

# Procurement Guide for 4<sup>th</sup> Generation District Heating and Cooling



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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.guidetodistrictheating.eu](http://www.guidetodistrictheating.eu).

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## Introduction

This procurement guide aims at assisting local authorities or local developers wanting to develop a 4<sup>th</sup> generation district heating and cooling system (4DHC), more specifically on how to reach out and access carefully selected multiple expert service providers, qualified expertise and develop good projects.

A 4<sup>th</sup> generation DHC system is a low-temperature distribution system that minimises heat loss, integrates energy storage and renewable energy sources, and supplies multiple low energy buildings. 4<sup>th</sup> generation district energy is an intelligent city development opportunity, which can have several advantages (see figure 1).

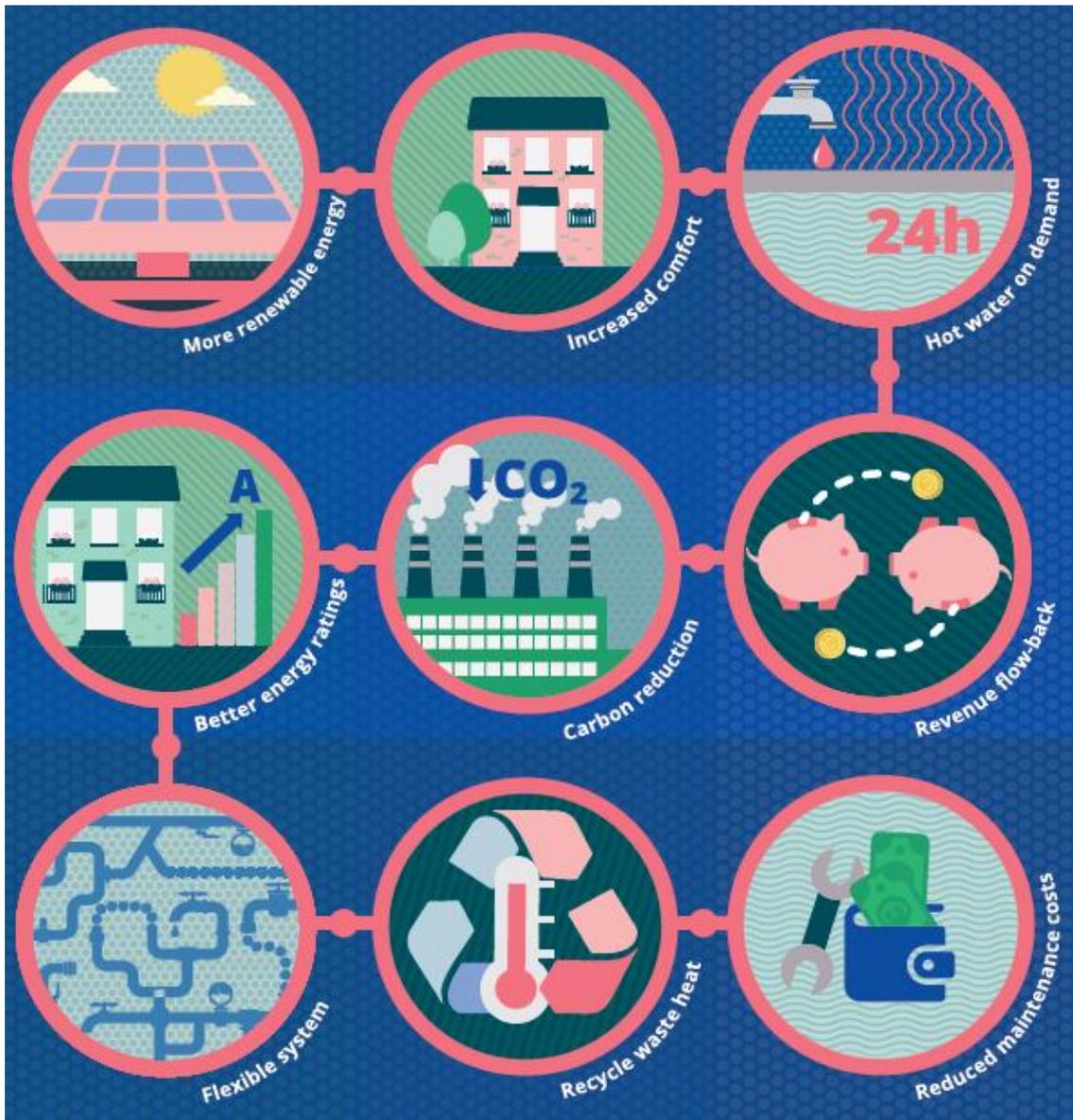


Figure 1: Advantages of 4<sup>th</sup> generation district heating and cooling (4DHC)

These infrastructure developments are both revolutionary and very complex, facing several organisational, technical and financial challenges and they are subject to meet European and national procurement standards. While there are some common key factors and pre-requisites of an infrastructure procurement process, there are as many local specificities and diverse national legislations that make them different.

Procuring consulting services as well as large-scale infrastructures that might be exploited by external companies (through a service/operation contract) needs serious competence and advanced knowledge. All key aspects have to be thought of, measured and analysed in order to secure high quality planning, construction and future operations processes resulting in positive economic, environmental and social impacts.

First part of this guide shall overview procurement strategies, procedures and general rules. The second part will discuss the procurement procedure; steps and timelines, proposing list of 'things to keep in mind'. Finally, in the third part, case studies from HeatNet pilot partners are proposed and some DHC good practices from other countries raised in the Appendix.

# How to procure?

## Procurement steps

For each service or goods you would like to procure to develop a 4DHC network, you will have to follow the steps described in the Figure 2 (although they can vary depending on the type of procedures and on local conditions [1]). If you think you do not have sufficient knowledge of the market to define requirements for final outcomes, then you should first do a preliminary market consultation.

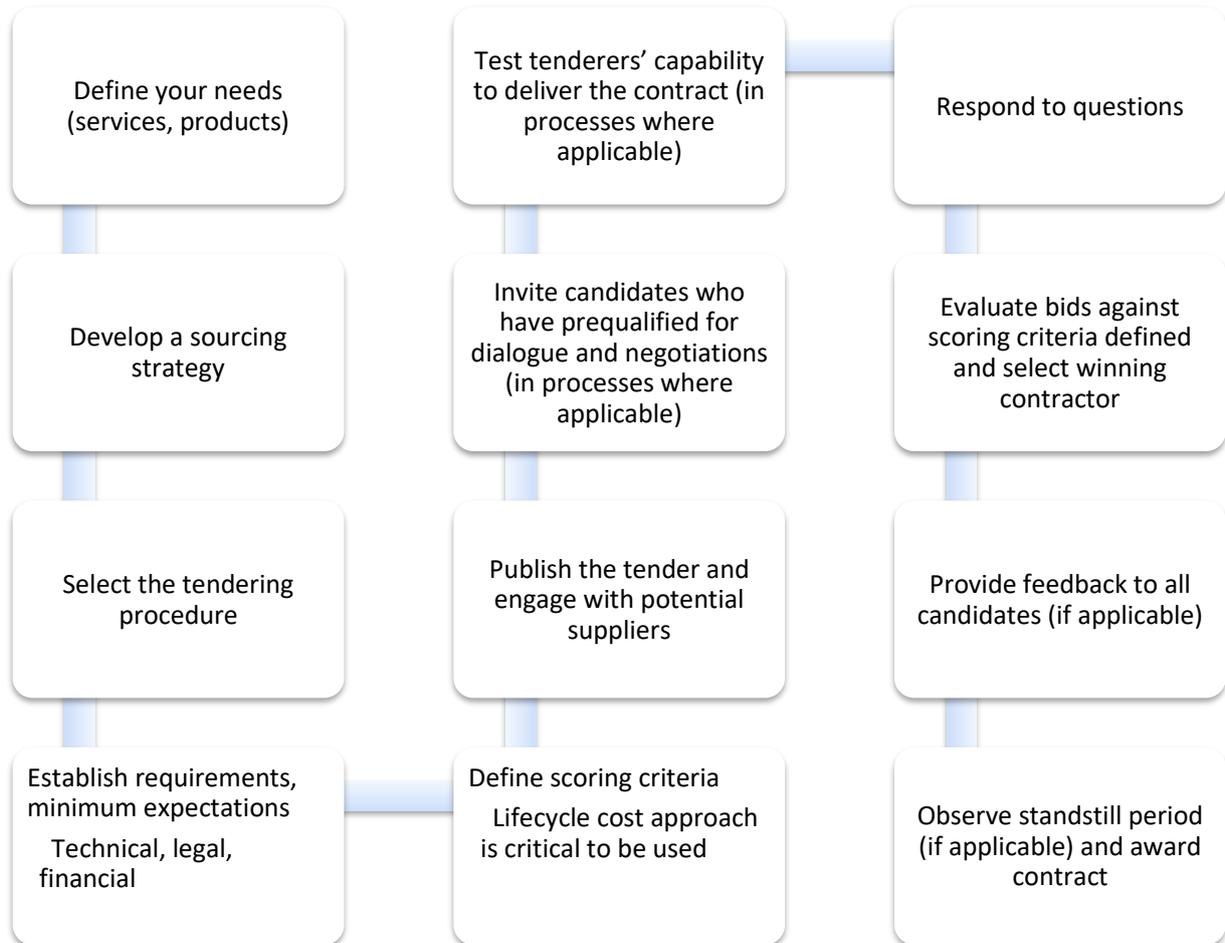


Figure 2: Steps of a procurement process

## Procurement strategy

In order to give you the best possible hints, a procurement strategy has to be set up [2]. It would allow anticipation and planning. This strategy should include the following points:

- **Project Team and Steering Committee:** Who within your organisation is best-placed to manage the procurement process and which departments should be involved? Is it relevant to include external experts or organisations in the group? For instance, departments for energy / infrastructure management, urban development should be considered to get involved in the process.

- **Joint procurement:** Are there other stakeholders who have the same needs as you? Is it worthwhile to work with them (for example in joining a procurement association)? Does it make sense to set up a framework agreement? For example, in case of a 4DHC development on a campus or tech park, it's worthwhile to ally with universities, research centres and companies on site.
- **Engaging Suppliers:** Are you going to contact suppliers informally prior to starting a procedure? Is it better to meet with suppliers one-on-one or in groups? How will you share information and guarantee confidentiality at the same time?
- **Risk management:** what are you going to do if there is only one or even no offer submitted at the end of the tendering process? What to do if the offers are beyond the calculated budget and make the business model not working? A form of mitigating risk can be downsizing / splitting the project in smaller parts, while setting up a project company to manage the tendering and mitigate those risks are also common solutions.

To avoid having one or no offer submitted you can actively engage with different potential suppliers, and try to get them interested in the project. If it still happens, then you have to understand the reasons (e.g. a lack of communication around the project, lack of definition of the requirements, no services or goods matching your needs available on the market). The problem can probably be solved by having a better market understanding and redefine your requirements. Then you can launch a new tendering process based on the acquired experience, potentially after changing the procedure type (see paragraph below). For example, applying a competitive procedure with negotiation without publication in case no tenders were submitted in an open or restricted procedure, could speed up the process.

When offers received are beyond your available budget, reasons behind might be similar. Then you can either opt for relaunching a tendering process or adapt your business model in consequence (for example including third-party investors).

## Types of procedure

Public procurement legislation varies country-by-country. However there are certain EU principles that apply to all member states: the award of contracts for the provision of public goods and services must be fair, equitable, transparent and non-discriminatory [3]. The EU sets minimum harmonised rules for tenders above certain monetary value, by type of procurement (e.g. works, supplies and services). For tenders of lower value, national rules apply, but procurement processes still have to respect general principles of EU law.

