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Study on business models and innovative funding structures for low temperature district heating

Main output GoA 5.3

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1 General introduction

1.1 LowTEMP project

The energy demand for heating and cooling in Europe and the Baltic Sea Region is responsible for more than one third of the final energy consumption. Thus, the deployment of more efficient and innovative DH technologies is key to a successful energy management in cities and districts. Efficient DH with LTDH technologies offers new possibilities for increased energy efficiency with reduced fossil energy consumption, which will help to achieve the EU targets in reduction of CO2 emissions.

LowTEMP, is a project that promotes smart and future-oriented heating supply technologies using low temperature grid structures. It is funded by Interreg Baltic Sea Program and project partners. The project provides district heating stakeholders with know-how and strategic tools on how to plan, finance, install and manage LTDH system. To successfully introduce low temperature district heating and secure that district heating remains competetive, business cases have to be evaluated and funding structures has to be examined. This report is written as a part of the LowTEMP project.

The LowTEMP partnership is composed of 19 full and 30 associated partners from 8 EU Member States (Poland, Germany, Denmark, Sweden, Estonia, Finland, Latvia, Lithuania) and Russia. The partners represent municipal, regional and national authorities, DH suppliers, energy agencies, associations, business support organisations, as well as research institutions.

1.2 Outline of report

This report is the main output of the group of activities 5.3 Business Models and innovative funding structures for LTDH. In the previous steps in work package 5, a report on funding gaps "Analysis of financial framework and funding gaps" has been produced by BTU Cottbus- Senftenberg in Goa 5.1 (LowTEMP 2020). And in output 5.2 "Financing, tariffication and contracting of LTDH" the district heating system owner structure, main supply models, trends and fees and tariffs in the partner regions is described by Tartuu Regional Energy Agency (LowTEMP 2019 (4)). The latter report also has a consumer perspective and describes some of the barriers to introduce 4th generation district heating. So, for further information on those aspects they are well covered in those previous outputs in the work package 5 and will just be referred to in this document.

In this report which is mainly directed to ditrict heating companies, municipalities and regional and national government, we will give an introduction to business models descring what it is and some general carachteristics about funding structures of district heating projects in the first part. In chapter 3 district heating in the Baltic sea region is described with respect to on ownership, funding structures and fuel profiles. Then lowtemperature district heating and potential of renewable energy sources are covered. In the next chapter business model developing tools are presented and adapted to low temperature district heating. Two of the tools, the Ladder of value and the helicopter method are developed with in the project. This is followed of examples of innovative pricing models and examples of new value chains and business opportunities and new professions. In chapter 5 examples of innovative funding structures susch as crowdfunding and Energy service Companies – ESCO are described.

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Examples of new value chains, professions and business opportunities are described in chapter 6.

In chapter 7 we will summaries our findings in work package 5.3 by give examples of how to apply the business model tools and funding structures, described in this report, on five common scenarios for introduction of low temperature district heating in the Baltic sea region. This concluding recommendations on business model approach and funding structures serve as a summary and contains the essence of the report. In the work package 5.3 we have also been studying what have been done in other projects regarding low temperature distric heating, conventional district heating, business models and tools. A table of selected projects are listed in chapter 8.

In appendix 1 of this report, you will find an investigation of the countries in the Baltic Sea Region; how their district heating companies are structured, how they usually fund their district heating projects and other relevant information related to the cost and funding of district heating operations, such as mandatory connections and heat tariff regulations.

1.3 Definition of terms

1.3.1 Low temperature district heating (LTDH)

There is no formal definition of low temperature district heating since temperatures for regular district heating differs between different markets. In this report and within the LowTEMP partnership we are focusing on district heating within the temperature interval of 50 -70 degrees Celsius. This also suits well with guidelines with respect to Legionella legislation in the Baltic countries and are in line with the project's pilot measures.

1.3.2 3rd generation district heating

3rd generation district heating was introdused in 1970s and is also called „Scandinavian District Heating ". Heat carring is pressurised water which has lower temperature than over 100 degrees Celsius. Pre-insulated pipes are directly buried into ground.

1.3.3 4th generation district heating

4th generation of district heating is defined according to Thorsen et al as district heating with flow-temperatures up to max 70 degrees celcius and return flow temperatures around 25 degrees celcius. (Thorsen et al 2018)

1.3.4 Business model

A business model describes the rationale of how an organization creates, delivers, and captures value. The business models include both soft values like strategies and hard values as price models.

1.3.5 Price model

A price model describes the cost structure and revenues and fees, i.e how the customers pay for the product. It is a component of the business model.

1.3.6 Funding structure

By funding structure, we in this report refer to the way a district heating project is financed. Investments by bank, investors, funds, capital, subsides etc.

1.3.7 Cost reduction gradient

Is a performance indicator measured in Euro divided by Tera joule (or kWh) and degree Celsius (€/(TJ, °C)). It describes the annual economic benefit (€) divided by the annual heat deliveries (TJ) and the reduction of the average heat distribution temperatures in the district heating system (°C). The Cost reduction gradient makes it possible to under certain stated conditions compare different DH systems regardless of size.

1.3.8 Renewables

The European parliament defines renewable energy sources as: Renewable sources of energy (wind power, solar power, hydroelectric power, ocean energy, geothermal energy, biomass and biofuels) are alternatives to fossil fuels that contribute to reducing greenhouse gas emissions, diversifying energy supply and reducing dependence on unreliable and volatile fossil fuel markets, in particular oil and gas.

In addition to the renewables covered by the definition, recycled energy such as waste incineration and surplus heat are also potential sources of energy for lowtemp district heating and covered by this report.

1.3.9 Surplus heat

In this report we refer to surplus heat as the waste heat or the industrial excess heat, residual heat (heat produced by machines, processes and industries when energy is used to perform work) remaining when other energy saving actions has been performed.

1.3.10 Prosumers

In this report a prosumer is referred to as a consumer who also is a producer. It could for example be a private consumer delivering energy from sun panel into the power grid or a factory delivering surplus heat into the district heating system.

1.3.11 Suppliers

The term suppliers is used in this report to describe any type of technical or technological supplier or supply company. It could for example be a supplier of whithe gods, smart indoor meters, substations, heat exchangers etc.

1.3.12 CHP-combined heat and power plant

The abbreviation CHP is used for a district heating plant where both power and heat is generated and delivered to the district heat grid and power grid.

1.3.13 Environmental energy

Environmental energy refers to energy from air, water, sewage, and ground etc which for example can be available with heat pumps.

1.3.14 Feed-in tariffs

Feed- in tariff is a payment made to households or businesses generating their own electricity through the use of methods that do not contribute to the depletion of natural resources, proportional to the amount of power generated.

1.3.15 Retun on investment ROI

Return on Investment (ROI) is a performance measure used to evaluate the efficiency of an investment or compare the efficiency of a number of different investments. To calculate ROI, the benefit (or return) of an investment is divided by the cost of the investment. The result is expressed as a percentage or a ratio.

1.3.16 Limited Liability Company or Corporation (LLC)

Limited Liability Company or Corporation is a type or form of for-profit incorporated company where ownership is divided into shares, and where the governing rules are set forth in a contract entered into by all of the initial shareholders. It is common in some states in america. The name derives from the fact that regardless of potential losses or even bankruptcy of the corporation, individual shareholders will bear a maximum liability of the price they paid for their shares.

1.3.17 Building code requirements

The building regulations in different countries, including rules on energy performance for new developedments and buildings undergoing major refurbishment.

2 Introduction to business models and funding structures

2.1 What is a business model?

A business model describes the rationale of how an organization creates, delivers, and captures value. The term business model is used for a broad range of descriptions to represent core aspects of a business, such as, target customers, value propositions, strategies, infrastructure, organizational structures, trading practices, and operational processes.

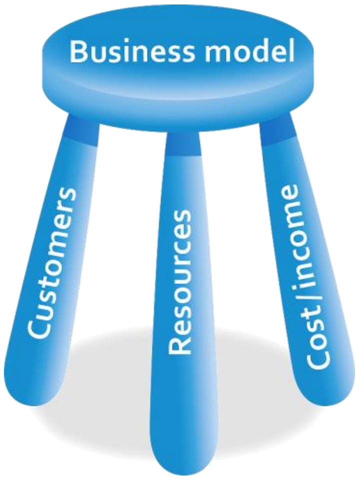

Figure 1 One schematic illustration of a Business model. The business model is like a three-legged stool where the legs support the business model. The legs are: 1. Customers (value, relationships, segments), 2. Resources (infrastructure, activities, partners, logistics) 3. Cost/income structure (tariffs, fees, price models, income, costs).

A business model is a theoretical description of how a company, or a business, is intended to work. It is a conceptual tool that contains a set of components and describes their interrelationships in such a way that the business logic can be described in concrete terms. It includes parts such as a revenue model that describes how revenue comes in, a production model that describes how goods and services are produced, and a delivery model that describes how goods or services will benefit the customer. Business models are used to describe and classify companies, especially for entrepreneurial.

Ultimately, a business model it is about matching resources of an organisation to the needs of the market in a better way than its competitors do. The business model describes how an organisation uses its resources to solve problems or needs experienced by the market and how well it does this in relation to other organizations.

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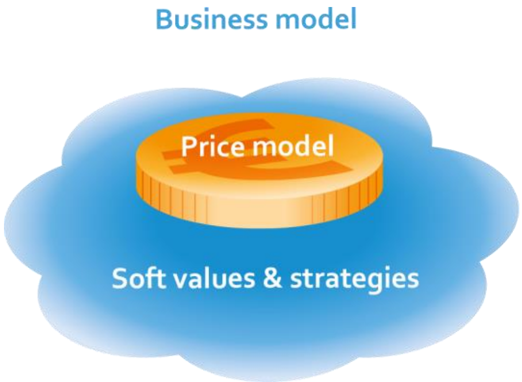

Figure 2 Schematic illustration of a Business model. The main potion of a business model refers to soft values and strategies and only a small part is the price model. The soft value and strategy part of the the business model could include policies such as keep all competence inhouse, choose fossil free when possible, strategic partnerships etc.

A business model can be defined in terms of the value chain and it can be divided into two interdependent parts. On the one hand, we have the organization's resources in relation to the product or service that the organization produces. Central to this is to optimize resource use in such a way that production costs are kept down without suffering the quality of the product or service. This work is usually referred to as internal efficiency. In terms of internal efficiency, this is something that can be improved if innovations occur in the production process or within an organization's logistics.

The second part of the business model is the relationship between an organization and the market. In this relationship, it is central to match existing market needs and demand in the best possible way with existing resources. The key is to create a value for the customers that exceeds the costs of production for the organisation to be able to charge a surplus. How well an organisation manages to create value for customers given the resource assets and the costs of production are usually referred to as external efficiency. The value that customers experience is also influenced by the service they experience in contact with an organization. Thus, how a product or service is delivered can affect the perceived value. Innovations in distribution can thus help to increase external efficiency. Ultimately, therefore, it is a matter of working to reduce costs while doing work that aims to increase customer value. Through this work, space is created to increase the profit margin. The overall picture of how an organisation works with both parts of the business model is usually referred to as total efficiency.

And it is the total effiency district heating companies will have to address when converting from heat produced from combustion of fossil based fuels with high CO_2 emission and heat distribution with large heat losses to heat and energy produced with renewable fuels, low CO_2 emission and a fine tuned and smart heat distribution with small heat losses.

Within this report a business model tools has been developed and examples of how renewable fossil free energy sources could be used for low temperature district heating.

2.2 Introduction to funding structure

There are several characteristics for investments in district heating systems. Firstly, the upfront capital costs involved are significant. Secondly, the investment must be seen as a long-term investment (10-30 years) with a relatively secure revenue stream, and thirdly the return of investment is under influence of public heat sector regulation, security of supply and providing affordable heat to the consumers and reducing environmental burdens in connection with both heat production and distribution.

Every country has its own models and traditions for funding structures often developed over many decades. This involves grands, direct subsidies, revolving funds and consumer payment.

Furthermore, funding possibilities can differ according to the specific project. A new district heating area demands one kind of finance while at conversion from high temperature to low temperature systems demands another financial structure.

In connection to the LowTemp work with innovative funding structures a huge number of structures are identified. Many funding models can be linked or combined. Within this report in chapter 5 we will focus on energy services and crowdfunding.

3 District heating in the Baltic Sea Region

In the countries around the Baltic sea district heating has been around as heating source for a long time. In general, centralized district heating is the most common heating solution both for space heating and domestic tap water especially in the cities and areas where the density of houses is high.Today many of these heating systems are old and in need of refurbishment. In the LowTEMP project the district heating context for the partner countries and regions are well covered within the group of activities 3.1 and the report "Report on current energy supply framework conditions for LTDH in partner municipalities and regions (LowTEMP 2019 (3))" . To learn more about the tariffs and financing of district heating read the report Financing, tariffication and contracting of LTDH developed in GoA 5.2 (LowTEMP 2019 (4)).

3.1 Ownership and funding structures for district heating in the Baltic region

3.1.1 Summation of funding structure in all the partner countries

There is a wide variety in how district heating is organized in the countries in the Baltic Sea Region. This also affect how different countries fund their district heating infrastructure.

In the table below, an overview of the differences (and similarities) between the different countries are presented. For detailed description for each partner country see Appendix 1.

Table 1 The table shows an overview of the differences (and similarities) in the ownership and legalisation for funding structures for district heating systems in countries in the Baltic sea region

	Usual DH company ownership	Usual grid/pro-duc-tion owner-ship	Building code require-ments (kWh/m2/a)	Allowed to charge prof-its?	Connec-tion to DH grid manda-tory?
Denmark	Public	Varies	30-60	No	No
Sweden	Public	Owns both	50	Yes (5-10%)	No
Germany	Public (78%)	Owns both	90-100	Yes	Possible (mu-nicipal deci-sion)
Poland	Large: Private Small: Public	Separate	95	Yes	No data
Finland	Public	Owns both	50-60	Yes (For LLCs)	Possible (for now)
Estonia	Large: Private Small: Mixed	Owns both	150-160	Yes (<9%)	Possible (mu-nicipal deci-sion)
Latvia	Public	Owns both	50-60	Yes (<9%)	Possible (mu-nicipal deci-sion)
Lithuania	Public (80%)	Owns both	108-420	No data	No data
Russia	Private (100%)	Owns both	110-130	Yes	No data

As a general trend, it seems that the private district heating companies tend to use their own capital, possibly supplemented by bank loans or similar. Many countries use ERDF (European Regional Development Fund) or other EU funds in order to subsidize or in other ways help fund their investments in district heating.

Especially in the Eastern countries in the Baltic Sea Region, there is a strong component of EU funds assisting the infrastructure investments. Most companies are also privately owned and are usually not eligible for public or state funding.

The Nordic countries operate slightly different, with their district heating companies being either run or owned by the municipalities in some way. In terms of funding structures for the Nordic countries, both Denmark and Sweden have large municipal loan organizations owned by a large percentage of the respective countries' municipalities/regions, with the one in Denmark being owned by all Danish municipalities and regions. This means that not only can they offer very low-cost loans, they are also not allowed to make a profit off the loans, which makes the loans very favorable, with interest rates around 2%. (KommuneKredit 2020, KommunInvest 2020)

In Denmark, as the only country in the Baltic Sea Region, all district heating companies are under strict legislation of being non-profit. Meaning their heat prices must represent the actual cost of production/purchase of heat and the delivery of it. No profits allowed, only cost-neutral operation.

For all other countries in the Baltic Sea Region, the district heating companies are expected and allowed to make a profit, which is usually regulated to be in the 5-10% range. This is mainly to protect customers from too high prices on heat.

Russia, being outside of the European Union, does not have access to any funds or subsidies like many of the EU countries do. They are fully private companies that will have to invest their own money in district heating projects.

