



LowTEMP

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Analysis of financial framework and funding gaps

GoA 5.1

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List of abbreviations

AGFW	German District Heating Association
BSR	Baltic Sea Region
CD	Connection density
DC	District cooling
DH	District heating
DHAT	District Heating Assessment Tool
EAC	Equivalent annual charge
EC	European Commission
EEAG	Environmental Protection and Energy Aid Guidelines (often referred to as Guidelines on State aid for environmental protection and energy 2014-2020)
ESI	European Structural and Investment Funds
GBER	General block exemption Regulation
GoA	Group of Activities
IEA	International Energy Agency
IRR	Internal rate of return
ISO	International Organization of Standardization
LCOE	Levelized Cost of Energy
LTDH	Low-temperature district heating
NPV	Net present value
PES	Pilot energy strategies
PI	Profitability index
RE	Renewable energies
VBA	Visual Basic
w.d.	Without dimension

WP	Work package
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List of symbols

a	annuity factor [w.d.]
A	annual costs for operating & maintaining the DH system at current prices [€]
CF_t	cash flow in year t [€]
CD	connection density [MWh/(a*m)]
k	discount rate [%]
n	lifespan of the investment of the measure [years]
L	length of the considered line [m]
L_{total}	total length of the grid including main, branch and house connection lines
PV	present value or net present value of the project [€]
Q_c	customers' annual heat consumption [MWh/a]
$Q_{G, s, a}$	annual quantity of heat supplied and fed into the grid [kWh/a]
$q_{l, a}$	relative annual heat distribution losses [%]
$\dot{q}_{l, L}$	specific heat losses per line [W/(mK)]
$Q_{l, a}$	absolute annual heat distribution losses [kWh/a]
$Q_{l, a, i}$	heat losses in each line [kWh/a]
Q_{useful}	useful heat [MWh]
$\Delta T_{L, m}$	mean temperature difference [K]
t	time index number, a certain year of the investment [w.d.]
τ_N	annual operation time of the grid [h/a]
T_{ground}	mean temperature of the ground [K]
T_{return}	return flow temperature [K]
T_{supply}	supply temperature [K]

Abstract

This group of activity of the LowTEMP project analyzes how economic efficiency and funding gaps of low-temperature district heating systems can be determined. The objective is to develop a calculation tool that is able to determine both and that can be used by future stakeholders such as municipal actors, district heat suppliers, funding authorities and potential investors. In addition to fundamental knowledge taken from desk research, knowledge from other groups of activities of the LowTEMP project is considered. In order to verify the comprehensibility, user-friendliness and functionality of the tool, it is tested on one pilot measure by a project partner. As a result, an excel based tool is developed that is calculating the profitability and funding gap of a project based on the internal rate of return and net present value of an investment. The user has the freedom to configure investments in either grid, generating plant, or both. Up to three different types of generating plants can be chosen out of a variety of different technologies. A manual provides the user with information on how to use the tool and what information is needed in order to do so. It includes a catalogue with possible cost and revenue parameters as a guidance. However, the results of the tool do not imply any approval of funding. The tool has its limits: energy savings due to investments in already existing district heating systems cannot be economically considered so far. Besides that, all investments are considered over a period of 20 years. It is planned to develop the tool further during the remaining project period in order to lift these restrictions.

Keywords: low-temperature district heating, economic efficiency, funding gap, planning tool

1 Introduction

1.1 Problem

Low-temperature district heating (LTDH) has a huge potential to achieve substantial environmental gains while reducing primary energy use and creating possibilities to use surplus energy and distributed renewables as sources in district heating (DH) networks. Using local energy sources also increases flexibility and energy security.

The major challenges when it comes LTDH are not so much related to technical issues but often connected to economic or organisational aspects. Not only, because DH systems are monopolistic by nature, i.e. strictly regulated in terms of prices and tariff models. Also, investments in LTDH seem to be a financial burden in the first realization phase and funding schemes seem to be missing.

Actions like the reduction of primary energy consumption, the introduction of efficient district heating systems with cogeneration plants, the integration of renewable energy supply, the increase of the system flexibility and the reduction of final energy consumption are realized in European (EU) municipalities mostly as specific local investments and not on a large scale. The reason for this is, that looking at these actions under short-term market-oriented aspects, such investments need large upfront capital and may lack profitability and have a funding gap. However, with regard to climate protection targets, the promotion of climate-relevant projects, which do not have sufficient economic viability, is still absolutely sensible and necessary.

1.2 Aim of the work

In the case of non-prioritized economic viability, it is necessary to demonstrate the economic viability gap in terms of investment and the amount of unprofitable costs. For this purpose, an objective, transparent and effective procedure will be developed in LowTEMP's GoA 5.1, which is both suitable to calculate the profitability as well as the funding gap.

The target groups for the first part of output 5.1 (profitability) are those stakeholders, authorities, and institutions in the BSR, that are interested in and/or responsible for the planning and financing of new smart energy supply systems that include low-temperature DH grids, i.e. all municipal actors responsible for the strategic planning of the DH grid and DH suppliers.

The second part of the output, the calculation model of funding gaps, shall serve as a method especially for funding authorities and potential investors. The output shall support them in determining how much funding and financial support is needed for the installation of a LTDH system in their region or municipality.

The outputs will first be used by the LowTEMP partners, e.g. within the development of the pilot energy strategies. Broader target groups are municipal actors responsible for the strategic planning of

the DH grids, DH suppliers, energy agencies, planners, and engineers.

1.3 Tasks

In order to create a practical solution, various calculation methods and regulations, which are already applied in practice in the context of granting of subsidies, will be checked regarding their transferability to the project partners' regions. In addition, proposals and guidance including the necessary key figures for the profitability calculation of the investment in LTDH are examined and evaluated.

On this basis, the calculation method will be developed. It consists of two parts, namely the determination of profitability and, if present, the calculation of the funding gap. The first part will be elaborated in conjunction with GoA 4.3 "Development of life cycle cost analysis". A catalogue with characteristic cost parameters will be provided (for example costs per meter district heating pipe).

In the second part, the economic efficiency calculation method will be further developed in order to be also used as a method for calculating the funding gap. The calculation method will be described in the form of a guideline.

The developed calculation method will be tested in one pilot project that is connected to the activities in WP 3: a feasibility study for one municipality (e.g. Gulbene, Latvia) will be developed to prove the method under realistic conditions.

2 Legal framework for economic efficiency and funding gaps of (LT)DH projects

There is no obligatory legal framework for determining economic efficiency specifically of DH systems or unprofitable costs of infrastructure projects on international level available, that goes beyond EU level).

Therefore, the following sections deal with the legal framework on European and national level from countries of the BSR Region.

2.1 Legal framework on European level

On EU level, there is no obligatory legal framework for determining the economic efficiency of DH systems.

Concerning funding gaps, EU regulations and guidelines refer to this topic when defining the eligible costs of energy-efficient district heating and cooling systems and will be described in the following.

2.1.1 General block exemption Regulation

The *General block exemption Regulation* (GBER) contains regulations with which “the [European] Commission can declare specific categories of State aid compatible with the Treaty¹ if they fulfil certain conditions, thus exempting them from the requirement of prior notification and Commission approval” (European Commission 2018).

Regarding investment aid for energy-efficient district heating and cooling systems, Article 46 of the GBER defines the eligible costs of generating plants and grids of respective measures and their max. aid intensity (European Commission, Article 46).

The determination of eligible costs and their aid intensity is not the object of this work as this has to happen through funding authorities. However, when developing a suitable calculation method for funding gaps, basic regulations of the GBER have to be considered as it is part of secondary legislation according to Art. 288 of the Treaty and has therefor direct effect (European Union, Article 288). Besides that, future users of this main output have to be aware of the fact that the GBER has to be considered when applying for funding.

2.1.2 Guidelines on State aid for environmental protection and energy 2014-2020

With the *Guidelines on State aid for environmental protection and energy 2014-2020* or also called *Environmental Protection and Energy Aid Guidelines* (EEAG) the “[European] Commission sets out the

¹ Treaty on the Functioning of the European Union. In the following referred to as “the Treaty”.

conditions under which aid for energy and environment may be considered compatible with the internal market under Article 107(3)(c) of the Treaty” (European Commission 2014a, point (10)).

Points (73)-(75) of the EEAG define the eligible costs for energy plants of energy efficient district heating and cooling projects (European Commission 2014a, point (73-75)). Point (76) defines that the funding gap represents the amount of eligible costs for district heating and cooling networks (European Commission 2014a, point (76)).

The determination of eligible costs and their aid intensity is not the object of this work but should be considered when developing a calculation method for the determination of funding gaps. Unlike with the GBER, the EEAG gives a more precise definition of the term *funding gap* which is discussed in 3.1.4 *Funding gap* and relevant for this work. As a guideline, the EEAG is part of tertiary legislation and gives a more detailed description of the situation (Stiftung Umweltenergierecht 2014, S. 64). However, the GBER is superior to the EEAG and stipulates the max. eligible costs and aid intensities.

2.2 Legal framework on national level

As a regulation, the GBER is mandatory to all member states of the EU (European Union, Article 288). For LowTEMP, its use is obligatory in all EU member states that are part of the Interreg Baltic Sea Region Programme². It is online available and written in the respective languages of these countries.

As a guideline, the consideration of the EEAG is allowed as long as the thresholds for eligible costs and aid intensities mentioned in the GBER are not exceeded (Stiftung Umweltenergierecht 2014, S. 64–65).

Therefore, no further legal framework on national level from different BSR countries was analysed more detailed.

² In LowTEMP, Russia is a partner country and no member state of the EU. Legal framework of this country is not considered in this work.

3 Current state of technology and knowledge

This chapter shows the current state of technology and knowledge on economic efficiency, funding gaps and the financial framework of DH and LTDH projects. It takes information into account that is gathered from literature during desk research and information that was already gathered in other work packages of the LowTEMP project in the form of questionnaires.

3.1 Definition of terms

There are various definitions of the keywords used in this work. To avoid any misunderstandings, these keywords are defined and described in this section. Their definitions apply to the studies which are done in section 3.4 *Financial framework of District Heating systems in the Baltic Sea Region*.

3.1.1 4th generation of district heating and low-temperature district heating

The aim of the LowTEMP project is to “promote the installation of so-called 4th generation district heating networks” (atene KOM GmbH und Thermopolis Ltd. 2018). According to Thorsen et al., 4th generation district heating networks have flow temperatures up to max. 70 °C and return flow temperatures around 25 °C, compare with figure 1.