The most common tendering procedures (see figure 3) are typically as follows (illustrative list):

- Open Procedure (one stage, invitation to tender),
- Restricted Procedure (two stages, pre-qualification questionnaire and invitation to tender),
- Competitive Procedure with negotiation,
- Competitive Dialogue.

**Open Procedure (one step)**



**Restricted Procedure (two steps)**



**Competitive Procedure with negotiation**



**Competitive Dialogue**



Figure 3: Steps for different procurement procedures

**Open Procedure**

The call is open to all businesses and facilitates the participation of SMEs. There is no restriction of the number of tenderers and everyone can submit a bid. This procedure is usually faster and used to procure services and goods that the authority can easily defined.

**Restricted Procedure**

The contractors willing to participate in a restricted procedure have to send a request to the authority. Then the authority is allowed to restrain the number of candidates invited to submit a tender by using an initial selection stage. The selection is done through a pre-qualification questionnaire based on a scoring system which typically concerns four aspects:

|                        |   |
|------------------------|---|
| Mandatory requirements | Comply with EU and local laws, solvency, litigation, conflicts of interest, etc. Failure to meet any mandatory requirements means automatic disqualification. |
| Minimum expectations   | Quality, health and safety, environmental, business continuity, disaster recovery and other procedures. Certain expertise relevant to a contract.             |
| Capability             | Range of specific capabilities required to deliver the contract.  |
| Capacity               | Amount of appropriate relevant experience.  |

**Competitive Procedure with negotiation**

In this procedure, the authority has to define the required characteristics of goods and services before competition. This procedure is similar to the restricted procedure but allows the authority to have an additional step of negotiation before assessing the bids. It is used to procure goods, services or works which include an element of adaptation, design, innovation or other features which make the award of a contract without prior negotiations unsuitable. Negotiation are conducted based on the initial bids submitted by contractors. *Contracting authorities in the energy sector may use it as a standard procedure.*

### Competitive Dialogue

This procedure is used for complex tenders like large infrastructures for which the municipality cannot define in advance all technical specifications. After a dialogue step, each contractor submits an offer based on their own solutions to the needs the municipality expressed, instead of answering to the same specification.

## Specific EU rules

According to Directive 2014/24, public service and supplies, as well as works tenders exceeding certain values have to be published at the EU level. It is EUR 443,000 and EUR 1 million for various types of services and supplies, EUR 5,548,000 for works.

According to the Utilities Sector Directive 2014/25 (Section 1, Article 15), the lowest threshold for any services and supplies contracts is EUR 443,000. According to this Directive (61): *“In view of the detrimental effects on competition, negotiated procedures without a prior call for competition should be used only in very exceptional circumstances. This exception should be limited to cases where publication is either not possible, for reasons of extreme urgency brought about by events unforeseeable for and not attributable to the contracting entity, or where it is clear from the outset that publication would not trigger more competition or better procurement outcomes, not least because there is objectively only one economic operator that can perform the contract.”* It also states that recourse to framework agreements can be an efficient procurement technique and that joint awarding of contracts by contracting entities from different Member States encounters specific legal difficulties concerning conflicts of national laws.

The municipality has to respect the *rules of publication* of contract notice, notice of design contest and contract awards. It also has to respect *transparency rules* by evaluating tenders after the deadline of submission, providing a detailed explanation to non-selected contractors and respecting the *confidentiality of contractor's data*.

Concerning technical specifications, the public tender can also include details on what the municipality expect to buy like safety criteria, conformity assessments and design or quality assurance. Contract can also specify that contractors could be submitted to tests and inspections. Offers can also be evaluated / weighted according to specific criteria (environmental, social, technical, etc.).

Under the EU procurement rules a contract must be awarded based on the *most economically advantageous tender (MEAT)*. Costs may be calculated on the basis of a product's life-cycle (LCC). Where *life-cycle costing (LCC)* is used, the calculation method and the data to be provided by tenderers has to be set out in the procurement documents. Specific rules apply regarding methods for assigning costs to environmental externalities to ensure that these methods are fair and transparent. LCC takes into account the costs of resource use, maintenance and disposal which are not reflected in the purchase price. This can lead to greener and overall cheaper products, work or service procured.

Here are some specific rules for the different procedures conducted at the EU level [4]:

- **Open Procedure:** The publication has to stay visible minimum 35 days allowing bids submission for this duration at least.
- **Restricted Procedure:** The time limit is 37 days for the publication, duration allowing contractors to request participating in the procedure. The qualification step has to select at least 5 candidates which are invited to submit a tender. Then the time limit for the offers' submissions should be at least 40 days.
- **Negotiated Procedure:** The time limit to receive requests to participate in the procedure is minimum 37 days. There has to be an invitation of at least 3 candidates to negotiate terms of the contract.
- **Competitive Dialogue:** After the publication of the contract notice, interested businesses have 37 days to request participation. After the selections step, at least 3 competitors are invited to a dialogue in which the final technical, legal and economic aspects are defined. **This procedure cannot be used by public services providers in the energy sector.**

The delays above can be reduced in some cases (e.g. prior information notice, notice sent electronically, extremely urgent cases).

## Framework contracts

Framework contracts – containing aggregated requirements of various municipalities – can be useful in certain circumstances. Tenders can be invited for part, or all of the requirements in different areas (lots). Municipalities can then award contracts to suppliers who are on the framework. This can allow SMEs to bid for lots. Every lot can be considered and evaluated on its own merit with a winning bid for that lot.

To implement framework contracts, it is usually useful to have a dedicated organisation taking care of the procurement process for several municipalities (see figure 3), like for example a non-profit procurement association owned by its members. Such associations exist in the utility sector, like VÄRMEK in Sweden or the District Energy Procurement Association (DEPA) in UK which are specialized in DHC [5].

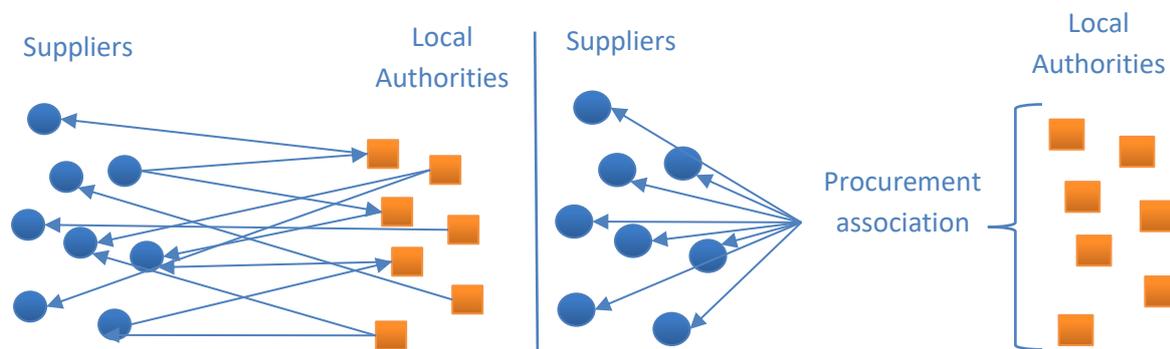


Figure 4: Schematic organisation of the usual market on the left and with a procurement association on the right

There are a lot of advantages for local authorities to join or to create a procurement association, including the following ones:

- procurement processes are shorter;
- buying power of LA increases, which enables lower prices and better conditions (like increased warranties; shorter deliveries, additional services);
- access to expertise, which minimizes risks of implementing wrong or outdated technologies and risks of fines due to improper procurement process;
- projects bundling attracts more suppliers and enables the implementation of high standards.

Besides this system also has many advantages for the suppliers:

- single entry-point to the market, which reduces barriers to market entry for new suppliers;
- they can negotiate with competent experts, which decreases transaction costs and fasten the process;
- higher selling volumes and potential for standardisation, allowing economies of scale and easier change of technologies;
- sales forecasts are more easily assessed, decreasing uncertainty.

# What needs to be procured?

## Procurement scope and timeline

To develop a 4<sup>th</sup> DHC network, a large range of services and goods are needed (see figure 5). Of course what is needed depends also on the type of the intended project which can be:

- creating a new district heating and cooling system;
- transforming and upgrading an existing 1<sup>st</sup>, 2<sup>nd</sup> or 3<sup>rd</sup> generation system into a 4<sup>th</sup> generation district energy system;
- extending an existing district energy system.

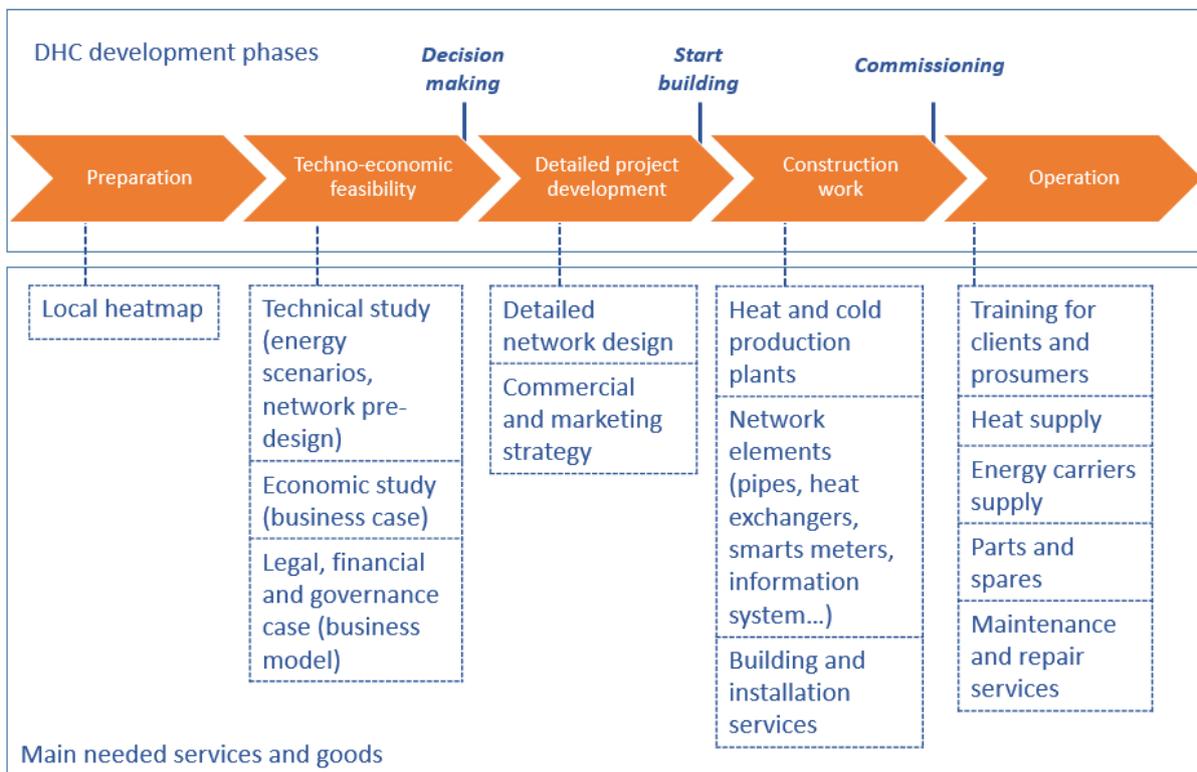


Figure 5: Goods and services which could be procured along a 4<sup>th</sup> DHC project

The way these items are procured may also vary: while the local heat map is usually procured alone, the studies (technical, economic as well as legal and financial) necessary to decide upon should be procured together. It will add consistency to the scenarios proposed: contractors answering the tender could gather in consortiums of consulting companies from different fields (technical, financial and legal services) [6]. Once the construction decision is made, the related services can be procured in different ways, depending on the chosen business model.

