# RELaTED

# D2.5 – Development schemes for new district heating developments

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## PROJECT SUMMARY

| Project Acronym | RELaTED |
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| Project Coordinator | Roberto Garay. TECNALIA<br>roberto.garay@tecnalia.com |
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## ABOUT RELATED

RELaTED is a joint initiative of 14 industrial companies and research institutes across from various countries in Europe, aimed at pushing forward Low Temperature District Heating networks with increased use of Renewable Energy Sources.

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## DE-CARBONISING DISTRICT HEATING SYSTEMS

District heating (DH) systems are one of the most energy efficient heating systems in urban environments, with proven reliability within many decades already. DHs are identified as key systems to achieve the de-carbonization of heating energy in European Cities.

Renewable and waste heat sources are foreseen at the same time as de-carbonized heat sources and the way to guarantee competitive energy costs with limited influence of fossil fuel supply price volatility. To achieve this, a transition is needed in DHs, comprising not only measures to improve overall performance (temperature level reductions, improvement of substations, etc.), but to guarantee system viability as a whole in a context of reduced heat loads with the transition to NZEB (Near Zero Energy Buildings).

RELaTED deploys a decentralized, Ultra-Low Temperature (ULT) DH network concept, which allows for the incorporation of low-grade heat sources with minimal constraints, larger shares of renewable energy sources (RES) and distributed heat sources. ULT DH reduces operational costs due to fewer heat losses, better energy performance of heat generation plants and extensive use of de-carbonized energy sources at low marginal costs.

In the transition towards NZEB and PEH (plus energy houses), RELaTED allows for a prosumer scheme, where positive buildings deliver energy to the grid.

## LIMITATIONS OF CURRENT DH NETWORKS

DH systems were designed many decades ago. In most cases, they are designed and operated to distribute heat at about 80 °C to consumers. Their capacity to reduce operational temperatures is related to radiator capacity to deliver sufficient heat to meet comfortable temperatures in buildings and to allow for the safe preparation of domestic hot water (DHW) preparation. DHW limits potential temperature reductions due to the need to avoid legionella-related issues. Depending on specific national regulations, storage temperatures in the range of 55-75 ºC are prescribed.

## OVERALL RELATED CONCEPT

RELaTED pursues the development of DH networks with service temperature levels as low as 40-50 ºC. In many alternatives, traditional DHW preparation methods are substituted by “innovative methods”. In these concepts, mains water is primarily heated by the DH, and then complemented by electric heaters/boosters up to the required temperature levels. In more advanced alternatives, heat pumps are used for such purposes.

In RELaTED every single building is converted into an energy node, where so-called triple function substations (3FS) allow for bi-directional heat exchange between the building and the network, with the additional functionality of grid injection of excess local solar heat. In fact, adaptations are made to Building Integrated Solar Thermal (BIST) systems to adapt them to Low Temperature (BILTST), with reduced local storage, as the connection to the DH makes it redundant.

Additionally, District-heating connected Reversible Heat Pump systems (DHRHP) allow for recovery of exhaust heat from cooling applications (e.g. air conditioning, ventilation, etc.).

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## ULT DH

Even before the consideration of further technological improvements, ULT temperature levels substantially improve the performance of heat production systems. Furthermore, ULT allows for the integration of virtually any waste heat source from industry, sewage, etc.

RELaTED builds atop of the existing trend for integration of large solar thermal plants systems in DH networks, some of them comprising large seasonal storage systems. RELaTED incorporates large ST plants, but also provides the framework for the integration of BIST into the main ULT DH concept.

With lower fluid temperature when compared with regular BIST integration levels, performance levels are expected to rise by 20%, due to lower heat loses. An additional 80% rise is calculated when avoiding local storage due to direct DH connection. The RELaTED ULT network acting as a perfect heat sink avoids storage stagnation situations, thus allowing for larger ST performance levels.

DHRHP systems allow for the de-coupling of temperature levels in DH network and building level HVAC systems. With the DH as heat source, stable temperatures at 35-40 ºC ensure stable COP levels of 6-7 for the DHRHP all-year-round. These units provide an economic way for the preparation of DHW, while at the same time allowing for the connection of buildings with higher temperatures in their HVAC design (i.e. older buildings).

The RELaTED concept, when implemented with a substantial share of RES provides a robust framework to ensure the economic viability of DH networks, in the context of the transition of the building stock to NZEB along the following decades.

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## Acronyms

| | |
|---|---|
| 3FS | Triple-function substation |
| BILTST | Building Integrated Low-Temperature Solar Thermal System |
| CHP | Combined Heat and Power |
| DCS | District Cooling System 10/15 °C |
| DER | Distributed Energy Resources |
| DH | District heating |
| DHRHP | District Heating Reversible Heat Pump |
| DHW | Domestic Hot Water |
| EC | European Commission |
| H2020 | Horizon 2020 EU Research and Innovation programme |
| HT | DH High Temperature 100/50 °C |
| LT | DH Low Temperature 80/40 °C |
| NZEB | Nearly Zero Energy Buildings? |
| PM | Project manager |
| RELaTED | Renewable Low Temperature District |
| RES | Renewable Energy Sources |
| TL | Task Leader |
| ULT | DH Ultra Low Temperature 45/30 °C |
| VLT | DH Very Low Temperature 60/30 °C |
| WP | Work Package |
| WPL | Work Package Leader |

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# 1. Executive summary


In RELaTED Task 2.5, a set of guidelines were developed for how low temperature concepts can be applied in new urban developments. This report (D2.5) is one of various RELaTED reports describing low temperature concepts from different perspectives. The report refers to other RELaTED reports when relevant.

The guidelines of this report are in general terms, based on best practice as most new urban development areas are different in relation to visions, DH network topology, temperature levels, buildings installations, tariff structure, management etc. In Annex 1 an example from Vinge, Denmark is used to illustrate and detail some of the paragraphs of the report.

The guidelines are concerning the following topics: Strategic and integrated energy planning for new developments areas. What is the vision and the strategy for the development of the DH system and how is it integrated in to the overall planning of the development area. For the DH supplier the economy focus is on investments, operation expenses and how this compares to the possible income from heat sales. For the customer this can be in the relation to which heat source is chosen for a new building or in relation to the energy costs. The impact on the society will rely on a socio- economic analysis.

The possible topology of a future DH network will have an impact on whether the heat sources will be individual, decentralized DH system or centralized DH system. Pros and cons are considered for these systems.

The scenarios when the development process lasts over a longer period of time and how the energy demand will raise as more buildings are erected which might require other energy resources over time.

Appropriate implementing measures, which include the delivery conditions as well as the technical building systems specifications for ULT DH, are considered. Tariffs and building regulation integration can support the concept as well

Project developments will cover which parties have which responsibilities in the process, how the information flow affects the process, the need for support and follow up in the process.

The guidelines will be used in the succeeding work packages of RELaTED to investigate further the architecture of the ULT concept (WP2), design and adaption of subsystems to facilitate the use of distributed energy resources (WP3), analyse the economic feasibility and business case (WP4) and prepare and conduct demonstrations (WP5), of the RELaTED project.



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# 2. Introduction

This deliverable will report on the activity carried out under RELaTED Task 2.5. It will define the RELaTED Development Schemes for new DH developments in new urban environments. This report is part of a set of reports that define the system architecture of the RELaTED concept. The reports are:

- D.2.1 Low temperature concepts
- D.2.2 Interconnection schemes for consumer installations
- D.2.3 Interconnection schemes for producer installations
- D.2.4 Energy flexibility and district heating control
- **D.2.5 Development schemes for new DH developments**
- D.2.6 Transition schemes for district heating in operation

## 2.1. Objective

The objective of task 2.5 is to develop a set of guidelines for low temperature district heating in new urban environments. The guidelines will focus on energy planning and economy, network topology, scenarios for timeline and energy sources, necessary measures for implementation, project developments and operation and management.

