

CASE STUDY

A heat network map for Chelmsford in 4 (months) easy meetings

A collaboration between Comsof, Chelmsford City Council, BEIS and the HV2030 project.



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How Comsof Heat adds value to heat network design

Comsof heat is used from the master-planning through to detailed project development and shortens the period of techno-economic feasibility analysis from months to weeks. It is a powerful technical and communications tool that is inclusive of all competencies and roles within a heat network development process.

Through automation of the thought process and then augmented with manual fine tuning and discussion, it makes it easy for development, technical and executive teams to compare different energy strategies inclusively and without compromising detail. Thereafter, Comsof Heat is used as

part of the zoning exercise to provide design insight applied into feasibility, planning and financial models.

Swift and accurate scenario building is built based on freely available GIS street and energy data, local knowledge and shaped based on basic technical parameters e.g. available heat supply and hydronic limitations.

The software provides key insights such as peak heat load, linear heat density, available heat supply, prevailing demand (selecting for dense heat demand), pipe selection, capital and operational expenditure and net benefit analyses.



Meeting 1 - Establishing goals and defining data collection Meeting 2 - Reviewing data and defining scope

Meeting 3 - Running model, presenting initial scenarios and identifying gaps for more granular analysis

Meeting 4 - Reviewing final scenario and drawing out conclusions for strategy



HEAT NETWORK PROJECT DEVELOPMENT STAGES

Background: a council with carbon neutral ambitions

Chelmsford City Council (CCC) has declared a climate and ecological emergency and a 2030 carbon neutral ambition and is at the beginning of the journey to realising that goal.

Energy Hub East and Michelle Wright, the Energy and Contracts Manager at CCC, approached Comsof and the Heat Vision 2030 group of companies with the suggestion that we apply our approach to assess the potential for a heat network for the city centre of Chelmsford.

The process was reviewed by the Heat Network Development Unit (a team within the U.K. Department for Business, Energy and Industrial Strategy) to provide insight and feedback with relation to best practice and what is demanded from the Heat Network Implementation Programme (HNIP) funding process and other city-wide initiatives.

Our goal was to produce a credible and tangible vision that could be shared with colleagues and decision makers from within CCC. In turn, this can be a trigger to inspire broader stakeholder and local community support for the 2030 carbon neutral goal. We set out to demonstrate how, through a collaborative approach, the Comsof Heat network route mapping and design tool could do just this. The goal of the project would be to demonstrate how quickly and comprehensively the Comsof Heat tool can answer the big questions relating to heat network deployment:

- Which zones would be desirable and potentially feasible?
- Which buildings and which mix of buildings can be connected?
- What is the energy demand and where can the energy be supplied from?
- What are the optimal routes as a function of cost and maximising heat supply?
- What are the ballpark costs relating to the capital expenditure?

We held four online meetings from start to finish to establish the goals, and to check on the work carried out. Hereunder we'll describe that process, the work carried out between each meeting, the conclusions and benefits.

Meeting 1: Define ambition Meeting 2: Data review and gap identification Meeting 3: Initial scenarios and identify favourite Meeting 4: Detailed heat network map

"Our goal was to produce a credible and tangible vision that could be shared with colleagues and decision makers from within CCC. In turn, this can be a trigger to inspire broader stakeholder and local community support for the 2030 carbon neutral goal."

Meeting 1: introductions - does it make sense to work together?

Attendees: Energy Hub East, CCC, BEIS, Comsof, HV2030 **Person hours used:** 5 (5 in total)

The purpose of the introductory meeting was to understand the current energy panorama in Chelmsford, the drivers for the parties involved and define the initial ambition of the analysis.

The CCC has declared a climate and ecological emergency and a 2030 net zero carbon goal. To this end, the driver for this project was to determine whether a heat network is a potentially useful solution to consider. But also, the idea was to be able to present the outline of a solution that could drive the ambition and confidence of the CCC to take feasible and significant action.

