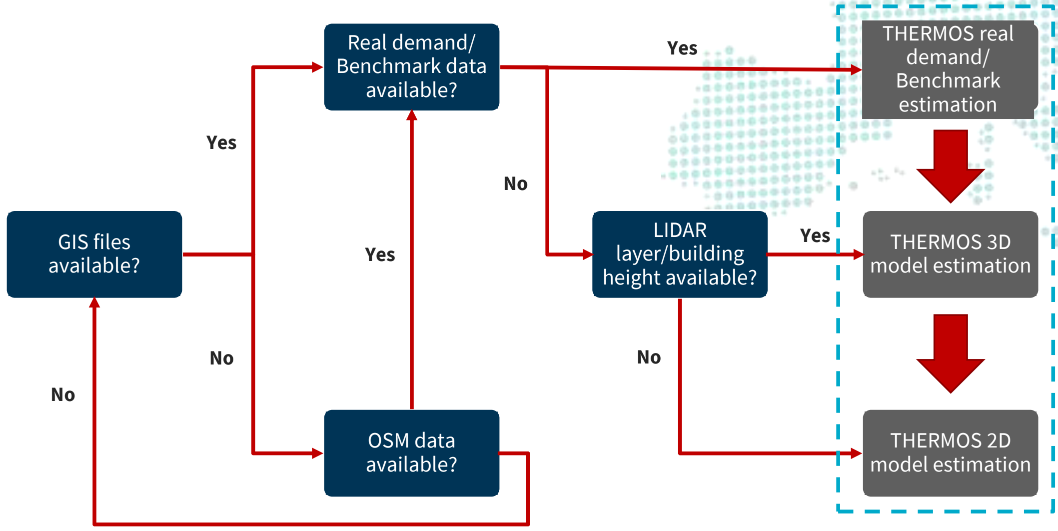

Figure 2.2 - Decision tree for demand estimation

Details on how to create a map in THERMOS can be found here. Edits to the heat demand of individual buildings can be undertaken within THERMOS (post-map creation), as described here. After map creation, users can download a GeoJSON file, which will contain the information seen on the map in a GIS file.

2.1.2.2 Bottom-up heat demand density raster generation

In order to create a heat demand density raster that could be inputted into Hotmaps, the following steps must be followed:

1. Select the LAU2 or the desired working area in THERMOS and create the map for the region.
2. Download the generated map in the form of a GeoJSON file.
3. Alterations need to be made to the file, to meet the data input formats of the Hotmaps calculation module (CM): **Customized heat and gross floor area density maps** as described here**.**
4. The newly generated raster layer is to be used for further analysis. EPSG:3035 is the CRS used in Hotmaps.

This process is depicted in Figure 2.3, where the expected inputs and outputs can be found.

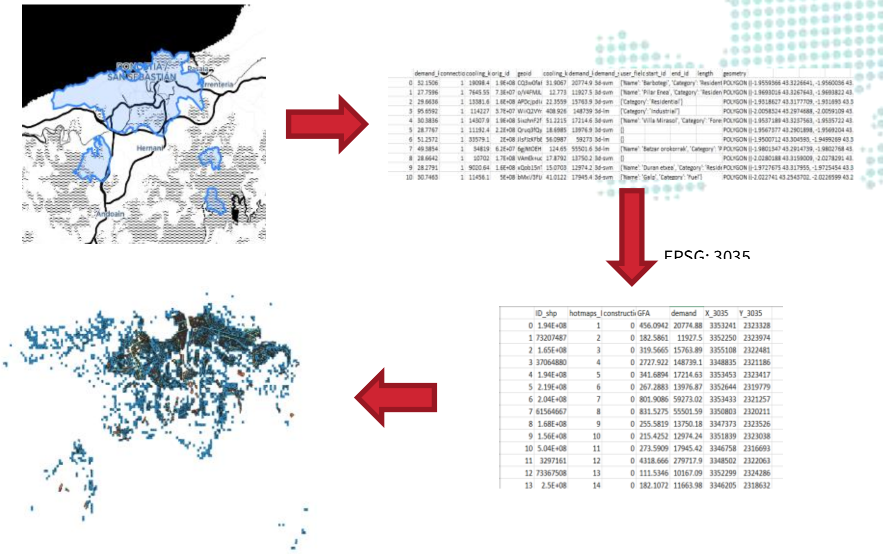

Figure 2.3 - Generation of heat demand density maps based on THERMOS data

Note: As CM: Customized heat and gross floor area density maps do not have a GUI, this raster development step is to be carried out externally (outside the Hotmaps online tool).