An interesting trend can also be seen in the individual countries' building regulations in terms of the lowered energy requirement for newer buildings. Most countries are getting close to zero-energy houses, meaning they will require less heat from the outside, which can both pose a threat and an opportunity for district heating companies. They can follow these recommendations and change their value propositions and maybe offer de-central heating solutions or offer some other forms of service for their heat customers to make it both attractive for their customers and their own bottom line. Read more about opportunities in section 4.10 and 4.11. For the countries that still have quite high energy requirements for new buildings, the transition to lower supply temperatures in district heating will usually take longer time, since buildings will not be insulated enough to make use of the lower temperature.

While countries used to have mandatory connections to the district heating grid or at least the possibility of it, the public opinion is usually not in favor for this. Therefore, the district heating providers will need to make their product attractive enough to compete with individual heating sources, such as heat pumps, pellet and biomass boilers or in some cases natural gas. Coming back to the above notion of changing the value proposition, district heating providers could potentially offer some of these solutions possibly including service and maintenance or some combination of low-temperature district heating grids combined with heat pumps, thereby keeping their customers while revising their own business models.

Most of the above applies to both traditional district heating and low-temperature district heating. However, due to the innovative nature of low-temperature district heating, it is often easier to receive EU funding for these types of projects, which are often also more expensive due to their innovative nature of using new or improved technology or designs. There are many different EU funding structures as well as national programs that seek to assist new and innovative technologies. For up-to-date information it is possible to contact a national knowledge bank or the different EU fund's homepages.

3.2 Fuel profiles in partner countries

When comparing the energy sources for producing district heating in the Baltic sea region countries it is apparent that all partners in the LowTEMP project start from a different baseline when comparing fuel profiles. Each country has a different history both when looking at natural resources, legislation as well as national sustainability goals. The latter are important for national grants and fundings to create incentives for reducing carbon emissions and climate impact.

The numbers in the graph below are based on the information presented in GoA 3.1 with some complementary questions to the LowTEMP project partners.

Within this work we have digged deeper in what renewable fuels are used in the project partner countries around the Baltic sea. As can be seen in figure 3, 4 and 5 there are differences. The differences are both in the varieties of different numbers of fuels and the type of energy source, fossil, renewable etc. In Latvia for example only three different fuels are used and in Sweden and Finland eight and nine different types of fuels are used. Some fuels such as natural gas and wood fuels are used by all investigated countries, but it is only Sweden who has registered a substantial amount of surplus energy for district heating.

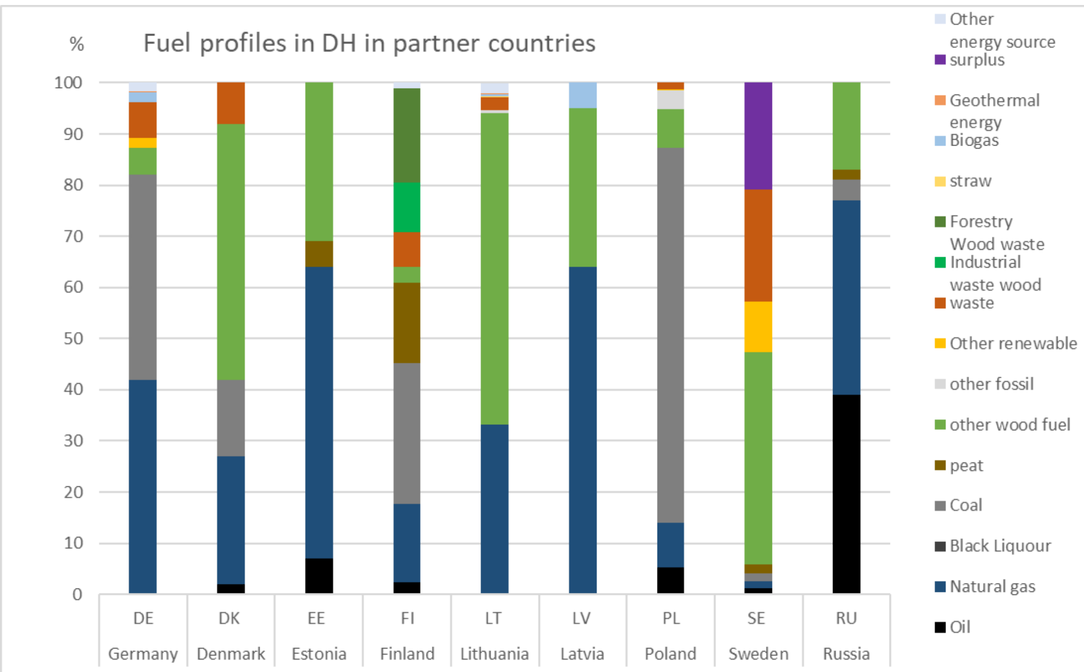

Figure 3 The graph visualises the energy fuel profile for the countries participating in the LowTEMP project. The numbers are based on the numbers each partner filled out in questionair A in output 3.1 with some coplement via email respond on RES.

The country with the highest share of one single fuel is Poland which had over 70% of the energy to district heating delivered by coal Figure 3 and 4. When studying the renewable energy sources biomass from other wood fuel, industrial wood waste and forestry wood waste is the most common in the countries Figure 5.

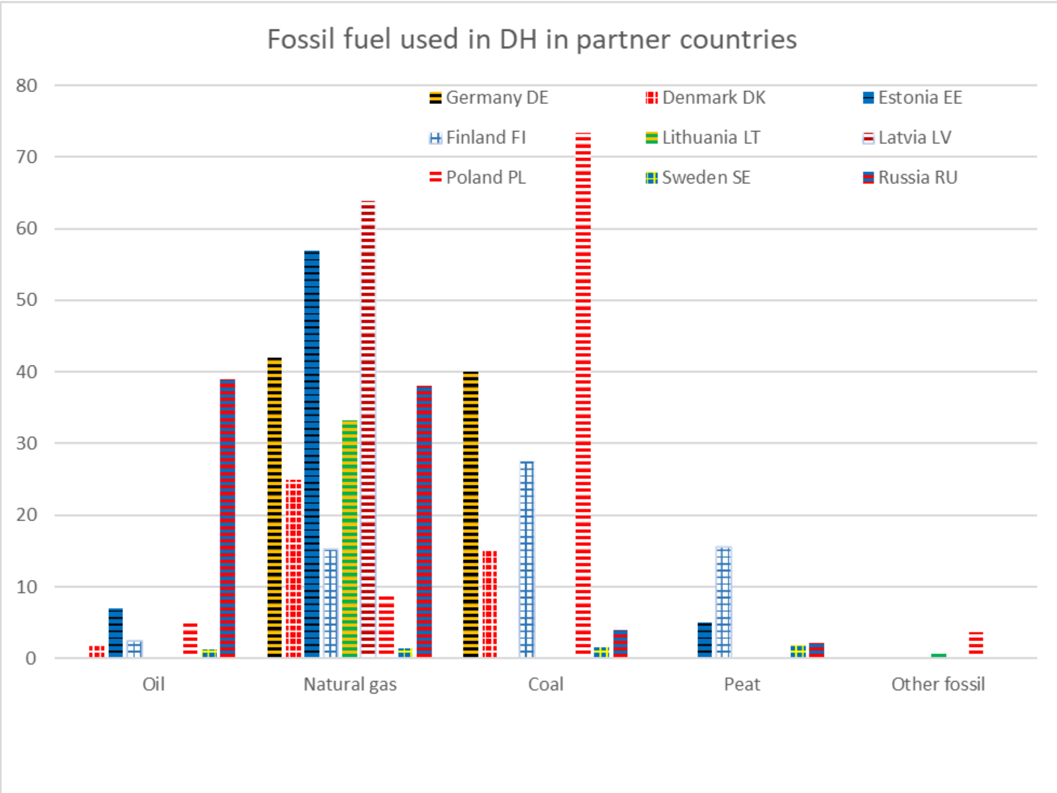

Figure 4 The grapf shows what fossil based fuels that are used in different countries and as reported from the partner region in Questionnair A in GoA 3.1 with som complementary answers

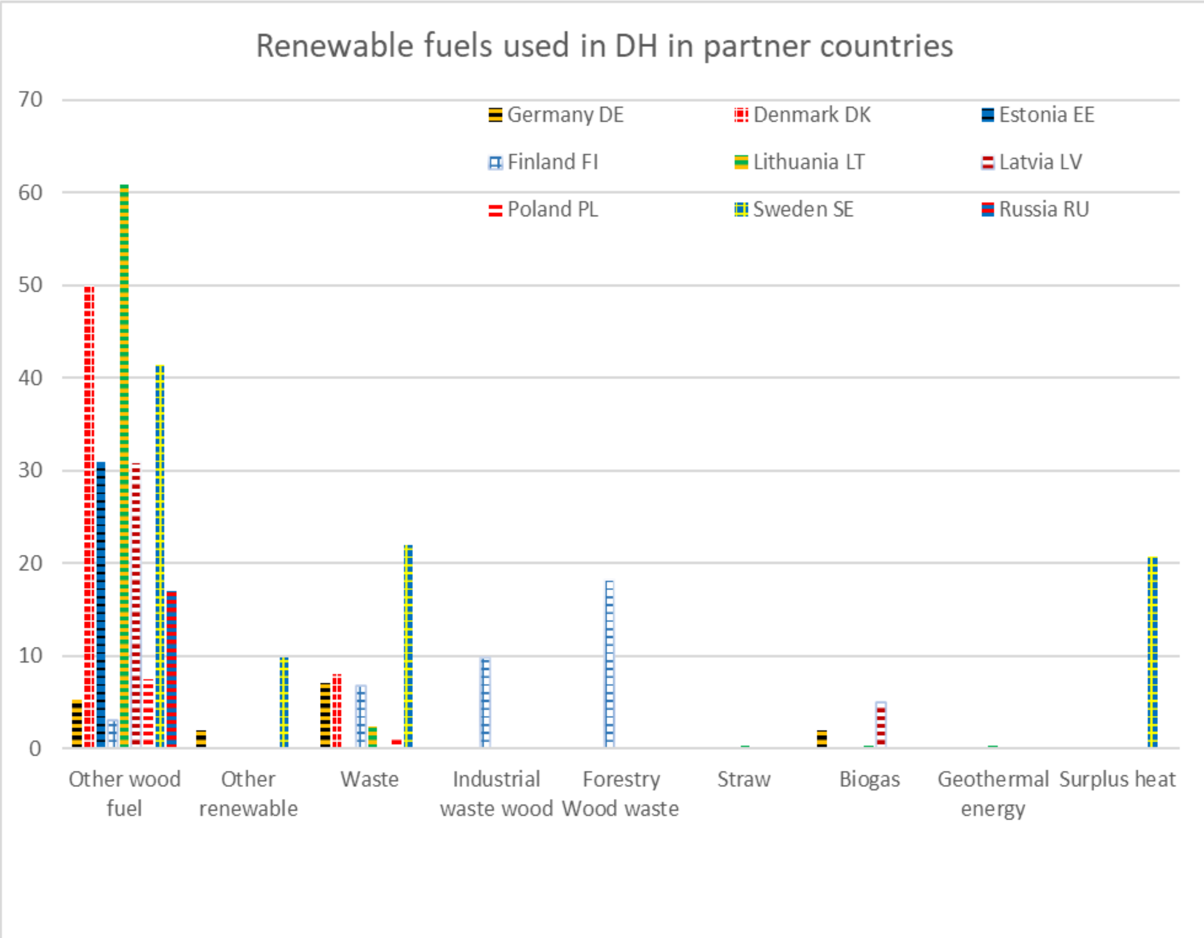

Figure 5 The grapf shows what renewable energy sources that are used in different countries and as reported from the partner region in Questionnair A in GoA 3.1 with som complementary answers on RES

3.3 Low temperature district heating

In this report and within the LowTEMP partnership low temperature district heating is defined as district heating within the temperature level of 50 -70 degrees Celsius. This temperature range also suits well with guidelines with respect to Legionella legislation and the pilot objects within the LowTEMP project. The district heating systems we are aiming for could be third generation district heating or fourth generation (Lund 2014) the technology or generation is not the main factor.

Due to new directive on energy performance in buildings within the European union (European Parliament and council, 2010) the heating demand from the houses has decreased as mentioned in chapter 3. Another parameter which influences the heat demand negatively is the increased outdoor temperature due to climate changes. When the demand for heating is decreased the business case for the district heating companies is not clear especially since there is an overall goal to use less energy and reduce CO_2 emissions. Business models for classic district heating is based on the business logic of scale (Lygnerud 2019) hence new business models for district heating are required.

3.4 Potential of renewable energy sources suitable for LTDH?

About 50% of the energy consumed in the European Union (EU) is in the heating and cooling sector (EU Commission 2016). The carbon footprint of heat supplied through district heating depends heavily on its source i.e. what kind of fuel or energy sources are used to produce the heat.

In order to reduce CO2 emissions from the heating and cooling sector there must be drastic changes. Transition from heat produced from combustion of fossil-based fuels with high CO2 emission and heat distribution with large heat losses to heat and energy produced with renewable fuels, low CO2 emission and a fine tuned and smart heat distribution with small heat losses.

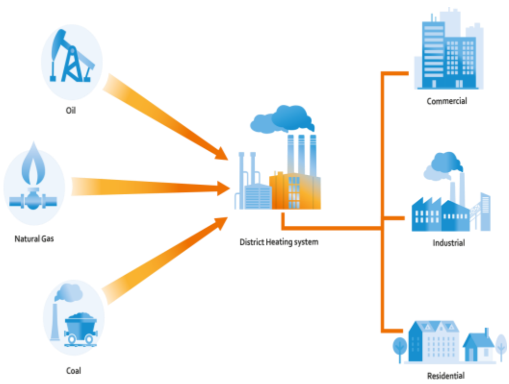

Figure 6 Fossil fuel-based district heating. The conventional district heating where high tempererature heat is produced and delivered to largre professional consumers

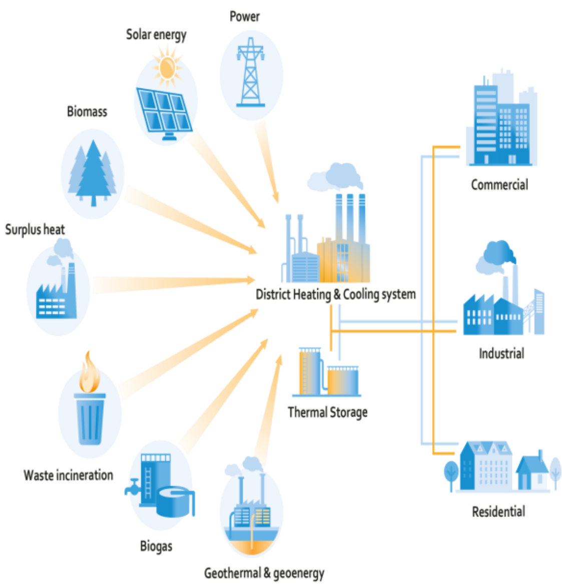

Figure 6 Future non fossil based low temperature district heating includes different energy sources, energy storage and maybe also district cooling

As can be seen in figures 6,7 and 8 there are many different energy sources that could be used for district heating. The conventional district heating uses fossil-based fuels such as oil, natural gas and coal. And the future and modern district heating is more complex and can use more energy sources. For example power to heat from excess electricity generated from wind and sun. Solar thermal panels, different types of biomass, surplus heat from different types of heat sources such as industry, sewage treatment plants, computer server centers etc. Waste incineration could also serve as heat source in combination with biogas from waste and sewage etc. Also high temperature geothermal energy and more shallow geoenergy from ground and water. The future district heating might also include storage of heat and perhaps also cooling. The main important message is that there is no standards solution because every city, municipality and region has its own unique conditions. Which might include surplus heat opportunities, municipality waste incineration, wind power, solar energy etc. It is important to see the possibilities and the local opportunities. This is also described in 3.2 Methodology for strategies to implement LTDH (LowTEMP 3.2, 2019 (5)).