## 2.2. Methodology

To carry out task 2.5 available information about the development process in various new DH developments was studied and used as background knowledge for the subjects covered in this report. The case of the ULT DH site of Vinge in Denmark was used as an example for some of the topics covered in the report

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## 2.3. Report content

The content of this report is sectioned as follow:

1. Executive summary: Contains a summary of the report.
2. Introduction: Introduces the report, the objective and the methodology
3. Development schemes for new district heating development areas: Guidelines regarding Strategic and integrated energy planning, Economy, Topology, Scenarios, implementing measures, project developments and operation and management.

Some of the contents in this report relies information already outlined in the reports: D.2.1 Low temperature concepts, D.2.2 Interconnection schemes for consumer installations and D.2.3 Interconnection schemes for producer installations. In these cases, the subject is briefly described in this report and referenced to the relevant report for more information.

Annex 1 and 2 to this report present applied cases of the development schemes proposed in this report for the DH network under development in VINGE, Denmark.

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# 3. Development schemes for new district heating development areas

The following sections are resuming the main issues to be considered in developing new ULT DH for new development areas.

## 3.1. Strategic and integrated energy planning

### 3.1.1. Vision

A new development area is typically based on or linked to one or more visions. Such visions could be on global, national, regional or local level. On local level ULT DH can support visions on for instance sustainable living, use of local heat sources and clean air. In the wider scope, ULT DH can support visions on reducing $CO_2$-emissions, phasing out fossil fuels and other climate related visions including the European Commission's long-term vision for a prosperous, modern, competitive and climate-neutral economy by 2050 – A Clean Planet for All. Source: A Clean planet for all, 2018 [1].

### 3.1.2. Strategy

The realization of a vision needs a strategy. Strategic energy planning is used on municipality, regional or national level to plan the most viable way to supply and use energy over a longer time horizon. Source: Strategic energy planning at municipal and regional level, 2015 [2], Regulation and planning of district heating in Denmark, 2017 [3], Varmeplan Danmark [4].

The energy planning will typically include both heating and electricity infrastructure but can also include infrastructure for transport and cooling. Taking this holistic approach different synergies and scenarios can be identified and analysed across traditional boundaries paving the way for the optimal solution for the society. ULT DH can in this respect provide energy efficient solutions for integrating surplus heat and renewables in the energy system including provide flexibility through thermal storage. The elements of strategic energy planning can also be used for a specific new development area.

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### 3.1.3. Integration

In a new development area energy supply and consumption may be underprioritized in the planning process. The idea of integrated energy planning is that energy supply, energy infrastructure and final use of energy are prioritised in the overall planning process along with other infrastructure and objectives. In planning ULT DH it is very important that energy is integrated from the beginning of the planning to make sure the special requirements according to the low temperatures are taking into considerations. Also, area reservations for renewable energy sources as for instance solar thermal panels, geothermal heat or heat pumps must be included.

## 3.2. Economy

The economy of ULT DH in a new development area must be economical attractive for the company operating the scheme, for the customers and for the society.

### 3.2.1. Company

In a new development area with no prior district heating supply, the economy of the scheme must be evaluated in detail. The topology (see section 3.3) and scenarios of long-term development (see section 3.4) of the ULT scheme must be studied thoroughly to identify if investment costs, operating expenses and income from heat sales makes it a feasible business for the DH operator.

### 3.2.2. Customer

Land of a new area is typically sold to one or more developers that will manage the erection of buildings for future sale or rent. Thus, the final user of energy does not normally take decisions on the energy source for space heating, domestic hot water or cooling. It is developer's interest to maximise profit. Therefore, much focus is on investment costs of the ULT DH at building level compared to other energy sources and solutions including traditional DH. However, the developer also needs to address future energy costs of owners or tenants – at least indicatively. This calls for a thorough comparison of the customer economy of different energy sources. From the customers point of view the price for DH should be reflected in the higher investment in equipment and the use of electricity for DHW boosting.

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#### 3.2.3. Society

In many cases, the difference in customer economy of different energy sources is relatively modest. Socio-economy analysis can then reveal what would be the best solution for the society. In Denmark, socio-economic calculations are used in both strategic and integrated energy planning Source: Scenarier for energiinfrastruktur [5] and would also be a valid tool, to evaluate ULT DH. Danish municipalities are using socio-economic calculations in their heat planning Source: How Danish communal heat planning empowers municipalities and benefits individual customers, Anna Chittum, Poul Alberg Østergaard [6]. The Danish Energy Agency is providing an international spreadsheet calculation tool to perform socio-economic calculations. Source: District heating assessment tool (DHAT) [7].

### 3.3. DH network Topology

The prognosis for the incremental expansion of a new development area and the mix of buildings (dwellings, office buildings, shops etc.) are important inputs for deciding the ULT DH network topology. The circumstances may be that some parts of the area are better suited with individual heating solutions than with collective. This could be the case for detached single family houses. The incremental expansion of the area may imply that a topology with smaller decentralised networks is a more attractive solution than planning a large central network and central heat supply from the beginning. At a later stage the decentralised solutions can be interconnected. In order to introduce distributed energy resources, their position and availability must be identified, and area reservations must be made for plants if feasible.

Failing to do a study of which topology is most beneficial in a new area can result in a scattered DH network with only few connections and a lot of individual solutions.

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### 3.3.1. Individual

Individual solutions for low-energy buildings will typically include one or more heat pumps and a mechanical ventilation system:

1. A combination heat pump can provide both space heating (hydronic system) and domestic hot water. The heat source can be ground source or ambient air. The ventilation air handling unit includes a passive heat recovery device.

2. A space heating heat pump can provide space heating (hydronic system). The heat source can be ground source or ambient air. The ventilation air handling unit can be equipped with an active heat recovery device using a heat pump to extract heat from the exhaust air and provide domestic hot water.

3. Various heat pump air heating systems for space heating, domestic hot water and ventilation (passive house type installations)

The individual solutions can be combined with on-site production from thermal solar and PVs.

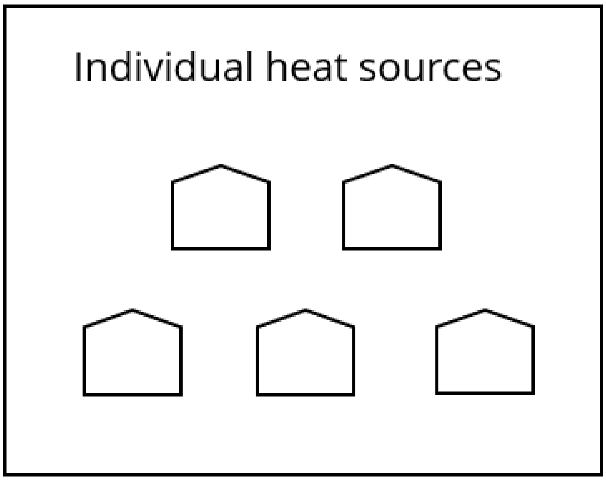


Figure 1 individual heat sources for all buildings

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### 3.3.2. Decentralised

In the decentralised solution with a smaller DH network the solution can be a combination of surplus heat sources and maybe a temporary mobile solution like a heat pump or a and the necessary control equipment built in to a container, so it is easy to upgrade or move to a new area when a larger or more permanent heat source is introduced. Source: Articles about mobile heat sources, 2018-2019 [8].