A local authority willing to build and own a network, can opt for diverse business models, depending on whether you aim to (illustrative list):

- build, operate and maintain a district energy network via a municipal company;
- build, operate and maintain a district energy network via a concession (public-private partnership);
- build a network and procure operation and maintenance services.

|   | <b>Municipal company builds, operates and maintains the system</b> | <b>Construction, operation and maintenance services are procured via a concession</b> | <b>A contractor operates and maintains municipal system assets</b> |
|---|--|---|--|
| <b>Consultancy services to generate the complex datasets required for quality analysis and planning</b>             | ✓  | ✓   | ✓  |
| <b>Consultancy services to generate the pre-feasibility and feasibility studies, certain draft tender documents</b> | ✓  | ✓   | ✓  |
| <b>Asset purchase (district energy generation or distribution assets)</b>   | ✓  |   | ✓  |
| <b>Construction works</b>   | ✓  | ✓   | ✓  |
| <b>Operation and maintenance services</b>   |  | ✓   | ✓  |
| <b>Heat purchase agreements</b>   | when third party heat sources are utilised too                     |   | possibly, when third party heat sources are utilised too           |
| <b>Building (social housing, public buildings) renovation, automation</b>   | when part of the municipal project                                 |   |  |

Table 1: Types of goods and services directly procured by a local authority in various (illustrative) business models

The question of the suppliers is also crucial. Before looking for an external company, local authorities can see whether the competencies are available internally or in a public company owned by them. Sourcing the services and goods internally can speed up the process and guarantee results which better take into account the local context and specificities.

In any case the first step before launching a 4DHC project is to establish a local heat map. Indeed key objectives of 4<sup>th</sup> generation district heating systems are increased system efficiency and the integration of sustainable heat production sources (renewables and excess heat). Comprehensive quality information regarding local heat and cold sources as well as energy demand are thus a must.

Below a focus is set on the procurement of the key elements to successfully develop a 4DHC. Some goods and services are quite common to all DHC projects and are not detailed in this procurement guide. You can refer to the other guides of the HeatNet model for more information.

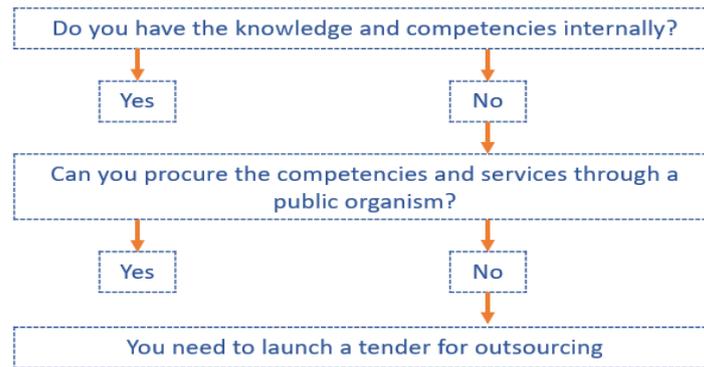


Figure 6: Simplified decision tree before launching an outsourcing process

## Local Heat map

### Key success factors

Heat mapping, and by extension, cool mapping, consists in describing the need for heating and cooling of a geographical area. It also contains information about energy sources (CHP, waste incineration plants, solar potential, etc.) [7]. It allows to better connect the needs and the sources in an integrated system, as well as to identify refurbishment needs to improve energy efficiency and alleviate socio-economic difficulties such as fuel poverty.

To better understand what it is, how it can be created, what input data needed, and what open source data tools are available you can refer to the Guide to Heat Mapping, part of the HeatNet model. In a summary main data are

- the availability of cost-efficient (competitive) and environmentally friendly heat sources (including spatial analysis);
- the current and projected heat and cold consumption of buildings (infrastructure should be planned for rational heat usage in buildings).

These data are usually expressed in MWh per year and enable to calculate heat density of the concerned areas, which is a key parameter for DHC development. This data collection and integration process necessary to produce a heat map is often a tedious, time-consuming task due to fragmented or unavailable, often inconsistent data from multiple sources. For example energy consumption data regarding different sectors (industry, residential, tertiary, agriculture) often come from different sources.

This process requires the cooperation of multiple municipal departments and working with multiple partners (e.g. building owners, facility managers, utility companies including transport and distribution system operators, civil groups, etc.). Breaking down organisational communication barriers within the municipality and integrating data possessed (and not shared) by various municipal departments is essential. This requires strong political commitment and often external assistance in redesigning internal (intra-departmental) municipal information flow and communications processes.

### Stakeholders' engagement

Creating a heat map as detailed as possible means gathering a large group of stakeholders (indicative list):

- municipal departments including energy, facilities and urban planning department, as well as facility managers from different public services (e.g. schools),
- utility companies (energy producers and transport and distribution system operators),

- local energy agency (if existing),
- social landlords,
- industrial companies (for example to know heat waste potential).

### **Procurement procedure**

A local heat map can be procured through an open or a restricted procedure, as it can be well defined before launching the tender procedure. For example pilot city of Aberdeen typically uses open or restricted procedure for this kind of services. Pilot city of Kortrijk also chose an open procedure to find a service provider for the preparation phase (see Case studies below).

### **Providers**

Typical companies able to deliver heat maps are engineering consulting companies specialized in energy management and energy planning with special competencies in Geographic Information System (GIS). To find qualified service providers, you can rely on engineering certifications which could be international (like ISO norms) or national certifications.

Local and regional energy agency can also be good providers. For example the local heat map for the South Dublin pilot project has been realised by Codema, the Dublin's Energy Agency.

## Technical study

### **Key success factors**

GOOD TO KNOW - in the assessment of the techno-economic feasibility:

- Learn from the best practices and mistakes of similar projects.
- Look at the long term big picture for the area by gathering data across sectors.
- Take into account local requirements and constrictions / boundaries.

Once a local heat map realised, the next step is the elaboration of an opportunity study for the development of a DHC network, which can be completed by a network pre-design in a second stage.

System design depends on a number of technical or non-technical conditions and the behaviour of the relevant stakeholders. DH networks are often planned as standard 3<sup>rd</sup> generation networks, without considering decentralised sources, storage or low temperature networks. The systems are designed traditionally by "rules of thumb" without any sophisticated scenario evaluation or the use of all available data sources. Thus underlining the will to have different scenarios integrating renewable and waste energy sources is a must in the tendering requirements for a technical study of a 4DHC. This study should focus on:

- the matching between sources and needs according to the temperatures of these sources (i.e. low temperature sources to supply low temperature energy demands);
- the matching between supply and demand on short-term (peak demand), medium-term (seasonal demand) and long-term basis (building refurbishment - infrastructure should be planned for rational heat usage in buildings) which could imply the use of storage technologies;
- the comparison between a baseline scenario (usually the status-quo scenario) and the proposed 4DHC development scenarios, in terms of impact beyond energy (e.g. air quality, social issues, facility management costs, working environment).

To have a better understanding of the available technological possibilities (like energy sources, cascading networks, heat and cold coupling, etc.), you can refer to the 4DHC Technology Guide, which is part of the HeatNet model. Of course, the cost of the feasibility study will depend on the number of scenarios asked to the bidders. In this matter, it is important not to multiply the number of scenarios and alternatives, otherwise the decision could become difficult. The supplier can be requested to present 2 or 3 specific scenarios based on different technologies, different energy sources and different spatial perimeters, while they can also propose alternatives, focusing on the local context.

In addition of these considerations, other points could be taken into account when drafting a tender for a technical study (illustrative list):

- individual interests of various stakeholders (utilities, network operators, city planners, etc.);
- land availability for installations' construction (like power plants);
- data protection issues during the study realisation;
- urban development' opportunities (like a new eco-district building, or a new transportation installation enabling works mutualisation);
- relevant European standards;
- design limitations posed by existing infrastructure, buildings;
- digitalisation opportunities. Modern district energy systems are demand driven which requires a holistic building approach. In the pre-design phase it is necessary to make sure that digitalisation and smart automation systems are included (see insert 1 regarding importance of digitalisation for 4DHC).
- the investment horizon (DHC infrastructure has a very long ROI and chosen technology has a certain lock-in effect). This can be dealt with asking the contractor to design the network so that it allows flexibility and further integration of different technologies.

It is also advisable to integrate such a DHC feasibility study into a broader **energy master plan or at least a heating and cooling roadmap for the city**. Indeed having a good understanding of the energy future of the city is a key advantage. It sets out an integrated vision of the DHC network development within the city's development strategy. Furthermore, it ensures that potential integration with other networks is taken into account, as well as a vision is proposed for areas in which DHC development is not feasible.

### ***Stakeholders' engagement***

Usually the earlier the stakeholders are engaged, the better it is. In addition with the data providers engaged in the local heat map realisation, it is necessary to engage the potential customers of the future DHC in the process during the technical study realisation. They can for example be part of the steering committee or be consulted regarding the different scenarios proposed. These potential customers can be social landlords, public building owners (like museums, swimming pools, theatres...). They can also be industrial or commercial building owners which can be both consumers and heat providers.

### ***Procurement procedure***

Depending on the competencies the local authority has, an open or restricted procedure can be used, as well as a competitive procedure with negotiation. The latter allows to have a negotiation with contractors, which provides access to the contractors' knowledge and helps to have a better view of the market. However in the negotiation phase needs cannot be redefined; they have to be well thought of before launching the tender. These needs should concern the technical requirements and expected deliverables of the feasibility studies. They should not advocate for one or another technical solution, which would not allow finding the best solution to maximise energy efficiency and renewable and waste energy use at the lowest cost.

Local authorities, lacking competencies in DHC planning may look for additional expertise to help with the procurement process. Such assistance may come from a local, regional or national energy agency, other local authorities, or a consulting company.

For instance, in the Aberdeen pilot project, a design engineer was found through an open tender. In Plymouth, the city council has invited three competitors to tender, in line with its procurement rules. The value of the technical study was lower than the threshold from which the EU rules should be applied (see Case studies below).

### **Providers**

Typical companies able to deliver a DHC technical feasibility study are engineering consulting companies specialized in renewable energy sources and low temperature technologies. The key point is to find companies with experience in several renewable and waste energy recovery technologies (and not only one or two technologies), so that you can be sure that all the options will be taken into consideration.

#### *Insert 1: Digitalisation and smart control for 4DHC, an essential component*

Digitalisation and smart control appliances enable end-users engagement and thus energy efficient 4th generation DH.

- Services for end-users are important to position district heating as an attractive offering.
- Enhanced information flow between the service provider and customers is needed for increased operational efficiency and customer comfort. Smart technologies play an enabling role. Customers' energy use awareness can be increased by visualisation tools using daily data and benchmarking.
- Beyond energy savings, indoor climate data can be useful to improve health conditions.
- End-user behaviour and building systems have a strong impact on DH efficiency. Building substation digitalisation can facilitate demand side management, transparent pricing, improved energy efficiency and fault detection. Traditionally, the monitoring and analysis of building level consumption is a manual process performed monthly. The automation of data collection and analysis can greatly improve efficiency and customer satisfaction.
- Smart meter data can also be instrumental in creating building ratings and suggestions for building system improvements.