When looking at the potential for which energy sources could be suitable for LTDH one way is to compare different energy sources and technologies and their working temperature range. When doing this comparison as in the figure 8 adjusted from (Sayegh et al 2018 and LowTEMP 3.2, 2019(5)) most fuels are suitability to both conventional 3rd generation district heating and low temperature district heating marked in light blue. See figure 8.

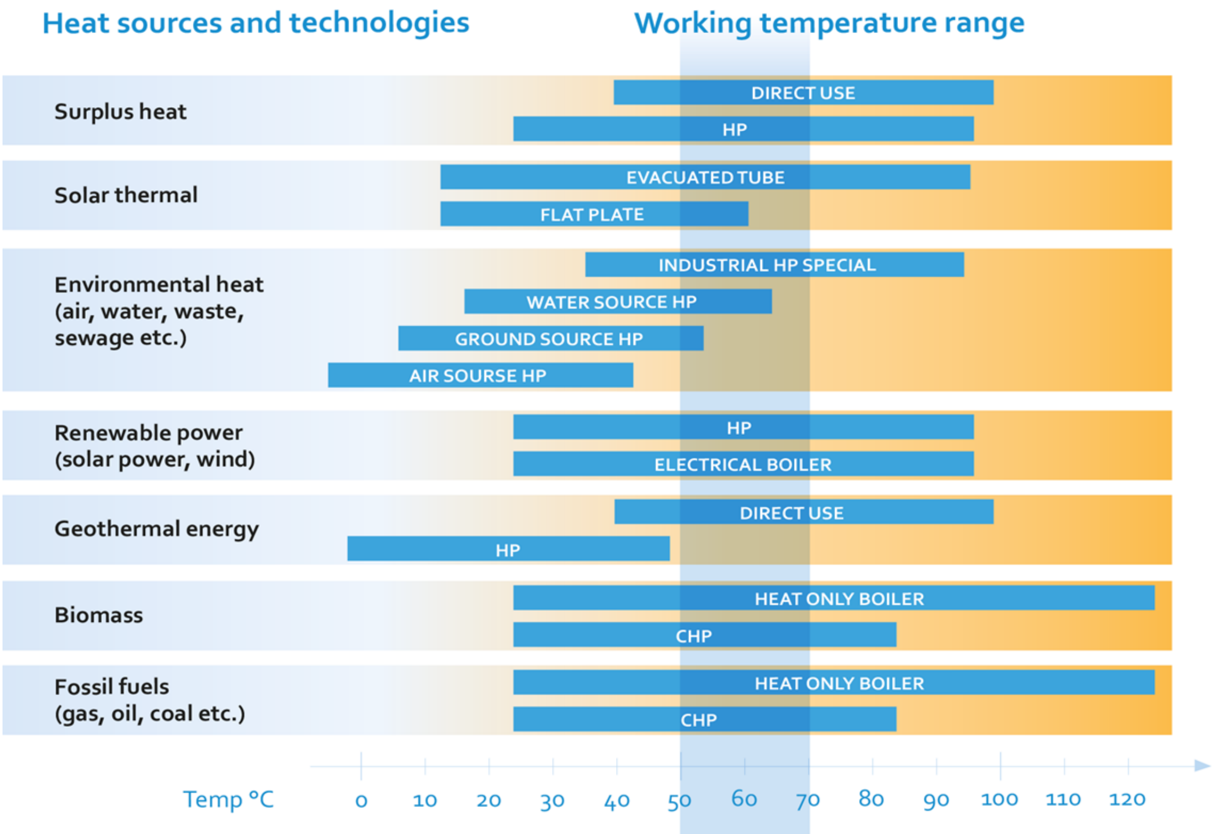

Figure 7 A illustration and comparason of different energy sources and their temperature working range modified from (Sayed et al 2018) and (LowTEMP 3.2 2019 (5))

In the paper "Economic benefits of fourth generation district heating" (Averfalk, 2020) the authors Averfalk and Werner use a spreadsheet-based model to analyse well-established theoretical rela-tionships from textbooks. The purpose was to model how heat supply efficiencies vary with heat dis-tribution temperatures.

In figure 9 the heat distribution temperature used in the model for third and fourth generation of district heating is shown as it varies with outdoor temperatures.

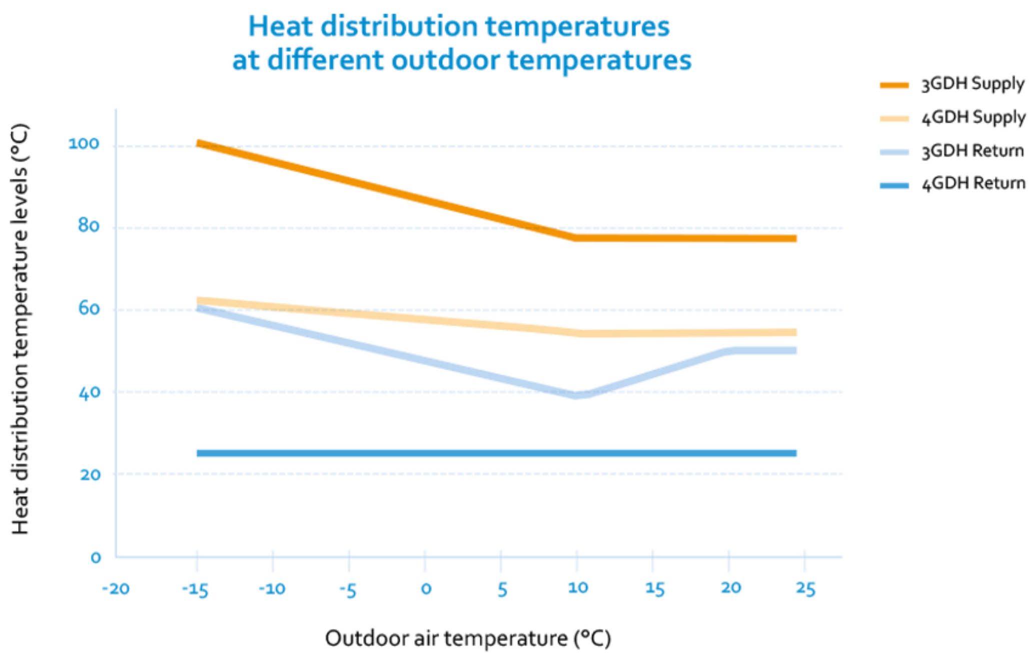

Figure 8 Shows the heat distribution temperature of 3rd and 4th generation district heating at different outdoor temperatures modified from (Averfalk 2020) with permission from the author

In table 2 (Averfalk, 2020) the authors are listing benefits associated with district heating distributed at lower temperatures. For example, when using lower distribution temperatures more heat could be extracted from geothermal heat sources, and surplus heat from industries and get a higher conversion efficiency in solar collectors. These examples indicate that there is a potential in in using renewable energy sources when using lower distribution temperatures in the district heating system.

Tabell 2 shows seven benefits when using lower distribution temperatures. The table is based on the reference (*Averfalk, 2020)*

	Benefit with lower distribution temperatures
1. More electricity	More electricity is generated per unit heat by obtaining higher power-to-heat ratios in CHP plants by lower pressures in turbine condensers.
2. More heat recovered in flue-gas	More heat recovered in flue-gas condensation units
3. More geothermal heat extracted	More heat extracted from geothermal wells having temperatures between 60 and 100 °C.
4. More industrial surplus heat extracted	More heat extracted from industrial surplus heat having temperatures between 60 and 100 °C.
5. Less electricity used in heat pumps low temp	Less electricity used in heat pumps when extracting heat from heat sources having temperatures just above the ambient temperature by lower pressures in the heat pump condensers.
6. Higher conversion efficiencies in solar collectors	Higher conversion efficiencies in solar collectors, since the heat losses from collectors become lower.
7. Lower heat distribution losses	Lower heat distribution losses, since the average temperature differences between the fluids in the distribution pipes and the environment become lower

By using the model, the previous listed preconditions and data from real district heating project and comparing the cost using different temperatures, the cost reduction gradient could be used to compare different DH system regardless of size. The cost reduction gradient [€/(Gwh, °C)] is a performance indicator where the annual economic benefit (€) is divided by the annual heat deliveries (TJ or GWh) and the reduction of the average heat distribution temperatures in the district heating system (°C). Using this cost reduction gradient, different sizes of district heating systems and different temperature reductions can be comparatively assessed.

When looking at the results in this paper and figure 10 one observation is that the cost reduction gradient is higher at lower temperatures i.e there are more savings to do at for example 60 degrees than 100 degrees celsius. In the example with geothermal heat in the figure above the cost reduction gra-

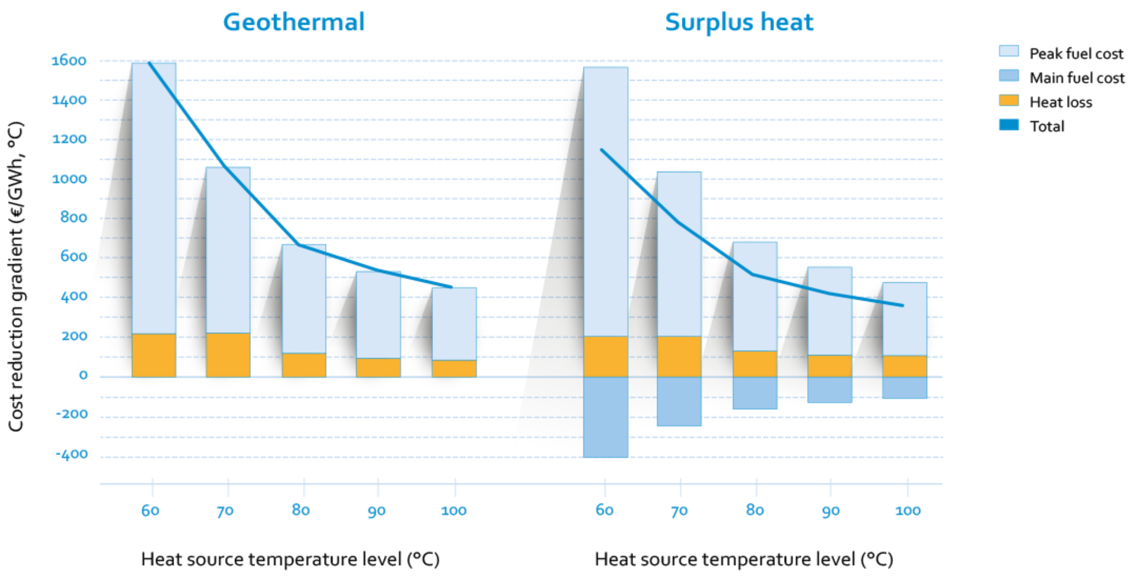

Figure 9 The Cost reduction gradient varies with heat source temperature and is different in its composition for different RES modified from (Averfalk 2020) with permission from the author

dient at 100 degrees Celsius is almost 450 [€/(Gwh, °C)] and 130 [€/(TJ, °C)] in (Averfalk, 2020) and at 60 degrees the gradient is almost 1600 [€/(Gwh, °C)] corresponding to 440 [€/(TJ, °C)] in (Averfalk, 2020). Hence the cost reduction gradient is about three to four times higher at 60 degrees compared to 100. What is also interesting and perhaps surprising is that most of the cost reduction gradient is due to peak fuel costs and not so much from the heat losses when lowering temperature.

To keep the peak fuel costs low is an efficient way to reduce costs for district heating companies.

There are several ways to keep the peak fuel cost low for example:

- Use smart system energy system and predict when the peaks will occur (historic data, weather forecasts etc)
- Storage of heat (in the grid, in buildings, in storage tanks, in the ground etc)
- Reduce the temperature in the grid. The amount of energy for reaching the peak is reduced.

In the paper the autors also compared the cost reductant gradient for different renewable energy district heating projects such as waste CHP, Biomass CHP, Geothermal etc see figure 11 their cost reductant gradient consists of different components since for example the investment is different, and they differ in dependence of for example electricity and peak fuel costs. The heat pumps for example are dependent on electricity and their profitability when using those are dependent on electricity price. Hence might be less profitable when electricity price is higher. The waste CHP and biomass CHP

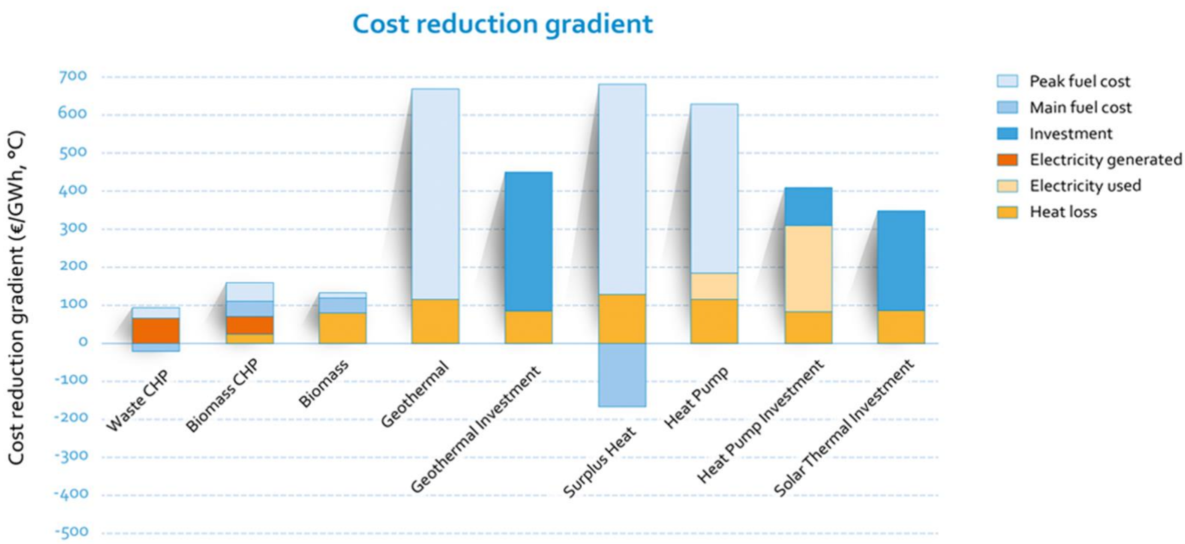

Figure 10 Cost reduction gradients at different RES projects. The graph is recalculated and modified from (Averfalk 2020) with permission from the author

are producing electricity and are also dependent on electricity price but in the opposite way i.e at high electricity price it might be more profitable.

In the paper it is also stated that there is a low cost-sensitivity for traditional waste and biomass combined heat and power (CHP) (Averfalk 2020). Hence the cost reduction gradient is low when comparing 3rd and 4th generation district heating. Which would indicate that the economic incentive is low to reduce the temperature to LTDH for those traditional district heating systems.

In the third generation and high temperature the fuel cost is more to consider but for renewable energy sources it is the investment cost and, in some case, also maintenance cost since the fuel costs are low. In order to create incentives to benefit LTDH with renewable energy sources those investment costs must be taken care of. And those could be the funding gap discussed in the LowTEMP report 5.1 "Analysis of financial framework and funding gaps" (LowTEMP 2020 (1)).

4 Business Model Tools

During the work with GoA 5.3 and this report it has been obvious that the countries in the Baltic sea regions and their district heating situation are very different with regards to main fuels, regulations and country and regional sustainability goals. The four business model tools described in this chapter has been chosen to be applicable regardless of the metioned local differences. The methods could include national, regional and local support schemes aswell as cooperation between customers and suppliers and other different stakeholders. The four tools can be used for developing business models for low temperature district heating. The tool Business model canvas has been chosen because it is a visual and useful tool. The helicopter model is developed in order to give an overview of the local situation. The Ladder of value has been developed within the LowTEMP project to illustrate the possibilities of how one could design different value propositions for low temperature district heating to add value to the customer or inhabitants. And finally, the Bridges method has been choosen for illustrating the importance of involving stakeholders and encourage them to put value on their incentives in order to induce collaboration to promote low temperature district heating. In chapter 6 we will summaries and give examples of how to use these tools presented in five common scenarios for introducing lowtemperature district heating systems in the Baltic sea region.