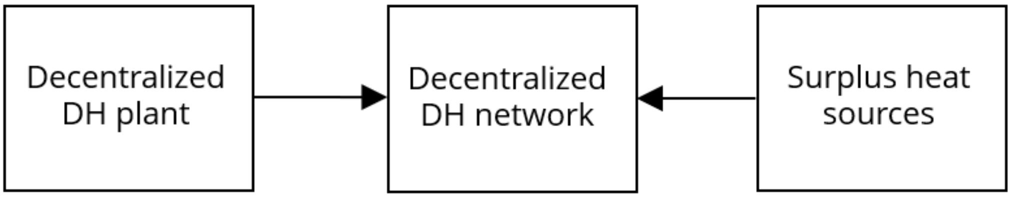


Figure 2 Decentralized DH network with a decentralized plant and surplus heat sources

## 3.4. Centralised

In a centralised solution the network will be prepared for a larger plant to cover the whole area. In the intervening period the mobile solution mentioned in 3.3.2 could be a temporary solution until a critical mass of users are connected to the network.

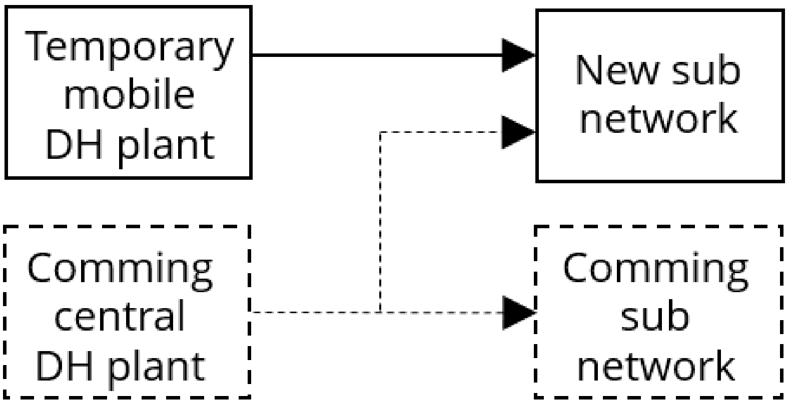


Figure 3 Temporary solution for a subnetwork in a coming bigger centralized network

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The feasibility of connecting a new development area to an existing network will greatly depend on the distance and the investments associated with the interconnection. If the new development area is close enough to an existing DH network the new area can function as a subnetwork of the existing network. For ULT DH this can be done either by temperature sectioning with a mixing loop or prefabricated temperature optimisation units [9]. Source: Optimize your network with low temperature zones in district heating, 2018 or by using the return water from the larger network if the temperature is sufficient, or a combination of these two principles. For examples of temperature sectioning methods see RELaTED report D2.6 section 3.3.

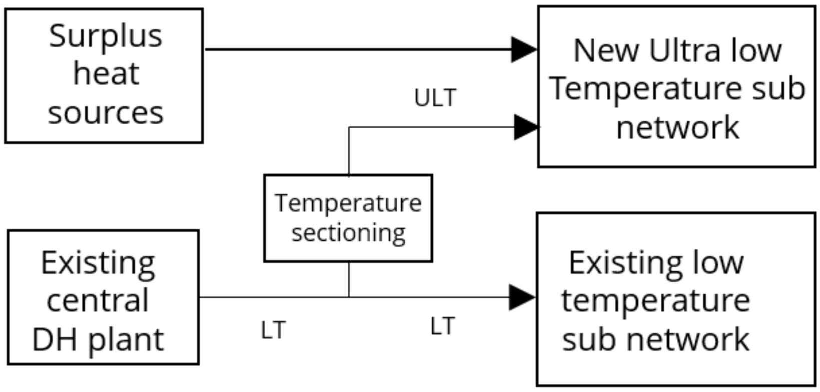


Figure 4 Temperature sectioning for a new ultra-low temperature subnetwork in an existing low temperature network

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## 3.5. Scenarios

### 3.5.1. Time period

An important part of the planning process is the time horizon or period for the complete development. The long-time plan can be interrupted or delayed by change in economy, new political directions and so on. Therefore, the plan of ULT DH must be flexible and robust for example to take into account that temporary heat sources might have to be in use longer than planned and larger service costs and/or reinvestments might be necessary to keep the heat source running.

Also, the heat source might not be feasible with small loads and therefore a prolonged time period might influence on the business plan and in worst case it might be necessary to adjust the tariffs for the connected customers for not loosing money on the heat deliveries.

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### 3.5.2. Energy demand

The DH supplier should be prepared for a low energy demand from the start where only few buildings will be connected to the DH network to the fully built area with the planned demand. An estimation of heat demand for different phases of a planned area can be done. An example of this This is illustrated in figure 3 below.

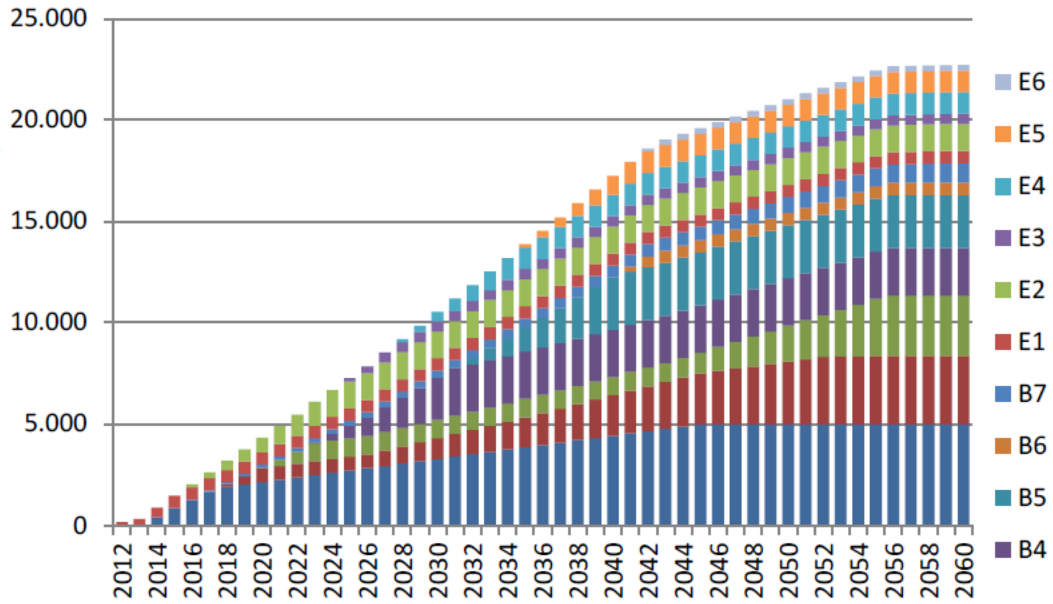


Figure 5 Accumulated development in yearly heat demand (MWh/yr) of the planned phases of a new development area over time. Source: Scenarier for energiinfrastruktur [5]

This estimation can be used for planning of when it is necessary to integrate new heat sources or when to switch from a mobile heat source to a more permanent one. Of course, the phases can take longer time than planned, but the start and ending of phases will still be useful markers for this planning.

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### 3.5.3. Mapping of possible energy resources

Selection of energy source(s) for a new development area will depend on availability of for example surplus heat sources, permits for use of ground sources, available space and placement of heating plant in relation to noise from for example air-to-water heat pumps or smoke and emissions from boilers. For more info regarding heat sources see RELaTED D2.1 report section 4.5 and 4.6 and RELaTED D2.3 report section 3.

### 3.5.4. Operational temperatures

A decision about which operational temperatures the new network should operate at have to be taken. It could be low temperature 60-30 °C or ultra-low temperature (ULT) 45-30 °C or another temperature regime suited the area. Where 60-30 °C will work without temperature boosting of the DHW, 45-30 °C will need the boosting but have a smaller heat loss in the network.

Some of these consequences of the choices are discussed in the following paragraphs.

For more info about operation temperature definitions see the RELaTED D2.1 report section 3.1 and for analyses of different temperature schemes see RELaTED D2.1section 5.6

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### 3.5.5. Design of building installations

Design of user installations should be considered in relation to the choice of operational temperatures and the energy performance requirements of new buildings. In near future, buildings will be nearly zero energy buildings (NZEB) which will in most cases require balanced mechanical ventilation systems with heat recovery. The choice of heat recovery, passive or active, may influence the feasibility of DH in new development areas.