Digitalisation is also a prerequisite for 4DHC operation (production, network and demand side management). Indeed smart control is required for:

- data collection and management enabling a more in-depth analysis of the operational characteristics, maintenance issues (like sections with over-capacity, bottlenecks, leakage detection, etc.);
- the utilisation of fluctuating renewable energy sources and excess heat volumes – which necessitate the smart control of controllable heat sources and demand management capabilities;
- a more efficient network control than traditional solutions (managing distribution simply by keeping the pressure head leading to heat losses) - needed for low-temperature networks operations;
- Plant scheduling (which heat plants to use at what time – as an increasing number of heat sources are integrated, scheduling and operation of heat plants is increasingly challenging).
- using a more dynamic approach as regards supply temperatures that can facilitate lower system temperatures (decreased heat loss, more efficient utilisation of sustainable energy sources);
- utilising the flexibility in heat networks as a balancing service to the electric grids.

## Economic study

### **Key success factors**

An economic study's first goal is to assess the economic viability of the 4DHC project. First part is to evaluate globally the investment costs and the operational and maintenance costs of the different technical scenarios. In consequence it is strongly advised to procure the technical study and the economic study together. The awarded contractor could be one company combining technical and economic competencies, or several companies grouped in a consortium.

The investment costs include for example the production plants, the land, the network elements (pipes, substations...), and the installation and design costs. A screening of the possible subventions have to be done too. The operational costs include especially energy carriers' costs, labour costs and maintenance costs. This analysis allows to calculate the prices of the heat sold, to guarantee the economic viability of the project. The costs structure is generally based on a fixed price for customers (subscription costs) and a variable price proportional to the heat consumption. Sensitivity tests should be conducted to analyse the impact of different parameters (like energy carrier prices, inflation, change on taxes, grant rates...) on the project profitability. This profitability should be assessed on the basis of a product's life-cycle, using indicators like the net present value or the internal rate of return. Some other indicators (like costs per quantity of avoided GHG emissions) can be analysed according to the specific project goals [8].

In a second phase, after having determined a most relevant scenario, the business model (including legal analysis and financial impacts) can be examined. There are a lot of business models available to local authorities interested in DHC going from fully publicly owned, operated and maintained to fully privately owned, operated and maintained with different degrees of public/private partnership options in between. The main criteria for local authorities to choose a business model are the key objectives of the project, the stakeholders' attitude to risk, the level of control desired over the life of the project, regulatory compliance requirements, access to finance, the desired rate of return on the investment.

For further details, you can refer to the 4DHC guide to governance and business models (part of the HeatNet model), as well as find an overview in the Business case to public sector.

### **Stakeholders' engagement**

The stakeholders engaged at this stage are the same as the ones engaged for the technical study, as both studies have to be done together. The more the optimal scenario starts to be defined, the more you have to engage with the concerned stakeholders. The political level has to be strongly involved too, in particular the deputy mayors for financial affairs and for energy. Some political city boards like the Environment or City Planning Committee can be associated too.

### **Procurement procedure**

To procure an economic analysis, like for the technical study, mostly the procedures used are the open procedure or the restricted procedure, less common is the use of a competitive procedure with negotiation. It depends on the time and the knowledge you have.

### **Providers**

Companies able to deliver an economic study regarding a 4DHC project are engineering consulting companies with competencies in project financing or consulting companies specialized in market analysis and technical projects. Usually costs are well known by engineering companies but a financial consulting company with good knowledge of energy markets may be handy for the global economic assessment.

## Training for clients and prosumers

### **Key success factors**

To take full advantages of 4DHC system in terms of flexibility and enhanced energy efficiency, customers and prosumers have to be engaged in the project and aware of the specificities of this technology. High-level automation and digitalisation has a wide range of advantages (see insert 1) but also might be a barrier in case customers and prosumers are not trained to understand and use smart devices. In the worst case, it could lead to the manual use of the system (emergency mode).

Innovative operation of a DHC system could also lead to special clauses in contractual agreement between DHC operators, customers and prosumers. A training about the system operations could ensure customers and prosumers understand and agree these clauses. For example contractual temperature guarantees for the inlet water could be expressed as a range of temperatures instead of a fixed temperature.

In light of the General Data Protection Regulation (GDPR) the frequent collection of smart meter data raises the issue of how it is processed and protected. Consumers could need to give their approval for the use of some personal data. Training can help get it if customers better see their interests in this digitalisation [9].

In addition 4DHC systems often supply low energy buildings. Customers training can be needed to raise awareness that well designed and insulated buildings could still consume a high amount of energy according to occupant behaviours. Training can help avoiding rebound effect and keep system operation conditions in the range for which it has been designed. You can also refer to the 4DHC Guide to home and building energy management (part of the HeatNet model) to get more information on training for clients and prosumers.

In the future, new technologies like blockchain could bring solutions to enhance customers and prosumers' involvements and offer them new services. For instance blockchain could allow customers to influence environmental decisions and impact the sustainability profile of DHC or to extend their control on load management [10].

Thus providing training for clients and prosumers is an important part of a 4DHC project to capture the full potential of energy savings of this kind of system. This training concerning at least sustainable behaviour, system operations and smart controllers should be done as soon as new customers are connected to the DHC network and sign their energy contracts. It could be renewed on a regular basis so that customers are kept engaged and updated on possible changes. The association of the DHC customers, in case it exists, can also be associated to this training.

### **Stakeholders' engagement**

Different stakeholders can be associated to the training of customers and prosumers depending on the chosen business model. One or several municipal departments could bring information for instance regarding regulatory aspects as well as city's engagement in the project. The district operator is likely to be the most qualified to explain DHC operations and impact of customers' behaviours on the DHC system. Manufacturers or distributors of smart controllers could also bring their expertise. More broadly all stakeholders, including heat producers, are potentially interested in elaborating a training for DHC customers and prosumers.

### **Procurement procedure and providers**

The procurement procedure is dependent on who is going to provide this training (most probably the DHC operator). It seems not necessary to have a procurement procedure for this service but to add it as a requirement in the procurement procedures set up for the other goods and services: winning tenderers of the different lots of the DHC project are due to participate in the customers and prosumers training.

## Heat supply

### **Key success factors**

As 4th generation district energy systems purchase heat from a variety of sources (local renewables, waste heat), heat supply agreements (HSAs) are likely to be required and should be secured before the construction starts (either it is a new network or a network extension). In these, clear minimum standards of service and a mechanism by which these can be enforced should be defined. These standards can concern the following points (illustrative list):

- heat price
- temperature and pressure
- continuity of service, interruptions of supply, notices, response times
- billing & metering
- carbon content (energy mix)
- complaints handling & resolution
- noise, vibration.

Failures to achieve the agreed service standards should have tangible consequences for the supplier. In defining the monitoring and enforcement of service standards, some key elements that shall be considered and specified are as follows:

- who is responsible for monitoring compliance with service standards;
- how monitoring will be done and reported;
- the level of deductions / compensation when failing to achieve agreed service levels, and how relief can be granted in certain situations;
- when repeated, poor performance by the supplier gives a right for the network operator to terminate the agreement for default.

### **Stakeholders' engagement**

In case a new heat provider is sought then the DHC operator could engage other project partners in the process:

- customers who are located in the district that can become heat providers;
- city representatives and officers;
- financial partners;
- neighbours if they are affected by the "new installation".

Indeed the installation and connection of a new heat plant could have a lot of different consequences (e.g. land use, air quality, network energy performance, noise...).

### **Procurement procedure**

The procurement procedure is inextricably intertwined with the technical solution identified. If no technology is preferred then a competitive dialogue can be used, so each competitor is able to provide its own solution based on its analysis. If a technical solution (solar heat or geothermal heat for example) is already provided, other types of procedure can be used with a preference for a competitive procedure with negotiation more suitable for complex infrastructure projects.

Sometimes only one company can provide the desired heat. For example if you have identified a waste heat potential from an industrial site, then the industrial owner is the only one able to provide it. In this case, usually there is no tendering procedure, you negotiate and sign a heat supply agreement directly with this company. This 'lighter' procedure, avoiding the need for tendering, is also supported by the Art. 14.5 of the EED (directive 2012/27/EU), which makes it mandatory to recover waste heat from a new industry through a

district heating system if the cost-benefit analysis shows it beneficial.

In South Dublin County, the heat supply comes from a datacentre free of charge. A heat supply agreement has been signed between the public DH Company and the data centre owner.

**Heat providers**

Heat providers are generally project developers and utility companies able to run geothermal plants, biomass-fired plants, solar thermal plants, heat pumps... Usually the heat provider and district heating operator are the same entities (except for waste heat). However, the new EU directive (EU) 2018/2001 on renewable energy tends to 'open' the DHC market to multiple heat providers. Qualified service providers with references and proven track record can be found by contacting the relevant industrial or trade associations or by contacting referents (like national or regional energy agencies) and cities who have successfully realised 4DHC projects.

Waste heat sources can also be industrial sites, commercial and tertiary buildings (swimming pools, data centres, shopping centres, etc.), power plants, waste water treatment plants or waste incinerators; these potential heat providers are supposed to have been identified during the local heat mapping step.

## List of resources to find providers

In Table 2, you can find a list of governmental bodies, public organisations, trade associations which could help with further information and advice for those willing to develop a 4DHC project. This list is neither exhaustive nor indicative.

Items procured for district energy shall meet the requirements of the relevant European and local standards. Suppliers of items or services shall demonstrate a proven track record. Then looking for standards can be a way to find qualified providers.

| Countries         | List of interesting resources  |
|-------------------|--|
| Several countries | <a href="#">EuroHeat&amp;Power</a> , network of district energy organisations and professionals<br><a href="#">CEDEC</a> , the European Federation of Local Energy Companies<br><a href="#">Celsius City</a> , network promoting sustainable heating and cooling<br><a href="#">Danish Energy Agency</a>   |
| Belgium           | <a href="#">Brussels Environment</a> , Environment and Energy Agency of Brussels Government<br><a href="#">Wallonie Energie SPW</a> , Energy Department of Wallonia Government<br><a href="#">Vlaams Energieagentschap</a> , Flemish Energy Agency<br><br><a href="#">TWEED Cluster</a> , association of sustainable energy companies in Wallonia  |
| Ireland           | <a href="#">Sustainable Energy Authority of Ireland</a><br><a href="#">Association of Irish Energy Agencies</a><br><a href="#">Irish District Energy Association</a>   |
| France            | <a href="#">CEREMA</a> , centre of studies and expertise on risks, environment, mobility and urban planning<br><a href="#">ADEME</a> , French Environment and Energy Management Agency<br><a href="#">Regional Energy Agencies' Network</a><br><a href="#">Federation of local energy agencies</a><br><a href="#">Fedene</a> , trade federation for Environment and Energy Services<br><a href="#">Technical Association Energy Environment</a> , federation of stakeholders (including consulting companies)<br><a href="#">AMORCE</a> , association of local authorities and companies<br><a href="#">FNCCR</a> , association of local authorities for public services |
| Netherlands       | <a href="#">PBL Netherlands Environmental Assessment Agency</a><br><br><a href="#">Energie-Nederland</a> , association of electricity producers, electricity and gas traders and electricity, gas and heat retail companies  |
| United-Kingdom    | <a href="#">Heat Networks Delivery Unit</a> of the Department for Business, Energy and Industrial Strategy, United Kingdom government<br><a href="#">Re:fit programme</a> of Local Partnerships LPP (a joint venture between HM Treasury, the Local Government Association and Welsh Government)<br><a href="#">Chartered Institution of Building Services Engineers</a> , association of consulting firms<br><a href="#">Energy UK</a> , association of energy companies<br><a href="#">Association of Decentralised Energy</a> , trade association   |