4.1 Business Model Canvas

A business model is argued to be a set of assumptions or hypotheses as described by Osterwalder and Pigneur (Osterwalder 2010), who developed the most well-known template to construct those hypotheses, the Business Model Canvas. Business Model Canvas is a strategic management template for developing new or documenting existing business models. It is a visual chart with elements describing value proposition, infrastructure, customers, and finances. The Business Model Canvas is based upon a strategic process that by means of using a template to document existing business models. It is a visual chart with elements describing a nine-component business model in an organized way to lay out assumptions about key resources, key partners and key activities of your value chain, and also value proposition, customer relationships, channels, customer segments, cost structures, and revenue streams.

Table 3 The nine components of the Business Model Canvas and the basic questions addressed for each of the components

Component	Basic questions addressed
Customer Segments	Who are the customers? What do they think?
Value Propositions	What is the gain you provide or the need you satisfy? Why do customers buy from you?
Channels	How are these propositions promoted, sold and delivered? Why? Is it working?
Customer Relation-ships	How do you interact with the customer and how do you get, keep, and grow your customers?
Revenue Streams	How does the business earn revenue from the value propositions?
Key Activities	What uniquely strategic things does the business do to deliver its prop-osition?
Key Resources	What strategic resources does your business have or need?
Key Partnerships	What non-key activities can you outsource to enable you to focus more on your key activities.?
Cost Structure	What are the major costs incurred by your business? How are they linked to revenue?

The Business Model Canvas is a business tool used to visualise nine components of a business, including customers, route to market, value proposition and finance. Table 1 show the nine components of the Business Model Canvas and the basic questions addressed for each of the components and Figure 12 illustrates the interrelations between the nine components of the Business Model Canvas.

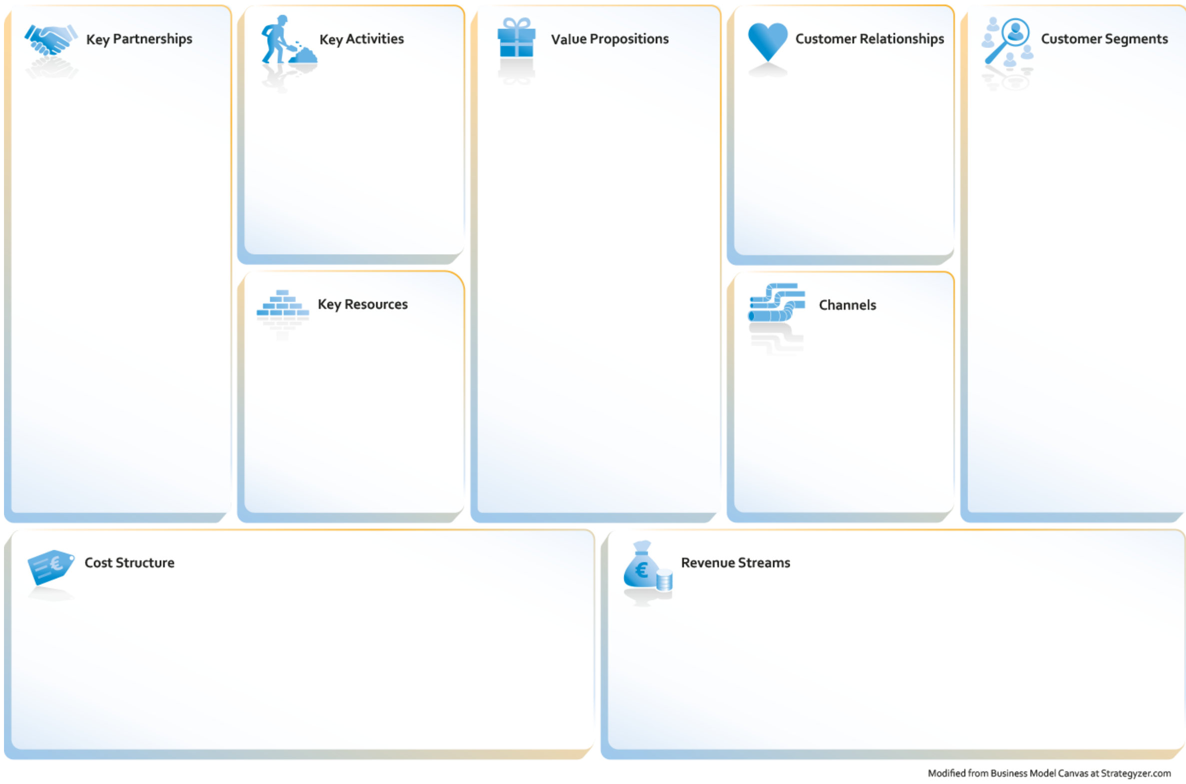

Figure 11 Business model canvas modified within the LowTEMP project and based on Business model canvas at strategyzer.com

Below, the components of Business Model Canvas are described more in detail.

Customer Segments

The customers are the heart of your business model, without profitable customers, a business does not survive over time. In order to better satisfy the customers, you may group them into distinct segments with common needs, common behaviours, or other attributes. The business model may have one or several large or small customer segments. Often a business needs to decide about which segments to prioritise and which segments you may ignore. Once this decision is made, the business model can be carefully designed around a strong understanding of specific customer segment needs. Customer groups represent separate segments if they for example needs a distinct value proposition or if they are reached through different distribution channels. They can also be determined through different aspects of the value proposition.

Value Propositions

The value proposition is the present that solves the customer's problem or satisfies its need and is the reason why a customer turn to one business over another. Each value proposition consists of a selected collection of products or services that match the requirements of a specific customer seg-ment. Some value propositions may be innovative and represent a new offer, others may be similar to existing market offers, but with added features and characteristics.

Channels

The sales channels contain the business interface with the customers, and they are the customer touch points that play an important role in the customer interaction. The channels serve several functions, including raising awareness among customers about products and services and helping customers evaluate a value proposition. Furthermore, the channels allow customers to purchase specific products and services, it delivers a value proposition and may provide post-purchase customer support.

Customer Relationships

A business needs to clarify the type of relationship it wants to establish with each customer segment. Relationships are established through different channels. Relationships can range from personal to automated, from short-term to long-term, and can aim to acquire customers, retain customers, or increase sales. The type of customer relationships strongly influ-ences the overall customer experience.

Revenue Streams

The revenue streams are essential for the business and dependent on which value each customer segment is willing to pay for? A business may generate one or more revenue streams from each customer segment. Each revenue stream may have different pricing mechanisms, such as fixed list prices, bargaining, auctioning, market dependent, volume dependent, or yield management. A business model can involve revenues resulting from one-time customer payments, or regular revenues (e.g. a subscription).

Key Activities

The Key activities of a business represent what the company must do to make the business model work. These activities can be producing a product or providing a service, or a mix of both. The Key activities are the most important actions a business must perform to operate successfully. Key activities need to create and offer the value proposition, reach markets, and earn revenues. The key activities differ depending on business model type.

Key Resources

Every business model requires key resources which allow the business to create and offer a value proposition, reach markets, maintain relationships with customer segments, and earn revenues. Different key resources are needed depending on the type of business model. Key resources can be physical, financial, intellectual, or human. Key resources can be owned or leased by the company or acquired from key partners.

Key Partners

Key partners are the external resources that a business need to perform the key activities and deliver value to the customers. It is not reasonable for a business to own all resources or perform every activity by itself, therefore, the relationship with key partners is intended to optimize the allocation of resources and activities. Optimization of partnerships are usually formed to reduce costs, and often involve outsourcing or sharing infrastructure.

Cost Structure

The cost structure describes the most important costs associated with a specific business model. Creating and delivering value, maintaining customer relationships, and generating revenue all incur costs. Such costs can be calculated relatively easily after defining a business model. Some business models, though, are more cost-driven than others.

4.1.1 Rules for using Business Model Canvas

The Business Model Canvas was released under Creative Commons license. Anyone may use the Business Model Canvas for their own work or to support others in understanding, analyzing or changing their business models. This includes people who use the tools within their own companies or in a consulting capacity. The requirement is full identification and credit of the source of the tool, the Business Model Canvas, which is Strategyzer.com.

The Business Model Canvas, released under Creative Commons license, is open for building other approaches and variations on the concept. There have been a number of variations discussed and demonstrated. Where variations have been made, recognition of the original source material must be included in the variation. The text and link Strategyzer.com should be clearly visible and legible under every canvas.

4.2 Business Model Canvas for conventional district heating

When using the business model canvas tool on conventional distict heating classic business model for district heating it is a conventional production and business logic is economies of scale. And the business model is rather straight forward see figure 13.

The customer segments of the DH business model, the largest customer segment is professional customers e.g., large building owners.

The key resources are production units and distribution networks.

Key partnerships are fuel providers. And the key activities are production, distribution, and maintenance. The value proposition for the conventional district heating is heat and hot water.

The customer relationship is that the company is provider of heat to the consumer. And the channel for communication are invoices and campaigns. The Cost structure are large fixed costs on the other hand the revenue streams are also rather fixed and large.

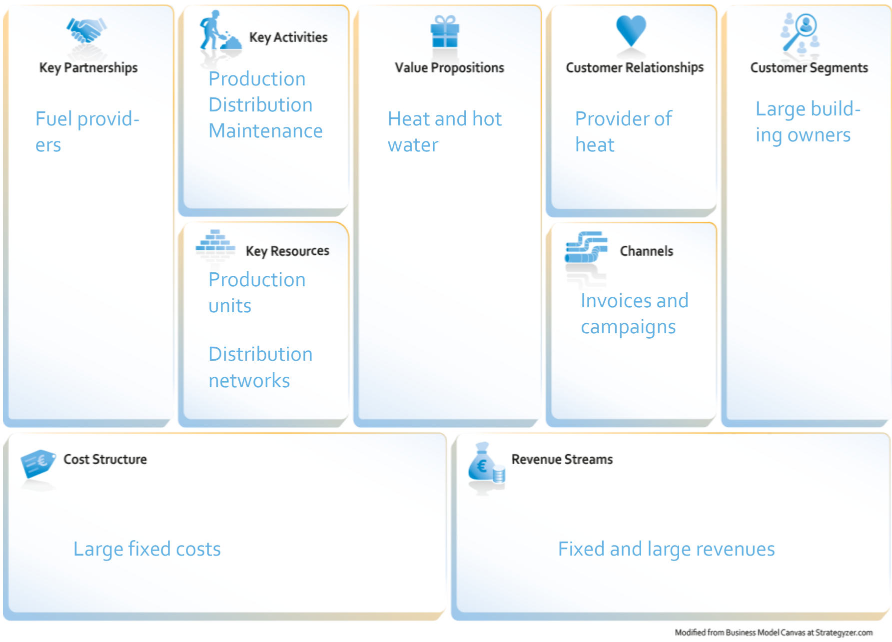

Figure 12 General example of Business model Canvas for conventional district heating

4.3 Business Model Canvas adapted to Low temperature district heating

In the following section follows a description of a prediction of how the different components in business model canvas is predicted look when the tool is adapted to LTDH. Should be pointed out that all changes are not possible to do at once and each company has ist own boundaries. But this could be seen as inspiration of how one could think and often one need to do several different business models in order to find those that are most likely to work. For each customer segment or value proposition a new canvass can be filled in order to see how the different segments need to be changed.

Customer segments for Low temperature district heating

In general terms one would expect that the customer segment will be more diversified. There will be both large and small consumers, industris, public buldings, landlords, private and public house owners. Prosumers will most likely also be part of the customer segments.

Value propositions for LTDH

Different value propositins for different costumers. More value such as „fossile free carefree indoor climate“. It might be possible to choose fossile free energy as have been for electricity.

Channels for LTDH

Predition the company will use different channels for different customers segments. Also, perhaps different type of information regarding energy usage etc. In the electricity sector cellphone applica-

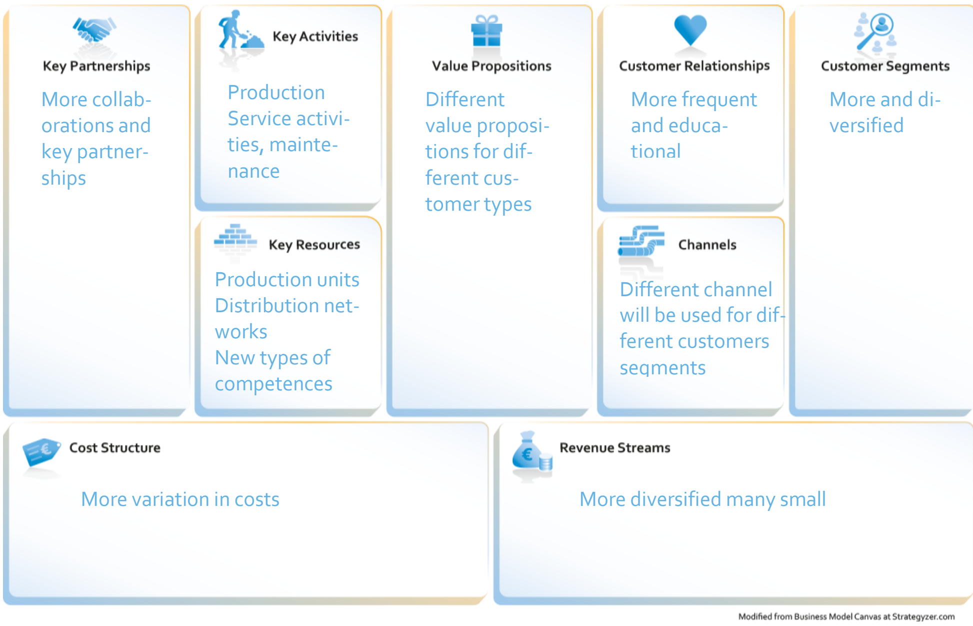

Figure 13 Example of a general Business model Canvas for LTDH compared to BMC for conventional district heating. For more information see text.

tions have been used so could also be done on the district heating. Especially when one starts to use solar panel and other renewables.

Customer relationship for LTDH

The prediction is that customer relations will be more frequent and educational. The district heating company could teach their customer how to save energy and money etc.

Revenue streams for LTDH

In general terms more variation in costs and new price models where a well funtioning system, sub-station is promoted in order to keep return tempeatures low. Different types of revenues for example fron service agreements and insurances.

Key resources for LTDH

The heat production unit and the grid will still be the core but new competences such as good service and neogotiation skills. Storage of heat, solar energy plants etc

Key activities

Shift from production activities to more services activities. Still production of heat but taking care of customers and equipment will be more and more important.

Key partnerships

More collaboration and key partnerships with consultants, prosumers, surplus suppliers, prefabricated house, suppliers of appliances.

District heat companies could work together with insurance companies in order to reduce the insurance fees if the customer change heating system to DH which in some cases removes on site fuel and chemical storage.

Cost structure for LTDH

Predition that the cost will vary more. Generally, investment costs for renewable energy are high but on the other hand the fuel price for most of the renewables are low. More cost for services and maintaines.

4.4 New business models for low temperature district heating

In the the paper "Economic benefits of fourth generation district heating" (Averfalk 2020) it is stated that it for several decades, has been common knowledge within the district heating community that lower distribution temperatures increase efficiencies and decrease the supply cost.

But the there has not been a strong economic driving force for vital changes in the basic technology for heat distribution. A recent energy system analysis assessing socioeconomic costs for low-temperature heat distribution from future renewable and recycled heat sources with lower temperatures has addressed significant cost reductions (Lund 2017). It is required a combination of low distribution temperatures and lower heat supply costs in combination in order to promote an economic driving force for low-temperature district heating.