If ULT is chosen, the end user installations could take one of the following forms:

1. DH for space heating. DH for preheating of DHW supplied with direct electric heating for heating the DHW to a sufficient temperature, see RELaTED D2.1 and D2.2 reports

2. DH for space heating. DH for preheating of DHW supplied with a microbooster for heating the DHW to a sufficient temperature. The microbooster concept is described in the RELaTED D2.1 and D2.2 reports.

3. DH for space heating. DH for preheating of DHW supplied a heat pump in a ventilation unit for heating the DHW to a sufficient temperature.

4. DH for space heating. Heat pump in a ventilation unit for heating DHW. No DH preheating. Backup heat with direct electricity.

Where solution 1, 2 and 3 will result in some DH sales in the summer period, solution 4 will not, as all DHW is produced by electricity. This should be considered in relation to how the operation of the DH system will be in the summer months. Solution 2 will result in the highest DH sale in the summer because of the Microboosters use of DH as a heat source for the integrated heat pump. If all user installations are made like In solution 4, it would be possible to shut down the DH network in summer. Of course, this will result in no heat sales in this period plus the incitement for use of surplus heat sources will be lower especially solar heating.

There has to be some rules about which possible solution can be chosen in order to prevent an inefficient system with a lot of heat wasted on heat loss for only supplying few consumers in the summer month.. In case the solutions are mixed, the full advantage of the different systems cannot be achieved.

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For more information about the possible designs of user installations see RELaTED D2.2 report section 6.

### 3.5.6. Heat loss

In relation to the above paragraphs regarding time period, operational temperatures and design it's worth noticing that the heat loss of the DH network will have a large share of the energy utilisation from the start when only few buildings are connected. This will have an impact on the energy price that might be higher per MWh because of the relatively large heat loss per customer until the area is fully developed especially for decentralised solutions.

Also, if some building owners choose individual solutions for DHW production and or/ heating of their buildings the heat loss share may be relatively higher than for a comparable network where both DHW production and heating is supplied fully from a DH network.

For small density areas a heat loss of 30% of the produced heat is not unseen, and this number could even be higher for a not fully populated area.

In the design phase it is important to focus on optimizing the network to keep the heat loss as low as possible. See also RELaTED report D2.1 section 4.5.2 and 4.5.3.

### 3.5.7. Overall evaluation

An overall evaluation of different scenarios including the above paragraphs regarding, time, energy demand, energy resources, operational temperatures, design, and heat loss could give the necessary input to choose the solution for the area in relation to economy and energy. As part of this evaluation the economy for company, customer and society should be calculated for the scenarios, see section 3.2.

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## 3.6. Implementing measures

Implementing measures are specifications and requirements that must be met to get a well-functioning and fair ULT DH system. The DH supplier should specify and make public available the delivery conditions and technical building system specifications for developers and customers. The impact of using ULT DH in energy performance of buildings calculations should be clarified. Investment models and tariff structure must also be in place before the developers take over land and start raising buildings.

### 3.6.1. Delivery conditions

Delivery conditions must be ready in time for to ensure implementation of the needed requirements to for the low temperature system to function probably. The Delivery conditions must as minimum specify the boundaries between the supplier and the customer, the supply temperature and pressure difference the customer can expect and specifics for meters (placement, power supply etc.)

### 3.6.2. Technical building systems specifications

The technical building systems specifications must specify more specific requirements for the installed building systems i.e. substation unit DHW production equipment and heat emitters. This could be requirements for how much the return water must be cooled down in the DHW production and the heat emitters respectively. For DHW production the requirements for the supply temperature could be lower than the general temperature in order to ensure proper operation in the summer where the flow in the network is very low and it’s harder to keep a sufficient supply temperature at the customer.

An example of the Technical Building specifications for Vinge can be seen in Annex 2 (Danish).

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### 3.6.3. Building regulation integration

For every new building, the energy performance must be calculated as a result of the EPBD and meet a certain level of performance. When ULT DH or DH in general are proposed for a new developing area it should be investigated how these concepts are accounted for in the EPBD calculations. Experience have shown that the definition of primary energy factors for DH and electricity can have a large impact on the result. Further, the calculation tools must be able to properly include the specifies of ULT DH substations such as booster solutions. This is not the case as of now in the Danish calculation tool BE18. Otherwise, if this matter is too difficult to handle, the developer might choose another heat solution for the building/development area in order to get the necessary building permissions.

### 3.6.4. Infrastructure investment model

The infrastructure investment model in the DH network can take many forms. For instance, it can be a part of the land development alongside other infrastructure development before the land is sold to individual developers. In this case, the DH network can be full or partly included in the price of the individual building plots. An alternative model can be that the developer, if only one, will take care of the construction of the network. In both of the above cases, a DH supplier must take over the operation of the network afterwards. This model have the advantage that the network investment is part of the land costs and not has to be taking into account in the DH tariffs.

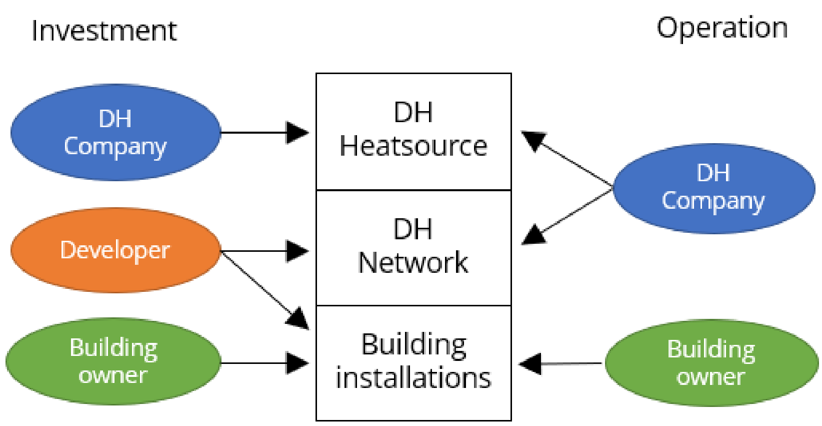


Figure 6 Illustration of investment model where the developer invests in the DH network

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Another model could be that the DH supplier take care of the investment in the new DH network and also the operation afterwards. In this case the investment in the network will be reflected in higher tariffs which may influence the on the choice of individual heat sources versus DH.

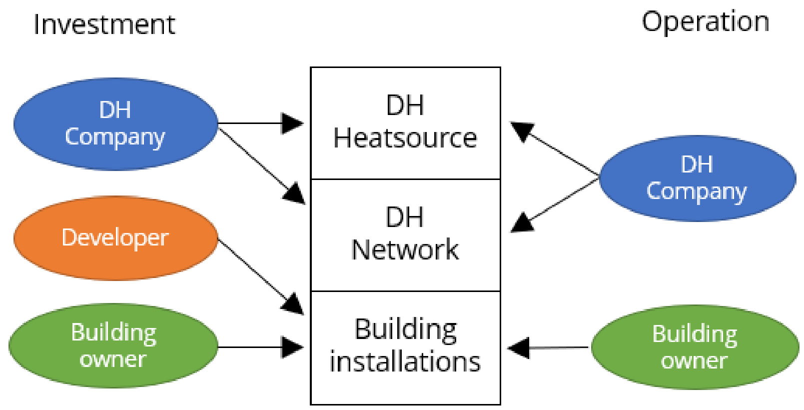


Figure 7 Illustration of investment model where the DH company invest in the DH network

It should be considered carefully what model is possible for the specific development area with consideration to the choice of topology.

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## 3.6.5. Tariff structure

The chosen tariff structure should take into account that the area will not be fully developed from the start and therefore the heating prices should reflect that.