Table 2: Resources to procure services and goods related to 4DHC projects

## Things to keep in mind

About 4DHC development:

- **Analyze energy consumption of buildings** (to be supplied) – not only historic consumption but also potential future consumption – especially in the case of buildings with excessive consumption, where building automation and control, billing linked to the actual energy consumption of individual flats, other relatively low cost measures can achieve significant savings. These and changes in the building envelope (e.g. external insulation) can result in more than 50% decrease in consumption, as experience shows.
- **Appropriate Heat map** – make sure that you have a proper analysis of local renewable and waste heat sources and potentials (e.g. rooftop solar, industrial, sewage or data centre waste heat) to optimise planning, create synergies.
- **Focus on measures to identify and seize network and buildings efficiency potentials** rather than installing more renewable heat sources as a first priority. Energy efficiency should be the first fuel, renewable energy sources should not be installed to feed wasteful systems.
- **Start with an unbiased comprehensive factual analysis of the actual local problem**, rather than a specific solution in mind.
- **Select open protocols for digital solutions** (e.g. smart meters, software) that can communicate with other systems without 'lock-in' effect. This is a key technical feature that can cause great harm to municipalities. „Open” protocols solutions should be utilised to enable a free selection among potential suppliers when upgrading the system in the future.
- **Design and implement supporting new internal working processes, procedures** that support the creation and operation of an integrated municipal database, essential for the implementation of 4<sup>th</sup> generation district energy solutions.
- **Ensure proper internal communications among municipal departments** and establish willingness to share data to create an integrated database. Releasing information may be seen by certain managers, bureaucrats as releasing power or a risk that mistakes made, inappropriate quality solutions may become known within the municipality. Therefore without a strong political will and project management, relevant (infrastructure, building, social, energy, etc.) data may stay in silos and not utilised for project planning and monitoring.

About procurement process:

- **Establish proper communications with all key stakeholders** (utilities, authorities, building owners, tenants, etc.) to mitigate risks and ensure stakeholder buy-in. Without timely engagement of relevant stakeholders, project risks increase significantly, citizens and local businesses are much less likely to be satisfied with the results [11].
- **Define a clear enough project scope** for running successful tenders. One of the barriers can be to find adequate expertise for developing the project.
- **Consider quality indicators when awarding tenders** – the awarded proposal of the tender procedure should not be the cheapest one. The chosen company should be also select on its ability of integral working and its solution-oriented thinking. Typically the weighting of scoring criteria could 25% cost (fixed price, budget and hourly rates) and 75% quality (split down into resourcing, skills, approach etc). To be transparent and fair to all tenderers, the scoring criteria should be attached with the Request for Quotations.
- **Take time to do a proper market research** before launching a procurement procedure, it will help you to better defined your needs and requirements and will save time in the following steps

- **Look for local companies** and engage them in your projects. It could lead to develop local competencies and increase local employment opportunities.
- **Specify the rules you apply in terms of subcontracting in the Request for Quotations** (allowed, forbidden, how many levels of subcontracting allowed, requirements set for subcontractors, etc.).

## Case studies of Pilot Partners

|  | Aberdeen   | Boulogne-sur-Mer                                  | Dublin   | Kortrijk                            | Mijnwater   | Plymouth   |
|--|--|---|--|-------------------------------------|---|--|
| <b>New installation</b>                                |  |   | X  | X                                   |   | X  |
| <b>Extension of existing network</b>                   | X  | X   |  |                                     | X   |  |
| <b>4<sup>th</sup> generation DH principles applied</b> | Smart meters<br>Tele-management<br>Waste heat recovery | Low temperature,<br>Renewable,<br>Tele-management | Use of low-grade waste heat<br>>50% zero-carbon heat supply<br>Integration of heat and electricity markets | Low temperature,<br>Tele-management | Ultra-low temperature<br>Waste heat recovery<br>Renewable<br>Tele-management<br>Integration of heat and electricity markets | Low temperature<br>Renewable<br>Tele-management<br>Integration of heat and electricity markets |

## Aberdeen – Competitive procedure / Public model

|  |  |
|--|--|
| <b>Kind of services procured</b>   | Feasibility study, design, materials, construction, labour   |
| <b>Procedure chosen</b>  | Competitive tendering process for the procurement of services, goods and design. The detailed feasibility study was carried out by a specialist consultant   |
| <b>Standards considered relevant</b>   | All relevant standards and procedures that apply to Scotland   |
| <b>How was expertise found to prepare a proper feasibility study</b>         | Feasibility study requirements were based upon previous experience.  |
| <b>Kind of data sources used</b>   | Data and information provided by ACC such as consumption data, information on boiler age and state etc. Scottish heat map also used.   |
| <b>Local low cost &amp; environmentally friendly sources of heat studied</b> | Proposed energy from waste plant and CHP plants.   |
| <b>Specific focus on 4DHC</b>  | Compatibility and connection pipes to energy-from-waste plant taking into consideration 4DHC, controls and monitoring of heat, pipes used  |
| <b>Suggestions for others</b>  | Learn from other similar projects. Look at the long term big picture - gather data across all sectors for project design. Consider local requirements and constrictions within the project design. |

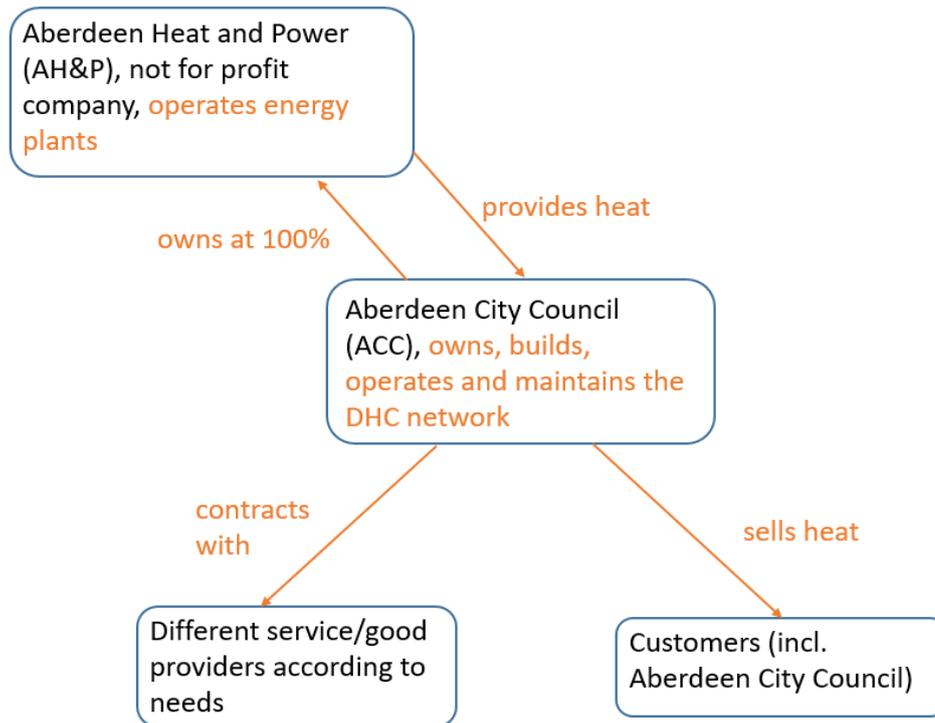


Figure 7: Schematic business model organisation of the Aberdeen DHC project

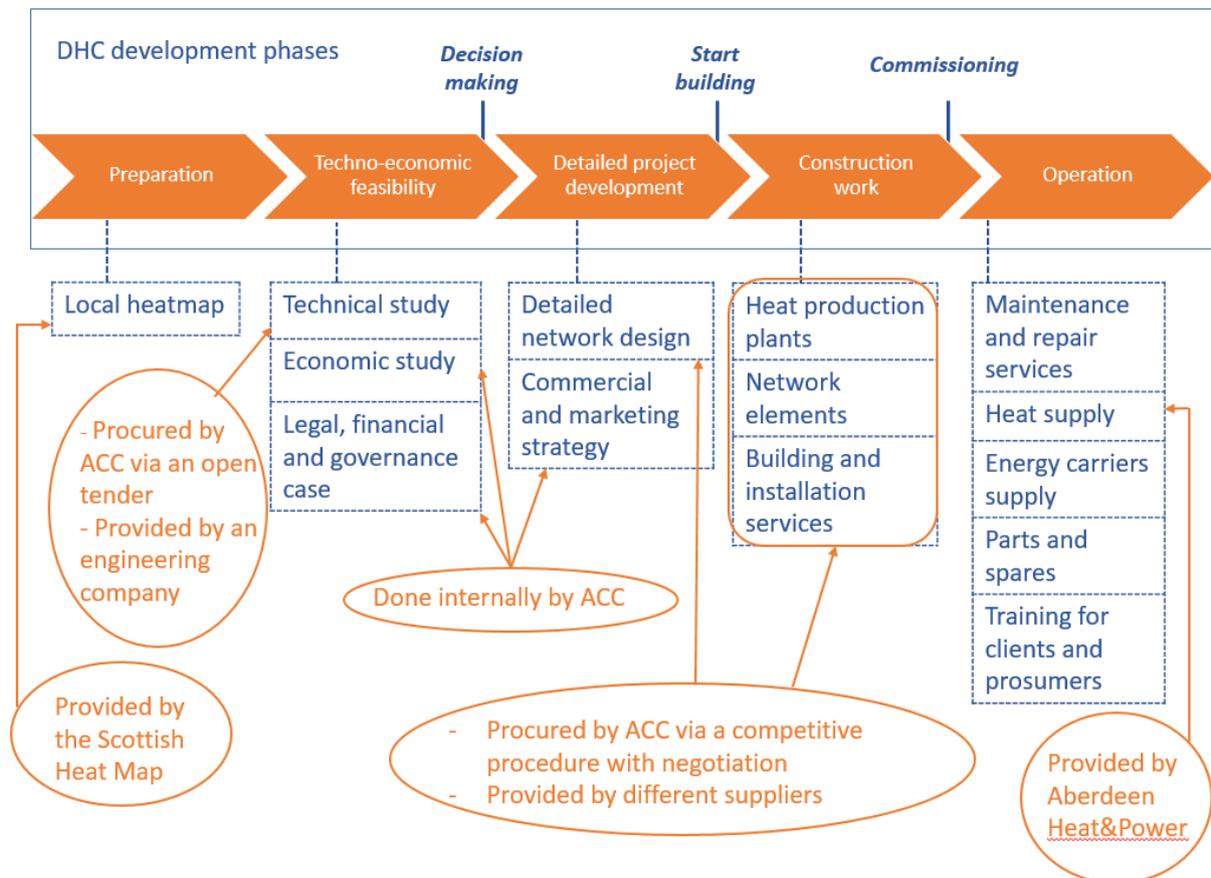


Figure 8: Procurement procedures along the 4DHC project of Aberdeen

## Boulogne-sur-Mer – Restricted procedure / ESCo model\*

|   |  |
|---|--|
| <b>Kind of services procured</b>  | Efficient thermal modules coupled with radiators to improve the obsolete secondary heating system at building level, bought by the social housing organisation (Investment 2)<br>Network elements and labour for the extension of the (new) primary network, procured by the ESCo (Investment 1)   |
| <b>Procedure chosen</b>   | Restricted procedure for the thermal modules at building level. (I2)<br>Network elements and labour are procured by the ESCo following open procedures.(I1)  |
| <b>Standards considered relevant</b>  | French Code des Marchés Publics for the thermal modules.<br>The ESCo is also obliged to follow the procurement rules of public organisations, as the ESCo has the concession through a public service delegation.  |
| <b>How was expertise found to prepare a proper feasibility study</b>        | Feasibility studies for network extension were internally coordinated by the ESCo in collaboration with Boulogne-sur-mer city. Suggestions were asked from partners on other projects. (for Investment 1)<br><br>For Investment 2, the project manager asked expertise from various companies he works with to discuss potential secondary heating system development scenarios at building level. |
| <b>Kind of data sources used</b>  | Technical diagnostics, tenants survey / feedback and complaints<br>Buildings' energy consumption data  |
| <b>Local low cost &amp; environmentally friendly sources of heat chosen</b> | Biomass, excess heat from waste incinerator and wastewater   |
| <b>Specific focus on 4DHC</b>   | Renewable energy sources, low temperature, smart control   |
| <b>Suggestions for others</b>   | Work with tenants not only beforehand but also afterwards to coach them.<br>Think in coherence with other work that could be planned in the buildings.   |

\* The procurement of an ESCo (to design, build, operate and maintain the network) was not part of the HeatNet project: it has been procured by the city before the start of the HeatNet project. The HeatNet project at Boulogne-sur-mer concerns only an extension of the DHC network which didn't need to organise a public procurement process, as it is part of the existing concession.