2.1.2.3 Creation of scenarios for the development of the heat demand (density) using Hotmaps

In the previous step a map of the current heat demand density from heat demand in buildings has been generated. As the potential future development of heat demand has a remarkable influence on the economic feasibility of district heating, maps of potential future situations are created in a subsequent step with the Hotmaps platform. For this the **CM: Demand projection** is used. It uses scenarios of future development of heat demand in buildings in line with EU wide decarbonisation goals until 2050 calculated at national levels with the building stock model Invert/EE-Lab. The CM shows the effect of these different pre-calculated national scenarios at local level for the selected region and allows for changing selected input parameters. Details on the module are available here. As the breakdown of the national scenario results to the local level is based on the distribution of buildings of certain construction periods in the regions, it can only be used together with the default heat demand density maps in the Hotmaps toolbox. Therefore, the **CM: Demand projection** is used to retrieve potential % reductions of heat in the region to be in line with long-term decarbonisation targets. For each scenario, based on this percentage energy consumption reduction from the default data, the THERMOS-based layers are scaled down using the **CM: Scale heat and gross floor area density maps**, as described here. The following figure shows this procedure graphically.

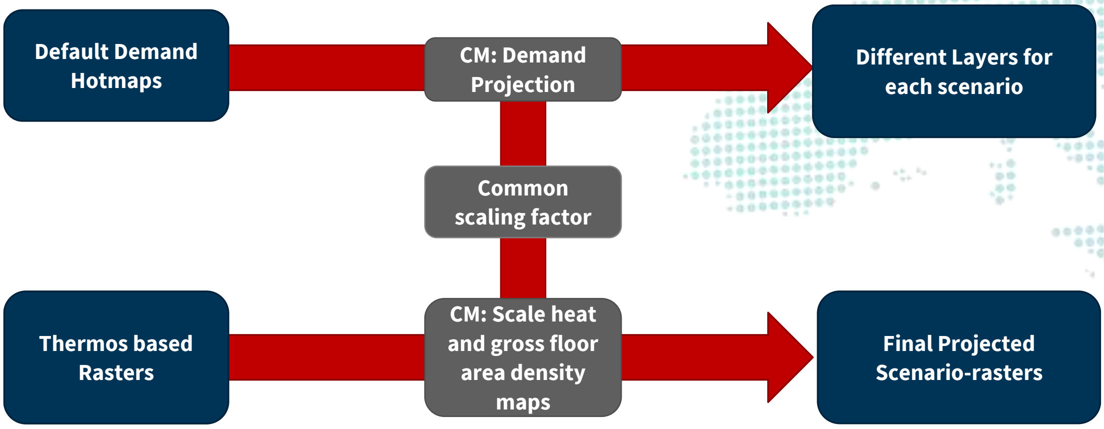

Figure 2.4 - Summary of the demand prognosis

2.2 Identification of the suitable DHC areas

For each of the potential future heat demand density maps (based on the retrofitting scenarios in the previous step), the next step is to identify the economically feasible areas for a district heating network. This can be done with Hotmaps using the **CM: District heating potential economic assessment**, explained here. The areas potentially suitable for district heating are identified via the estimation of distribution costs in the analysis area based on network construction costs, targeted market shares of district heating and thus heat delivered via the network, as well as a threshold for the average grid costs. Already existing district heating network infrastructure in the analysis area is not considered in the calculation.

With the **CM: District heating potential economic assessment**, various scenarios for each of the potential future heat demand density maps as well as the map for the current state should be developed. The scenarios hereby should differ in the settings for targeted market shares and grid cost ceilings, as these two parameters have a remarkable influence on the heat distribution costs and thus will result in different areas shown to potentially be feasible for district heating.

Figure 2.5 - Identification of economic potential areas

2.2.1 Interpretation of Hotmaps results for the definition of the THERMOS cases

The areas identified to potentially be feasible for district heating by Hotmaps are used as an input that defines the working area to develop detailed THERMOS cases. Of the multiple areas identified in the numerous sensitivity cases in the previous step, the common areas identified by each of these sensitivities are taken as the final working area, relating to the most suitable area for district heating grid developments.