As described in the previous section 4.2 and 4.3 the business model for traditional district heating is a classic production of heat where the logic of economy is scale. The bigger the production site is and the bigger the customers are the there bigger the income becomes because the production cost for each kilo watt hour is reduced. If one put conventional district heating into a Business Model Canvas it could look like figure 13.

When a district heating system shift and goes from high to low temperature the margins in the system reduces and then you need to have better control of what is happening in the system. The low temperature district heating system is dependent on the right return temperatures. In order to keep track of return temperatures etc investments are required to be able to measure and monitoring supply and return temperature. In addition, substations need to be working properly.

In the traditional Business model for district heating the revenue are based on connection charge, fixed element and a variable element based on the amount of heat consumed. In the LowTEMP project theses revenues are described in deliverable GoA 5.2.

Due to new directive on energy performance in buildings within the European union (European Parliament and council, 2010) the heating and the increased outdoor temperature due to climate change the heating demand from the houses has decreased. But the demand for hotwater is almost the same since people will keep up with their personal hygiene taking shower and washing up as before. Hence the volumes of kWh which lowers the income from that element in the business model for conventional district heating.

If a district heating company lowers the temperature the heat losses will decrease and the generation cost would also go down since the amount of fuel is lowered but on the income and revenue side the amount of heat delivered to the customer will also go down so the income will also decrease.

As been discussed in section 3.4 of this report there is an economic potential to use renewable energy sources and they are more suitable for low temperature district heating than traditional combustion fuels.

But the incentive to convert to lower temperature hence selling fewer kWh has previously not been there. This is mainly since the business models of conventional district heating referred to as 3rd generation district heating is referring to the business logic of scale both within the production and in the price models the consumers pay for the amount of energy the consume.

But the renewables are better suited for low temperture and it wold be unlogic to charge more per kwh when a lower temperature is delivered. That is one reason why new business models are re-quired in order to make the business profitable.

In a paper by Lund et al.2017 it is assumed that the current DH systems need to be developed further to be part of a future, 100% renewable energy system. The writers stated that next (4th) generation of DH must fulfil the following aspects and be able to:

- supply low-temperature DH for space heating and domestic hot water to existing buildings, energy renovated buildings and new low-energy buildings
- distribute heat in networks where the distribution losses are lower (than the conventional 10–30%)
- recycle heat from low-temperature heat sources and integrate renewable sources such as solar and geothermal heat
- be a part of an integrated, smart energy system (encompassing electricity, gas, fluid and thermal grids)
- ensure planning, cost and motivation structures to develop a future sustainable energy system

The business models for low temperature district heating is more complex since for example the heat supplier is more dependent on the performance of the devices and the heating system at the costumer and the customer relation needs to be more developed. Today there is no renewable energy source that is the Sustainable Solution with capital S and works in all weather. That is why our prediction is that low temperature district heating systems will depend on several energy sources.

In order to minimise the risk of high dependence on electricity price a business model where a combination of both energy sources which benefits from a low electricity price is combined with energy source which benefits from a high electricity price might be preferable (Authors own comment).

4.5 The Helicopter model

In the LowTEMP output 3.2 „Methodology for strategies to implement LTDH“ in chapter 2 “Analysis of preconditions” the authors addresses the importance of Urban preconditions in addition to technical preconditions and analysis of excisting planning documents.

The helicopter model described below could be used as a complement and perhaps as a brain storming tool followed of the more technical oriented GoA 2.3 “Methodology for strategies to implement LTDH “

The target groups are municipalities and regional politicians, district heating companies and decision makers. It could also be used as a visionary tool in order to mentally put the users in a time machine and asking the question “what do you want to see when you come back in 10 years?”.

The helicopter model is supposed to give an overview of the geography and the urban preconditions at a certain time in a local or regional area where one could develop a low temperature district heating grid or system.

The name helicopter model is chosen to give the user the feeling of travelling by helicopter over the landscape and notice what preconditions there are in the area. And sometimes the helicopter is hovering some specific spot.

This model could be used by the municipalities and regional government as well as district heating company when preparing for a new district heating network or renovating an old one.

The tool gives an overview and put the heating system into the regional context by addressing different targets with the limelight.

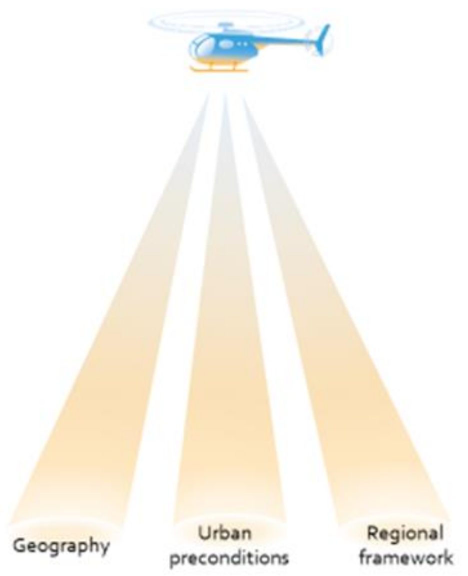

Figure 1 The helicopter model developed within the LowTEMP project. A tool that could be used to get an overview

Geography :

- Where in the world are we?
- Close to water? Sea, lakes, rivers?
- What kind of landscape is it? Forests? Agricultural?
- Climate zone?
- What kind of geology?
- Is it possible to store heat in the ground, water?

Urban preconditions:

- What are the main industries, shopping centres, swimming hall or ice rink?
- The settlement structure, i.e what kind of buildings (appartments, family houses, public buildings, industrial area?
- Could they be interested in heat, energy or cooling?
- Potential suppliers of surplus heat (e.g. data centres, industrial objects, sewage plants)? Who will be customer? Who owns the buildings? When will the heat loads be?

Regional framework:

- Are there any legislation or incentives, that promotes or prevents certain fuels?
- Are there urban plans to be considered?

4.6 Ladder of value

The ladder of value tool complements the Business model Canvas but focuse on the value proposition and value proposition over time in oder to give the user a tool to illustrate its visions and goals.

The value ladder tool is a tool to be used when planning development of a district heating company for a longer time. In this tool one set what the value proposition i.e what product and services the district company want to offer. As we see it the tool could also be used by a municipality in order to set a value proposition in order to attract new inhabitants/ taxpayers and companies and organisations.

In this tool the change in value propostion is illustrated by a staircase for each step the value is increased. The value proposition is written on the steps. Below each step one identify and list the key activities (the action points), the key resources (the equipment, infrastructure and competences) and key partners (collaboration and partnerships) that are need to be in place in order to reach the step and the value proposition.

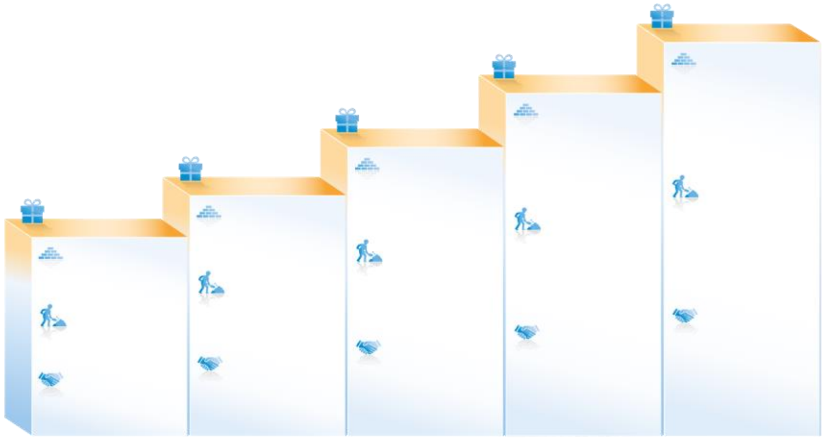

Figure 14 Ladder of value a business model tool which can be used when developing new value propositions. The higher up in the ladder the greate value.

The purpose of the tool is to inspire to set goal for new value proposition and identify what needs to be done in order to reach these goals.

When working with the ladder of value one can use a table tool se table 4 for an example of how a transition from the value proposition "heat" to "Climate positive, carefree indoor climate & energy" might look like. Just to make some examples. Exactly what is needed could vary from case to case and the examples are just examples

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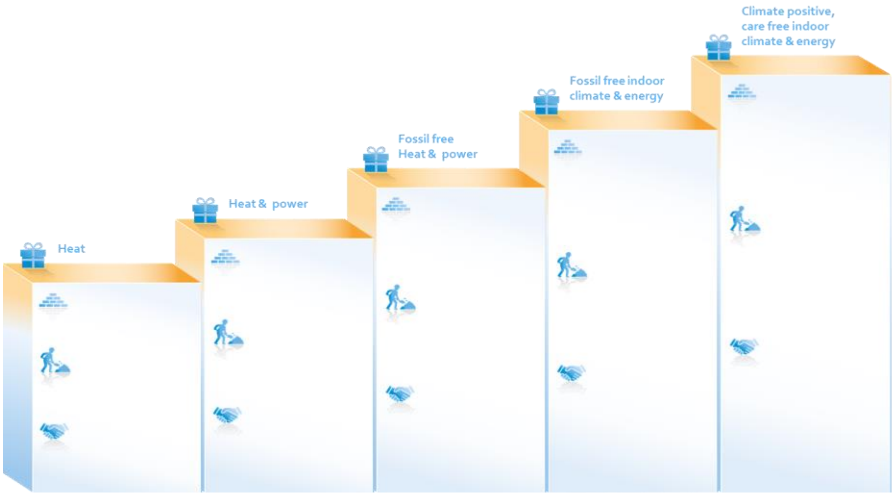

Figure 15 Example of the ladder of Value with different value propositions

As mentioned in section 4.2 in this report. The value proposition for conventional district heating company is "Heat".

Hence "Heat" is placed on the first step here in the bottom of the value chain.

The key activities to produce heat is:

- combustion of fuel
- heating water
- Deliver heat to costumers

The key resources to be able to deliver heat is

- Fuel
- boiler
- district heating grid

The key partners to be able to deliver heat could be

- Fuel suppliers

If we now jump to the last step in the example when the heating company has the value proposition "Climate positive, carefree indoor climate & energy"

The key activities to deliver Climate positive, carefree indoor climate & energy could be:

- Produce biochar
- Store CO_2

- Deliver service and "a good nights sleep" to costumers

The key resources to be able to deliver the value proposition is

- Pyrolysis boiler
- Service competence and customer knowledge
- Smart measuring devices. In order to get early notice when service is required and malfunction of substations mm. Also to get information about when peak hours will be. The smart measuring devices could also in corporate weather forecasts in order to predict when more energy will be required in the system.

The key partners to be able to deliver value proposal could be

- Farmers and other biochar users such as municipalities.
- House manufactures to sell in Low temperature district heating and have good prices on heat exchangers.
- Appliance manufactuers since in order to reduce the customers electricity bill LTDH water could be used for washing machines and dish washers.

Table 4 An example of listed key activities, key resources, and key partners for each of the value propositions in a four step step Ladder of value

Value Proposition	Heat and hot water	Heat, hot water & electricity	Fossilfree indoor climate & energy	Climate positive, carefree indoor climate & energy
	1st step	2nd step	3rd step	4th step
Key Activities	1. Combustion of fuels 2. Heating water 3. Deliver heat to customers	1.Convert heat to electricity 2.Deliver electricity to costumers	1. Convert to fossil free fuel 2.Deliver cooling, heat , hot water and electricity	1.Produce biochar 2. "Store CO2" 3. Deliver service to customers
Key Resources	1. Boiler 2. Grid	1. Steam generator 2. Electricity grid 3. Electricity competence	1. Heat and cooling storage 2. Cooling grid 3. Cooling competence	1. Pyrolysis boiler 2.Service competence 3.Smart measuring devices
Key Partnerships	1. Fuel supplier	1. Electricity organisations 2. Building owners	1. Procumers 2. Forrest owners 3. Air device suppliers	1. Farmers and other biochar users 2. House manufacturers 3.Appliances suppliers

4.7 The bridge model - price of value

As mentioned in report 3.2 "Methodology for strategies of implement LTDH" (LowTEMP 3.2 2019 (5)) and Pilot Energy Strategy documents in the LowTEMP project the stakeholders are pointed out as very important factor when planning for a low temperature district heating net. The authors of this report agree very much to this and the importance of the stakeholder analysis.

We have borrowed and adapted the stake holder part from the bridge method with permission from the inventors (Klevhag 2020). The Bridge method in its fully form is described in reference (the Bridge)

The tool could be used as a complement to the the stake holder analysis and virtually gather several stakeholders around the same „table" and goal.

The first step is to identify each stake holder's incentive their gains of a low temperature district network. In this step it is good to put on the "visionary glasses" and highlight the advantages with LTDH. Each local district heating network is unique and depending on the starting point the incentives may differ from case to case. But some incentives seem to be universal such as for example each regional healthcare system want a healthier public, most municipals want to attract more companies and new taxpayers, most consumers are not willing to pay more for less.

Figure 16 In the bridge method each stakeholder is placed around the table and theire incentives are investigated then the monetary value is estimeted

Below an example of what the incentives for each stakeholder could be when a low temperature district heating net with renewable energy sources replaces a high temperature district heating grid heated with fossil fuels.

- **Government** within the region- Less CO_2 emissions, less health care costs due to pollutant related illness, more energy and money to other activities
- **District heating company**- lower cost for heating, more locally produced energy sources less dependent on fossil fuel import and fluctuating prices. Higher investment costs. In switching from high to low temperature, introducing renewable energy sources and using surplus energy the companies has the opportunity to increase their corporate social responsibility.
- **Municipality**- a more attractive living area resulting in new inhabitants which care about the environment, more attractive area for producing companies caring about the environment which could result in more taxes which could be used for better municipality services and an environmental friendly
- **Customer**- not willing to pay more for less. But if the service is better (i.e the value proposition is changed to a more valuable product and service. The willingness to pay more increases.
- **Suppliers** – might be willing to give a better price for devices in order to get a good reference, pipe suppliers, washing machines, dishwashers.
- **Insurance company**- might be able to give lower insurance price to Customers connected to LTDH since district heating is a more robust and reliable heat source. And if the customers previously were using local heat sources which had a much higher risk of causing fire this might also be an incentive to insurance companies to recruit new customers by lowering the home insurance fees.
- **Investors**- want to have return of investment. The incentive is that it might be good for their environmental or social responsibility image which could attract other picky and conscious companies with shorter return of investment time horizon to let the investor invest in their business. This could also be the bank realising that this is a business opportunity since new inhabitants could bring new customers to the bank. As an example of investors with very long investment horizon are pension funds in Denmark that are investing in district heating grids.

When the incentives are identified the next step is to estimate the monetary value of the incentive. This is not so easy, but the purpose is not to have the correct numbers the purpose is the awaken the stakeholder's interest to convert them in favour for LTDH, i.e LTDH ambassadors and make the LTDH grid a reality.

In order to put some figures for the incentive one could start calculating with percent and assumptions.

- If this new LTDH results in 50% less COekv/kWh. What will that correspond in health care cost due to pollutant related illnesses?
- If this new LTDH could support 5 000 new family apartments or 8 000 new taxpayers what will that result in taxes? And so on.

One should remember that the value for each stakeholder group depends on the present situation and the goal. The challenge is to identify the monetary value for each stakeholder. When the monetary value is identified there could be incentives to set up subsides, funding etc in order to create or increase incentives to initiate the realisation of LTDH project.

For example of incentive that could result in subsides or funding could be the regional government realises that many lives or days in hospital could be saved and thereby initiate a subsides to cover a funding gap that could create or increase the incentive for the investors to dare to invest or the bank to give a loan. It could also be the bank that realises that this could give them a chance to do something good for the society and thereby also get good publicity which could attract new conscious customers.