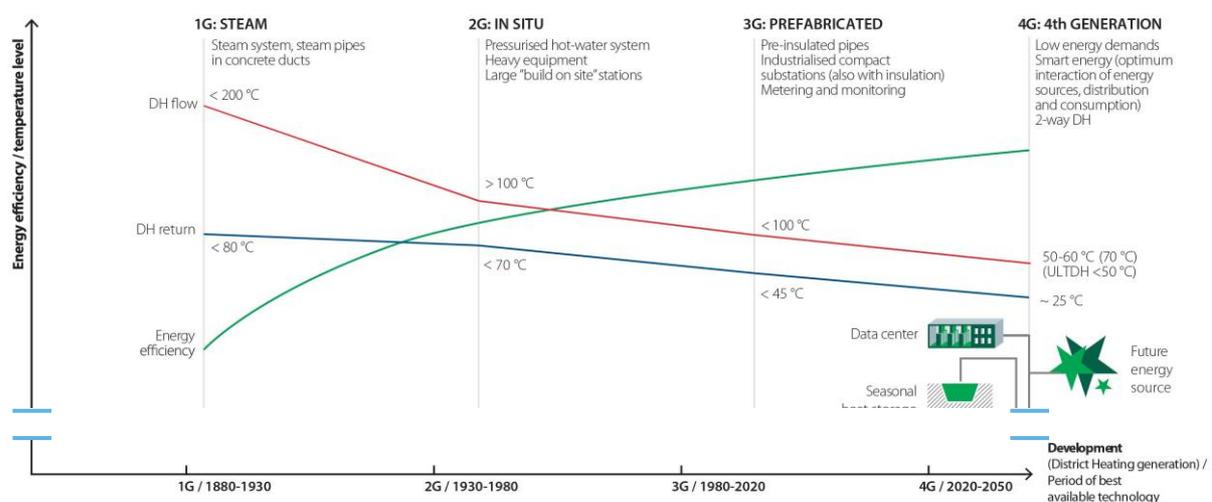


figure 1: definition of 4th generation DH networks depending on temperature level (section from Thorsen et al., 2018, p. 2)

Other definitions categorise 4th generation DH systems into temperature levels of 20 – 95 °C (ifeu 2017, S. 21). The LowTEMP partnership and thus this work recognize a temperature level of 50 – 70 °C (atene KOM GmbH und Thermopolis Ltd. 2019) as low temperature which complies with the other definitions mentioned.

3.1.2 Economic efficiency

There are several different ways from different areas to define the term “economic efficiency”. The most accurate term to describe “economic efficiency” which is meant in this work would be “economic feasibility”. It is “the degree to which the economic advantages of something to be made, done, or achieved are greater than the economic costs” (Cambridge Dictionary 2019a). Economic efficiency describes a value and “Value is created for an investor if the investor earns more than the investment costs” (Crundwell 2008, S. 163).

Simply said and applicable for this work: absolutely speaking, an investment is economically efficient when the sum of all revenues is higher than the sum of all costs (over a certain period of time). Relatively, one measure is more economic efficient than another one when its ratio of revenues and costs is more favourable than the ratio of the other measure.

3.1.3 Funding

The Cambridge dictionary describes funding as “money given by a government or organization for an event or activity” (Cambridge Dictionary 2019b). This implies that not just governmental institutions, but also private investors can provide money for a project. The word „funding“ itself in this definition does not say if money is given in form of a non-repayable grant or if it is some form of credit with interest rates that has to be paid back in the future. This is why further definition is needed:

Repayable and non-repayable grants can be described as financing and funding. The difference between these terms is that funding “is usually free of charge (...) [and] there are no requirements to pay back the capital. The most common facilitators that normally fulfill the funding needs of an organization are (...) governments” (Waqar 2015). On the other hand, financing is the “amount of capital or the sum of money provided to an organization with the expectation to repay, and organizations are liable to pay back the capital amount along with a certain percentage of interest” (Waqar 2015).

The author of this work shares this definition of the word funding and its differentiation from the term financing. Hence, if the term funding is used in this work, it will only consider it under these aspects.

3.1.4 Funding gap

In general, a funding gap can be described as “the amount of money needed to fund the ongoing operations or future development of a business or project that is not currently provided by cash, equity or debt. Funding gaps can be covered by investment from venture capital or angel investors, equity sales, or through debt offerings and bank loans” (Investopedia 2019b).

Regarding energy efficiency and energy infrastructure, the European Commission (EC) defines the term “funding gap” in the EEAG as the “difference between the positive and negative cash flows over the lifetime of the investment, discounted to their current value (typically using the cost of capital)” (European Commission 2014a, (point 19 (32))).

The German District Heating Association (AGFW) uses the term *uneconomical costs* instead of *funding gaps*. They represent that part of an investment that cannot be covered by revenues within the usual amortization period and are the basis for applying for funding (AGFW 2019).

The principle of funding gaps can be seen in figure 2.

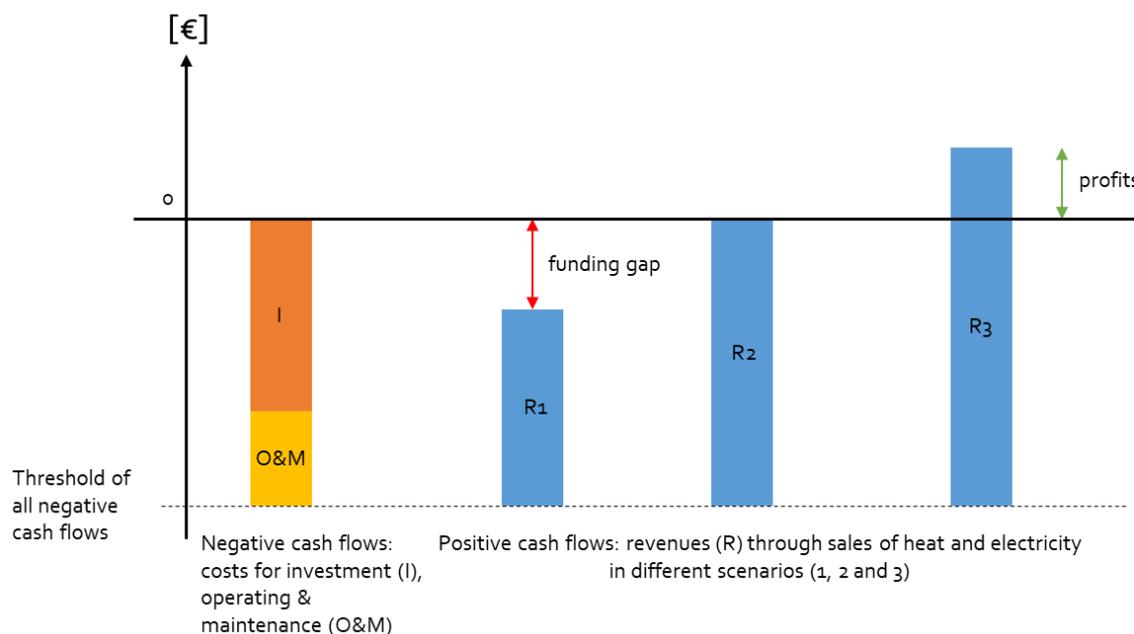


figure 2: principle of funding gaps, positive and negative cash flows (own source, 2019)

In figure 2, the costs (for investment, operating, and maintenance) are set against three different scenarios of revenues that can be made in a project:

- Revenue 1: the sum of all revenues are smaller than the amount of all costs during the considered life span of a project. In the end, a funding gap will be present and the project is not profitable.
- Revenue 2: the sum of all revenues is as high as the amount of all costs during the considered life span of a project. In the end, no funding gap will be present but also no profits will be made as the project in this scenario just pays itself off. However, the project will be economically efficient in this case.
- Revenue 3: the sum of all revenues is higher than the amount of all costs during the considered life span of a project. In the end, no funding gap will be present as the project is generating profits. The project will be economically efficient in this case.

Hence, a funding gap only appears in projects that are not economically efficient during a considered period.

3.2 Economic efficiency

This section deals with methods on how to calculate the economic efficiency of DH projects especially and shows additional indicators that can be used further. It analyses already existing tools that can be used to determine the profitability of DH projects and gives a brief overview of the economic challenges that stakeholders can face when implementing LTDH projects.

3.2.1 Calculation methods for economic efficiency

Economic efficiency, as defined in 3.1.2 *Economic efficiency*, can be determined by different methods. In general, there are two different types of methods, namely static and dynamic calculation methods.

Static calculation methods can be done quickly and easily. They are normally used when underlying data is unreliable and rough estimates are sufficient. However, they do not consider developments over time. Investments in infrastructure projects, such as the construction or extension of a DH system, are long-term decisions and spread over many years. That is why dynamic calculation methods are more suitable for determining the economic efficiency of DH measures. They are also called *discounted cash flow techniques* and include the time value of money (Crundwell 2008, S. 163).

Konstantin proposes three different dynamic techniques for determining the economic efficiency of DH projects (Konstantin und Konstantin 2018, S. 139–142):

- net present value
- equivalent annual charge
- internal rate of return

These are also proposed by Crundwell and Leemann (Leemann 1992, S. 31–38; Crundwell 2008, S. 168–183). Besides that, they also suggest the method of discounted payback period (Leemann 1992, S. 39; Crundwell 2008, S. 181). Crundwell adds two more methods, namely the modified internal rate of return and the profitability index (Crundwell 2008, pp. 172 & 180).

The three techniques mentioned firstly will be explained further including equations as they are specifically recommended for DH projects. The other techniques will be explained as less descriptive.

Net present value (NPV)

The net present value (NPV) “is the sum of all the cash flows (incomes and costs) discounted to the present using the time value of money. If the NPV is greater than zero, it is expected that value will be created for the investor. If it is less than zero, it is expected that value will be destroyed for the investor” (Crundwell 2008, S. 168–169). It is an absolute measure. Formula (1) shows how to determine the NPV of an investment where the following shall be (Crundwell 2008, S. 169):

- NPV = net present value [€]

- n = lifespan of the investment of the measure [years]
- t = time index number, a certain year of the investment [w.d.]
- CF_t = cash flow in year t or in other words the difference between costs and incomes in year t [€]
- k = discount rate [%]

$$NPV = \sum_{t=0}^n \frac{CF_t}{(1+k)^t} \quad (1)$$

Equivalent annual charge (EAC)

The Equivalent annual charge (EAC) “distributes the present value of the project equally over the life of the project as if it were an annuity” (Crundwell 2008, S. 183). It is an absolute measure and mainly used to compare alternatives (Crundwell 2008, S. 183). In this context, it cannot be used as an indicator on its own. Formula (2) shows the mathematical expression of it where the following shall be (Crundwell 2008, S. 183):

- EAC = equivalent annual charge [€]
- PV = present value or net present value of the project [€]
- a = annuity factor [w.d.]
- k = discount rate [%]
- n = lifespan of the investment of the measure [years]

$$EAC = PV \times a = PV \times \left(\frac{k(1+k)^n}{(1+k)^n - 1} \right) \quad (2)$$

Internal rate of return (IRR)

Internal rate of return (IRR) “is the value of the discount rate at which the net present value is zero” (Crundwell 2008, S. 173–174). It is a relative measure and can be compared with that of another project or with a specified rate that has to be exceeded (Crundwell 2008, S. 175). Formula (3) shows the mathematical expression of it where the following shall be (Crundwell 2008, S. 174):

- n = lifespan of the investment of the measure [years]
- t = time index number, a certain year of the investment [w.d.]
- CF_t = cash flow in year t or in other words the difference between costs and revenues in year

t [€]

- IRR = internal rate of return [%]

$$0 = \sum_{t=0}^n \frac{CF_t}{(1 + IRR)^t} \quad (3)$$

The IRR cannot be solved directly but through trial and error, interpolation, computer search algorithms or built-in functions like the goalseek function in MS Excel (Crundwell 2008, S. 174).