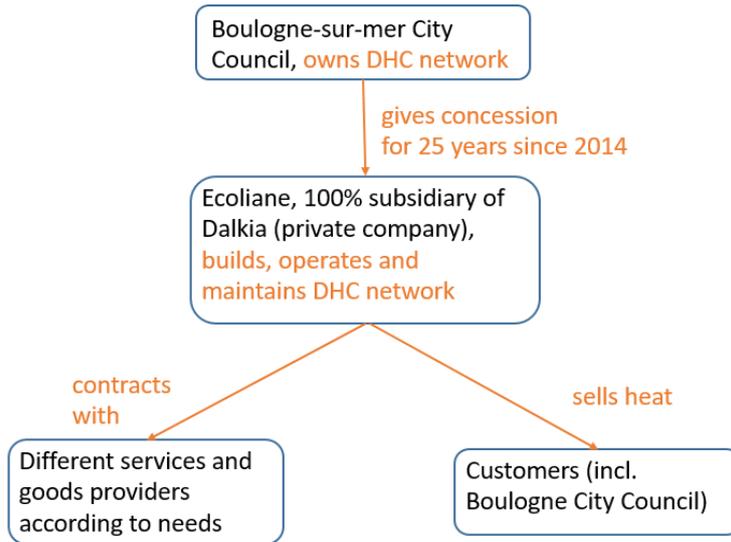


Figure 9: Schematic business model organisation of the Boulogne-sur-mer DHC project (Investment 1)

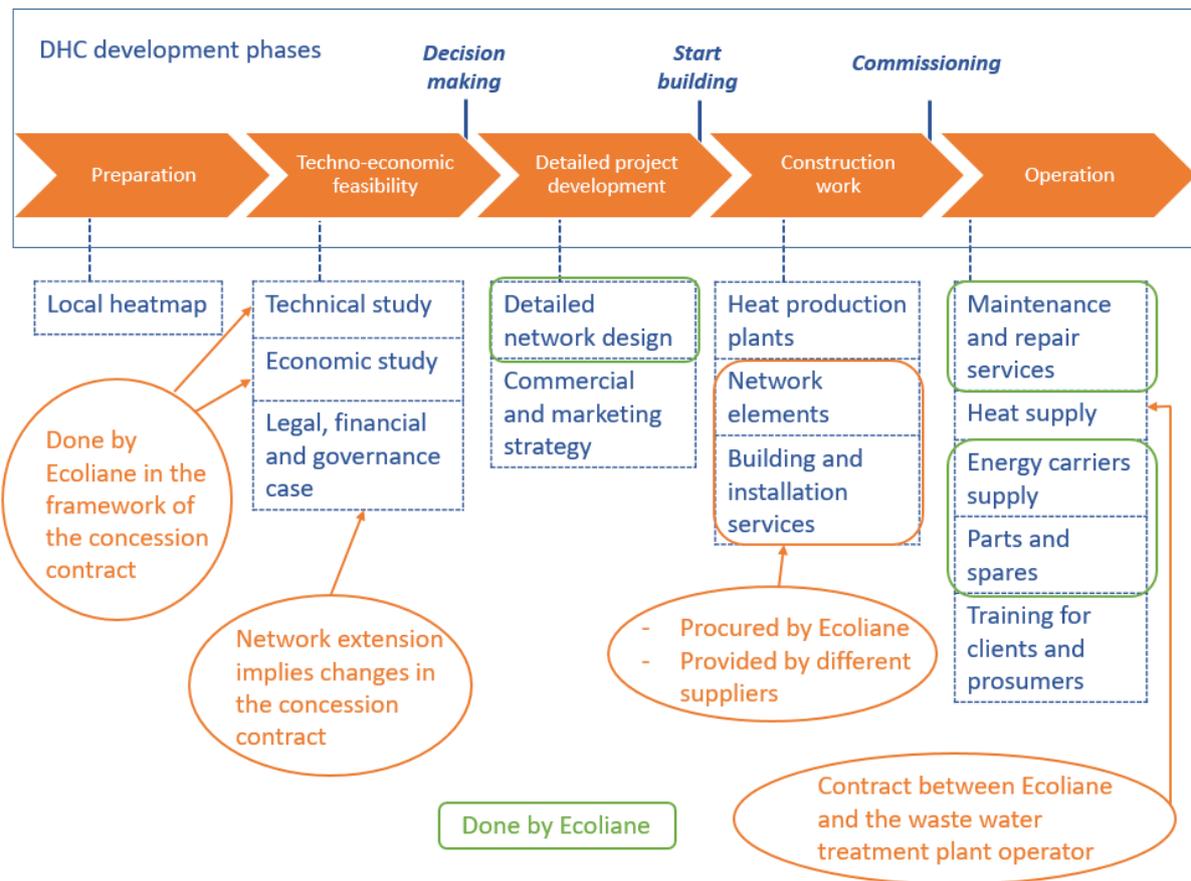


Figure 10: Procurement procedures along the 4DHC project of Boulogne-sur-mer

## Dublin – competitive dialogue / ESCo model

|   |   |
|---|---|
| <b>Kind of services procured</b>  | The solution chosen for the development of the DH system is for South Dublin County Council to invest in and procure a Design, Build, Operate & Maintain (DBOM) contract with an Energy Service Company.  |
| <b>Procedure chosen</b>   | <i>Competitive Dialogue</i> procedure is a two stage (or restricted) procedure for the DBOM of the initial phase of the Tallaght DH scheme. First phase is the Pre-Qualificative Questionnaire (PQQ), which the bidders are narrowed down to go through to the second stage, based on previous relevant experience. The Invitation to Competitive Dialogue (ITCD) is the second stage, and sees the qualified bidders present an Outline Solution. Based on the outline solutions submitted, the final tender document is then drawn up and bidders submit their final solution and costs to be evaluated. The contract chosen is a <i>Local Energy Supply Contract</i> (LESC) which includes separate works phase and heat supply phase. |
| <b>Standards considered relevant</b>  | OJEU and Irish public sector procurement standards as well as internal South Dublin County Council procurement rules and procedures.  |
| <b>How was expertise found to prepare a proper feasibility study</b>        | The feasibility study was completed by South Dublin County Council’s Energy Agency, Codema, who are also partners on HeatNet project. Energy Agencies in Ireland support the local authorities to implement energy related projects, and most have the in-house skills required to carry out feasibility studies.   |
| <b>Kind of data sources used</b>  | For technical and economic feasibility analysis, data is required for the heat demands and heat load profiles of the buildings to be connected, the current heating costs, and the costs of all equipment necessary to supply heat to those buildings.  |
| <b>Local low cost &amp; environmentally friendly sources of heat chosen</b> | The scheme is utilising low-grade waste heat from a data centre, which will be brought to a usable temperature through a large scale heat pump. The heat pump operation will be optimised using night-rate and low carbon grid electricity through the use of thermal storage capacity to reduce carbon and costs further.  |
| <b>Specific focus on 4DHC</b>   | Due to the high temperature requirements of the existing buildings to be connected, low temperature supply is not possible at this time. Other elements of 4DHC have been included, such as the use of low-grade waste heat, and electricity demand response.   |
| <b>Suggestions for others</b>   | Ensure a variety of stakeholders are involved in the development of the project, not just engineers! Need support from planners, procurement, commercial and legal expertise throughout the project.  |

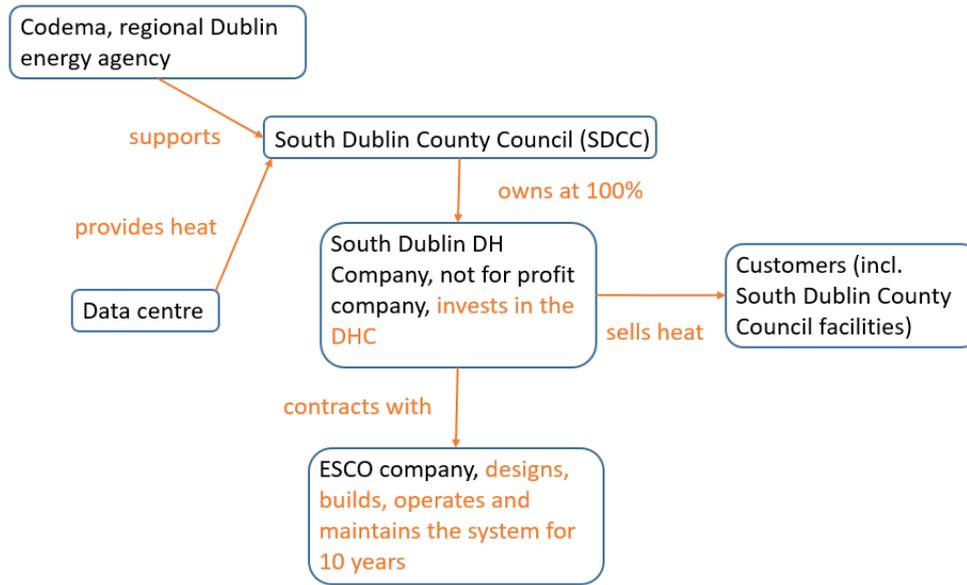


Figure 11: Schematic business model organisation of the South Dublin DHC project

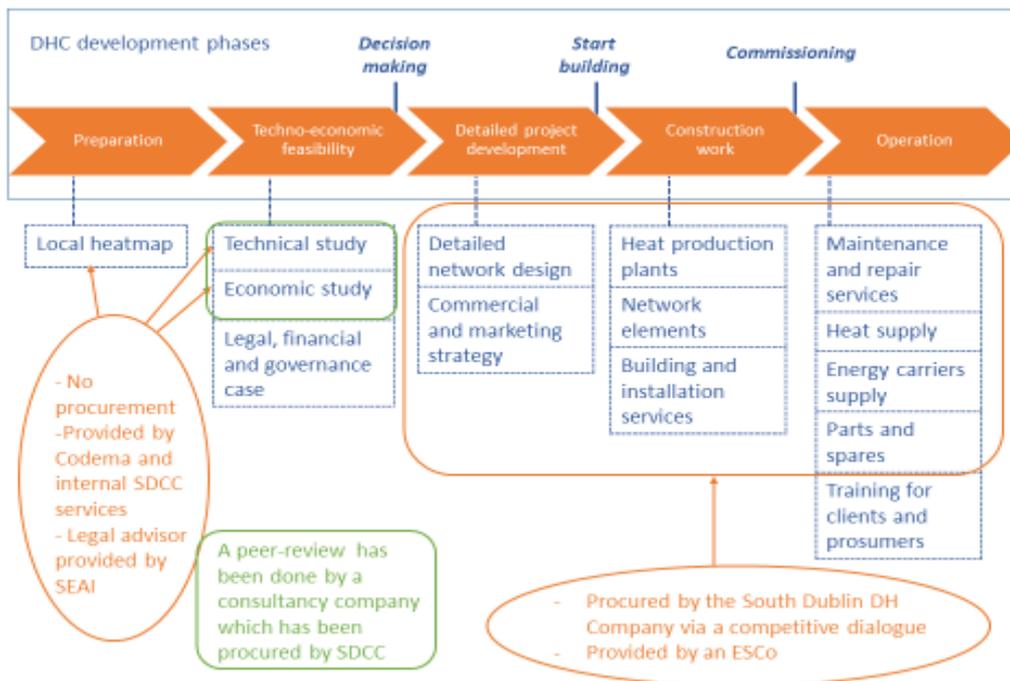


Figure 12: Procurement procedures along the 4DHC project of the South Dublin County Council