Another incentive could be initiating labour measures such as education for coal mining work crafts that might be out of work when coal will be replaced with other energy sources. Problems with unemployment among coal diggers have been seen in for example Spain when coal is fased out.

4.8 Other examples of innovative pricing and business models

- **Negotiable tariff** – i.e many Bank offices have negotiable interests for loans on housing. Would it be possible to have a similar system for district heating? One part of the tariff could be negotiable perhaps depending on when the energy is used to avoid top loads. It could also have to do with if the customer buy several services from the same company as compared to insurance companies where you could get a discount if you have both your car, health and house insurance at the same company.
- **Reduction on Insurance cost**- The heating company could cooperate with insurance companies. The risks of fire reduce if you go from i.e gas boiler to district heating. It could also be a way for the insurance company to promote „environmental friendly „ businesses.
- **Heat account** – the customer could choose to pay a fixed amount each month regardless of what the consumption is. The heat account could balance the heat costs over the year. Some month the customer pay more than he needs and others less. It works as a balancing bank account.
- **3 times Safty** – An insurance offer as a service in collaboration with insurance company where the customers each month pay a small insurance fee. In exchange the insurance pay the costumers heating bills if the customer becomes unemployed or sick. And in case of accident caused by the LTDH system the excess is repayed. This insurance is already used i Sweden for electricity companies.
- **"Green heat"**: The ability for the consumers to pay a little bit more per kwh in order for the district company to deliver fossil free heat. A similar alternative is used for electricity in Sweden for example.

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4.8.1 Example of innovative price model for LTDH

A price model which promotes return temperatures below 20 degrees celcius could be introduced. This exemple is borrowed from Kraftringen and the COOLDH project. The price model consists of the following:

- Connection fee -one time fee
- Minimum energy price- there is a limit on the minimal level of consumed energy
- Return temperature fee- each degree is important, and the fee is raised at different rate depending on the temperature range. This promotes well functioning substations
  - Return temperatures below 20 degrees Celsius results in no return temperature fee
  - Return temperatures between 20 -35 degrees are "level one"
  - Return temperatures above 35 degrees are "level two"

The price model is self-regulating so that the customers never pay less than the minimum energy price, and never more than the energy price plus the maximum "level two" return. (CoolDH 2019)

4.8.2 Example Gentofte Gladsaxe District Heating different prices models

Gentofte Gladsaxe District Heating in Denmark offers two different price models for the customers. Price model A were the district company is doing all installations when the customer is connected to the district heating. This results in a higher heat price but less worries. And the value proposition to the customer is different from the model B where the customer by themselves are supposed to contract VVS utility companies etc on the other hand the heat price euro/kWh is less since no ser-vice fee is included. According to the website 95% of the customers choose the model A.

Essentially, the DH company takes over the entire installation, including the unit inside the house. They also offer the connection for free in limited periods when they are rolling out DH in new areas. (Gentofte 2019)

5 Innovative funding structures

District heating is a corner stone in national energy policies and district heating systems has been developed and continuous expanded over the last 100 years all over Europe. All countries have their own regulation and financial instruments for expansion and upgrading the heating systems. A key element is access to funding. Most countries have funding structures with elements of grants, guaranties for pay – back of loans or subsidies to introduction of renewable energy sources etc.

The characteristics of investments in district heating are almost the same. District heating costs are usually quite heavy in initial investment costs, due to the high prices of the heat production plant and the infrastructure required to deliver heat to the customers. Large loans are taken in financial institutions and the pay-back time is often between 20 and 30 years. Both funding and direct subsidies from national or EU-funds are important for the investment design.

Most of the above applies to both traditional district heating and low-temperature district heating. However, due to the innovative nature of low-temperature district heating, it is often easier to receive EU funding for these types of projects, which are often also more expensive due to their innovative nature of using new or improved technology or designs. There are many different EU funding structures as well as national programs that seek to assist new and innovative technologies. For up-to-date information it is possible to contact a national knowledge bank or the different EU fund's homepages.

The graph below (Figure 18) shows the German model of funding gaps, where I is investment cost (CAPEX), O&M is operation and maintenance cost (OPEX) and R is Revenue. Our approach to funding channels mostly focuses on the initial investment costs I/CAPEX and possibly O&M/OPEX, as well as the option to have a non-repayable grant.

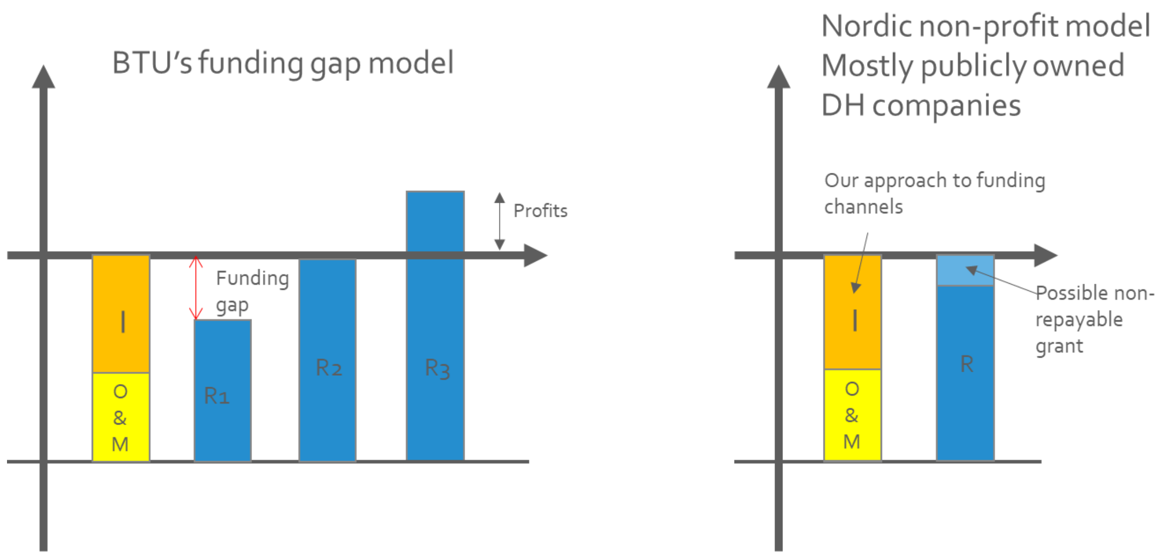

Figure 17 An illustration for different funding scenarios of district heat projects modified from report 5.1 (LowTEMP 2020)

In appendix 1 of this report, you will find an investigation of the countries in the Baltic Sea Region; how their district heating companies are structured, how they usually fund their district heating projects and other relevant information related to the cost and funding of district heating operations, such as mandatory connections and heat tariff regulations.

This investigation is summarized in chapter 3 where the countries are compared to each other and suggestions of innovative and alternative funding structures are presented.

Since the most common way for district heating companies to fund their projects is through their own capital, private or public loans and EU funding, it is important to also talk about some of the lesser-known funding structures that are available.

Listed below are two tried-and-tested methods that could have a positive impact on district heating projects.

5.1 Crowdfunding

Crowdfunding is not a new concept. It has been used in many aspects and many fields before. Some famous crowdfunding platforms are Kickstarter and Indiegogo, which lets innovative ideas get funding and gauge interest before starting a project. It has also been used in many solar, wind power and other RES projects in various forms. Crowdfunding falls into two main categories. A non-financial category, where investors are either donating or get some sort of reward or benefit in exchange. This type is used a lot in Kickstarter campaigns, but rarely in energy projects. The other category is the financial part, where a funder will either act as a lender and receive a fixed interest on their investment or as a type of shareholder, where the funder will receive an equity share. This category is what we will be focusing on here.

In district heating and especially low-temperature district heating, crowdfunding can play a significant role. It is a well-proven fact that personal engagement reduces resistance to projects and financial engagement even more so. Especially when talking about nimbyism (Not In My Back Yard Syndrome), the more engaged and invested you get your stakeholders/customers, the less resistance you will get.

When you look at certain cooperative business models for district heating, you get a very different buy-in from the customers and a bigger engagement in how and what the company should involve itself in. Crowdfunding can be another opportunity for district heating companies to gain a better customer/stakeholder relationship, spread more knowledge about district heating and its benefits and how increased connection counts helps drive down the marginal price per customer.

The practical implementation of crowdfunding for the lending category is like any other type of investor situation, where a fixed return on investment is offered. For equity offerings, this will be better implemented in a new company structure, so existing district heating companies do not offer equity in all their services, but only on the services and assets that the crowdfunding helped finance.

All in all, crowdfunding is an interesting and promising concept that is gaining more and more ground and is being used for bigger and bigger projects within the energy sector. It can be readily used for district heating providers and might help strengthen the connection with their customers and stakeholders. (Tempo 2018)

5.2 Energy Service Companies - ESCO

Energy performance contracting (EPC) is an agreement between a producer of energy and an energy consumer. This type of agreements has been developed over the last two decades in order to attract investments and improve efficiency within the energy sector. The most widespread type of EPC is linked to Energy Service Companies.

The Energy Service Company (ESCO) provides energy services to end users such as households, schools or sport arenas. The ESCO could be a national and an international company with high expertise within energy production, distribution of heat and energy efficiency in buildings. Furthermore, the ESCOs have a huge sum of money to the investment or they have access to capital.

Table4 A description of ESCO and other stuctures (Nwe Europe 2019)

Type	Description	Contracts required
ESCo	An energy services company (ESCo) undertakes to supply heat to the customers, and for that purpose to build and operate the DH system. This could be set up with a defined set of consumer buildings to be connected, or to provide the service to developments within a defined area.	• Master agreement • Connection contract • Heat supply contract • Service level agreement (SLA) • Property leases
Wholesale supply of energy (Design-Build-Operate)	A sponsor appoints a single contractor to design, build, operate and supply wholesale heat and electricity. The sponsor sells the energy retail to consumers and may be a consumer itself.	• DBO Contract • Wholesale heat supply contract with SLA • Connection contract • Property leases
Network delivery and operation	A sponsor (such as an owner of tenanted properties) appoints one or more contractors to design, build, operate and maintain a DH network but the sponsor remains the asset owner and contracts to supply heat and electricity to consumers. The sponsor may also purchase the fuel required.	• D&B Contract • O&M contract with SLA • (Metering and billing contract) • (Connection contract)
Network operation	An operator is contracted to run a DH system that has already been constructed, for example under a main building contract. The operator may also be contracted to undertake metering and billing	• O&M contract with SLA (Metering and billing contract)

	and customers services, if the landlord wishes to outsource these activities.

Normally the ESCO invest in production or distribution facilities and/or energy efficient equipment in buildings. They estimate the value of the improved energy performance and they guarantees energy savings and a provision of the same level of energy service at lower cost. The investment is linked to a contractually agreed level of energy efficiency performance over a period of 10 – 15 years. The risk of the investment by not achieving the energy performance target is normally taken by the ESCO.

A part of an ESCO contract could be provisions of investments in renewable energy sources in order to transform the heat production facility away from fossils fuels towards low carbon emission systems. As an example, is investments in greater heat pumps.

The ESCO concept is often used in areas where the production facilities and building standards are poorly renovated over many decades. The advantages for the consumers are low investments, low risk, stable energy prices for an agreed period and a clear responsibility of energy performance and maintenance. This is attractive to many households or municipalities.

Large heat plans and bigger district heating systems are favoured by the ESCO – concept simply because the investments are huge, and the payback time is long and there are many costumers to pay back the investment. This can be a challenge to small systems and small companies.

There are many advantages within the ESCO concept but also a few disadvantages. One of the disadvantages is the lack of introduction of new technologies during the contracting period of e.g. 15 years. Once the investment has been made by the ESCO the company is less interested in making new investments during the pay-back period. This could be related and additional investments in solar panels or heat pumps as a supplement to the existing production facility.

The ESCO contract can be combined with ownership models like a build-own-operate-transfer (BOOT) model. In the ESCO contracting period the ownership is transferred to ESCO and after the period the heat plant could be given back to the original owner – the municipality or a district heating company.

In the table below (Tabel 6) different ESCO ownership models are shown.

Table 5 Different ownership models are described (Nwe Europe 2019)

Abbreviation	Description
BLT	Build – Lease – Transfer
BOO	Build – Own – Operate
BOOT	Build – Own – Operate – Transfer
BOT	Build – Own – Transfer
BRT	Build – Rent – Transfer
D&B	Design – Build
DB(F)O	Design – Build – (Finance) – Operate
PFI	Private Finance Initiative
FBOOT	Finance – Build – Own – Operate – Transfer
O&M	Operation – Maintenance

In many countries the authorities (Energy Regulator) have to approve an ESCO contract in order to check that the consumers have fair heat prices and reasonable conditions of there are changes in energy markets prices. The check of the ESCO-agreement is also relevant if the municipalities subsidise the agreement by paying a part of the renewed heat installations.

If municipalities are interested in ESCO – agreements first step will be to contact the national energy authorities in order to investigate the regulations within this area. They also have experiences with the different ESCOs and can provide contact details. (Coolheating 2017, Upgrade DH 2019)

6 New value chains, professions and business opportunities

6.1 Examples of new value chains

When starting to think about cicular economy new value chains could be formed when for example different types of waste are converted into energy. Below two examples of value chains coupled to biomass are presented in both examples most of the value is added in the heat production and distribution.

Business models for District Heating Companies (DHC) can be developed with various different earning logics or strategies to generate revenues, maintain profitability and sustainable business operations. The more operations entrepreneurs can manage, or in other words utilize the value added, the better is the profitability. Of course, this requires efficiency in each stage of the process. (CoolHeating, 2017)

As an example of typical heat energy entrepreneurship, forest residues could have a price of 1 €/MWh (paid to the forest owner), as pro-duced wood fuel the price in the silo could be about 14 €/ MWh, while the price of sold heat could be 55 €/MWh (Okkonen, et al. 2010). Therefore, the most value added is in the heat production and distribution stage.

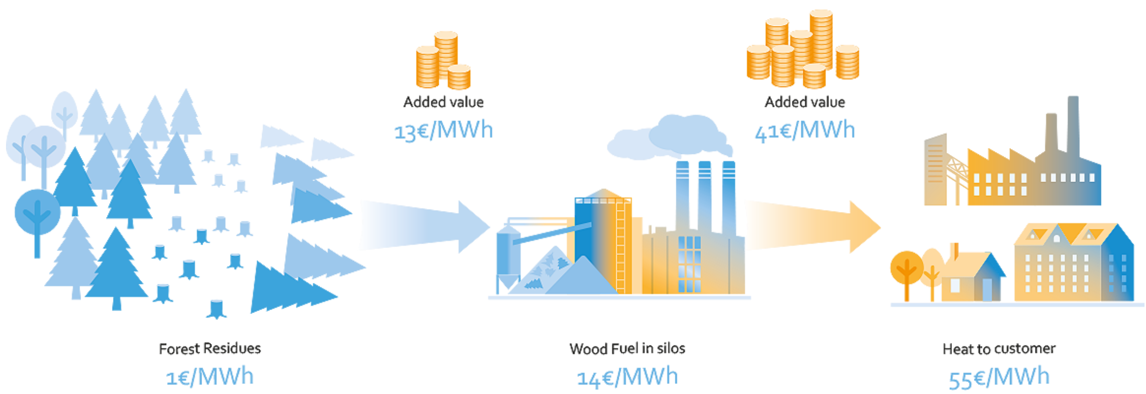

Figure 18 Value chain where forest residues are converted to district heat

Another example of how a value chain could be created is the story of Skånefrö and Bio-agro energy in south of Sweden. Skånefrö is an agricultural company producing grass seeds. They created a valu chain from grass husks and residues to climate-positive district heating. The transformation went step wise. First the grass husks and residues are converted to a type of pellet which could be used for heat. Then the local district heating system was developed. In the next step there was an investment in a small pyrolysis facility in order to produce biochar and heat in the next step a bigger pyrolysis facility is producing biochar and heat. The biochar is then used as soil improvement medium and since biochar stays in the ground for a very long time (store CO2) the district heating is climate positive.