The **Modified Internal Rate of Return** method (MIRR) “is the return earned by the project as if the cash flows from the project are reinvested at the company’s discount rate” (Crundwell 2008, S. 180).

The **Profitability Index (PI)** or benefit-cost ratio “measures the amount earned per dollar invested. If the amount generated is less than the amount invested, the PI is less than one, and the investment is rejected. If the amount generated is more than the amount invested, the PI is greater than one, and the investment is recommended” (Crundwell 2008, S. 172). The PI method is sometimes called the benefit-cost ratio method when it aims to calculate the ratio of costs and benefits instead of cash flows generated and investments. This happens more often in the public sector where benefits for citizens have to be determined rather than profits (Crundwell 2008, S. 183).

The **Discounted payback period** method determines the point in the project at which he or she gets the investment or money back considering the time value of money (Crundwell 2008, pp. 164 & 181).

As seen above, several methods exist and each of them has a different goal. For the analysis of investments, it is important to know, what indicator (NPV, IRR, EAC, etc.) is important and appropriate for decision making and it is possible that not just one but a number of them are necessary.

3.2.2 Additional indicators for economic efficient (low-temperature) district heating systems

In general, a DH system is run in an economical way, if the revenues from heat sales exceed the costs consisting of costs of capital and for operating (Arbeitsgemeinschaft QM Fernwärme 2018, S. 108). Besides this rule of thumb and the techniques mentioned above, additional indicators can give further information on whether a DH system will run economically or not. However, it is advised not to use these indicators on their own as they do not replace profitability analysis.

The Swiss Working Group QM District Heating (German/Swiss: QM Fernwärme) recommends to determine the following indicators:

- Connection density
- Heat distribution losses

- Mean levelized costs of energy³

As (LT)DH projects develop over several years, these indicators can change over time. That is why it is recommended to repeat the process of determining these indicators several times and to adjust them to current figures. In general, the development of a (LT)DH project can be divided into six stages: preliminary studies, design planning, planning-tendering-award of contract, execution and acceptance of building work, optimization of operation, operation and management. This can be seen in figure 3:



figure 3: six stages of developing a DH system (according to Arbeitsgemeinschaft QM Fernwärme, 2018, p. 102)

It is recommended, to determine the indicators during the planning stages 1-3, especially (Arbeitsgemeinschaft QM Fernwärme 2018, S. 110–116). As of stage 4, only calculations for the purpose of controlling and optimization are done (Arbeitsgemeinschaft QM Fernwärme 2018, S. 118–122).

The three indicators are described in the following, according to (Arbeitsgemeinschaft QM Fernwärme 2018, S. 108–114) unless specified differently.

Connection density

Connection density CD is calculated according to formula (4) where the following shall be:

- CD = connection density [MWh/(a*m)]
- Q_C = costumers' annual heat consumption [MWh/a]
- L_{total} = total length of the grid including main, branch and house connection lines

$$CD = \frac{Q_C}{L_{total}} \quad (4)$$

In general, the connection density should be > 2 MWh/(a*m) after the final installation.

Heat distribution losses

The absolute heat distribution losses $Q_{l,a}$ are the difference between the heat quantity that is fed into the grid and the heat quantity that is consumed by all costumers. In already existing DH systems, the latter two values can be determined through heat meters.

³ In this case heat

The relative annual heat distribution losses $q_{l,a}$ can be calculated according to formula (5) where the following shall be (Arbeitsgemeinschaft QM Fernwärme 2018, S. 126–127):

- $q_{l,a}$ = relative annual heat distribution losses [%]
- $Q_{l,a}$ = absolute annual heat distribution losses [kWh/a]
- $Q_{G,s,a}$ = annual quantity of heat supplied and fed into the grid [kWh/a]

$$q_{l,a} = \frac{Q_{l,a} \times 100 \%}{Q_{G,s,a}} \quad (5)$$

However, in non existing future DH systems or planned extensions, heat distribution losses $Q_{l,a}$ cannot be measured and have to be calculated⁴. Their calculation is shown in the following.

Heat distribution losses $Q_{l,a}$ are the sum of all heat losses in each line $Q_{l,a,i}$. The annual heat distribution losses of one line $Q_{l,a,i}$ is calculated according to formula (6) where the following shall be (Arbeitsgemeinschaft QM Fernwärme 2018, S. 126–127):

- $Q_{l,a,i}$ = heat losses in each line [kWh/a]
- $\dot{q}_{l,L}$ = specific heat losses per line [W/(mK)] which can be taken from product information from the manufacturer of lines and pipes
- $\Delta T_{L,m}$ = mean temperature difference [K] which is calculated according to formula (7)
- L = length of the considered line [m]
- τ_N = annual operation time of the grid [h/a]

$$Q_{l,a,i} = \frac{\dot{q}_{l,L} \times \Delta T_{L,m} \times L}{1000} \times \tau_N \quad (6)$$

The mean temperature difference $\Delta T_{L,m}$ is calculated according to formula (7) where the following shall be:

- $\Delta T_{L,m}$ = mean temperature difference [K]
- T_{supply} = supply temperature [K]
- T_{return} = return flow temperature [K]

⁴ These results should be lower than the measured losses as they do not consider losses due to convection and radiation (Arbeitsgemeinschaft QM Fernwärme 2018, S. 126).

- T_{ground} = mean temperature of the ground [K]

$$\Delta T_{L,m} = \frac{T_{supply} + T_{return}}{2} - T_{ground} \quad (7)$$

The following aspects have an influence on heat distribution losses: dimensions of pipes, the thickness of insulation of pipes, levels of flow and return flow temperature, connection density and operation time. In general, heat distribution losses should be < 10 %.

Levelized costs of energy

Mean levelized costs of energy (LCOE), or sometimes called Levelized energy costs (LEC) (Konstantin und Konstantin 2018, S. 143) represent the costs of capital and for operating per MWh net heat consumption. It can be calculated via the EAC method, see 3.2.1 *Calculation methods for economic efficiency*. However, further simplifications can be made when determining the LCOE (Arbeitsgemeinschaft QM Fernwärme 2018, S. 173):

- All investments occur at the beginning of the investment
- The time considered equals the length of the investment and therefore neither replacements are necessary during nor do any residual values remain after this time

Under these conditions, the LCOE is calculated according to formula (8) where the following shall be:

- LCOE = levelized costs of energy (heat) [€/MWh]
- I = investment costs [€]
- a = annuity factor, see 3.2.1 *Calculation methods for economic efficiency*
- A = annual costs for operating & maintaining the DH system at current prices [€]
- k = discount rate [%]
- Q_{useful} = useful heat [MWh]

$$LCOE = \frac{I \times a + A \times k \times a}{Q_{useful}} \quad (8)$$

The LCOE can be used to compare different DH systems with each other regarding their profitability⁵. In a German study on 4th generation district heating systems, the authors have calculated LCOE in order to compare several already existing but different types of LTDH systems⁶ with each other (ifeu

⁵ When comparing different systems by their LCOE, the same calculation method has to be used in order to ensure equivalence.

⁶ Different types: LTDH systems based on solar energy with and without storage, surplus heat and solar energy with heat pump

2017, S. 74).

Moreover and as mentioned at the beginning of this subsection, a DH system is run in an economical way, if the revenues from heat sales exceed the costs consisting of costs of capital and for operating. The latter value is represented by the LCOE and can be compared with heat selling prices in order to determine economic efficiency.

3.2.3 Existing tools for determining the economic feasibility of (Low-TEMP) District Heating Projects

Rämä and Klobut did a background review of various existing planning tools for energy-efficient district systems in order for the development of their own district cooling (DC) planning tool INDIGO (Rämä und Klobut 2018, S. 1–3). The following planning tools consider the determination of economic efficiency explicitly⁷:

- CoolHeating
- District Heating Assessment Tool

These tools are examined in greater detail below.

CoolHeating

Cool Heating was developed within the eponymous Horizon 2020 project *CoolHeating* for determining the economic efficiency of small modular district heating and cooling projects (Sunke 2017, S. 3).

The main target groups are “non professionals [and] non experts” (Sunke 2017, S. 3) who are working in the field of district heating.

It is an excel based tool, using Macros and Visual Basic (VBA), and is secured by a password which is given by the author. It comes with a manual as a separate file and included in the manual also. Both, the tool and the manual, are online available on the project’s website and there is no fee required. The tool is multilingual and the user can choose between one of seven languages, incl. English.

In order to use the tool, the following data must be known to the user:

- Investment and financing
- Annual costs: operating, services, labour and other (to be given by the user)
- Revenues from selling heat, electricity and other sources (to be given by the user)

⁷ Other planning tools consider economic feasibility besides other topics but not on its own. As this main output shall deliver a planning tool for economic efficiency and funding gaps explicitly, only those kind of planning tools are reviewed here.

The tool's output represents an overview for a business plan or a bank case. It forecasts the profitability of the project and summarizes key aspects of that. The manual claims to simulate all models with a "linear "year2year" (...) change simulation" (Sunko 2017, S. 3). It is not clear to the author of this work, what kind of calculation method from 3.2.1 *Calculation methods for economic efficiency* might comply with this method but it is assumed that this method complies with the NPV method. It can consider projects with life spans of either 10, 15 or 20 years. The discount rate is preset to 4 % but can be adjusted by the user.

District Heating Assessment Tool

The District Heating Assessment Tool (DHAT) from the Danish Energy Agency is developed for calculating the economic feasibility of district heating projects (Danish Energy Agency 2017, S. 4). The defined DH project is compared with a reference system with the individual supply of energy which is defined by the user as well.

The main target group are heat planners (Danish Energy Agency 2019a).

It is an excel based tool without any password securing it and it is not using any Macros and VBA. It comes along with a report, including a manual and a case study. Both are online available on the agency's website, in English, and there is no fee required.