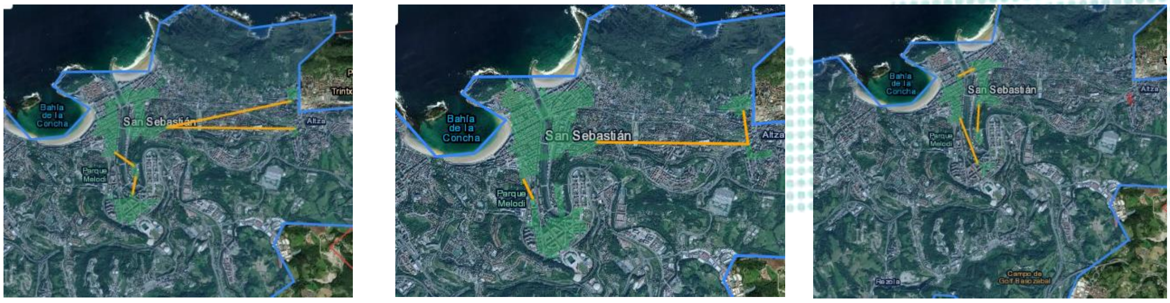

Figure 2.6 - Comparison of different scenarios

In case of multiple identified potential areas, the THERMOS analysis can be started for those areas with the largest heat demand densities or vicinity of the demand to the supply source (this could be area/case-specific).

For example, Figure 2.7, which shows the case study for San Sebastian performed during the Hotmaps project, four different areas highlighted in red were identified as potentially feasible locations for district heating networks under multiple scenarios. Hence, these locations are deemed feasible for further detailed THERMOS analyses.

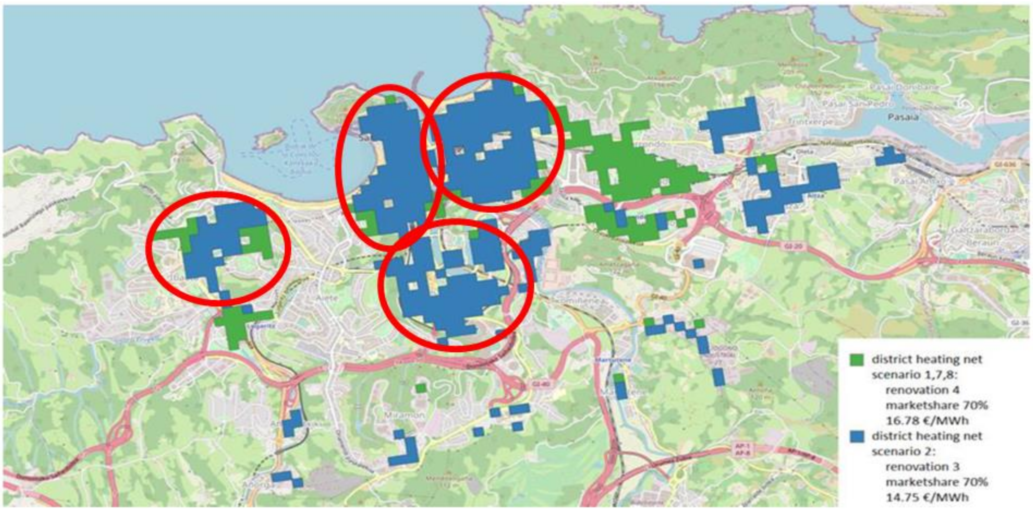

Figure 2.7 - Identification of multiple potential areas within the case study during the Hotmaps project[2]

In the case of an existing network in the identified area, the THERMOS analysis can be used to analyze the expansion of the network to reach the market share used in Hotmaps to initially identify the potential area.

Note: The case study for San Sebastian was carried out on the assumption that no network exists in the region.

[2] Within the Hotmaps project case studies for 6 cities across Europe have been performed, one of them for the city of San Sebastian in Spain. The resulting heating and cooling strategy documents can be found under the following link: https://www.hotmaps-project.eu/hotmaps-pilot-cities-hc-strategies-are-available/

2.2.2 Data alignment between both tools

As the THERMOS and Hotmaps tools have different objectives, they also use different inputs when performing their calculations. Some of this data does not need to be aligned, as simply carrying out the calculations using values previously generated using the other tool would imply that those parameters have been already taken into account. For example, for the Hotmaps **CM: District heating potential economic assessment**, the value of the grid cost ceiling is used and it doesn't have an associated THERMOS input that needs to be similar. By using the areas identified by Hotmaps, the grid cost ceiling is already considered when performing the network optimization with THERMOS. In such a case, it is recommended to use contrasted values that provide realistic results.