Since Skånefrö is a commercial company and not a public district company there was some concerns with the district heating costumers that they might increase the heat price to much. In order to avoid this uncertainty, there is a clause in the contract with the costumers that states that the heat price cannot be increased more than the mean value of the three surrounding district heating companies heat price increase.

6.2 Examples of new business opportunities

New actors in the supply chain and new strategic partnerships could forexample be when a district heating company starts to own forrest or start to collaborate with a mining company in order to develop geoenergy and there by ensuring their energy source.

Examples of new partnership could be manufacturers of prefabricated houses in order to promote low temperature district heating and substations and heat exchangers. It could also be fruitful to collaborate with suppliers of appliances such as washing machines, dish washers and substations.

New partnership could also include landloards in order to add a part of the connection fee to the price of the plot or lot of house. Also, collaboration with building owners and housing cooperatives in order to for example ensure well functioning substations etc.

The heating company could cooperate with insurance companies. The risk of fire reduces if you go from i.e gas boiler to district heating. It could also be a way for the insurance company to promote „environmentally friendly „ businesses. (Veolia 2019)

There could also be new business opportunities for companies specialicing on collaboration and organisation of challenges. Especially if more cities do as Helsiki did when they announced a global one-million-euro challenge competition to answer the question: How can we decarbonise the heating of Helsinki, using as little biomass as possible (Energy challenge 2020).

6.3 New business opportunities and professions

As the collaboration between the heating company and different industries with surplus energy is developed. The heating companies either will need to have the competence to collaborate or de-velop strategic partnership with consultants and organisations experts in the area. This could for instance develop a new business area for symbiosis match making organisation or a profession within the municipalities or regional government.

In Kalundborg in Denmark there is an interesting example of an organisation working for symbiosis between different companies. The Kalundborg Symbiosis creates sustainable development in companies through joint projects.

Sustainable Business Hub
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EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

6.3.1 Symbiosis broker

Since the collaboration between heating companies and heat suppliers requires a win win situation and negotiation for both partes to feel safe a new profession could evolve i.e. a Symbiosis broker or neogotiator. This symbiosis broker might be employed by the municipality and investigate which companies and organisations that might be able to offer surplus heat.

6.3.2 Digital district heating for a flexible energy system

To evenout the heat demand over the day i e peak shaving. Smart devices and services have been developed by for example the energy company Eon. These devices can be introduced to buildings management system for large buildings to store heat within the building construction without affecting the indoor climate. Via this short time storage of heat within the buildings the heat system is prepared when when the heat peaks come without creating heat peaks at the pro-duction site. For example this way to use digital district heating for a flexible energy system the flexible capacity for the city of Malmö in Sweden is 70 MW which is 10% of the genera-tion/production capacity according to Peter Berne at the conference „the future of theremal grids". (LowTEMP 2019 (1))

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7 Concluding recommendations on business model approach and funding structures

This chapter serve as summary of the core of the report and we will give som examples of how the business model tools and funding structers presented in this report could be applied on five common scenarios for introducing low temperature district heating in the Baltic Sea Region.

The five common scenarios are:

- Scenario 1: Existing DH operator: New development area with energy efficient buildings
- Scenario 2: Existing DH operator preparing to replace fossil fuels and/or improvning primary energy factor
- Scenario 3: Access to surplus heat or RES, no DH grid
- Scenario 4: Older private buildings with local heat supply, which will undergo major refurbishment
- Scenario 5: Existing building stock of large buildings, which will undergo refurbishment

7.1 Common scenarios for introducing LTDH in the Baltic Sea Region

According to the desciption of GoA 5.3, the business models and funding structures we present, should be applicable to the most common LTDH scenarios in the Baltic region. To set the scene of how it might look in the district heating reality in the partner region, some common scenarios are described below. They are partly based on the pilot measures tested in the LowTEMP project. Suitable business model tools and funding structures are presented for the different scenarios.

7.1.1 Common scenario 1

<u>Existing DH operator: New development area with energy efficient buildings</u>

- Key stakeholder: Existing district heating operator, owning both grid and a substantial part of the energy production
- Connection of area with new development, consisting of energy efficienct buildings, with low heating demand and technical installations suitable for lower supply temperatures
- The regular business plan and price model will not be profitable and technically optimal, since the new buildings will consume less energy and heat losses in the grid will not be covered
- A new secondary grid (separate loop) with lower temperature is built within the new development area to decrease heat losses
- The DH company can choose to use the same (well known) grid infrastructure as is used in the rest of the grid or switching to cheaper plastic grid solutions to cut overall costs
- The DH company could look at offering additional services to the customers

There are a number of potential heat sources, which is chosen depending on availablity and local conditions:

- Exisiting heat production is used, lowering of temperature in the secondary grid
- Connection of surplus heat from third party
- Solar Thermal Heat
- Environmental energy
- Use of return pipe heat
- Heat pumps, geoenergy
- Power to heat (PV or wind power)

Funding structure recommendation for scenario 1:

Existing DH operator: New development area with energy efficient buildings

An existing district heating company which expands into an area with energy efficient buildings, will usually not sell much heat per building compared to older buildings, per definition. Therefore, the costs will have to be managed in some other way. This also means, that connection coverage in the area, if not mandatory, is crucial for the financial feasibility of the project. Depending on whether it is individual houseowners or one big contractor that needs to decide, the approach will vary. A contractor will usually think in terms of costs and resale value and not operation (costs). So here some type of ESCO model might be the most beneficial, where a suitable ownership and operator distribution will be agreed upon. For individual houseowners, the engagement needs to be present for the connection percentage to be as high as possible, in order to keep costs low and revenues high. This can be achieved by either publicity or a type of crowdfunding campaign.

Business model recommendation for scenario 1:

In this scenario we would recommend using Business model Canvas and Ladder of Value to find new value propositions to reach the new customers and to create new business models for the second grid.

It could also be recommended to introduce an innovative price model where the amount of energy consumed is not the cost driving factor for the consumers. If instead of or in combination with a new price model the DH company encourage the customer to increase the amount of energy consumed as heat by initiate a key partnership with white gods supplier and add a service to use domestic hot water for white goods. This has been shown to reduce the amount of electric energy used by 35 % or 0.3 kWh/wash cycle for dishwasher and up to 60 % reduction of electric energy and 0.6 kWh per cycle for washing machines (Kralmark 2013) and (Kralmark 2018).

7.1.2 Common scenario 2

Existing DH operator preparing to replace fossil fuels and/or improvning primary energy factor

- Key stakeholder: Exisiting district heating company operating fossile fueled CHP plants
- The company is preparing to change the energy source in the future or improving primary energy factor, du-e to regulatory reasons or the company's environmental goals
- The connected customers mostly have existing buildings with varying needs for supply tem-perature, but mostly high temperatures
- The new heat source should be renewable or recycled: surplus heat, geoenergy, solar energy, environmental energy, bioenergy
- The local availability of energy sources, might point to a low temperature grid being the most sustainable solution
  - To prepare a possible shift to a low temperature grid, the DH company need to map which supply temperatures customers really need
  - Customers need to adapt to enable lowering the temperature in the grid for the DH company
  - Cooperation is needed with building owners to refurbish houses to become better adapted for lower temperatures
  - Short term, buildings with a need for low supply temperatures, could be connected to the return pipe

Funding structure recommendations for scenario 2:

Existing DH operator: Replacing fossil fuels and/or improving primary energy factor

Getting public engagement for an "internal" efficiency project might be troublesome, so here it would make sense to use a combination of the company's own capital and funding from a place like the EU, for improving CO2 emissions and energy efficiencies, which, for the moment, there are plenty of funds supporting.

Business model recommendations for scenario 2:

For this scenario it would be a good approach to get an overview and use the helicopter model in order to investigate and screen for alternative energy sources, the need for energy and heat storage etc within the area. There could be some regional or national investment funding supporting suitable fossil free fuels.

It is also recommended to use the Bridge method to get the bets from the players i.e investigate the incentives and the value of the incentives for the different stake holders. How much is it worth for the municipality or the regional government to reach the environmental goals.

When the different customers demand is mapped it might be useful to use the tool Ladder of value and Business model canvas to develop different business models and value proposition for different customer segments with regards to their temperature demand. It might also be a business opportunity to provide energy saving services to some of the high temperature costumers. They might not need the high temperature requirements if they implement some energy efficiency measures within their processes.

The Ladder of value could also be useful to the DH company to use as a way to illustrate their future goals i.e the development of the company over several years.

7.1.3 Common scenario 3

Access to surplus heat or RES, no DH grid

- Access to large, stable amounts of surplus heat and/or land area for solar thermal park and/or heat pumps
- There is a nearby area with local heat solutions in the buildings or a natural gas grid today
- An entirely new DH grid needs to be developed and build, LTDH would offer lower investment costs
- The key stakeholders could vary and include factories, households, municipalities, small DH companies
- Ownership of grid and production could be organized in different manners
- Some buildings could need refurbishment to be able to connect to LTDH

Funding structure recommendation for scenario 3:

Access to surplus heat or RES, but no DH grid

For this scenario, there is no existing infrastructure, which is a major investment if traditional district heating grids are to be implemented. So low-temperature grids are to be selected if possible. Investment costs will also be dependent on how many customers will be connected. This means that public engagement is critical for the project to be implemented. Therefore, a crowdfunding campaign would be highly beneficial, to increase awareness and publicity of the project, while at the same time possibly drawing in investors. The ownership structure, depending on availability, could be either an existing district heating company expanding, possibly as an island system or as a cooperative venture, owned by the investors or customers.

Business model recommendation for scenario 3:

For this scenario it is recommended to use the Bridge method tool investigate the incentives and the value of the incentives for the different stake holders as has been identified in stakeholder mapping. How much is it worth for the municipality to attract new businesses and inhabitants i.e taxpayers and to be able to show a sustainable leadership in order to introduce long term goals. Since local heating solutions and natural gas is used.

It might be a good idea to include insurance companies as stakeholders since they might give lower insurance fees to buildings connected to district heating. For houses previously connected to natural gas solutions often also needs to change their stoves. Hence suitable technical suppliers might be interesting stakeholders and key partners to

Before initiating the new LTDH grid project it would be a good approach to get an overview and use the helicopter model in order to investigate and screen for alternative energy and heat storage etc within the area. There could be some regional or national investment funding supporting suitable fossil free fuels such as solar thermal energy.

7.1.4 Common scenario 4

Older private buildings with local heat supply, which will undergo major refurbishment

- Larger area with older buildings (households) with local heat supply, which will undergo major refurbishment
- Heat supply includes older wood furnaces or oil burners of different environmental standards, which cases poor air quality locally
- Municipality have strong incentives to decrease health hazardous emissions
- Buildings will undergo energy efficient refurbishment and new technical installations will enable lower supply temperatures
- There is an option to shift to centralized heat production; solar energy, heat pumps, environmental energy, bio energy or surplus heat

Funding structure recommendation for scenario 4:

Older private buildings with local heat supply, about to be renovated

For this scenario, depending on what exactly needs to be financed, municipal funds could be utilized and a collaboration with the heat provider, whether a district heating company or a cooperative of the buildings being renovated, will need to be established. This could utilize elements of ESCO models in terms of ownership and crowdfunding for stakeholder engagement and fundraising/equity-sharing.

Business model recommendation for scenario 4:

For this scenario it is recommended to use the Bridge method tool to investigate the incentives and the value of the incentives for the different stake holders as has been identified in stakeholder mapping. In this scenario when old houses are included it is especially important to include house owners, architects, insurance companies, municipality units for tourism, social services.

Since local heating solutions is used. It might be a good idea to include insurance companies as stakeholders since they might give lower insurance fees to buildings connected to district heating. For houses previously connected to natural gas solutions often also needs to change their stoves. Hence suitable technical suppliers might be interesting stakeholders and key partners to offer lowered price on stoves etc. Since old houses might have a high value for tourism the refurbishment would have to be "gentile" to keep the attraction to the area hence suppliers of building and roof integrated solar cells might also be interesting stakeholders.

Before initiating the new LTDH grid project it would be a good approach to get an overview and use the helicopter model to investigate and screen for alternative energy and heat storage etc within the area. There could be some regional or national investment funding supporting conversion of social burdened neighbourhoods.

The Ladder of value could also be useful to use for the municipality to communicate and illustrate their future goals for the neighbourhood i.e the development of the area over several years. The value propositions are directed to the inhabitants since the refurbishment most likely will increase life quality, for the inhabitants. Different activities could be initiated to reduce costs, introduce maintenance activities and build pride within the inhabitants. By turning a social burdened neighbourhood to an economic, social, and environmentally sustainable neighbourhood there is a great value to the municipality. There are some good examples in the city of Malmö in south of Sweden (Malmö 2020)

7.1.5 Common scenario 5

<u>Existing building stock of large buildings, which will undergo refurbishment</u>

- Major energy efficient refurishments of larger existing buildings (for instance public) will take place, in accordance with new near- zero- energy-house regulations
- The business case for the existing DH operator is becoming less profitable, as less heat can be sold to some large customers
- Risk of higher return temperatures and increased heat losses since the grid still need to be run as a high temperature grid
- Refurbishment could mean there will an adaption of technical installations within the buildings
- If buildings within a DH area with many customers are refurbished one at a time, use of return pipes to heat selected energy efficient buildings could offer a slow shift to LTDH

Funding structure recommendation for scenario 5:

Existing building stock of large buildings, about to be renovated

If the building stock is refurbished to near-zero-energy regulations, then the heat sales will plummet, making it an unfavorable transition for the heat provider. Therefore, a collaboration must be made between the building owners and the heat provider to ensure a common ground. A transition to a low-temperature grid/connection or even a cold one, might be required for the project to be financially feasible for the heat provider, if even a grid is needed. ESCO models could be investigated here in terms of ownership. Crowdfunding is a possibility, but it might not make sense depending on who the owners are and how many of them there are. EU funding could be an option given the ambitious goal of the zero-energy outcome.

Business model recommendation for scenario 5:

In this scenario we would recommend to use BMC in order to find new value propositions to reach the old customers and to create new business models.

Use the helicopter model in order to investigate possibilities for heat storage, in the ground, in buildings etc. Could also be used for map heat demand at different costumers. This together with weather forecasts, technical devices and monitors could to be used to predict when the heat peaks are in the system and by fine tuning the grid there might be option to lower the supply temperature with few degrees at some hours and increase it at other in order to reduce the overall fuel costs. Since the peak fuel cost has a great impact on the heat production cost.

Recommended to introduce an innovative price model where consumers are rewarded for low return temperatures and where high return temperatures is a cost driving factor. In order to further reduce peak fuel costs the price model could include hourly heat prices reflecting the heat production cost at peak hours.

It would also be a business opportunity to provide energy saving services to the costumers. They might save electrical energy if they use domestic tap water for white goods such as dishwashers and washing machines see example in scenario 1.

8 An outlook of other projects

As a part of the 5.3 work package an orientation about previous work within the area business models for low temperature district heating has been done. In table 7 an outlook of projects with regards to business models and financing of LTDH are presented with project names and links to their work on business models, pricing and low temperature district heating is listed. The results and reports of these projects can be studied for complementay tools and knowledge on the subjects covered in this report and the LowTEMP project.