In order to use the tool, the following data must be known to the user:

- For the reference system
 - Heat demand
 - Heat production and expected replacements of technologies
 - Subsidy payments
- For the DH project
 - DH production technologies
 - Distribution of DH production
 - Solar pit storages (if planned)
 - Development of DH network and sales of DH
 - Economic parameters
 - Subsidy payments

Where possible, cost estimates and price projections based on data from the Danish Energy Agency are already given but can be adjusted by the user (Danish Energy Agency 2017, S. 10).

As an output, LCOE are calculated and a feasibility study, as well as socio economic calculations, are performed (Danish Energy Agency 2017, S. 8–9). The latter two compare a reference system with the individual supply of energy with the planned measure. A ready to print project report is created.

The tool is using the NPV method from 3.2.1 *Calculation methods for economic efficiency* and considering a lifespan of 20 years. The “discount rate is set to 4 % in accordance with Danish standards” (Danish Energy Agency 2017, S. 11) but the user is free to make his or her own decisions on that.

3.2.4 Economical challenges of low-temperature district heating systems and possible solutions

Due to their lower temperature levels, 4th generation DH systems have some advantages over conventional DH systems of the 1st – 3rd generation. For example, they are able to use heat sources with lower temperatures such as renewable energies or surplus heat⁸. Besides that, lower flow temperatures come with less heat losses in the grid. These advantages can result in energy savings. Leemann raises the question, if profitable energy-saving or energy efficiency measures result in any cost savings over their lifetime, on balance (Leemann, 1992, p. 2).

Many studies and pilot measures have already shown that LTDH can be a technical feasible and reasonable solution. Besides these two criteria, the economic feasibility of a project is crucial for municipalities or utility companies when deciding on whether to spend money on it or not. LTDH projects can face some major challenges when it comes to costs, economic efficiency, and risks. The German study on 4th generation district heating systems summarizes these challenges and possible solutions based on discussions and interviews with planners, utility companies, municipalities, and scientists which are shown in table 1.

⁸ Surplus heat can but does not always has lower temperature levels to max. 70 °C.

table 1: economic challenges of and solutions for 4th generation DH systems (ifeu 2017, S. 70)

challenges	solutions
High costs for infrastructure, high investment risks	Adequate rates of funding, high funding caps
Lower prices for gas and oil compared to renewable energies (RE)	CO ₂ steering tax or similar
Lower prices for fossil fuel-based district heat and other competing grid-based energy carriers	CO ₂ steering tax or similar
Funding cap for energy storage systems	Sufficiently high funding caps in order to implement large energy storage systems
High initial costs for concepts and planning	Significant funding of concept and planning stages, if necessary through lump-sum funding
Competition with decentralized systems	(long-term) guarantee of lower heating prices
Risks of low connection rates	Hedging the risks of low connection rates, if necessary through the funding of measures regarding densification and transition to LT heating systems

table 1 shows that LTDH systems not only come with high initial or investments costs but are also in financial competition with fossil fuel-driven and decentralized systems. Already existing funding caps on technologies that support the operating of LTDH systems interfere with their development as well. Interviewees see the opportunity to meet these challenges through funding and CO₂ steering taxes.

3.3 Funding gap

3.3.1 Calculation methods for funding gaps

As already mentioned in 2.1.2 *Guidelines on State aid for environmental protection and energy 2014-2020* Point (76) of the EEAG defines the funding gap as the amount of eligible costs for district heating and cooling networks. It is the “difference between the positive [revenues] and negative cash flows [expenses] over the lifetime of the investment, discounted to their current value (typically using the cost of capital)” (European Commission 2014a, (point 32)). In other words, the NPV method, refer to 3.2.1 *Calculation methods for economic efficiency*, has to be used when determining the funding gap when complying with the EEAG.

3.3.2 Existing tools for calculating funding gaps in district heating projects

The following tools consider the determination of funding gaps in DH projects:

- Guideline and tool FW 703 of the German District Heating Association
- Guideline and tool FW 704 of the German District Heating Association

These tools are examined in greater detail below.

FW 703

The German District Heating Association released the guideline FW 703 on how to determine funding gaps in urban development projects. This guideline comes with a calculation tool that was developed by the author of this work.

Climate-relevant projects that are not economically viable from the start need funding in order to become economically viable. The amount of funding or in other words the funding gap for such projects can be determined with the guideline and the tool.

Both the guideline and the tool are made for applicants and funding authorities who work in the field of urban development projects and want to determine the funding gap of either new constructions or extensions of already existing developments (AGFW 2015, S. 3). As it is mainly used for investments in DH projects, the tool is particularly tuned for investments either in grids, generating plants or both. The user can choose between a variety of different technologies of generating plants.

The tool is excel based and is not using Macros or VBA. It is secured by a password which is not given. Both documents are available on the association's website and can be downloaded for free but are available in German only.

In order to use the tool, the following data must be known to the user:

- the type of investment (either generating plant with grid, generating plant, or grid)
- amount of investment or in other words capital expenses
- information on costs for maintenance and operating incl. fuel costs
- expected revenues by selling heat and/or electricity (the latter in case of cogeneration units)
- general information on heat distribution and further data of the DH system

The tool is using the NPV method from 3.2.1 *Calculation methods for economic efficiency* and calculates the cash flows over a lifespan of 20 years considering a discount rate of 7 %. If the project is not economically viable under these circumstances, a funding gap will be present and calculated. It is the

difference between all positive and all negative cash flows discounted to their present value. If the value is less than zero, it means that the discounted negative cash flows are higher than the discounted positive cash flows. This difference represents the funding gap.

The results of the tool do not imply any approval of funding as they have to be checked by a reviewer and the funding authority.

FW 704

Besides the guideline FW 703, the German District Heating Association released the guideline FW 704 on how to determine funding gaps in DHC and thermal storage projects, mainly when CHP is part of the system. The guideline comes with a calculation tool that was developed by AGFW.

According to the German Combined Heat and Power Act, utility companies, which apply for funding for their DHC systems or thermal accumulators, have to prove that a non-repayable grant is necessary in order to guarantee an economically viable project. Under the guidelines of the EEAG, see 2.1.2 *Guidelines on State aid for environmental protection and energy 2014-2020*, an incentive for utility companies is intended through the promotion of the German Combined Heat and Power Act. This incentive should result in utility companies changing their behaviour and activities that they would not perform at all, only to a limited extent, or in a different way. This incentive is represented by closing the funding gap through non-repayable grants. (AGFW 2017, S. 3)

The tool is excel based and is not using Macros or VBA. It is secured by a password which is not given. Both documents are available on the association's website and can be downloaded for free but are available in German only.

Both the FW 704 guideline and the tool are made for utility companies who run DHC systems and/or thermal accumulators and are applying for funding of either new constructions or extensions of already existing developments (BAFA 2017)

As FW 703 and its calculation method serve as a basis for FW 704, nearly the same input data is needed: information on investment, maintenance and operating costs (incl. fuel costs), expected revenues and general information on the system.

The tool is using the NPV method from 3.2.1 *Calculation methods for economic efficiency* and calculates the cash flows over a lifespan of 20 years (networks/grids) or 15 years (accumulators) considering a discount rate of 8 % (AGFW 2017, S. 7–8). If the project is not economically viable under these circumstances, a funding gap will be present and calculated.

The results of the tool do not imply any approval of funding as they have to be checked by the funding authority.

3.4 Financial framework of District Heating systems in the Baltic Sea Region

In order to get an overview of the current financial framework of the DH systems in the BSR, the work of GoA 3.1 *Analysis of institutional, organisational and technical framework for LTDH* of the LowTEMP project is analysed. In this GoA, the current situation of DH in the BSR partner countries was queried in the form of two questionnaires, A and B. This was done by PP g Thermopolis Ltd. The data collection of questionnaire A contains not just institutional, organisational and technical information but also information on the current financial framework in the respective partner countries. This section excerpts this kind of information, see appendix I *Financial framework of DH systems in the BSR*.

3.5 Cost catalogues from BSR partner countries

As one of the tasks of this GoA is the creation of a catalogue with characteristic cost parameters, desk research is done to find out whether such catalogues already exist in the BSR.

3.5.1 Cost catalogues from the Danish Energy Agency

The Danish Energy Agency has published several catalogues regarding energy generation and transport. These catalogues give information on “technology, economy and environment for a number of energy installations and are among other things used by the Danish Energy Agency for energy projections” (Danish Energy Agency 2019b). The catalogues *Technology Data for Generation of Electricity and District Heating* and *Technology Data for Energy Transport* include information on energy generation, transmission, and distribution in DH systems.

Regarding economics, the catalogues list cost parameters and values for typical DH system components including costs for investment, operating and maintenance of each component (Danish Energy Agency und Energinet 2016, S. 7, 2017, S. 21).

The data on costs for distribution DH is differentiated between the following areas: rural, suburban, city, new development and new development with LTDH (Danish Energy Agency und Energinet 2017, S. 78–86). Some of the data were consolidated with the former Swedish district heating association Svensk Fjärrvärme (Danish Energy Agency und Energinet 2017, S. 77–87).

During the creation of these catalogues, “European data, with a particular focus on Danish sources, have been emphasized in developing this catalogue. This is done as generalizations of costs of energy technologies have been found to be impossible above the regional or local levels (...). For renewable energy technologies this effect is even stronger as the costs are widely determined by local conditions.” (Danish Energy Agency und Energinet 2017, S. 21).

The catalogues are available in English on the agency’s website and there is no fee required.

3.5.2 District heating pipe cost catalogue from the Swedish district heating association

Svensk Fjärrvärme has published a district heating pipe cost catalogue in 2007. It gives information on construction costs for underground pipes in different areas: city, suburban, parks and natural areas, and areas where distribution infrastructure can be installed during road construction (Svensk Fjärrvärme AB 2007, S. 10).

The catalogues are available in Sweden on Swedenergy's website and there is no fee required.

4 Methods

In this chapter, the methods for fulfilling the tasks mentioned in the introduction are described, see 1.3 *Tasks*. The results are shown in chapter 5 *Results*.

4.1 Selecting calculation methods for determining economic efficiency and funding gaps

In order to select suitable calculation methods, the minimum requirements for them are identified. In the end, the calculation method that has to be used in this work has to meet these requirements.

After that, already existing tools are analysed with respect to several different criteria that have to be met by the calculation method selected in this work as well. This ensures that the output considers the state of the art.

4.1.1 Determining minimum requirements for calculation tools

First, gathered information on the current state of technology and knowledge regarding the determination of economic efficiency and funding gaps of (LT)DH projects is analysed by answering the following questions:

- What parameters are needed at least to determine economic efficiency?
- What calculations methods should be used?
- What language should be used?
- Who is the user of such a tool and what needs do they have that must be met?
- How much effort should be needed at least to produce meaningful results?
- What expressions have to be used?
- How does the tool have to be made available for the user?