At the project inception meeting CCC wanted to ensure all partners were aware of the scale of Chelmsford, it is not

a big City; but it is growing rapidly. Given the ease with which we can add in technical detail and produce detailed results our approach is entirely applicable to locations whose building stock is currently small but expanding.

We agreed that we would use proxy capital expenditure numbers to give us the ability to compare the scenarios create, but without the goal of having accurate or even broadly realistic costs.

The initial ambition was to determine what zones would be desirable and potentially feasible based on assumptions around what mix of building types could be connected. Thereafter, we would analyse the results in terms of coverage, notional cost and decarbonisation.

"Chelmsford, it is not a big City; but it is growing rapidly. Given the ease with which we can add in technical detail and produce detailed results our approach is entirely applicable to locations whose building stock is currently small but expanding."

Actions agreed from meeting 1

Action taken by: Comsof, CCC Person hours used: 25 (30 in total)

The starting point was to determine the geographic area of analysis.

We needed to identify which buildings could easily be connected to a heat network. These are defined as all buildings that are in or near the city centre. We also identified buildings with a large heat demand. These 'anchor loads' are often crucial to selling a heat network in the first instance as they provide large enough heat demand to justify some investment. Often, publicly owned buildings assigned as 'anchor loads' in the first instance, as they are seen as 'guaranteed' points of heat demand. In a post-covid world, this assumption may not hold so readily. As such, we also identified other areas with large commercial heat loads, and densely populated social and private residential areas. We also wanted to know about planned developments, high density residential areas that could be connected to the heat network in the future.

Comsof used publicly available GIS data sets relating to street locations (open street maps) and heat demand of the buildings (hotmaps.eu) in the defined area.

Michelle and the GIS team within the council identified what areas were of interest. Their local knowledge was crucial to determine boundary of study, determine what zones could be connected to a heat network and where heat sources could be located e.g. vacant/ underused land/ publicly owned land.

The team at CCC investigated what heat demand data was available that could be used to refine the accuracy of the heat mapping.

Commercial properties (building polygons)

- 527 private sector estates
- 6 public sector estates
- Excluded buildings < 20m²
- Excluded buildings overlapping large loads
- Excluded remote area in the east

Large loads (points)

- 35 commercial
- 28 housing
- 10 public sector
- Open street maps (building polygons)
- Possible Heat source locations (points)
 4 Options
- Hotmaps
 - Yearly consumptions
 - Distributed based on building polygon footprint

Meeting 2: review of data collected and identifying gaps

Attendees: CCC, BEIS, Comsof Heat, HV2030 Person hours used: 6 (36 in total)

With openstreet maps we are able to determine the street centre lines. The heat loads derived from hotmaps.eu were mapped in the Comsf Heat software These buildings were labelled within the software so that it can determine where the pipe routes should go. We now have a map of Chelmsford, with all the buildings identified, their estimated annual heat usage and potential energy centre locations selected.

At this stage the hydronic parameters are also discussed and defined. The key parameters are: the assumed operating pressure of the heat network and the flow and return temperatures. The Comsof heat software determines which energy centre will supply the heat to each building as a function of the heat density and pipe costs. Temperatures

- Supply: 90°C
- Return: 50°C

Steel pipe system

Pressure: PN16

Minimum simultaneity/ load diversity: 0.62

Figure 1: Initial Hydraulic Design Parameters

"Next, we wanted to map out the different heat network scenarios. We decided to create heat networks as a function of the types of buildings that were to be connected and supplied by the heat network."



Actions agreed from meeting 2: Running the model

Action taken by: Comsof Heat Person hours used: 5 (41 in total)



The technical team starts running the models based on five scenarios defined, see below. For each scenario a map was produced, Scenario A map shown below. An indicative CapEx was calculated as a way to benchmark the relative impact of each scenario, allowing us to compare the energy supply required and the cost of each scenario compared to scenario A as a benchmark.