If an ULT solution is chosen for the network, it should be considered if the electricity used for boosting the DHW temperature in the buildings should be included in the tariff or if the building owners should have some compensation in the DH price to reflect the energy level.

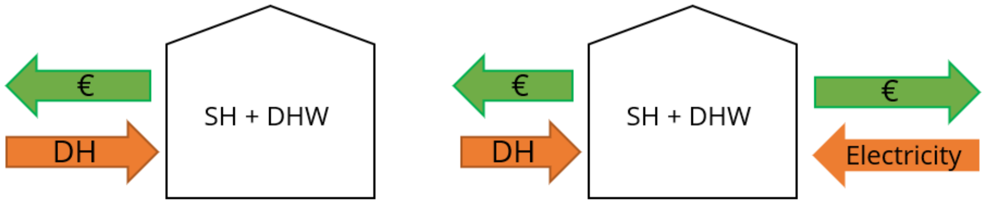


Figure 8 Illustration of tariff structure for conventional DH (Right) and for ULT with electricity supplement (Left)

This will not always be the case. In Vinge there is not mentioned a compensation in the Tariffs. An example of the Tariffs in Vinge can be seen in Annex 2 (Danish)

In another example, the DH supplier in Aarhus, AffaldVarme has tried to integrate ULT-DH in a small village called Geding. In this case the users pay for the electricity up to 500 kWh/year and are compensated if the usage of electricity used for the Microboosters is higher. Source: Demonstrationsprojekter om varmepumper eller andre VE-baserede opvarmningsformer, 2015 [10]

For more information about tariff structure see RELaTED report D2.2 section 5.2.

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## 3.7. Project development

### 3.7.1. Responsibilities

A definition of the responsibilities for the involved parties should be made. The local authority like the municipality could be responsible for the consideration of the project plans, while the DH supplier could be responsible for the planning and implementation of the energy source, DH network, enforcement of the delivery conditions, and the building owners have the responsibility for the house installations.

### 3.7.2. Information

Information to all involved parties is a very important part of the process in order to make sure that all the prerequisites for the new DH system is maintained throughout the entire development. It is important to clarify who will take care of the information or if it is split between the involved parties i.e. Investor, DH supplier, municipality.

### 3.7.3. Support

The DH supplier should from the start have an organisation ready for support to the individual installation in the buildings in order to ensure an efficient system an avoid escalation of problems that could lead to inefficient operation.

### 3.7.4. Follow up

In order to ensure the above paragraphs, there need to be follow up on a regular basis, for example monthly meetings with the involved parties.

## 3.8. Operation and management

It's is important that the DH supplier is ready with an organization when the operation of the network is starting up to handle operation, troubleshooting payments, complaints etc. For an existing supplier this might just be part of the existing staff, but for e new supplier this is an important part that needs to be taken care of even if there are only few customers in the first time of operation.

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# Annex 1 – Development in Vinge

This annex describes how the main issues presented in the guidelines are handled for the new ‘greenfield, development area of Vinge.

## About Vinge and VESTFOR

Vinge is a planned new town (suburb in Greater Copenhagen) of about 20.000 people and with direct train access to Copenhagen. The development area is 370 hectares and with a planning horizon of about 40 years. Vinge is situated in the Municipality of Frederikssund about 40 km from Copenhagen City.


Figure 9 Location of VINGE, a new settlement 40 km away from Copenhagen

In phase 1 of Vinge, the so-called Deltakvarteret, 23 interconnected townhouses of a total of 36 planned and 31 detached houses of a total of 38 planned were built in 2017 and 2018. A DH network is established for all the houses in phase 1. A dedicated air-source heat pump is supplying heat to phase 1. The heat pump and DH network is operated by VESTFOR (Vestforbrænding)

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Figure 10 Present status of VINGE

VESTFOR is Denmark's largest waste management company with 330 employees and is owned by 19 municipalities in the Copenhagen area. It services around 900,000 people and 60,000 businesses. Each year it handles around 1 million tonnes of waste and our focus is on the resource value of the waste – whether it is materials for recycling or fuel for energy production.

## Strategic and integrated energy planning

The idea of a completely new town in Frederikssund Municipality is not new but got closer realization with the publishing of a general plan for the whole Vinge area in 2013. The general plan included the following vision of the area (freely translated) Source: Helhedsplan for Vinge, Henning Larsen Architects, EFFEKT, MOE & Marianne Levinsen Landskab, Frederikssund, 2013 [11]:

> *'Vinge is developed from the vision of creating a new type of urban community in the metropolitan region of Copenhagen, where the presence of landscape and nature goes hand in hand with a close and vibrant urban community. Vinge unites city life and nature, proximity and community.'*

The general plan and the vision did not specifically address energy supply. Though, different options were analysed in a report regarding a strategic plan for energy infrastructure made in 2013 by three major Danish consultant companies including DTI. Source: Scenarier for energiinfrastruktur [5].

The objective of the strategic plan was to show ways that Vinge can be $CO_2$ energy neutral including heat and electricity supply, transport and waste water treatment.

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In the report, scenarios for the energy infrastructure in Vinge were evaluated according to the methodology shown in figure 9.

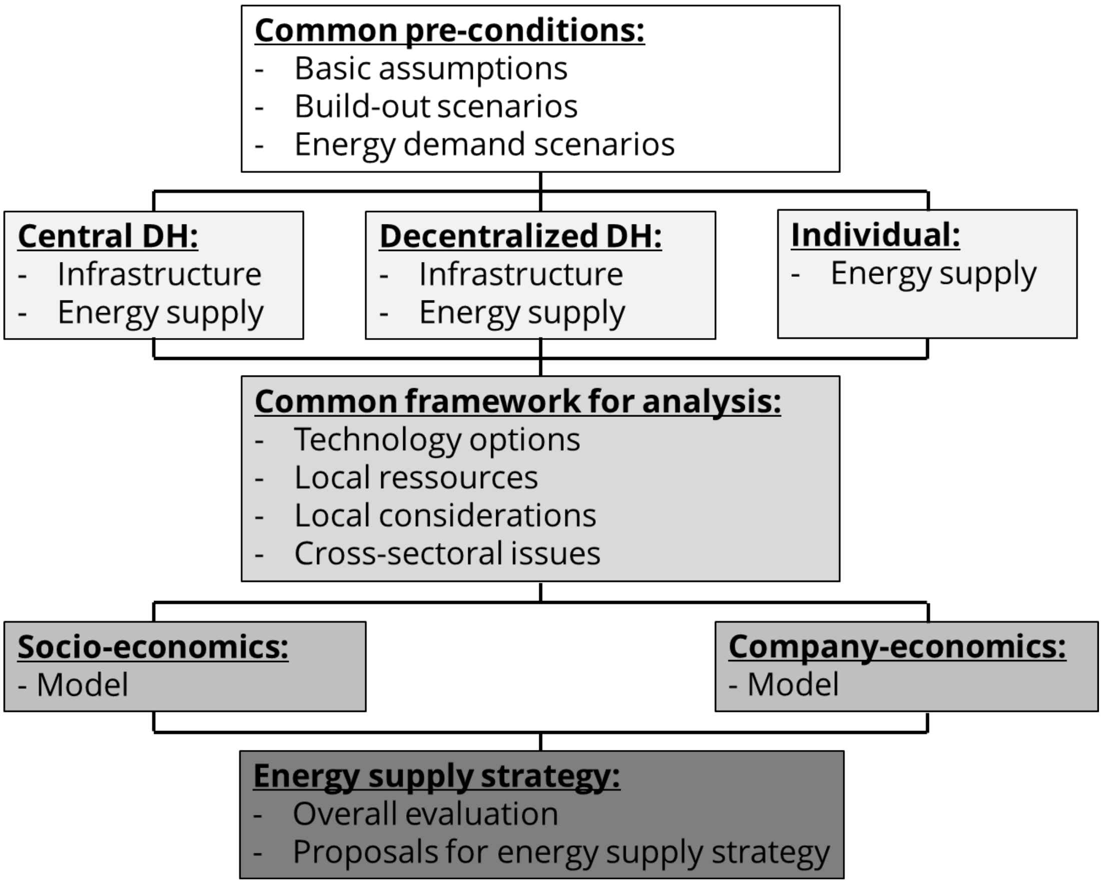


Figure 11 Methodology for scenarios leading to a heat supply strategy

First, common pre-conditions were set with stakeholders including basic assumptions and calculation methodology, build-out plans and energy demand scenarios of Vinge.