Thereof, the minimum requirements for such calculation tools are derived.

4.1.2 Identifying the advantages and disadvantages of already existing tools

Advantages and disadvantages of existing tools are identified regarding the following criteria, primarily minimum requirements from 4.1.1 *Determining minimum requirements for calculation tools*. Other criteria, which are not seen as minimum requirements by the author, are the following:

- Applicability to both determination of economic efficiency and funding gaps

- Unique features of the tool
- Demonstration of physical correlations
- Acceptance and proof on a municipal level

By seeing the advantages and disadvantages of already existing tools, it is possible to select the most suitable method and to develop a new tool on this basis.

4.2 Creating a catalogue of cost and revenue parameters

One of the tasks of this GoA is to create a catalogue with characteristic cost parameters, for example, costs per meter district heating pipe and as seen in 3.5 *Cost catalogues from BSR partner countries*. This task will be broadened for this work by characteristic revenue parameters. The reason for that is the following: both economic efficiency and funding gaps can be determined only by considering all cash flows of an investment. This includes not just costs (negative cash flows) but revenues (positive cash flows) over the life span of an investment as well.

The main idea of a catalogue is not only to name the types of parameters but also to quantify these in the form of values. In order to create a catalogue with such characteristic parameters that are deposited with financial data, the following has to be given:

- Parameters, i.e. their values need to be consistent nationwide or at least in one region of a country. As soon as parameters are too heterogeneous in one country or region, no universal value can be given for a parameter.
- There must be parameters and values for all BSR partner countries. As soon as one information is lacking at some point, the catalogue does not achieve its objective.

Based on the data gathered in chapter 3 *Current state of technology and knowledge*, cost and income parameters can be derived from the following:

- parameters from questionnaires of LowTEMP's GoA 3.1, see 3.4 Financial framework of District Heating systems in the Baltic Sea Region
- parameters used in already existing cost catalogues
- Experience from carrying out assessments of DH projects and funding gaps

These three options are analyzed in order to find out whether it is possible to create a cost and revenue catalogue for this main output that follows the requirements mentioned above. If so, parameters and values, the latter if possible, are listed in the form of a catalogue.

4.2.1 Analysing parameters based on questionnaires for the analysis of institutional, organisational and technical framework

Based on the financial framework in appendix I *Financial framework of DH systems in the BSR* the following questions and their answers of each partner country are considered as important for the development of a catalogue with characteristic parameters. The reasons why are directly named afterwards.

- **VAT [%]:** direct impact on prices
- **Acknowledged DH losses [%]:** direct information on the operation of DH systems and indirect information on operating costs
- **Acknowledged supply and return temperatures in DH network [°C]:** indirect information on the efficiency of DH systems
- **Financial aids that a DH company can receive in the respective country:** direct information on possible revenue parameters
- **Organizing institution for granting investments and/or subsidies:** in case further information is needed
- **Method for determining investment subsidies for DH companies:** in case further information is needed
- **Tax aids for DH companies [€/MWh]:** direct information on possible savings within cost parameters
- **Energy taxation and fuels under energy taxation [€/MWh]:** direct information on possible cost parameter
- **Taxation information available in English:** in case further information is needed
- **Other possible drivers of DH price:** indirect information on possible cost parameters
- **Method for calculating DH price for producers:** in case further information is needed
- **Customer prices for DH by sector [€/MWh]:** direct information on revenue parameters
- **Differences in pricing between different consumer groups:** in case further information is needed
- **Regulator of pricing:** in case further information is needed

- **Heat meter (or other) as a basis for payment:** direct information of revenue parameters

The parameters and their values are summarized in one table in order to get an overview and to see how consistent they are in one country or region and if there are values for each BSR partner country.

4.2.2 Analysing already existing cost catalogues and their parameters

Already existing cost catalogues are analysed whether it is possible to derive a catalogue based on the parameters given there. If they fulfill the requirements mentioned above, a list of cost and revenue parameters is given with corresponding values.

4.2.3 Analysing parameters based on experience from carrying out assessments of DH projects and funding gaps

The author of this work has done several assessments of DH projects in Germany regarding the investment of such projects and funding gaps. During this work, the FW 703 tool was developed and used, see 3.3.2 *Existing tools for calculating funding gaps* parameters used in these assessments are analysed on whether they fulfill the requirements mentioned above.

4.3 Developing a tool with a selected calculation method

Based on the results of the preceding steps, a tool that will be able to determine the profitability and, if present, the funding gap is created or further developed. Therefore, the minimum requirements are considered. If one requirement is not met, the tool will be adapted in order to do so.

4.4 Testing and further developing of both calculation methods on one LowTEMP pilot measure

In order to ensure that the developed calculation tool is easy to use for future stakeholders, it is tested on at least one partner municipality of the LowTEMP partner consortium that is implementing a pilot measure and where a pilot energy strategy shall be developed. Therefore, the author of this work held a short input on a draft of the developed tool during a project partner meeting in March 2019 in Klai-peda/Latvia. The audience consisted of several representatives of three municipalities, namely Gul-bene/Latvia, Ilmajoki/Finland and Holbaek/Denmark. At least one of the three municipalities shall be a research subject for this GoA.

For the test, the developed calculation tool and a questionnaire are sent to at least one project partner per E-Mail. The partner is asked to fill out the questionnaire and the tool by his or her own and to send both back to the author per E-Mail. The questionnaire asks for the same input that is needed for working with the tool. By answering the questionnaire as well as filling out the tool, it shall be ensured that any misunderstandings or typing mistakes are detected. Besides that, the questionnaire gives more information on the required input data for the tool for the user.

After receiving the filled out tool and questionnaire, an evaluation sheet is answered based on the answers and remarks which the project partner will have made. The evaluation sheet is filled out by the author and covers the following topics and questions:

- General
 - Regarding response / Pilot measure from
 - Response was given by [name]
 - Did the respondent give any further and important information in the E-Mail (beyond the filled out questionnaire and the tool)?
 - If so, what is the information?
 - Does this information lead to further questions?
- Questionnaire
 - Did the respondent answer every question of the questionnaire?
 - If the respondent did not answer every question, which answer is missing?
 - Are there any answers which lead to further questions or are not understandable?
- Tool
 - Did the respondent fill in every cell of the tool which is needed for calculation?
 - If the respondent did not fill in every needed cell, which information is missing?
 - Is there any information that leads to further questions or is not understandable?
 - Based on the answers given in the response – is the calculation of a funding gap possible?
 - If so, is the result plausible?
- Conclusion
 - Based on the answers given in the response - Is the usage of the tool viable for the pilot measure?
 - Were there any misunderstandings by the project partner who filled out the questionnaire and the tool? What has to be done to resolve them?

- Based on the answers given in the response – is the pilot measure obvious?
- Can it be summarised in own words?
- Are there any questions and remarks from the respondent regarding the tool?
- Further remarks from the author

Based on the results of the evaluation sheet, it is possible to see if the project partner has understood the tool correctly and to adapt the tool further if needed.

5 Results

The results of the tasks performed with the methods mentioned in chapter 4 *Methods* are shown in the following.

5.1 Calculation method for determining economic efficiency and funding gaps

5.1.1 Minimum requirements for the calculation method

The answers to the following questions show the minimum requirements for a calculation method.

- What parameters are needed at least to determine economic efficiency?

According to 3.1.2 *Economic efficiency*, the profitability of a measure is given when the sum of all revenues is higher than the sum of all costs. Therefore, all cash flows, negative and positive, need to be given when determining the profitability. Besides that, the profitability of (LT)DH projects needs to be considered over a certain life span as these kinds of investments are long-term decisions and spread over many years, see 3.2.1 *Calculation methods for economic efficiency*. That is why the life span of the investment needs to be given as well as a discount rate with which the time value of money and any uncertainty and risks are considered.

- What calculations methods should be used?

As mentioned in 3.2.1 *Calculation methods for economic efficiency*, (LT)DH projects are longterm decisions. Only discounted cashflow techniques can be used when determining the profitability of a project. For (LT)DH projects, the methods of either net present value, equivalent annual charge or internal rate of return come into question.

Discussed in 3.2.4 *Economical challenges of low-temperature district heating systems and possible solutions*, profitable energy-saving or energy efficiency measures, such as LTDH measures, can result in cost savings over their lifetime, on balance (Leemann, 1992, p. 2). For LTDH projects, this backs up the need for tools that determine economic efficiency and funding gaps not just only based on direct costs and profits but also on cost savings due to energy savings compared to conventional, non-low-temperature approaches.

- What language should be used?

As English is the main language used in the LowTEMP project, the tool and its appendices have to be available in English at least.

- Who is the user of such a tool and what needs do they have that must be met?

As mentioned in 1.2 *Aim of the work*, the target groups of this output are municipal actors responsible for the strategic planning of the DH grids, DH suppliers, energy agencies, planners, engineers, funding authorities and potential investors.

- How much effort should be needed at least to produce meaningful results?

The target groups have to be able to use the tool on their own, if necessary with the help of other stakeholders mentioned before. No other specialist than the ones mentioned before should have to be consulted during this progress.

- What expressions have to be used?

As there are various target groups with different backgrounds and knowledge concerning economic efficiency and funding gaps of (LT)DH systems, the target group who knows the least about this topic has to be able to understand the tool. That is why simple language is required and special terminology has to be explained in a manual that comes along with the tool.

- How does the tool have to be made available for the user?

The tool and its annexes have to be available with no fee required and have to be downloadable from the internet.

5.1.2 Advantages and disadvantages of already existing tools

In order to choose a suitable tool for further development, all tools shown in chapter 3 are analysed by their advantages and disadvantages. The criteria used for this are mainly derived from the minimum requirements established in 5.1.1 *Minimum requirements for the calculation method* and re-phrased into questions that can be answered mostly with yes or no:

- Used parameters: Are all positive and negative cash flows, the life span of the investment and the discount rate considered in the tool?
- Calculation method: Can it be seen which calculation method is used? Is it either NPV, EAC or IRR or at least one of these methods?
- Language: Is the tool available in English?
- User-friendliness: is a special software required in order to use the tool? Can it be used with MS Excel and is knowledge of Macros and Visual Basic Applications necessary in order to do so? Is the tool secured with a password and is the password given to the user? Does the tool come with a manual?
- Workload for the user: Is a lot of research expected in order to gather the required data? Are

certain steps automated so that the user does not have to repeat certain inputs or has to carry out calculation steps which apply to standard calculation rules? Are other specialists required to fill out the tool, which are not mentioned under *target groups*?