However, there are other parameters that need to be aligned in order to ensure that the results produced by both modules are coherent. These parameters may need to be aligned from the beginning or may need to be checked after producing the results from the feasibility study, thus turning the methodology into an iterative process where the analysis in Hotmaps might need to be reworked using new inputs if there is a significant deviation from the THERMOS results.

The most significant parameters to be aligned are:

- Heat demand
- Economic parameters
- Market Share

2.2.2.1 Demand

In case the integrated use methodology as described here has been followed up to this point, the heat demand estimates used to obtain feasible areas for DHC deployment using Hotmaps should have been produced using the THERMOS tool. Then both calculations are using the same source, and thus are already aligned by definition.

Where the GIS files needed for the development of a THERMOS case study do not include the demand estimation directly (for example, the demands/ratios come from a separate excel file), an additional step will be needed in order to incorporate the demand data into the GIS files. This step will depend on the format of the demand data and could range from linking unique fields to creating a dot layer based on the coordinates of the demands and merging it with the polygon layer representing the buildings

2.2.2.2 Economic Parameters

The economic parameters have significant impact on the results of the financial models. As both tools are based on economic feasibility, significant overlap between the inputs has been identified. The following common input parameters are required for both tools:

- Accounting period (first and last year of investment)
- Discount rate
- Investment costs for the construction of district heating networks

Alignment of these parameters/inputs is crucial to ensure that the results obtained using each tool are comparable.

2.2.2.3 Market Share

Defining a correct district heating network share is integral to identifying economically feasible district heating areas. This defines the proportion of heat demand in a specific area that is assumed will be connected to a network. The identified potential areas in Hotmaps are largely influenced by the assigned/assumed district heating market share. The higher the share, the lower the energetic specific distribution cost due to larger heat delivery over the constructed network.

To ensure that the estimated market share accurately depicts reality, an additional check must be carried out in THERMOS by dividing the annual heat demand connected to the network (which can be found in the results tab) by the overall annual heat demand of the study area, thus obtaining the percentage of demand that has been connected. If this value is significantly higher than the Hotmaps estimation, it could be interesting to re-execute the **CM: District heating economic assessment** with a higher target market share than was set previously (before the THERMOS analysis). New areas might be identified or the size of the identified areas might change as a result of this updated target market share in Hotmaps. The THERMOS analysis can then be performed again for the new areas. It is envisaged that this would be an iterative process.

The Hotmaps inputs that need to be aligned or checked are defined in Table 2.1. The rest of the inputs, such us load hours, grid cost ceiling or the accumulated energy savings, are only part of the Hotmaps estimation and would not have a counterpart in THERMOS.

Hotmaps inputs		
Intrinsically aligned	**To be aligned before optimization**	**To be checked after results**
Demand estimation	Accounting period/Years of investment	Market Share
	Interest rate	
	Investment costs	

Table 2.1 - Summary of Hotmaps and THERMOS parameters that should be aligned when integrating the tools

2.2.3 Limitation of the network analysis

The Hotmaps **CM: Demand projection** does not permit the use of demand density maps developed by the users. As stated in chapter 2.1.2.3, the module can only be applied to the default heat demand density map. Scaling of the individually generated demand density maps with one single factor is therefore seen as the simplest solution.

Also, while in Hotmaps the analysis of potentially feasible district heating areas takes into account estimates of future demand development (due to building retrofitting), the THERMOS feasibility study uses the current demand estimation to carry out the financial analysis.

Nonetheless, as the DHC potential areas identified using Hotmaps already account for the evolution of the demand, which tends to be reduced in future scenarios, this would already be considered in the feasibility study using THERMOS. Demand estimates in THERMOS can however be adjusted for the purpose of creating different scenarios for optimization.

2.3 Detailed feasibility analysis

The outputs from the steps conducted in Hotmaps (section 2.2.1) are the areas within the municipality deemed most feasible for heat networks. These are the areas where a detailed feasibility analysis in THERMOS should be conducted first.