Scenario A/E: Public & Commercial Buildings only (each with a different heat source)
Scenario B: All the large loads
Scenario C: Businesses Only
Scenario D: Maximum Coverage

Figure 3: Scenario A mapped out- Public Sector buildings with large loads

	Scenarios			
	A / E	В	С	D
Description	Public & Commercial Buildings (comparing distinct heat sources)	All the large loads	Businesses Only	Maximum Coverage
Large loads Public	Yes	Yes	Х	Yes
Large loads Housing	Х	Yes	Х	Yes
Large loads Commercial	Yes	Yes	Yes	Yes
Public sector Estates	Yes	Х	Х	Yes
Private Sector Estates	Х	Х	Х	Yes
Total # demand points	51	73	35	606
Network length (km)	7.57	8.34	6.12	23.65
Heat source	D/ B	А	С	D
Total power required (MW_{th})	7.6	10	4.9	17
Total yearly consumption (MW_{th})	15,253	20,368	9,762	40,852
Project Cost (%/connection)	100/98	78	120	19

Figure 4: Energy and cost outputs for each scenario

Meeting 3: review of 1st Iteration of mapping of scenarios

Attendees: CCC, BEIS, Comsof Heat, HV2030 Person hours used: 6 (46 in total)

We presented the multiple heat network scenarios that we produced based on the agreed criteria in Meeting 2. Scenario D, shown, was by far the largest heat network, by including all housing. Whilst the network was significantly larger, with around 10 times as many buildings, the heat load was not much more than 3 times larger than C, the lowest load scenario. Having tested a range of scenarios it was clear that biggest impact and therefore the potential return on investment and carbon reduction would be made by exploring the largest area further.

Scenario D was selected for further testing and augmented by adding in a low carbon 10MWth water source heat pump heat supply, new build housing estates and a comparison of pipework costings. This allowed us to test the heat networks capability to deal with future changes in heat load and demand profiles. Given that we had chosen the biggest network by far, we focused on the cost of supply and fit of pipework to demonstrate the impact of using different assumptions on such a key component. In this next iteration, we would give a bit more credence to the broad CapEx implication of such a heat network.



Figure 5: Scenario D Maximum coverage of initial area of analysis

"Scenario D was selected for further testing and augmented by adding in a low carbon 10MWth water source heat pump heat supply, new build housing estates and a comparison of pipework costings."

Actions agreed from meeting 3: updating the Scenarios

Action taken by: Comsof Heat Person hours used: 4 (50 in total)

Our map evolves in couple of ways as we move to a larger heat network. Firstly, it is broken into two sub areas- each one served by an independent heat source. The WSHP cannot provide sufficient heat for the whole heat demand and as such the software calculates which area is best served by the WSHP and subsequently selects the best location for the other heat source to supply the remaining area. Secondly, with a larger heat network, booster points known as sub-stations (denoted by red squares) are selected to take the primary heat delivered in the Transport pipework and integrate with local Distribution pipework. "The software calculates which area is best served by the WSHP and subsequently selects the best location for the other heat source to supply the remaining area."

RULES CONFIGURATION

Transport Layer

- Temperatures
 - Supply Temperature: 90°C
 - Return Temperature: 50°C
- Steel pipe system
- Pressure: PN16
- Minimum simultaneity: 0.62
- Cost calculation:
 - Heat Source
 - ______£ 500 000 / MW installed
 - Heat Pump @ £1.6 million per MW installed
 - Heat Pipes (2 scenarios)
 - 1. Fixed cost of £ 2000 /m
 - £ 1000 /m DN50 and smaller £ 3000 /m DN65 and larger

Distribution Layer

- Temperatures
 - Supply temperature 80°C
 - Return temperature 40 °C
- Steel pipe system
- Pressure: PN6
- Cost Calculation

0

- Substation cost: £10 800 /MW (assumption)
 - Heat Pipes (2 scenarios)
 - 1. Fixed cost of £ 2000 /m
 - £ 1000 /m DN50 and smaller
 £ 3000 /m DN65 and larger

Meeting 4: review of 2nd, final, iteration.