- **Comprehensibility:** Is the tool clear and comprehensible without any special technical knowledge and does it do without complex correlations? While user-friendliness addresses the progress of working with the tool and typing in data, comprehensibility addresses the question, how well a tool and its results can be understood by the user. This is important for non-technicians, non-economists, and other people who have to work with the tool but only know the basics of its topics.
- **Accessibility:** Is there a fee required in order to get access to the tool? Is it possible to download it from the internet?

Besides that, additional criteria, which are important in the view of the author, are given:

- **Applicability to both determination of economic efficiency and funding gaps**
- **Unique features:** Does the tool have any unique features that go beyond the minimum requirements and the state of the art?
- **Demonstration of physical correlations:** If physical correlations are used, do they follow thermodynamic laws? DH and LTDH systems are based on thermodynamic laws. The profitability relies on them and the well-functioning of the systems.
- **Acceptance and proven on a municipal level:** Has the tool shown its practicality and acceptance in any project before? A method is accepted and recognized as soon as it is defined through standardization. This ensures the transferability and comparability of the results. Furthermore, a method is considered to be positive when it has been already used and has proven its practicality.

On the basis of these criteria, the following table 2 rates the calculation methods mentioned in chapter 3.

table 2: qualitative assessment of the analysed calculation tools

Criteria/tool	CoolHeating	DHAT	FW 703	FW 704
Consideration of needed parameters	Yes	Yes	Yes	Yes
Usage of at least NPV, EAC, or IRR	Probably NPV	Yes, NPV	Yes, NPV	Yes, NPV

<i>Set-up in English</i>	Yes	Yes	No	No
<i>Necessity of special software</i>	No	No	No	No
<i>Usage of Macros or VBA</i>	Yes	No	No	No
<i>Password security</i>	Yes, password given	No	Yes	Yes
<i>Release with manual</i>	Yes	Yes	Yes	Yes
<i>Research effort for needed data</i>	Adequate	High	Adequate	Adequate
<i>Automatisation of calculation steps</i>	Yes	Yes	Yes	Yes
<i>Need for expertise from external specialists</i>	No	No	No	No
<i>Comprehensibility</i>	Yes	Yes but to some extent	Yes	Yes
<i>Fee-required</i>	No	No	No	No
<i>Accessibility via internet download</i>	Yes	Yes	Yes	Yes
<i>Applicable for economic efficiency</i>	Yes	Yes	Indirectly	Yes
<i>Applicable for funding gaps</i>	No	No	Yes	Yes
<i>Unique features</i>	Yes ⁹	Yes ¹⁰	No	Yes ¹¹
<i>Physical plausible</i>	Cannot be assessed	Yes	Yes	Yes
<i>Recognized and proven</i>	unknown	Yes	Yes	Yes

⁹ Ready for printing overview for business plan or bank case

¹⁰ Comparison with reference system, ready for printing project overview

¹¹ Works only when CHP is involved, ready for printing out project overview for funding application

5.1.3 Choice of a suitable calculation method for further development

As seen in table 2, only the FW 704 method determines both economic efficiency and funding gaps directly at once. It can be assumed this method is the one of choice for this work. However, it is strictly limited to systems that include CHP technology and to German funding framework conditions and laws. Its usage for this main output is therefore not recommended.

On the other hand, the FW 703 method offers more open framework conditions: it is bound neither to one particular technology nor to country-specific laws. Though not directly determined, it makes statements to the profitability of a project when determining a funding gap. It has one major disadvantage: it is not available in English at the moment. This is one of the minimum requirements set prior to the evaluation in table 2. However, as the author of this work is also the developer of the calculation method FW 703 and its excel tool, it is possible to translate it and make further adaptations. This is why the method of FW 703 is chosen as a basis for the calculation method developed in this main output.

The other two calculation methods, namely CoolHeating and DHAT, are not further developed in this work. CoolHeating is VBA and Macro based and therefore classified as not suitable for the target groups of this main output. Its recognition and acceptance are unknown, which does not promote its usage. Although recognized through the Danish Energy Agency, DHAT needs a lot of input and knowledge on planning DH systems which cannot be expected from all target groups mentioned in *1.2 Aim of the work*.

5.2 Catalogue with characteristic cost and income parameters

5.2.1 Parameters and values based on questionnaires for the analysis of institutional, organisational and technical framework

By now, 8 out of 9 partner countries answered questionnaire A. Therefore, a catalogue with parameters and values based on these 8 questionnaires does not fulfill one of the requirements mentioned in *4.2 Creating a catalogue of cost and revenue parameters*, namely data from each of the nine BSR countries.

However, in the event that the last questionnaire might arrive after this work has ended but still during the LowTEMP project, the answers of the 8 filled out questionnaires are at least examined regarding their consistency which is the second requirement for such catalogues. All direct and indirect information is summarized in table 3.

table 3: direct and indirect information on parameters and their values from questionnaires (answered by project partners)

	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia	Sweden
VAT [%]	20	24	19	21	21	23	18	25
Network losses [%]	10-20	5-15	14	12-30	15	n/a	12-20	8
T_{supply} & T_{return} [°C]	90-95 & 60-80	65-115 & 40-60	75-110 & 45-50	60-90 & 40-70	60-65	68-119	95-150 & 70	80-90 & 50-60
Financial aids								
Feed-in tariff [€/MWh]	0.0537	83.50	Depended on technology	no	no	no	no	no
Feed-in premium	yes	no	yes	no	no	no	no	yes
Green certificates [€/MWh]	no	no	no	Yes but not yet introduced	no	9.12	no	16
Investment subsidy	No, but later yes	yes	yes	No, but later yes	yes	no	no	No, but later yes
Tax aids	no	Only with CHP	Only with CHP	no	n/a	n/a	no	No
Other possible aids	yes	yes	yes	yes	n/a	n/a	no	No
Taxes								
CO₂ tax	yes	yes	No	Yes	n/a	Yes	No	Yes
Energy content tax	No	Yes	Yes	Yes	n/a	No	No	Yes
Strategic stock pile fee	no	Yes	No	No	n/a	No	No	No
other	Natural gas excise	No	No	No	n/a	No	No	No
Fuels under energy taxation	yes	yes	yes	yes	yes	yes	no	Yes

Other possible drivers of DH price	yes	yes	yes	yes	yes	n/a	yes	Yes
Customer prices								
Residential [€/MWh]	35-84	80.35-94.44	Depending on output in kW	42-70	n/a	66.18	35	85
Industrial [€/MWh]	35-84	Vary	Depending on output in kW	42-70	n/a	n/a	35	Not public
Public sector [€/MWh]	35-84	Vary	Depending on output in kW	42-70	n/a	66.18	n/a	n/a
Payment made on basis of heat meter	yes	yes	yes	yes	n/a	yes	No, just 50 % of all customers	yes

As seen in table 3, some answers were not given (marked with "n/a"). Hence, the second requirement is not fulfilled as well as it cannot be assured that parameters and their values are consistent nation or regional wide.

5.2.2 Parameters and values used in already existing catalogues

Cost catalogues are found for Denmark and Sweden. During the desk research, no other cost catalogues were found. As only 2 out of 9 BSR countries provide such cost catalogues, the creation of a new catalogue based on this data is terminated as it does not fulfill the requirements mentioned in 4.2 *Creating a catalogue of cost and revenue parameters*, namely consistency within one nation or region and data from each of the nine BSR countries.

5.2.3 Parameters based on experience from carrying out assessments of DH projects and funding gaps according to FW 703

The following financial parameters are considered during the assessment of DH projects:

- Costs

- Investment costs
 - Construction costs [€]
 - Auxiliary costs [€] which are preset with 8 % of construction costs
 - Correction factor for market conditions [%] which is preset to 1,1 of construction costs incl. auxiliary costs
- Costs for operating and maintenance
 - Fuel costs [€/MWh]
 - Increase in fuel costs [%/a]
 - Maintenance [% of investment] or [€/a]
 - Increase in maintenance costs [%/a]
 - Operating costs [% of revenues] or [€/a]
- Revenues
 - Revenues by selling DH [€/MWh]
 - Revenues by selling electricity if CHP is involved [€/MWh]
 - Other revenues [€] which can be filled out by the user optionally
- Other economic data
 - Considered life span of investment: preset to 20 years
 - Discount rate: preset to 7 %

Most of the data or in other words the values of these parameters have to be typed in by the user¹². This means that parameters are given but not their values. Regarding the two requirements for cost and revenue catalogues from 4.2 *Creating a catalogue of cost and revenue parameters*, namely consistency and data from each of the nine BSR countries, this neither fulfills nor fails to comply with them as it is the user's responsibility to fulfill the requirements.

¹² Except of those that are already preset

5.2.4 Choice of catalogue with characteristic cost and revenue parameters

As neither the answered questionnaires from GoA 3.1 fulfill the requirements for cost and revenue catalogues nor all BSR countries provide cost catalogues for DH projects, this task has to be changed. Instead of creating a catalogue with not just parameters but also values, a list of minimum parameters is created wherefore the user of the tool has to deliver suitable values. The list of these parameters is derived in the subsection before and goes with the calculation method chosen in 5.1.3 *Choice of a suitable calculation method for further development*. A full list of parameters is given with the corresponding manual of the tool.

5.3 Development of calculation tool for economic efficiency and funding gaps

According to 5.1.2 *Advantages and disadvantages of already existing tools*, the FW 703 lacks the following (minimum) requirements:

- Availability in English
- No password given in order to unlock the tool
- Unique feature

Hence, the FW 703 tool is now translated into English and the password security is switched off. The unique feature of the developed tool is that it is able to determine economic efficiency and funding gaps directly at once. This happens through calculating the NPV of all cash flows and the IRR of the investment without any limits to country-specific laws or certain technologies. If the IRR is below 0 %, the project is not profitable and a funding gap will be calculated.

5.4 Testing of calculation tool with LowTEMP pilot measure Gulbene

The tool was tested on the pilot measure in Gulbene/Latvia. Employees of the municipality answered the questionnaire and filled out the tool.

The answered questionnaire can be seen in the appendix II *Filled out questionnaire for testing developed calculation tool from Gulbene municipality*. The evaluation sheet that was filled out afterward can be seen in the appendix III *Evaluation sheet of testing developed calculation tool*.

According to these two appendices, the testing shows the following:

In general, the respondent, Gulbene municipality, was able to answer the questionnaire and to fill out the excel tool. However, it was not possible to calculate any results due to some translation mistakes in excel formulas. The mistake was found and is now fixed. Besides that, smaller misunderstandings

and discrepancies between the questionnaire and the filled out tool were found and discussed with the project partners from Gulbene via E-Mail. The tool gives a plausible result on the pilot measure from Gulbene now.