Also, in addition to the areas identified using Hotmaps, potential supply locations and supply parameters (MW size, CAPEX, and OPEX) are useful as inputs for the detailed feasibility analysis in THERMOS. This might be information acquired from desk research or directly from the municipality.

Figure 2.78 shows potential supply locations (yellow circles) and areas deemed most feasible for heat networks (red polygons) in San Sebastian, as an example. All this information could be contained in a single GIS file with separate layers for identified areas and potential supply locations.

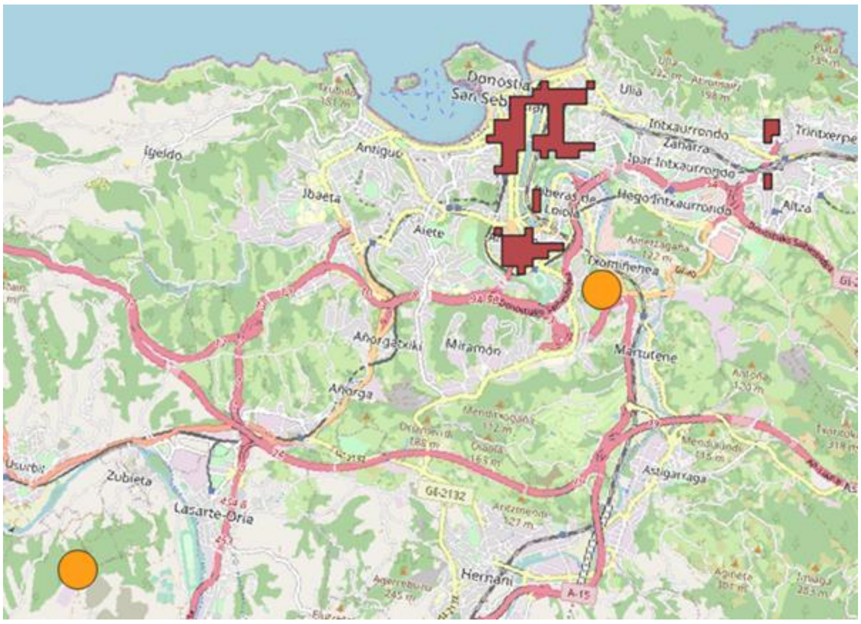

Figure 2.8 - Potential supply locations (yellow circles) and areas deemed most feasible for heat networks (red polygons) in San Sebastian.

2.3.1 Setting up a case study in THERMOS

1. Create a map in THERMOS that covers an area containing a potential heat network location. If available, use a GIS file containing accurate data on buildings, pathways and heat demands, otherwise THERMOS can use OpenStreetMap for baseline data. If available, use LIDAR data. Refer to Figure 2.2 for the hierarchy of demand estimates.
2. Use the area selection buttons in THERMOS to select the buildings and paths that roughly fall within one of the potential heat network polygons (the red polygons in Figure 2.8). Details on how to do this can be found here. The selection could include nearby potential supply locations. However, if the potential supply location is too far away from the polygons, e.g. the supply location in the bottom left of Figure 2.8, then it cannot be used in THERMOS.
3. Change the constraint to “optional” on all the buildings and paths selected

4. Make one of the buildings in the selection a supply point and enter the supply parameters (details on how to do this are here).
5. The minimum remaining parameters to input if conducting a whole-system optimisation are:
    a. Heat supply cost for the network supply
    b. Counterfactual individual heating systems and the heat cost of the system
6. The minimum remaining parameters to input if conducting a network optimisation are:
    a. Heat supply cost for the network supply
    b. Heat tariff rates
7. Details on the two different choices of objective, “maximise whole-system NPV” and “maximise network NPV” are given here.

3 Recommended bibliography

Throughout this document, links are provided to specific websites where the most relevant information can be found. This chapter provides an overview of the most relevant support materials that could be used to expand the information presented in this document. The information is split into two different sections based on the tool the materials refer to.