| Kortrijk – Open procedure / Public model                                     |   |
|--|---|
| <b>Kind of services procured</b>   | Predesign and design on the public domain, Heatnet ambassador (project coordinator), goods (heat exchangers, pipes, meters), construction works   |
| <b>Procedures chosen</b>   | <i>European and open procedure</i> for planning and technical studies, pipes, connections with heat source and the connection under railway<br><i>Restricted procedure</i> for Heatnet ambassador, pre-selection of 3 possible partners, mini-competition |
| <b>Standards considered relevant</b>   | European tendering rules and procedures for European (European directive 2014/24) and the Belgian legislation originating from this directive   |
| <b>How was expertise found to prepare a proper feasibility study</b>         | Open procedure and the mini-competition   |
| <b>Kind of data sources used</b>   | Energy use of existing buildings, tentative energy use of new buildings, energy production of the waste incinerator, energy from Leie river   |
| <b>Local low cost &amp; environmentally friendly sources of heat studied</b> | Heat from water (Leie river and groundwater), solar, biomass from the recycling facility in the neighbourhood   |
| <b>Specific focus on 4DHC</b>  | Smart metering and low temperature heat   |
| <b>Suggestions for others</b>  | Start early, do not think you have the knowledge in house, seek for technical support and communicate a lot with all stakeholders.  |

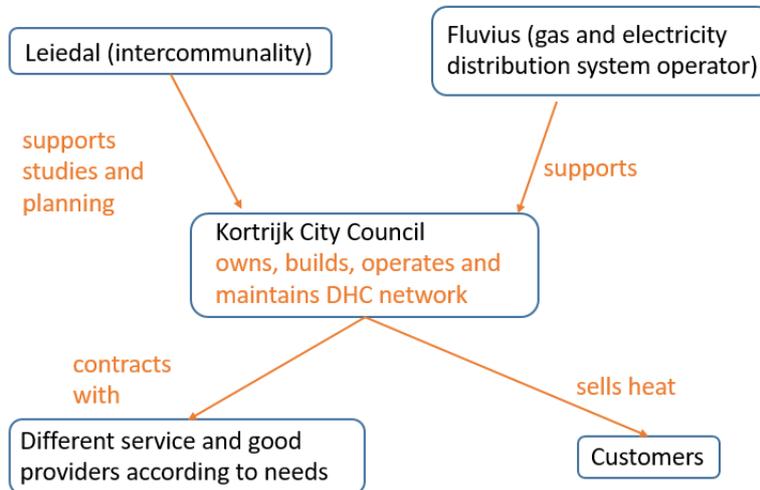


Figure 13: Schematic business model organisation of the Kortrijk DHC project

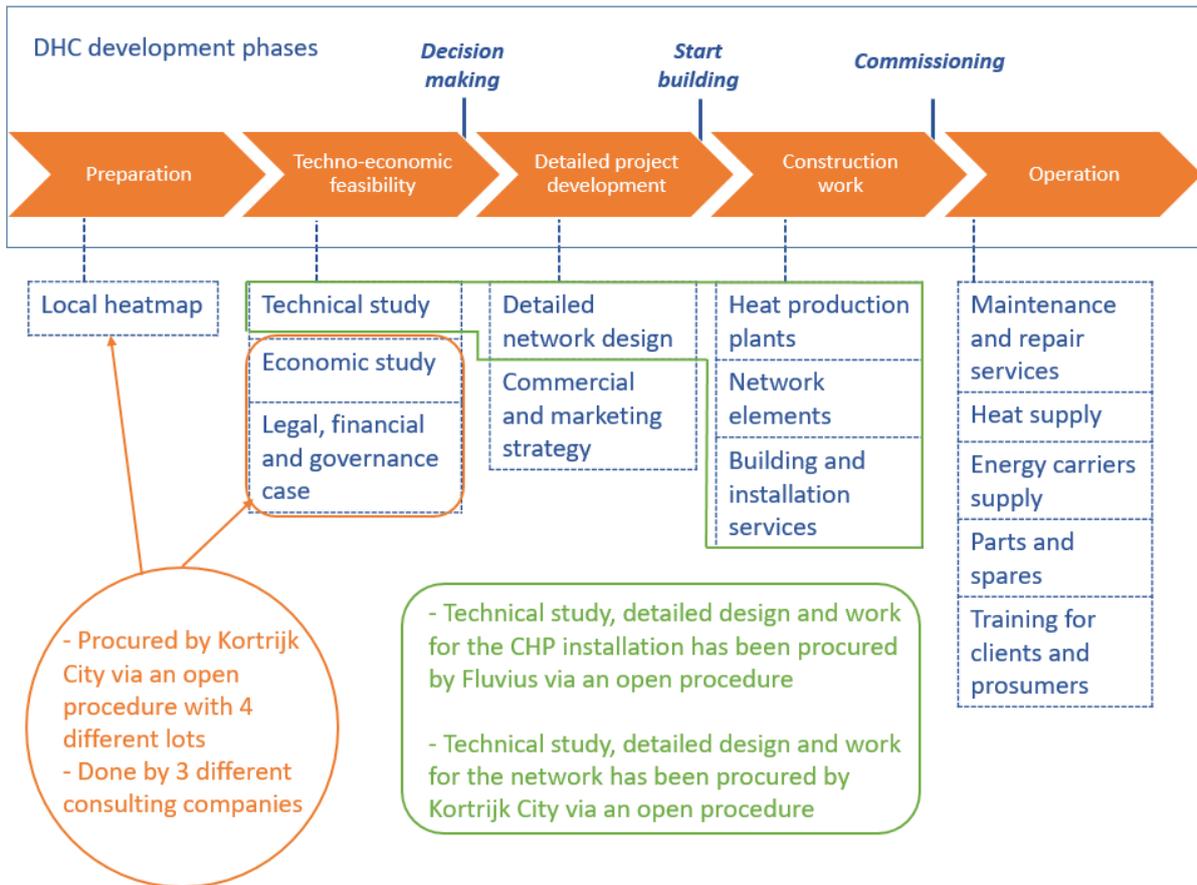


Figure 14: Procurement procedures along the 4DHC project of Kortrijk

| Heerlen – Restricted procedure/Regional company                           |  |
|---|--|
| <b>Kind of services procured</b>  | Detailed network design, construction work and network elements (pipes, heat pumps...). 80% of maintenance is done by ESCo.  |
| <b>Procedure chosen</b>   | Restricted procedure, minimum 3 companies are invited to propose bids.   |
| <b>Standards considered relevant</b>                                      | Public procurement standards of the municipality of Heerlen, the former owner of the company, which are compliant with the public procurement standards of the Netherlands   |
| <b>How was expertise found to prepare a proper feasibility study</b>      | Expertise is based on former projects done, as the Mijwater concept has been developed for more than 15 years  |
| <b>Kind of data sources used</b>  | Building energy consumption, heat and cold loads, potential of waste heat recovery of industries, data centres, shopping centres...  |
| <b>Local low cost &amp; environmentally friendly sources of heat used</b> | Waste heat and cooling from data centres, industries, tertiary buildings, houses<br>Geothermal energy  |
| <b>Specific focus on 4DHC</b>   | Ultra-low temperature network, low-grade waste heat, demand-driven network fully automatized (energy management system). Demand response services for power grid is studied (coupling of power and thermal grids).   |
| <b>Suggestions for others</b>   | Start with a market research and try to focus on local companies to increase the employment opportunities of the region. Select suppliers on the quality of their work, ability of integral working and solution-oriented thinking, do not consider only consider prices. Procurement procedures take time and it should be implemented in the planning. |