Then a technical analysis of heat supply, electricity supply and distribution systems was carried out for three situations, where DH network temperatures were based on low temperature design temperatures of 55/25°:

- Central DH network
- Decentralised DH networks (which can be interconnected at a later stage)
- Individual heat supply

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A special analysis included evaluation of availability of local energy sources both for heat (ground sources, solar thermal) and electricity (availability of biomass and biogas for CHP, sites for wind turbines and PV). All this, lead to a number of combinations which were evaluated in relation to socio economics and consumer economics. Finally, the investigations are resulting in proposals for an energy supply strategy.

The general conclusions in relation to economy and the development of Vinge were:

- Individual solutions can be pointed out to be advantageous if the urban development is more widespread, while the decentralised solutions have advantages if the city is developed in clusters or as island areas. In addition, the decentralized solutions can be prepared for a later connection to a common central district heating system.
- The expected electricity price purchase/sale will be crucial for the choice of energy system for Vinge and that all 3 solutions with marginal changes are very close to each other
- If all the results of this analysis are rounded off, there is no significant difference in economy. So, a number of other advantages and disadvantages of the various solutions will be more important for the decision on the choice of energy supply.

Inspired by this, the Municipality of Frederikssund published a district plan for Phase 1 of Vinge in 2015 including a vision for the heat supply (freely translated) Source: Lokalplan nr. 065: Lokalplan for boliger nord for Dalvejen i Vinge [12]:

> *'It is the City Council's vision for Vinge's future heat supply that it must consist of a low temperature district heating transmission network for the whole city, where the heat is supplied by several $CO_2$ neutral heat sources such as surplus heat from buildings and businesses, heat pump systems, solar energy plants and which can simultaneously store summer's thermal energy for use in the winter months, e.g. in the form of ATES (Aquifer Thermal Energy Storage) plant. It must be added that the City Council at the same time finds that it would be natural to work for, that such an internal heat supply of Vinge will in the longer term could be connected to other heat supply systems both regionally and locally'.*

More specifically, the district plan of phase 1 includes area reservations for a collective heat pump and ground source pipes. Further, the district plan underlines that $CO_2$ neutral heat sources are preferred. Traditional fossil fuels

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and even biofuels are not foreseen. Similar district plans are to be developed for other phases of the Vinge development as it progresses.

## Economy

During the planning process, the economy of heat supply for Vinge phase 1 was evaluated by independent consultancy companies. In a study, Source: Vinge - Varmeforsyning af Delta-kvarteret, Sammenfatning, COWI for Frederikssund Kommune, August 2015 [13], carried out for Frederikssund Municipality, different heat supply solutions were compared for the 23 detached houses:

- Individual air-source heat pumps
- Individual ground source heat pumps
- Individual air-air heat pumps
- Individual direct electric heat

For the 36 interconnected town houses a heat supply solution with a distribution network and one collective heat pump based on either air-source or ground-source were compared. The economy was calculated with a consumer perspective as net present value (NPV) over a 20 years period with a discount rate of 4%. Under these conditions the following heat supply solutions were found most attractive for the consumers:

- Interconnected town houses, heat supply by distribution network and collective air-source heat pump
- Detached houses, heat supply by individual air-source heat pumps

A project proposal, ordered by VESTFOR, is including both company, customer and socio economy calculations for Vinge phase 1. Source: Projektforslag for fjernvarme til Vinge etape 1, Rapport, Rambøll for Vestforbrænding, December 2015 [14]. The estimated total investment costs including district heating network, heat pump and customer connections for 36 interconnected town houses and 17 detached houses amount to DKK 5.4 million (approximate EUR 0.725 million). No as-built costs are publicly available. Both customer economy and socio-economy are positive compared with individual heat pumps in the calculations. Also, the company economy is slightly positive.

The heat supply in Vinge has separate economy from the rest of VESTFOR's activities and is run on an economy-wise self-sustaining basis.

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Investments in the heat pump in phase 1 Vinge is done by VESTFOR. However, the network investment was done by the Municipality of Frederikssund. In this investment model, the cost of the network is covered in the sales price of the land/plots along with other infrastructure such as roads. This reduces the risk of the operator and makes it more attractive to connect to the network, as the fixed part of the DH tariffs can be reduced considerable.

## DH network topology

Vinge is situated away from the natural DH supply area for VESTFOR. However, VESTFOR is expanding its networks and operations. Thus, in the planning and starting up phase of the new development, VESTFOR agreed to be the operator of the new DH supply network in the small decentralized DH network of Phase 1.

For the next phases of Vinge, it is most likely, the heat supply will be small decentralized DH networks as well that can potentially be interconnected when feasible.

In phase 1 of the development it is mandatory for the interconnected town–houses to use the DH network as their heat source, but owners of detached houses can choose to use individual heat sources.

The RELaTED D2.1 report describes in more detail the network and heat supply.

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## Scenarios

An estimation of the heat demand for the whole Vinge area over the 40 years expected development time period is shown on figure 4. The yearly heat demand is expected to be more than 22000 MWh, when Vinge is built out.

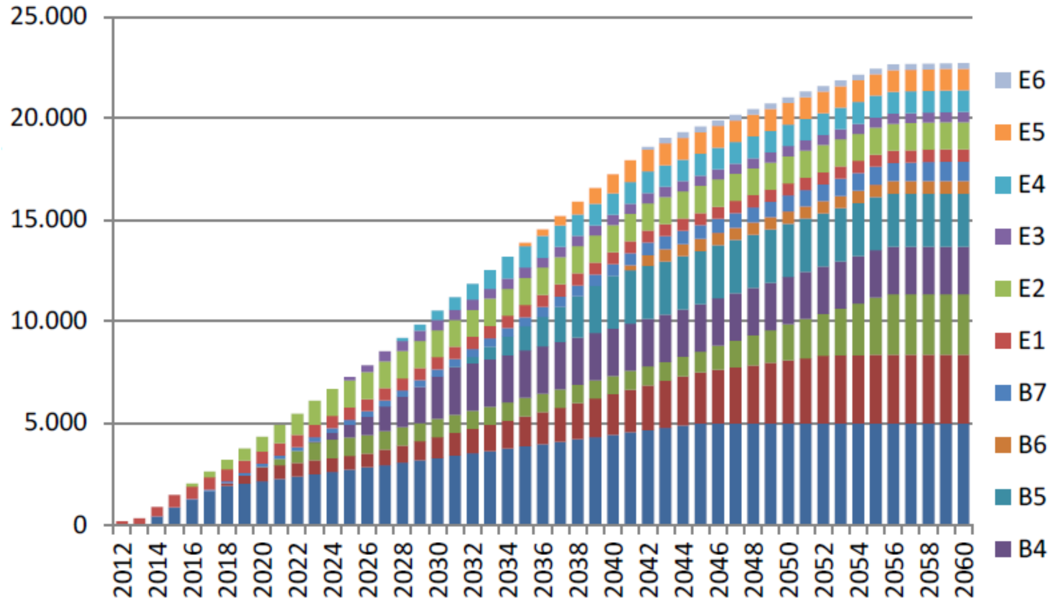


Figure 4 Accumulated development in yearly heat demand (MWh/yr) of the planned phases of a new development area over time. Source: Scenarier for energiinfrastruktur [5]

Phase 1 of Vinge is only a little part of the planned area. As the energy demand is relatively low for now and the next phases has not begun the DH network in Vinge work as a decentralized solution. When the development expands to the next phases and the energy demand increases, decisions on new decentralized networks and heat sources will be taken. This stepwise approach will minimize the risk of the investments according to technology development, energy prices and the time horizon of completion of the individual phases. Compared to Figure 4, the development is already considerably delayed. The next phase is not expected complete before 2022 at the earliest.