3.1 Hotmaps

The most relevant support materials for using the Hotmaps toolbox are:

- **Hotmaps Wiki** – It is the most complete guide for Hotmaps use, users can find documentation, guidance and a manual to easily use Hotmaps (link)
- **Short tutorial** – It is an online video that provides a quick overview of Hotmaps and its main features (link)
- **Free trainings** – Set of materials used during the several free training sessions offered throughout the project lifespan (link)
- **Hotmaps Brochure** – Brief document explaining what strategic heat planning is and how the toolbox helps to perform it, as well as examples from the pilot areas experience (link)
- **Hotmaps Handbooks** - Set of “how to” documents to support the users of the software (link)

3.2 THERMOS

The most relevant support materials for using the THERMOS toolbox are split into training materials and publications.

3.2.1 Training materials

3.2.1.1 Get started

- **THERMOS Software demo video** (link)
- **Webinar: Energy system mapping and modelling with THERMOS** (link) – The pdf presentation associated to this webinar was also made available online (link)

- **Webinar: Embedding THERMOS in your city** (link)
- **Webinar: Presentation of Cases by Trainers** (link)

3.2.1.2 Advance from theory to THERMOS practice

- **Exercise 1: Planning & evaluating a project with THERMOS**
  - Clip for Exercise 1: Getting started (link)
  - Exercise 1: Planning & evaluating a project with THERMOS. (link)
  - Model solutions: Exercise 1 (link)
- **Exercise 2: Optimising planning decisions**
  - Clip for Exercise 2: Optimising network results (link)
  - Exercise 2: Optimising planning decisions (link)
  - Model solutions: Exercise 2 (link)
- **Exercise 3: Modifying demand and network paths**
  - Clip for Exercise 3: Modifying paths and demand (link)
  - Exercise 3: Modifying demand and network paths (link)
  - Model solutions: Exercise 3 (link)

3.2.1.3 Dive deep into energy planning & market dynamics

- **Webinar 1: Thermal energy supply and demand in Europe** (link)
  - Test your knowledge with a short multiple choice questionnaire here.
- **Webinar 5: Heating and cooling market and finance** (link)
  - Test your knowledge with a short multiple choice questionnaire here.
- **Webinar 6: Stakeholders involvement for adopting THERMOS** (link)
  - Test your knowledge with a short multiple choice questionnaire here.

3.2.2 Publications

- **THERMOS Replication Guide -** Document that provides a high level of guidance on exploiting the methodologies and tools developed during the project, with special focus on the THERMOS Software. Moreover, it contains facts and advice for using the THERMOS Software, as well as examples and lessons learnt from the THERMOS pilot and replication cities' experience of employing it (link)
- **THERMOS Sustainable Adoption Roadmap –** Document outlining the adoption of the THERMOS tool in the last few years by different energy stakeholders, and based on those experiences provides insights on how THERMOS can be used to achieve district heating and cooling planning related goals in policy, commercial and/or research applications by different stakeholders, as well as the tool's availability for the next three years (link)
- **THERMOS City Case Studies -** A collection of THERMOS Case Studies by partners developed with THERMOS users from Ukraine to Spain (link)
- **THERMOS User Case Studies -** Report presenting the work carried out by a group of tool users for developing high efficiency energy projects with the software (link)

- **Case Studies by THERMOS Trainers**
    - Eurométropole de Strasbourg: Assessing implications of a district heating network for the area of Lingolsheim, France (Dec 2019). (link)
    - SF2E - Manergy: Assessing feasibility and cost-effectiveness of a DHC network for Meylan, France (Dec 2019) (link)
    - ALL Ing ABATE: Development of a Heat Network for municipal buildings in San Lucido, Italy (Dec 2019) (link)
    - Filippo Capizzi, Greenfish Consultancy: Case study for a district heating network between Université libre de Bruxelles and a residential area in Brussels, Belgium (June 2020) (link)

About Act!onHeat

Heating and cooling (H&C) accounts for about half of Europe's total energy needs with 75% still dependent on fossil fuels. Thus, rapid and significant change is needed to reach the EU 2050 goals. Due to the local nature of H&C systems, action has to be taken at local level involving a variety of stakeholders. This has been recognised in recent years and activities have been started like developing best practice policies and open source analysis tools. However, (efficient) H&C planning and project development are still not commonplace in most European municipalities.

Act!onHeat will enable and accelerate local Heating & Cooling transitions by:

- identifying success factors of effective energy plans, turning them into practical workflows;
- developing individual and group support activities to guide municipalities, local planners and stakeholder in applying these workflows;
- facilitating finance and the design of effective heat & cooling projects and policy frameworks

www.actionheat.eu