Attendees: CCC, BEIS, Comsof Heat, HV2030 Person hours used: 6 (56 in total

We have built up a scenario that demonstrates an ambitious catchment area, covering all buildings both new, old and the planned for new build estates. We have included for a zero carbon heat source via the WSHP.

The map demonstrates how the whole heat network would be divided into smaller clusters. Each cluster has a different colour and is served by a substation (denoted by the red box). The substation is where the, 'Transport', network integrates with the, 'Distribution', network and the heat is boosted to support that local area.

We have been able to quickly establish an estimated CapEx of ± 60 million and 608 buildings with 50GWh of heat sales every year.

We have also provided insight based on varying the cost elements, in this case comparing pipework cost assumptions.

"We have been able to quickly establish an estimated CapEx of £60 million and 608 buildings with 50GWh of heat sales every year."



Figure 6: Chelmsford heat network distribution clusters

	Scenario 1: Fixed-price pipe	Scenario 2: Variable-priced pipe
Heat Sources	C,D	C,D
Pipe Price	£2000/m	< DN65: £1000/m ≥ DN65: £3000/m
# demand points	608	608
Total power	17.0 MW	17.0 MW
Total yearly consumption	50 188 MWh	50 188 MWh
Total trench length	23 514 m	23 514 m
Relative cost	100%	82,5%
Relative cost per home	100%	82,5%
Linear heat density	2.134	2.134

Figure 7: Testing different price scenarios: Fixed versus Variable pipe pricing

A credible vision: conclusions and benefits for Chelmsford

Michelle started with an open mind, dipped Chelmsford's toe in the water and was given the confidence to go big. She had a skilled and engaged GIS colleague and allied that to local knowledge to help determine a realistic map of where the heat network could go.

The project provided Michelle with the tools to communicate within her organisation what is possible enabling her to inform the debate within the council. It provided confidence and invaluable insight to discussions about what a low carbon city could look like.

We are missing granular data on building performance and heat usage and more detail regarding CapEx and OpEx such as the cost of electricity. Further areas of research to provide greater detail to feed into master planning and the techno-economic analysis that complies with the BEIS heat network development model:

- Financial modelling
- Carbon legislation
- Subsidies/ taxes
- Investment in building efficiency
- Change of Zone use e.g. more housing and less commercial and public

KEY SUCCESSES:

Return on time investment 56 hours in total

This process with light touch and limited demand on councils resources. Michelle and her team needed 2 days whilst the Comsof team 4 days, with 4 follow-up calls.

Interaction with other departments

The work has been very helpful and helping Michelle to make contact with other departments within Chelmsford. Increases credibility including Planning & policy, Economic development and Environmental promotion teams. "The project provided Michelle with the tools to communicate within her organisation what is possible enabling her to inform the debate within the council. It provided confidence and invaluable insight to discussions about what a low carbon city could look like."

Fits with the Heat Network Development Unit pathway

We were able to have an assessment from BEIS that confirms that using the Comsof Heat tool is compliant with the approved methodology for heat network feasibility and design.

KEY LEARNINGS:

This allowed the CCC to engage and evaluate existing datasets, leading to the conclusion that the ordnance survey did not actually reflect what was really there, for example relying on building height data did not reveal where high rise developments were; Local knowledge is key. We started with a limited idea of what was possible and ended up with something both credible and ambitious.

The next action, regardless of the Council's ambition following this initial heat network study, will be to promote the improvement of existing building stock as no matter which heat technology is deployed, improvement to building fabric will be key to its success.

Thank yous to: Energy Hub, BEIS, Chelmsford.

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Appendix 1: Heat Vision 2030 Partners



heatvision2030.com