In the design of Phase 1, the heat demand of low energy residential buildings was estimated to 40 kWh/m$^2$ resulting in estimated heat sales of about 300 MWh per year and heat supplied to net of about 385 MWh per year when distribution losses were taking into account. Anticipating 1800 full load hours this results in a required heat capacity of about 200 kW of Phase 1. Similarly, the capacity of the next phases must be estimated along with the development.

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An air-to-water heat pump in a temporary container installation has been chosen as the heat source for the network as of now. There has been discussed a biomass boiler as the heat source, but this was not preferred as a solution by the municipality.

The current network was planned as an VLT DH network and is running as such for now, but the delivery conditions require the installations to be ready for ULT DH as described under implementing measures.

The design of the actual user installations varies from substations with traditional DHW heat exchangers to substations for space heating only, supplied with ventilation units with a heat pump for heating the DWH. In some of the buildings the ventilation unit's DHW storage tank has a DH coil in the bottom to cover the base load with DH. Because of these different installation designs there will be need for the network to run in the summer even if the demand is only from a small part of the buildings. This is not an optimal solution which underlines the importance of adequate implementing measures.

For now, the initial heat loss from the network per building is relatively high but will lower as more buildings in Phase 1 is connecting to the network.

## Implementing measures

Implementing measures are specifications and requirements that must be met to get a well-functioning and fair ULT DH system. The implementing measures of Vinge are coping with ULT DH operation. Alternatively, the network can be operated at supply temperature of 60 °C.

The delivery conditions specified by VESTFOR for the DH network in Vinge states that the operational temperatures of the DH network will be 55 °C at maximum demand and 45 °C at minimum demand (ULT DH).

The Technical buildings specifications states that heat emitters shall be dimensioned for 55 °C supply temperature and 30 °C return temperature.

As for the DHW systems it is required to be dimensioned for 45 °C supply temperature and 25 °C return temperature for heating the water from 10 °C to 40 °C and there should be a supplementary heat source to boost the temperature from 40 °C to 55 °C.

These requirements lay the ground for ULT DH operations, and must be met by all connected houses in order to be able to run at the specified supply temperature of 45 °C.

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Along with this, the delivery conditions of Vinge also specify minimum delivered pressure difference of 0.5 bar at the house connections. Based on this, manufacturers can design ULT DH substations including in-house connections with pressure losses that will not exceed this value. Normally, the lower the supply temperature, the higher the flow and the pressure loss, so this specification must be considered carefully.

The Tarif structure for Vinge is a combination of a fixed tariff for every connection for covering basic cost of operation and an energy tariff for the actual energy consumption. Table 1 shows the tariffs of 2019 in Vinge [15].

Table 1 Tariffs for DH in Vinge for the year 2019, 1 EUR = 7.43 DKK [10]

| Tariffs 2019 | Unit | excl. sales tax | incl. sales tax |
|---|---|---|---|
| Fixed heat tariff | EUR/Month | 47,96 | 59,95 |
| Variable heat tariff | EUR/MWh | 58,16 | 72,70 |
| Connection fee | EUR | 4038 | 5047 |

Because of the self-sustaining basis, energy tariffs may be more volatile than in a larger consolidated network. For 2019 (compared to 2018) the fixed heat tariff increases due to fewer connections in the area than expected. Future positive developments in the area are expected to result in more connections and consequently fewer costs per household over the coming years. The variable heat tariff relates mainly to the heat production by heat pump. The variable tariff falls due to reduced taxes on electricity, which, however, are partly offset by rising electricity prices.

For new customers there is a connection fee to cover the cost of branch pipes to the buildings, meters etc.

The tariff structure in Vinge does not consider the use of electricity for boosting the DHW temperature.

The Annex 2 of this report includes tariffs and technical building systems specifications (Danish) Source: Technical buildings systems specifications, Deltakvarteret, Vinge [16]

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During the period of the RELaTED project, there have been two regulatory changes impacting the Vinge development. The Danish parliament have agreed that it shall no longer be possible to demand connection to the district heating network, as was the case of the 36 interconnected town houses of the first phase in Vinge. This may jeopardy the future development of district heating in Vinge, as the risk of investment in DH gets higher. Another issue is that per July 2018, the (primary) energy factors to be used in Danish EPBD calculations have changed as well. The energy factor for electricity have decreased from 2.5 to 1.9 and the energy factor for district heating have increased from 0.8 to 0.85. The decrease in the electricity factor is due to the increased amounts of renewables in the electricity system of Denmark, the increase of the energy factor of district heating is due to less cogenerated heat. In general, this will be more favourable for buildings supplied by individual heat pumps than buildings supplied by district heating.

## Project development

VESTFOR was from the start involved in implementation and operation of the DH network and the heat source in Vinge phase 1. Whether this will also be the case for the next phases is undecided. After a period with interruption of the development of Vinge and reconsiderations of the development plans, Fredrikssund Municipality has in Spring 2019, published a new tender for the next phase consisting in approximate 22000 m$^2$ of buildings. Lessons learned from the first phase of Vinge are:

- Information to developers from municipality and district heating operator must be aligned and clear on tariffs, the additional benefits, delivery conditions and technical building specifications of DH compared to traditional DH or individual heat pumps.
- ULT DH is new technology and requires a close dialogue with DH operator, installers and manufacturers on delivery conditions and technical building specifications. Operator must monitor closely, the requirements are met.
- Implementing ULT DH substations in EPBD calculation tools may be challenging for consultants and developers due to the fact these calculation tools can typically not handle appropriately the combination of ULT DH and boosting with heat pump. This can be a barrier for developers choosing ULT DH.

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## Operation and management

As VESTFOR already had existing organization they could use to take care of operation and mangement of the DH network in Vinge from the beginning without having to build up a new organization for that. This also include mobile capacity to supply heat in case of break-down of the heat pump.

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# Annex 2 – Vinge tariffs and specifications

## Extracts from the VESTFOR webpage on tariffs (Danish)

# Priser Frederikssund

**Her kan du se fjernvarmepriser for Vinge-området i Frederikssund. Fjernvarmesystemet i Vingeområdet er et separat anlæg som skal 'hvile i sig selv', ligesom fjernvarmenettet, der forsynes fra anlægget i Glostrup, også skal 'hvile i sig selv'. Der føres derfor et selvstændigt regnskab med selvstændig takst for Vingeområdet.**

| Priser 2019 | Ekskl. moms | Inkl. moms |
|---|---|---|
| Fast varmepris | 356,34 kr./mdr. | 445,42 kr./mdr. |
| Variabel varmepris | 432,14 kr./MWh | 540,17 kr./MWh |
| Tilslutningsbidrag | 30.000 kr. | 37.500 kr. |

Den faste tarif stiger pga færre tilslutninger i området. Der forventes en fremtidig positivt udvikling i området, der vil resulterer i flere tilslutninger og deraf følgende færre omkost-ninger pr husstand de kommende år.
Den variable tarif falder på grund af reducerede afgifter på el, der dog delvist modvirkes af stigende el-priser.