Concerning the tool, the following problems occurred during the testing phase which have been fixed by the following measures:

- The differentiation between three different types of investment, namely grid and generating plant, generating plant, or grid only, is misleading and therefore deleted. Inputs will no longer be differentiated by that and are treated equally.
- As the pilot measure in Gulbene can be categorized as a small investment (total investment = 157.645 €), a discount rate of 7 % seems too high. Besides that, the user should have the possibility to define his or her own discount rate. That is why an extra input cell for defining the discount rate is created and the manual will explain how to determine discount rates of (LT)DH projects.
- The input for the increase in heat capacity was misleading for the project partner. Further explanation is needed in the manual on how to insert data there.
- The spreadsheet "recalc. Construction costs" was misleading for the project partner. That is why this input is moved to the spreadsheet "input data" and summarized in one cell. There the user has to insert the whole investment costs of the project.
- The accounting boundaries were not clear to the user. That is why the manual has to show what kind of investments can be considered with this tool and where accounting boundaries are.
- Although the pilot measure in Gulbene received funding, the amount of funding was not inserted in the spreadsheet "results". A new colour coding and the manual shall highlight this optional input.

The end version of the tool, which represents one of the aims of this work, is uploaded as an excel file together with this work and a corresponding manual.

The results of the pilot measure from Gulbene, i.e. the profitability and the funding gap, are shown as an example of calculation in the manual.

6 Discussion and outlook

6.1 A further developed version of the FW 703 method as the calculation method of choice

The current state of knowledge shows that not just DH but LTDH projects as well can lack profitability due to high investment costs and the fact that they are also in financial competition with fossil fuel-driven and decentralized systems. Funding can be one of the opportunities to meet these challenges. In order to promote the implementation of LTDH systems, it is important to demonstrate the profitability of a (LT)DH project and, if present, its funding gap. Both are linked together as funding gaps only occur when economic efficiency is not given.

With the tool and the manual developed in this work, stakeholders are able to determine both economic efficiency and funding gaps of investments in (LT)DH systems at once and directly without being limited to certain technologies or country-specific laws. Possible investments that can be considered with that are investments in grid and generating plant, generating plant only, and grid only. The user has to set own accounting boundaries, the manual provides assistance with that.

The tool is based on the calculation method and tool of AGFW's worksheet FW 703 and is further developed in order to meet all minimum requirements set in this work. It determines economic efficiency in the form of an IRR and the funding gap as the discounted difference between positive and negative cash flows of an investment. Therefore, the NPV method is used. Both IRR and NPV are discounted cash flow techniques and state of the art calculation methods which are recommended and used for determining the economic efficiency of not just DH projects but energy-related projects in general. Besides that, the principle of determining funding gaps used here takes up the definition of funding gaps given by the European Commission in the *Guidelines on State aid for environmental protection and energy 2014-2020*.

The tool considers investments over a period of 20 years. The length of an investment in the DH sector and its considered period is determined by the length of the economic life of the operation (Frederiksen und Werner 2014, S. 504). The economic life of an operation or a project is connected to depreciation schedules (Investopedia 2019a). Depreciation tables from Germany for DH components show that underground pipes are the components with the longest depreciation period¹³, namely 20 years (Federal Ministry of Finance Germany 2019). This supports the consideration over max. 20 years. However, it is not possible to change the length of the considered period to shorter periods.

The user of this tool has the opportunity to either choose a discount rate on his or her own or to follow recommendations given in the manual. When using discounted cash flow techniques, the choice of the right discount rate is important as this has an impact of all cash flows and their present value. In

¹³ Pipes above the ground have a longer depreciation period, namely 25 years Federal Ministry of Finance Germany 2019, but underground pipes are mostly used nowadays.

general, the following can be said: the higher the risks of a project, the higher the discount rate should be but this demands higher returns as higher discount rates reduce future cash flows more (Frederiksen und Werner 2014, S. 504). For public investment operations co-financed by European Structural and Investments Funds (ESI), a discount rate of 4 % is given but exceptions may be made (European Commission 2014b, Art. 19). That is why the user is responsible to consider an appropriate discount rate.

The cash flows of a (LT)DH project consist of positive and negative cash flows. Positive cash flows are revenues generated within the project. Negative cash flows are investment costs and costs for operating and maintenance. These kinds of cash flows are summarized as categories for cost and revenue parameters in one catalogue. Energy savings, which occur in LTDH measures, due to investments in already existing systems can be described as a profit and therefore as a positive cash flow. However, it is not possible to describe energy savings as a parameter at this time because of the following:

Investments in already existing systems, which goal it is to increase the efficiency of the DH systems, have no cash-effective revenues against the expenditures but primarily savings due to avoided costs. In general, there are two options on how to assess such savings economically:

- First, it is possible to technically and economically assess the savings on fuel and their impact on costs for operating and maintenance due to the increased efficiency of the system. In practice, this approach is very challenging as all savings have to be technological and economical clearly definable and have to be assigned to the considered investment clearly. In bigger systems, this can be done only by the operator of the DH system and with the help of simulation tools. An assessment from outside is not possible.
- Second, it is possible to determine the release of additional generating capacities due to the increase in efficiency. With this, the operator is able to connect new DH customers to the system. This results in new revenues that are occurring outside the accounting boundaries though. This approach is only possible when the expansion of the system is planned and not just structural adjustments of the generating plant. Costs for the expansion have to be estimated and deducted from the investment as they do not lie within the accounting boundaries.

In view of the above, both approaches have limits and are difficult to implement in the tool. That is why at this time it is not possible to consider energy savings due to investments in already existing systems economically with the output of this work.

Additional indicators as connection density, heat distribution losses, and mean levelized costs of energy can give further information on whether a DH system runs economically. However, they are not calculated by the tool as they are not absolute necessary for evaluating an investment in (LT)DH projects. Moreover, the parameter heat distribution losses is needed for using the tool and must be given by the user.

The tool takes up definitions and methods that have already been proven and defined by legislative

on EU level. However, the results of the tool do not imply any approval of funding as the inputs rely on the information the user has given. In order to receive funding, the results have to be checked by the funding authority. Therefore, the tool can only give support while planning investments in (LT)DH projects.

6.2 A catalogue with needed cost and revenue parameters without country-specific values

It is not possible to provide a catalogue with cost and revenue parameters that define country-specific values of DH components and systems in all nine partner countries. Research shows that such catalogues already exist in only two countries, namely Denmark and Sweden. The analysis of the financial framework of DH in the nine BSR countries shows that values for cost and revenue parameters are not always consistent nation or regional wide.

This circumstance is confirmed by AGFW when they were asked to give information on any cost catalogues in Germany. No such catalogues as the ones shown from Denmark exist there (Bernhardt-Vautz 2019). AGFW has a great overview of DH systems and their project development from institutions that are member of the association. The reason for this lack of cost catalogues is the following:

When an institution is planning a DH measure and is analysing its profitability or determining the funding gap, values taken from experience or similar projects are used normally. These values can differ from one municipality to the next to such an extent that it is impossible to create a general catalogue which provides characteristic cost parameters and values. Besides that, institutions try to keep secret as much information as possible and therefore do not disclose information on cost parameters. (Bernhardt-Vautz 2019)

Besides that, the Danish Energy Agency has mentioned that for generalizations on European data on cost parameters are impossible above regional or local level as local conditions have a strong effect on them (Danish Energy Agency und Energinet 2017, S. 21).

Uncertainties in creating specific cost values exist as prices for LTDH components not only vary from country to country but also because of other reasons such as "contract value, the number of pieces ordered and the business relation of the network operator/planner and the provider of the components" (Köfinger et al. 2016, S. 102). Also, technically innovative and new components often do not have a mass-market price yet (Köfinger et al. 2016, S. 102).

Hence, a catalogue of possible cost and revenue parameters is given in the manual but without country or region related values. With this, the user knows what parameters can be considered when determining especially investment costs but also costs for operating and maintenance as well as revenues. This is necessary as the testing of the tool with one pilot measure of the LowTEMP project shows that otherwise, the user does not know exactly what parameters to consider.

6.3 Outlook

As mentioned in the subsection before, there is a need for further development of the tool and the catalogue provided in the manual:

- Economical consideration of energy savings due to investments in already existing DH systems: the two approaches explained before will be tested with the tool, namely the technical and economical assessment of savings on fuel and their impact on costs for operating and maintenance as well as the determination of additional generating capacities released due to the increase of efficiency. In order to do so, suitable case studies will be researched and tested with further developments of the tool.
- Integration of the catalogue with cost and revenue parameters in the tool: at this moment, the catalogue of cost and revenue parameters is provided as a checklist in the manual. The user has to go through the checklist and sum up all costs and revenues by hand. The results have to be typed into the tool manually. This approach is not just effortful but also prone to errors. Hence, it is the goal to integrate the catalogue in the excel tool prior to the input mask. The user will have the choice to either fill out the catalogue with own values or to follow the approach that is used so far, namely typing in values manually.
- Integrating the calculation of additional indicators as connection density and mean levelized costs of energy: the state of technology and knowledge shows that these two indicators are used when making statements on the profitability of (LT)DH systems. Though not needed necessarily, their calculation will be integrated within the next developments of the tool to meet the state of the art.
- Dynamic design of the tool in order to consider investments with shorter lifespans: at the moment, the tool considers investments over a period of 20 years. More time is not needed but short periods can occur, especially when smaller investments are considered, e.g. an investment in a new generating plant with a shorter economic life. These scenarios will be taken into account within the next developments.

It is planned to carry out these developments during the remaining project period of LowTEMP and to upload further developments onto the project consortium's database on LinA.