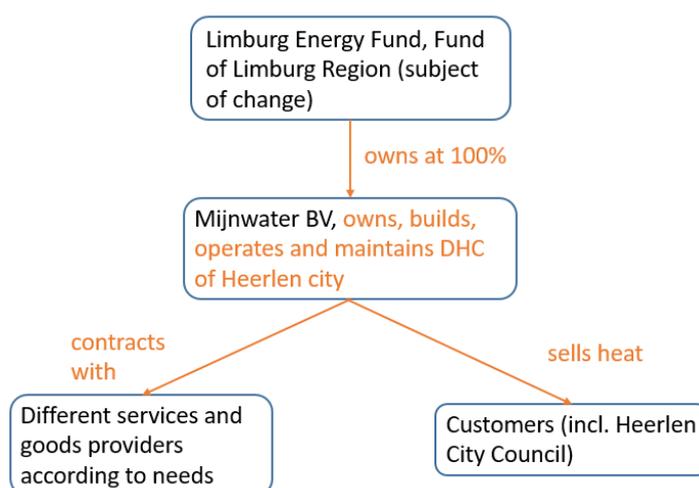


Figure 15: Schematic business model organisation of the Heerlen DHC project

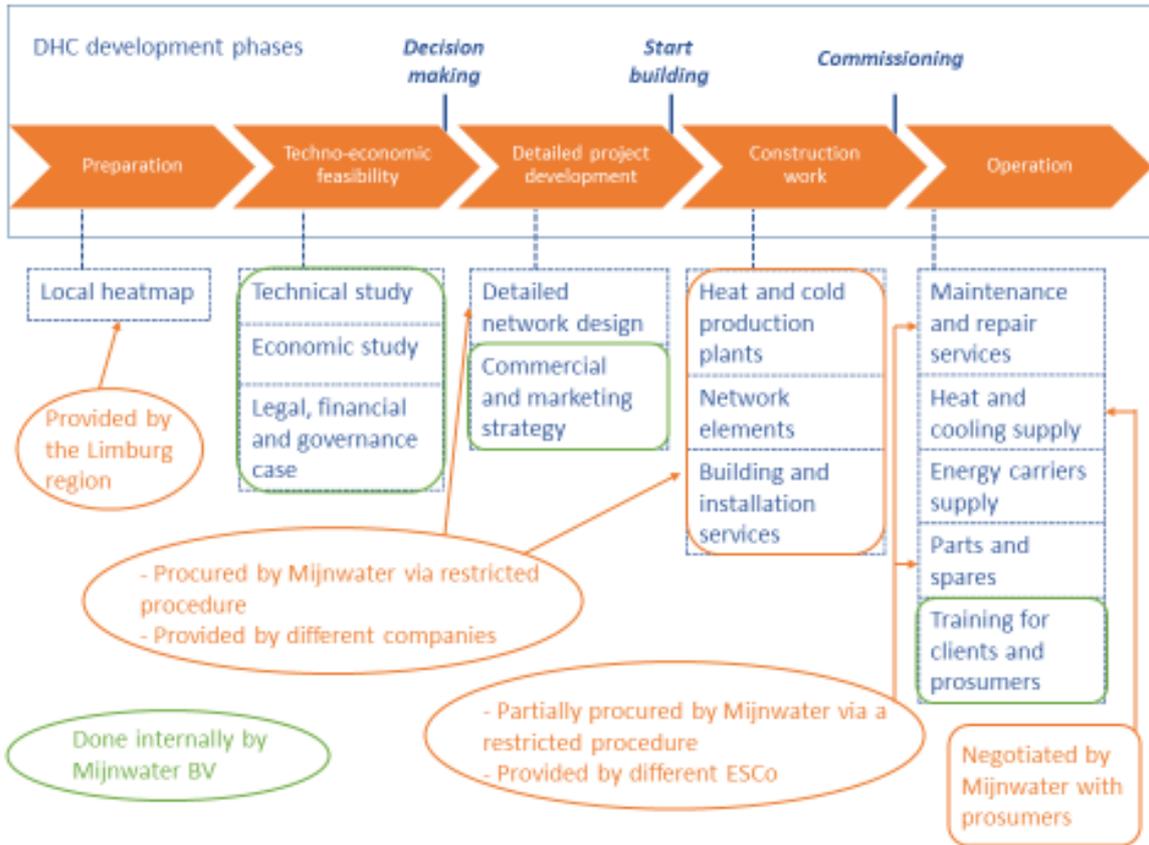


Figure 16: Procurement procedures along the 4DHC project of Heerlen

| Plymouth – Simple procurement / Public model                                 |   |
|--|---|
| <b>Kind of services procured</b>   | Professional services for the Heat Roadmap, feasibility studies and legal, technical, financial and commercial support for the business case.   |
| <b>Procedure chosen</b>  | Simple procurement for the professional services, inviting at least 3 consultancies to tender. It was done directly or via an accredited procurement framework. Some works (like renewal of heating systems at building levels and wells’ drilling) are currently procured, pipes installation and operation of the network is not defined yet. |
| <b>Standards considered relevant</b>   | Procurement: OJEU (EU) requirements, Plymouth City Council standing orders. Technical standards: UK CIBSE Standards. Other relevant standards cover buildings, planning, or Health & Safety.  |
| <b>How was expertise found to prepare a proper feasibility study</b>         | Lists of consultants are available from the UK government (Heat Networks Delivery Unit). Local authorities and professional bodies were contacted too.  |
| <b>Kind of data sources used</b>   | Heat mapping and cooling sources  |
| <b>Local low cost &amp; environmentally friendly sources of heat studied</b> | Energy from waste, water bodies (sea), geology, solar   |
| <b>Specific focus on 4DHC</b>  | Required consultancies’ skills reflect the focus of 4DHC. Contractors will need to have relevant skills/experience for ground source heat pumps, cooling and lower temperatures, etc.<br><br>Potential to propose demand response services to electricity market via heat pumps and heat storage.   |
| <b>Suggestions for others</b>  | Consider the availability of skills and experience in this area (technical consultancies, contractors). Research similar projects, learn from any national government/industry bodies.  |

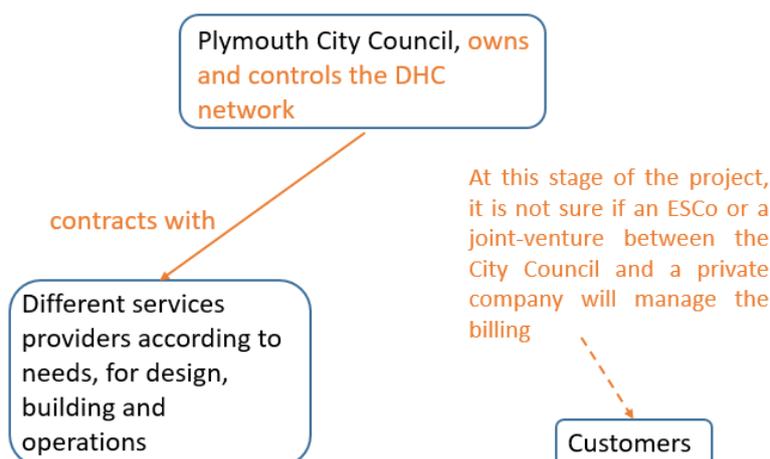


Figure 19: Schematic business model organisation of the Plymouth DHC project

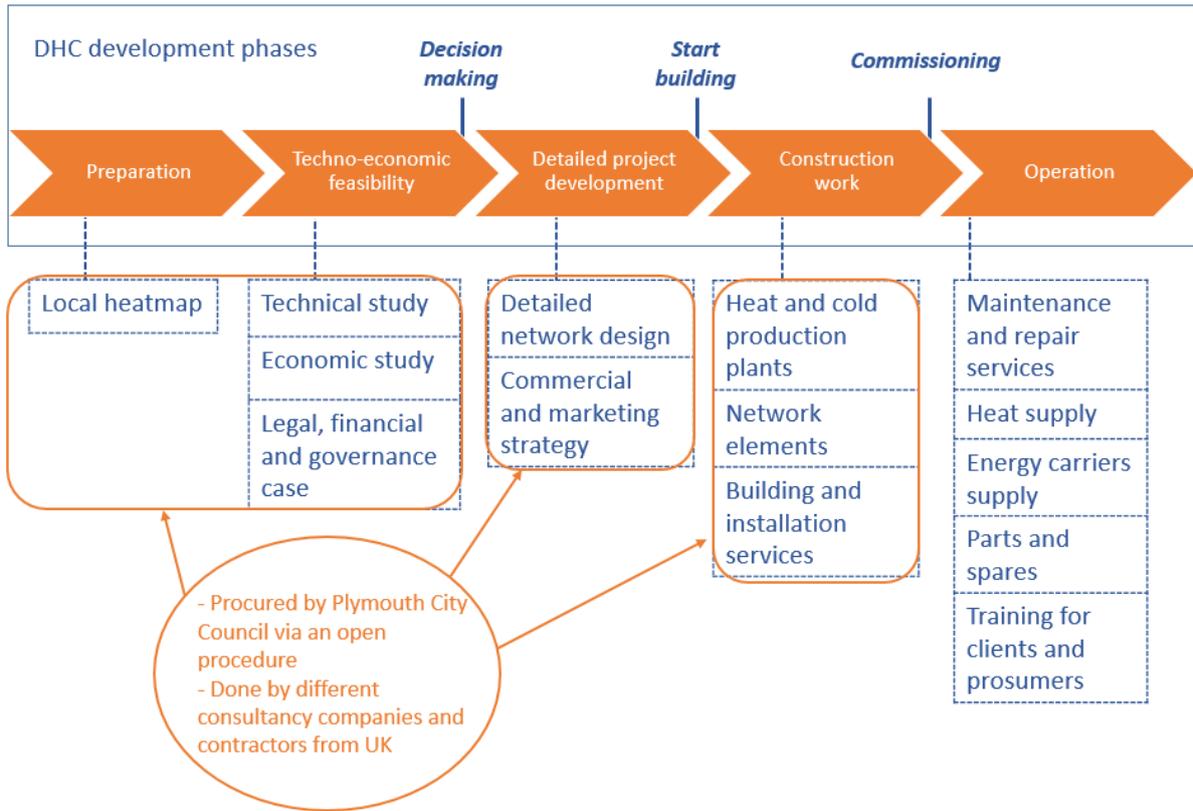


Figure 20: Procurement procedures along the 4DHC project of Plymouth

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## Appendix: Innovative DHC practices in other countries

### **Waste and renewable energy and heat storage**

In **Vienna's** Simmering district a heat storage tank makes it possible the heat to be used when it is actually required in the district energy network – irrespective of the time it is produced. This enables a better use of biomass (forest residues), co-generation technology, and waste incineration plants. The municipality has also published an analysis of rooftop solar thermal potential in the city. An [internet application](#) shows the theoretical solar thermal and solar PV potential for each rooftop in Vienna.

There is over 1 million m<sup>2</sup> solar heat collector capacity installed in total at over 80 **Danish** district heating companies, together with significant heat storage capacity.

- In **Brædstrup** (Denmark) an innovative district energy system has been constructed. A 8000 m<sup>2</sup> solar heating plant produces about 10 % of the total heat production.
- In **Vojens**, Denmark the local consumer-owned district heating company established a solar heating plant (70,000 m<sup>2</sup>) and an underground thermal storage pit (an excavated old sand pit, 200,000 m<sup>3</sup>). The storage is operated as an interseasonal heat storage allowing the solar heating plant to deliver more than 50% of the annual heat production to the network.

In **Bjerringbro**, Denmark Grundfos headquarters and the local district heating company created a joint system to store the surplus heat from the Grundfos factories in obsolete groundwater boreholes, and use it in the district heating network when needed. Grundfos production facilities are cooled by cold water from the district heating network (which thus becomes hot). During the heating season, this hot water is sent to the district heating network. During summer, when the heating demand is minimal, the surplus heat is stored in underground energy storage located 80 metres underground. More than 80% of the energy stored during summer is supplied to the district heating network during the heating season. This system covers more than 15% of the town's annual heat requirement.

### **Local energy mapping**

In **Vilnius** (Lithuania) a public online interactive heat map has been created by the municipality and the municipal district heating company. It is widely used by the population when looking for real estate. The specific heat consumption of buildings on district heating can be quickly analysed, comparing these to similar (structure) buildings, with weather (outside temperature) correction applied for various periods. City buildings are divided into groups according to their technical project types. 330 typical projects and 740 additional modifications of these types are used in the analysis. Other factors, such as whether heat cost allocators are used in a given building, construction period, or whether it has been modernised can also be used when looking for comparable buildings. There is a user-friendly graphical interface including search function and display. Vilnius received a prize for this system. The specific heat consumption of buildings on district heating is more than 10% less than in the capital of a neighbouring state, with similar climate.

### **Smart metering and energy management**

In **Miskolc** (Hungary), heat from renewable sources (primarily geothermal and biomass) covers the majority of heat district heating needs outside the heating season and a significant part of it in the heating season. Smart water meters have been installed in more than 100 municipal buildings – a large part of them using district heating. A municipal company prepares regular analysis of the specific energy consumption of public buildings,

using digital solutions like automatic data collection, processing and analysis to produce visual presentation of the results. This forms the basis of planning energy efficiency and renewable energy projects.

In **Graz** (Austria) the municipality operates a central public buildings energy monitoring database. It contains district heating, electricity, natural gas and water consumption data, beyond buildings data. Larger building systems can be controlled too. KPIs of buildings and key systems are visualised on a central dashboard. The software is compatible with various types of metering hardware. The average annual savings is about 1.5 EUR/m<sup>2</sup>, while the operating cost of the systems is about 0.5 EUR /m<sup>2</sup>.

In **Aachen** (Germany) about 200 public buildings are monitored in the central buildings energy monitoring database, using about 1,200 meters of different types. Specific consumption is automatically analysed and the system creates automatic alerts where appropriate, based on threshold values. Annual heat energy savings achieved has been about 200 MWh, beyond electricity and water saved.