### Tilmeld dig fjernvarme i Vinge

Du kan tilmelde dig fjernvarme i Vinge ved at udfylde og indsende denne Ansøgning om tilslutning til fjernvarme
Når vi har modtaget ansøgningen, kontakter vi jer med information om tidsplan for arbejdet og videre instruktioner for konvertering. I kan forvente at der kan/bliver installeret fjernvarme ca. 2. måneder efter underskrevet ansøgning om fjernvarme.
Du skal sende det udfyldte ansøgningsskema til tilslutning@vestfor.dk

### Leveringsbestemmelser

I vores leveringsbestemmelser kan du blandt andet læse om tekniske forhold, drift og vedligeholdelse, forsikring, varmeinstallationer og etablering af målerudstyr.

**Leveringsbestemmelser for Frederikssund, Vinge, Deltakvarteret (PDF)**

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## Technical buildings systems specifications (Danish)

# Fjernvarme Vinge

VESTFORBRÆNDING

Den 21. februar 2017
Jens Munk Pedersen (JMP)
Sagsnr. 15-01710

### Indledning

Grundlaget for en aftale om fjernvarmeforsyning fra Vestforbrænding (VF) er en underskrevet "Ansøgning om tilslutning til fjernvarme" samt VF's til enhver tid gældende "Leveringsbestemmelser for fjernvarme".

I denne skrivelse oplyser vi om nogle vigtige forhold i Leveringsbestemmelserne samt særlige forhold i relation til varmeforsyningen i Vinge.

### Fjernvarmeforsyning

Fjernvarmeforsyningen i Vinge bygges til ultra-lavtemperatur for at sikre lavest mulige varmepriser. Lave temperaturer giver den bedste driftsøkonomi på varmepumpen, der aktuelt skal varmeforsyne området. Med lavtemperatur er fjernvarmen endvidere bedst mulig forberedt til fremtidens energikilder, samt udnyttelse af overskudsvarme.

Ultra-lavtemperatur stiller imidlertid særlige krav til varmtvandssystemet i husinstallationen, idet dette skal være forsynet med en el-booster for, at der kan opnås tilfredsstillende varmtvandstemperaturer.

Varmtvandssystemet til ultra-lavtemperatur skal endvidere udføres, så det kan fungere i en alternativ driftsform, hvor VF hæver fjernvarmetemperaturen. Derved skal varmtvandsopvarmningen kunne ske uden el-boost.

### Fjernvarmestik

Fjernvarmenettet fra den fælles varmecentral og ud i området er afsluttet med et stik ind på hver grund.

Hvis du ønsker fjernvarme, skal du indgå en leveringsaftale med VF via ovennævnte ansøgning, hvorefter VF graver stikket hen til dit hus. Her afsluttes det i et ventilskab ved husets yderfacade med 2 hovedafspærringsventiler.

Disse hovedafspærringsventiler er grænsefladen ift. både VF's og dine ydelser og forpligtelser, som beskrevet i Leveringsbestemmelserne.

VESTFORBRÆNDING

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CVR 10866111

C:\Users\ajk\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\YHBQ2RVR\VF Tekniske forhold kunder Vinge LAVTEMP 2017-02-21.docx
Redigeret af Jens Harald Munk Pedersen (JMP)

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VF ejer og vedligeholder fjernvarmestikket til og med hovedafspærringsventilerne.

Hovedafspærringsventilerne er endvidere det punkt, hvor VF skal levere aftalt varmekapacitet og dimensionerende temperaturer og tryk.

Fra ventilskabet skal din VVS-installatør føre stikket ind gennem yderfacaden og hen til husets fjernvarmeunit (tilslutningsarrangement).

Ventilskabet skal altså placeres hensigtsmæssigt ift. både eksisterende fjernvarmenet og fjernvarmeunitten i huset, således at der bliver kortest mulige rørføringer. Endvidere skal placeringen tilpasses udformningen af facaden med vinduer og døre mm.

## Husinstallation

Husinstallationen består af:

- Fjernvarmeunitten med varmeregulering og brugsvandsopvarmning.
- Tilslutning til VF's hovedafspærringsventiler i ventilskabet.
- Interne varme og brugsvandsanlæg i boligen.

Du forestår udførelse af hele husinstallationen. Dette gør du ved at indgå aftale med en autoriseret VVS-installatør. Sammen vælger I en fjernvarmeunit, som opfylder dine krav og behov samt VF's bestemmelser. Installatøren skal være certificeret efter FjR-ordningen. Dette er din sikkerhed for, at installatøren er kvalificeret til at rådgive dig og udføre arbejdet.

Sammen med Ansøgning om tilslutning til fjernvarme skal du fremsende et specificeret tilbud fra VVS-installatøren. VF godkender herefter installationen iht. Leveringsbestemmelserne samtidig med, at der gives tilsagn om fjernvarmeforsyning.

Det er vigtigt, at installatøren er bekendt med VF's Leveringsbestemmelser, og følger de givne anvisninger og krav. Projektering og udførelse som beskrevet for Zone 1 med de korrektioner og tilføjelser, der er givet i denne skrivelse.

VF udleverer varmemåler og fjernaflæsningsudstyr til installatøren, som han skal installere. Udstyret skal have egen strømforsyning i husets el-tavle.

Når installationen er klar til idriftsætning, skal den trykprøves i overværelse af VF. Samtidig kontrollerer VF, om der er fejl og mangler på installationen. Efter godkendt trykprøve åbnes for fjernvarmen, og varmemåler og fjernaflæsningsudstyr opstartes.

Til slut skal du sikre dig, at automatikken samt alle ventiler og pumper er indreguleret. Husk at få en indreguleringsrapport fra installatøren.

Se efterfølgende skema med generelle forudsætninger for dimensionering/udførelse.

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## Dimensionering / udførelse husinstallation i Vinge

Supplering til Vestforbrændings Leveringsbestemmelser.

| | |
|---|---|
| Sikkerhed og komponenter | Min. 90°C<br>Min. 6 bar<br>Trykprøve 9 bar |
| Drift fjernvarme (ultra-lavtemperatur) | 55°C frem fjernvarme max. belastning<br>45°C frem fjernvarme min. belastning |
| Drift fjernvarme (alternativ) | 60°C frem fjernvarme |
| Differenstryk v hoved-afspærringsventiler | 0,5 - 4,0 bar |
| Varmemåler | Placering i fremløb<br>Suppleret med lækagekontrol |
| Radiatorer og gulvvarme | Max. 55°C frem fjernvarme<br>Max. 30°C retur fjernvarme<br>Max. 55°C frem husinstallation<br><br>Direkte fjernvarme uden varmeveksler anbefales.<br>Udekompensering af fremløbstemperatur og temperaturbegrænsning på fjernvarme retur. |
| Varmt brugsvand (ultra-lavtemperatur) | 45°C frem fjernvarme<br>Max. 25°C retur fjernvarme<br><br>Varmtvandsbeholder med 2-trinsopvarmning af brugsvand.<br><br>Trin 1.<br>10→40°C brugsvandsforvarmning m fjernvarme.<br>Regulering af forvarmningstemperatur (40°C) og temperaturbegrænsning (40°C) på fjernvarme retur.<br>Indregulering af fjernvarmeflow til ønsket effekt.<br>Volumen og effekt skal være tilstrækkeligt til at der efter endt standard-tappeprogram altid er fuldt forvarmet vand (40°C) til trin 2.<br><br>Trin 2.<br>40→55°C brugsvandsboost m el.<br>Regulering til brugervalgt sluttemperatur (50-55°C) i varmtvandsbeholder. |
| Varmt brugsvand (samme varmtvandssystem ved alternativ drift) | 60°C frem fjernvarme<br>25°C retur fjernvarme<br><br>Trin 1.<br>10→55°C brugsvandsforvarmning m fjernvarme.<br>Regulering af forvarmningstemperatur og temperaturbegrænsning på fjernvarme retur.<br>Indregulering af fjernvarmeflow til ønsket effekt.<br><br>Trin 2.<br>Brugsvandsboost m el slukket. |

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