Table6 Project and links to business model related work

Project name	Short description and links to business model related work
Cool DH	In this Horizon2020 project business plans for the two demo sites are developed http://www.cooldh.eu/reports/business-plans-and-legislation/ and http://www.cooldh.eu/reports/webinars/
KeepWarm	EU-funded project addressing cost-effective investments in the modernisation of District Heating Systems. Tools and guidelines related to analysis of fuel and energy prices, business models and social acceptance of district heating http://www.keepwarmeurope.eu/learning-centre/business-models-and-funding/
ReUseHeat	https://www.reuseheat.eu/ https://www.mdpi.com/2076-3417/9/15/3142/htm Creating awareness and raising interest – to create a demand for urban waste heat recovery investments Fostering engagement – to create an acceptance of urban excess heat recovery investments Accelerating the market uptake of the ReUseHeat solutions – to facilitate implementation through a handbook that also outlines business models, contractual and legal arrangements, financing and technology solutions
Flexynets	www.flexynets.eu FLEXYNETS will develop, demonstrate and deploy a new generation of intelligent district heating and cooling networks that reduce energy transportation losses by working at "neutral" (15-20°C) temperature levels. Reversible heat pumps will be used to exchange heat with the DHC network on the demand side, providing the necessary cooling and heating for the buildings

GEODH	Examples of business models for geothermal district heating projects could be found in https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/geodh_final_publishable_results_oriented_report.pdf
EFFECT4buildings	http://www.effect4buildings.se/en/Pages/default.aspx In this Interreg project exceltools have been developed for Effective Financing for implementing Energy Efficiency in Buildings http://www.effect4buildings.se/en/financial-Tools/Pages/default.aspx
Celsius-2-0	This collaboration hub has resulted in a toolbox of district energy knowledge and business models https://celsiuscity.eu/toolbox/ https://celsiuscity.eu/toolbox/business-finance/
Hotmaps	https://www.hotmaps-project.eu/ In this horizon 2020 project has developed a toolbox that supports local, regional and national heating and cooling planning processes. https://www.hotmaps-project.eu/how-to-use/ https://www.hotmaps.hevs.ch/map
Heat Roadmap Europe	The Heat Roadmap Europe 4 (HRE4) project developed energy scenarios and energy models https://heatroadmap.eu/energy-models/ Peta and FORECAST will be used to understand the heating and cooling sectors, while JRC-EU-TIMES and EnergyPLAN will be used to model the development of the heating and cooling sectors into the wider energy system. Also guidelines for policy makers has been developed https://heatroadmap.eu/webinars/#fifteen
Euroheat & Power EHP	Examples with innovative success stories of conversion to 100% Renewables https://www.euroheat.org/knowledge-hub/case-studies/ Guide book for LTDH https://www.euroheat.org/wp-content/uploads/2017/12/IEA-Annex-TS1-Final-Report.pdf PLANHEAT tool can be used both for policy decisions and master planning oriented activities https://www.euroheat.org/news/planheat-tool-now-available-download/

UBIS	https://ubis.nu/ In this Interreg project has been working with industrial symbiosis and developed some tools for decision and evaluation of symbiosis https://ubis.nu/publications/
TEMPO	TEMPO will demonstrate the applicability of low temperature district heating. Including technological innovations on the network and building side, consumer empowerment enabled by digital solutions and innovative business model for EU replication. https://www.tempo-dhc.eu/
UPGRADE DH	The overall objective of the Upgrade DH project is to improve the performance of district heating (DH) networks in Europe by supporting selected demonstration cases for upgrading, which can be replicated in Europe. https://www.upgrade-dh.eu/en/publications-reports/ https://www.upgrade-dh.eu/en/home/
Rewardheat	Focusing on the exploitation of the energy sources available within the urban context allows to maximize the replicability potential of the decentralized solutions developed in the eight demo sites within the project. Change of paradigm with respect to the business models devised: thermal energy will be sold as a service to the customers. https://cordis.europa.eu/project/id/857811

9 Authorship

The proposed funding business models and funding structures has been developed and finalized within the group of activity 5.3 of LowTEMP project with contribution from the partners reported below:

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11 Appendix 1: Ownership and funding structures for district heating in the Baltic region

11.1.1 Estonia

Usual ownership structures:

Large district heating and CHP: Foreign and national corporations

Smaller plants: Private company, subsidiary of a municipality or a municipality

Utility company owns both the district heating plant and the distribution grid

3rd generation district heating

Funding structure:

Investment subsidies and soft loans for district heating investments:

- Environmental Investment Centre (Up to 50% subsidization) by ERDF Measure "Effective production and transmission of thermal energy"
- EIC is the managing authority for grants and subsidies and ERFD measure is the source of money
- Direct Investment finance and subsidies

Feed-in tariffs for co-generation

Legal framework for district heating regulation:

Local authorities can decide to establish district heating regions in densely populated areas

Puts regulations on pricing for sale of heat

Minimum requirements for buildings are at 150-160 kWh/m2/a (multi-apartment building and small residential buildings respectively)

No direct legislation for domestic hot water DHW, although the norm is 55 °C

District heating companies are allowed to include a profit in their calculation of heat prices. The maximum selling price is agreed upon, approved and supervised by the National Competition Authority. The regulations are determined by the District Heating Act. The profits are usually in the range of 7-9 % but are capped at 9%. (LowTEMP 2019 (3))

District heating regions can be determined by a comprehensive plan, in order to "ensure a secure, reliable and effective heat supply". Therefore, the council of a local authority can determine such district heating regions to be established in densely populated areas.
(District Heating Act. § 5. District heating regions.)

11.1.2 Finland

Usual ownership structures:

District heating companies are usually owned either completely or partially by municipalities and cities.

Some companies may have ownership among external organizations, such as joint-stock energy companies, cooperatives and municipal enterprises. Some state-owned enterprises are also producing district heating.

In high population density areas, district heating companies are typically larger utility companies that provide heat, cooling, electricity and water. In the more sparsely populated areas, district heating is provided by companies which only deal with district heating.

District heating companies usually own both the distribution grid and the heat production facilities.

Primarily 3rd generation district heating, with some 4th generation

Funding structure:

District heating is based on financial subsidies, tariffs and regulation and guidelines.

Allocation of state aid, such as Energy Aid, is granted for investment and development projects that further renewable energy production or use. The investment subsidies are usually between 15 and 30% of the investment cost. For new technologies/innovations the cap is 40%.

Feed-in tariffs for co-generation.

Legal framework for district heating regulation:

Pricing for district heating is meant to be "appropriate pricing" and is regulated by the competition legislation and enforced by the Finnish Competition Authority, while also being guided by the Finnish Energy trade association. These measures are in place to ensure that pricing for district heating is cost-correlated and reasonable, as well as dominant players not using their position to abuse the market.

Municipalities have the option to force new buildings to join a district heating network, but this provision is under discussion to be removed.

New buildings are required to be 50-60 kWh/m2/a. (LowTEMP 2019 (3))

11.1.3 Germany

Usual ownership structures:

District heating companies usually own both heat production facilities and the distribution network.

Ownership is usually a pluralist structure (joint stock companies and limited liability companies), with a strong public component and a multitude of mixed ownership forms.

Approximately 78 % of district heating suppliers are owned by a municipality as a main shareholder (>50 %), the remaining 22 % are regional or transnational companies and stock corporations.

Funding structure:

Germany has a unique approach to district heating projects, which concerns the funding gap. Project economy will be calculated from the current assumptions and a funding gap will possibly be identified. This will in many cases be funded by state aid as a non-repayable grant in order to make the project financially feasible.

Investment subsidies for renewable energy sources and building new pipelines. developed by the Ministry for Economics and Energy. Additionally, there are subsidies for investments related to district cooling grids and heat storage. There are websites that list all available funding and subsidies available for applications.

Smaller district heating grids have energy cooperatives and utilize crowd funding

Feed-in tariffs on cogeneration.

Legal framework for district heating regulation:

Obligation to connect to district heating and District Cooling systems in some municipalities. Regulated by a law that municipalities can use.

Heat tariffs are regulated by law.

For newly built houses heated by district heating, the approximate energy consumption is limited to around 90-100 kWh/m2/a (BBSR 2020, Förderdatenbank 2020, AGFW 2020, LowTEMP 2019 (3))

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11.1.4 Latvia

Usual ownership structures:

Municipally owned district heating companies represent the majority. But there are private limited district heating companies, where the main shareholders are usually either companies or private people.

The Government of Latvia also owns district heating companies. They are the main owner of the largest district heating company operating in Riga.

It is characteristic for district heating companies to own both the heat distribution networks and the production facilities, but it is not uncommon that the heat is also bought from other heat producers and energy companies.

Funding structure:

District heating companies either finance the projects via their own capital or apply for available European Funds (e.g. Cohesion Fund). Additionally, some projects can be financed by municipal funds. However, municipalities do not finance private district heating companies, but they can support them in other ways, such as favorable lease conditions, etc.

In the case of EU financed projects, the terms are equal for private and public district heating companies

Legal framework for district heating regulation:

In high pollution areas the municipality can steer the development in a less polluting direction. (Either by requiring connection to district heating networks or by requiring low emissions energy systems (solar heating, heat pumps, etc.)

Newly constructed residential buildings have a cap on their energy use of 50-60 kWh/m2/a.

Regulated tariffs allow district heating companies to include up to 9% of profits. (LowTEMP 2019 (3))

11.1.5 Lithuania

Usual ownership structures:

80% of district heating companies are municipally owned.

Uncommon for heat supply companies to be public institutions, foreign capital companies or state enterprises.

Common practice that the heat producer is the owner of both the distribution network and the heat production facilities.

Funding structure:

Legal framework for district heating regulation:

Newly built houses are estimated to have a maximum energy efficiency of between

9 kWh/m2/month = 108 kWh/m2/a

35 kWh/m2/month = 420 kWh/m2/a

(Likumi 2020, LowTEMP 2019 (3))

11.1.6 Poland

Usual ownership structures:

Larger district heating companies are typically national or foreign companies.Smaller utility and district heating companies are typically domestic municipal or national companies. A Communal Association can be the owner of a district heating company.

Larger utility companies are in electricity generation, but due to high cogeneration numbers, they also sell district heating. Usually the ownership of the heat production facilities and the distribution networks are separated, there are also places where they are owned by the same entity.

Most companies in the energy industry are managed by a Polish operator. Some of them are publicly traded.

Funding structure:

Form of financing from the company's own funds, bank loans, national funds and EU funds. Operational Program Infrastructure and Environment, ERDF (European Regional Development Fund) and regional programs.
The funds obtained are allocated to improving energy efficiency, e.g. modernization of the transmission network, modernization of existing boilers or their replacement with modern gas boilers or renewable energy technologies.

Legal framework for heating regulation:
Heat tariffs should be calculated so as to cover business costs, taking into account return on investment (including CO_2 emissions).

The average price for heat is: 64.12 PLN / GJ (14.08 EUR / GJ) and the average price for a basic set of fuels for heat production is: 15.22 PLN / GJ (3.34 EUR / GJ)
Heating network parameters: ~ 120 ° C (heating season), ~ 65 ° C (outside the heating season)
EP indicator for newly built buildings: 95 kWh / m2 / a (now), 70 kWh / m2 / a (from 2021 Auer)
In order to obtain a building permit for a new building, it is necessary to provide a statement from the designer about the possibility of connecting the building to the heating network. (LowTEMP 2019 (3))

11.1.7 Russia (Republic of Karelia)

Usual ownership structures:

Commonly in Russia, district heating companies are large regional power and heat generation companies. These types of companies are often public joint stock companies. Major shareholders are usually private limited companies (LLC) or public limited companies (PLC). District heating companies are always private, never municipally- or city-owned. Exceptionally, the state may own a share of a district heating company.

Funding structure:

Since all the district heating companies are private companies, they all use their own capital and private loans in order to fund their district heating projects. There are no regional, national or international funds, subsidies or support schemes that the district heating companies can apply for.

Legal framework for district heating regulation:

70 °C with ambient temperature >0 °C, and ~115 °C with ambient temperatures < -10 °C for most favorable conditions. However, in many municipalities, temperatures are usually higher.

For Petrozavodsk the supply and return temperatures are on average 125 °C/70 °C (The 125 °C are connected to -29 °C outdoor temperatures), but in some small settlements the supply and return temperatures are lowered, in some places down to 90 °C /70 °C.

Heat tariffs in Karelia can only be increased up to 6% annually, but there are no limitations on how much a district heating company is allowed to charge for heat. Consequently, the regulated tariffs can differ a lot in neighboring regions or even within a city.

On average, households consume around 110-130 kWh/m2/a. (LowTEMP 2019 (3))

11.1.8 Sweden

Usual ownership structures:

Most commonly, district heating companies are owned by a municipality or a group of municipalities. Sometimes larger or medium-sized companies own some of the district heating plants.

District heating companies usually own both the distribution grids and the heat production facilities. However, due to a law passed recently, grid owners are forced to accept heat from third parties unless it poses a risk to heat delivery. Therefore, some heat production plants do not own their own grid. Some larger companies might separate their grid and production units into separate entities.

Funding structure:

The main source of financing in Sweden is Kommuninvest.se, similar to the Danish funding structure below, this is a municipally owned organization whose only purpose it to provide public institutions and organizations with cheap loans.

However, since not all district heating companies in Sweden are publicly owned, this method is not available for everyone, so other options must be investigated.

In Sweden there are also a few national funds that will assist with funding for climate friendly initiatives, however, they are difficult to obtain since they are not only directed towards district heating initiatives, but towards any technology. Moreover, they will rarely fund full-scale or large-scale implementations, since they are usually more geared towards test and demonstration projects. This might be applicable in some LTDH business cases, but the competition is fierce.

For HEM (an energy company owned by Halmstad municipality), must show their board a ROI of at least 8% and a payback time of 10 years or less for each investment. This is the case for all their network extensions and is a part of their standard growth strategy. They are self-sustained and always use their own money for investment capital.

The same goes for most, if not all, of the energy companies in Sweden.

Legal framework for district heating regulation:

Heat tariff prices are regulated by a national authority called "Energimarkandsinspektionen" (Energy Market Inspection). There is not a clear limit, only that the prices need to be reasonable.

National regulations are the same, whether the district heating company is publicly or privately owned. However, publicly owned district heating companies can have certain limitations pushed on them from their owners, usually municipalities, such as lower profits.

It can be made mandatory for customers to be connected to the district heating grid, for instance in newly developed areas, however, due to a general negative public opinion, not many municipalities make use of this.

Newly constructed buildings are required to use less than 50 kWh/m2/a. (LowTEMP 2019 (3))

11.1.9 Denmark

Usual ownership structures:

Larger heat production plants are usually owned by large energy companies, while smaller plants are owned by municipalities or consumer-owned cooperatives.

Of all district heating companies (400), around 350 are cooperatives.

Larger district heating systems tend to have separate companies for the heat production and heat transmission, while for smaller systems the district heating company usually owns both the distribution grid and the heat production facility.

Funding structures:

No further grants or subsidies for district heating companies exist anymore, instead loans from a common municipal credit institution named KommuneKredit offers loans at around 2% rate of interest, with security being one of the world's best. Almost all expansions in district heating systems are financed by loans from KommuneKredit.

Legal framework for district heating regulation:

Danish District heating is a non-profit system. This legislation means that the heating price paid by the consumer should cover all necessary costs to supply heat, and they are not allowed to make a profit. Moreover, heating plants cannot charge more for the heating than the costs of producing and transporting heat to the consumer/distributor.

Biomass for heating is heavily supported by grants, policies and tax exemptions. Biomass for heating is exempt from fuel taxes. Co-generation used to be subsidized as well, however, that expired in April 2019, with current plants keeping the subsidy until 2023.

It used to be mandatory to be connected and remain connected to district heating networks if it was available, helping spread the district heating systems nationally. However, in 2018, this provision was removed in order to avoid having customers being bound to companies with non-competitive prices.

All new district heating system projects are subject to certain regulations and calculations. They must all be subjected to socio-economic calculations as well as consumer price comparison (with other individual heating forms), to ensure that citizens are offered a good deal.

Newly constructed buildings are required to use less than 60 kWh/m2/a. (Bygningsreglementet 2020, LowTEMP 2019 (3))

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