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Appendix

I Financial framework of DH systems in the BSR

Financial framework of DH systems – Estonia

- VAT (general)
 - 20 %
- Network losses (operation)
 - Cities 10-15%; sparsely populated areas 15-20%
- Acknowledged supply and return temperature (operation & energy savings potential)
 - Supply: 90-95 °C; return: 60-80 %
- Financial aids
 - Feed-in tariff (operation)
 - 0,0537 €/MWh
 - Feed-in premium (operation)
 - if electricity is produced in a process of efficient cogeneration by biomass except condensation plants.
- Responsible institution for granting & subsidies
 - Environmental Investment Centre
- Subsidy measure
 - ERDF Measure "Effective production and transmission of thermal energy"
- Amount of money spent on development of DH networks and boiler rooms over the last 5 years
 - 202M€ investment of which 98 M€ subsidies
- Determination of investment subsidies for DH companies
 - "Effective production and transmission of thermal energy". The purpose of the measure is reducing the final consumption of energy on the account of more efficient production and transmission of heat energy. The supported activities are:
 - Renovation of district heating boilers and replacement of fuel;
 - Renovation of amortised and inefficient heating piping;
 - Preparation of the development plan for heating management;
 - Construction of a local heating solution to replace district heating solutions.
- Tax aids for DH companies
 - None

- Other possible aids
 - Subsidies for reconstruction/renovation of grid
- Taxes
 - Carbon dioxide tax
 - Other: natural gas excise
- Fuels under energy taxation
 - Charge on use of natural resources - Environmental charges act: <https://www.riigiteataja.ee/en/eli/ee/Riigikogu/act/521122017003/consolide>
 - In addition there is excise on fossile fuels - Alcohol, Tobacco, Fuel and Electricity Excise Duty Act: <https://www.riigiteataja.ee/en/eli/ee/Riigikogu/act/503072018010/consolide>
 - unleaded petrol - 563 euros per one thousand litres
 - liquid petroleum gas - 68.94
 - motor liquid petroleum gas - 193 euros per one thousand kilograms
 - diesel fuel - 493 euros per one thousand litres
 - light heating oil - 493 euros per one thousand litres
 - heavy fuel oil - 559 euros per one thousand kilograms
 - shale-derived fuel oil - 548 euros per one thousand kilograms
 - natural gas - 50,65 euros per one thousand cubic metres
 - motor natural gas in liquefied form - 66 euros per one thousand kilograms
 - coal, lignite and coke - 0.93 euros per one gigajoule of the upper calorific value
 - oil shale - 0.93 euros per one gigajoule of the upper calorific value
 - electricity - 4.47 euros per one megawatt-hour
- taxation information in English available
 - yes, see above
- other possible drivers of DH price
 - According to District Heating Act (<https://www.riigiteataja.ee/en/eli/520062017016/consolide>):
 - § 8. Sale and pricing of heat
 - (3) The maximum price of heat shall be set such that:
 - 1) the necessary operating expenses, including the expenses incurred in relation to the production, distribution and sale of heat, are covered;
 - 2) any investments necessary in order to perform the operational and development obligations can be made;
 - 3) environmental requirements are met;
 - 4) quality and safety requirements are met;

- 5) justified profitability is ensured.
- § 9. Approval of price of heat
- (1) A heating undertaking which:
 - must obtain, for each network area separately, the approval of the Competition Authority regarding the maximum price of the heat to be sold.
- Calculation method for determining DH price
 - Covered by District Heating Act
- Customer prices for DH incl. VAT
 - Residential
 - 35-84 €/MWh
 - Industrial
 - Same
 - Public sector
 - Same
- Why are there differences?
 - No differences
- Regulator of pricing
 - Price is suggested by DH company and approved by Competition Authority
- Payment made on basis of heat meter (in majority)
 - Yes

Financial framework of DH systems – Finland

- VAT (general)
 - 24 %
- Network losses (operation)
- 5-8 % in city center's, slightly higher 8-9 % in urban areas and 10-15 % (occasionally higher) in low density areas.
- Acknowledged supply and return temperature (operation & energy savings potential)
 - Vary seasonally, Supply in winter: 115 °C; supply in summer: 65 °C, return: 40-60 %
- Financial aids
 - Feed-in tariff (operation)
 - 83,50 €/MWh
 - Feed-in tariffs can be granted for CHP producers for the electricity production. The plant have to use either wood chips or other wood fuels, or it has to be a bio-gas plant. These plants are eligible only if they have not received any state aid.

Beside feed-in tariff for electricity, eligible producers can apply also for increased feed-in tariff (including feed-in premium for heat) if they produce also heat. There are more restrictions whether the producer can join feed-in tariff or not: legislation in Finnish: <https://www.finlex.fi/fi/laki/ajantasa/2010/20101396>

Producer can receive the grant for 12 years from the date when it has been accepted as a receiver of feed-in tariff. Maximum amount is 750,000 € / 4 tariff periods (3 periods in a year). Electricity is sold normally at the electricity markets. If the price is higher, the electricity price gets the

For wood chip power plants the budget was 54,000,000 € in 2018 (from the budget of Ministry of Finland). Biogas 10, 100,000 and wood fuel 1,500,000.

Heat premium is 20 €/MWh for wood fuel based plants where electricity is produced. Biogas power plants have 50 €/MWh.

- Green certificates
volunteer in the field of electricity production. For heat production there are no specific certificates
- Investment subsidy
- Responsible institution for granting & subsidies
Ministry of Economic Affairs and Employment in cooperation with Business Finland
- Subsidy measure
N.N.
- Amount of money spent on development of DH networks and boiler rooms over the last 5 years
N.N.
- Determination of investment subsidies for DH companies

Heat only boilers (biomass) 10-15 %, heat pumps 15%, solar heat 20%, solar electricity 25%, biogas 20-30%, subsidies of the investment price. Over 10 MW heat only boilers are not eligible to receive investment subsidies. Requirement for eligible heat only boilers is to achieve at least 70% usage of renewable energy. Investments have to be higher than 10 000 €. Flew gas scrubbers are not eligible
For new technology innovation projects 40 % subsidies.

Energy aid / investment subsidies can be found here in English: <https://www.businessfinland.fi/en/for-finnish-customers/services/funding/sme/energy-aid/>

40,000,000 € were allocated to investment subsidies for years 2016-2018 that are eligible due to the terms of subsidies.

- Tax aids for DH companies

In Finland fuels that are used in electricity production are tax free. However, for CHP production there are calculation tools how to measure the tax amount for the produced heat. Therefore, in district heat production companies have to pay fuel taxes but fuels in electricity production are tax free.

For CHP there are also lower carbon dioxide taxes, if the fuel is LFO, biofuel, HFO, coal, or natural gas. The amount of the tax is 50 % of the chart price. The tax aid is applied afterwards as tax returns, unless the company is authorized stock pile holder.

- Other possible aid

Electricity tax is added to the electricity price when distributed via distribution network to customers. Therefore, if district heating company has a CHP plant and use electricity for own process needs, it's tax free.

- Taxes

- Carbon dioxide tax
- Energy content tax
- Strategic stock pile fee

- Fuels under energy taxation

Coal is tax free if used in electricity production. For CHP and Heat only there are other regulations. Excise duty is paid of peat if used in heat production. Company is set free of the duty if peat is used less than 5,000 MWh/a.

For coal, company have to pay excise duty and strategic stock pile fee (if deputy stock pile holder, or registered receiver). If coal is used only for electricity production, it's tax free..

Coal: energy content tax 53.13 €/t, carbon dioxide tax 149.56€/t, strategic stock pile fee 1.18€/t. SUM: 203.87 €/t.

Natural gas: 7.50€/MWh, 12.28€/MWh, 0.084 €/MWh, SUM: 19.864 €/MWh

Peat: content tax: 1.90 €/MWh, SUM: 1.90 €/MWh

Electricity: 2.24 c/kWh, 0.013 c/kWh, 2.253 c/kWh. Price class I (for normal customers, incl. housholds)

- Electricity: 0.69 c/kWh, 0.013 c/kWh, 0.703 c/kWh. Price class II (only for industrial customers, and some other high intensity energy users)

- taxation information in English available

yes

Data was not updated but here is the links: energy taxation guide: https://www.vero.fi/en/detailed-guidance/guidance/56206/energy_taxation/

taxes for coal, peat etc.: https://www.vero.fi/en/businesses-and-corporations/about-corporate-taxes/excise_taxes/valmisteverolajit/sahko_eraat_polttoaineet/s%C3%A4hk%C3%B6n-ja-er%C3%A4iden-polttoaineiden-verotaulukot/

taxes for liquids: https://www.vero.fi/en/businesses-and-corporations/about-corporate-taxes/excise_taxes/valmisteverolajit/nestemaiset_polttoaineet/nestem%C3%A4isten-polttoaineiden-verotaulukko/

- other possible drivers of DH price

One argument for price increases beside taxes are the availability of fuels. When the reliability of a specific fuel is insecure, fuel price will increase, which will lead to higher district heating prices. Other arguments for district heat price increases are e.g. the increase of general price levels.

- Calculation method for determining DH price

District heating companies determine their district heat prices as cost correlated as possible.

Energy fee covers the fuel costs, energy taxation, emission trading, electricity usage in production and distribution.

Power fee (basic fee): Fixed costs of a district heating company are mainly covered with power fee.

Energy taxation - especially excise taxes of fuels have an important role in energy prices. Prices increase when taxes increase.

Connection fee: customer will pay district heating company a connection fee, which will cover the production and network investment capital costs. The price of connection fee is determined for customers so that it's feasible and reasonable for customers to join district heating and so that the connection prices won't change significantly in long term. Customers doesn't have to pay taxes of connection fee if the heating system can be used by the next user (resident) or it can be transferred.

- Customer prices for DH incl. VAT

- Prices vary yearly. CHP is cheaper for customers than heat produced in heat only boilers, in general.

https://energia.fi/ajankohtaista_ja_materiaalipankki/materiaalipankki/kaukolammon_hintatilasto.html#material-view

- Residential

Aritmetic average for 1 family house: 94.44 €/MWh, incl. energy and power fee.

For 15 house detached house / apartment building: 84.62 €/MWh.

80 house apartment building: 80.35 €/MWh

- Industrial

Industrial and public prices are in the same scale, depending on the power fee.

- Public sector

Industrial and public prices are in the same scale, depending on the power fee.

- Why are there differences?

In Finland the district heating pricing can be divided in two sectors: connection pricing and pricing during the use of district heat.

Pricing during the use of district heat:

Energy fee is a price for the measured heat consumption. The price varies but the significance in total heat bill is usually smaller among customers with low heat consumption. The used fuel and the variable costs of heat delivery for the district heating company determine the unit price of energy fee. In general the % share of energy fee is higher for apartment houses compared to single

houses. Prices will include VAT, 24%. Some district heating companies use pricing that is based on seasonal changes. In this kind of pricing the prices are based on actual fuel usage in the production site (->cost correlated prices). The pricing is based on estimated shares of different fuels in different seasons.

Power fee (basic fee): is typically 10...50 % of district heating bill. Fixed costs of a district heating company are mainly covered with power fee. The power fee can be based on actual heat power need/actual water flow need. Power fee can also be based on the same principles as in the connection fee (power/water flow). In general, the % share of power fee is higher for single house owners compared to apartment houses.

Finnish Energy has made national recommendations and guides for pricing of power and water flow contracts. There can also be other pricing methods that a district heating company can include to the price of district heat.

Each customer will make an individual heat power contract (hourly heat demand, kW) or a contract based on the water flow.

Power connection contract or water flow contract are typical basis of district heating pricing.

Connection pricing: Connection fee: customer will pay district heating company a connection fee, which will cover the production and network investment capital costs. District heating company will make the sizing of connection pipes, which is based on the HVAC designer's (or other representative of the customer) district heating power requirement calculations. When connecting an apartment to a district heating system, a district heating enterprise will calculate and estimate heat consumption of the building. This will be the background for the selection of power connection contract or water flow contract.

- Regulator of pricing

Supervising bodies for the prices are especially Finnish Competition and Consumer Authority and Energy Authority (more for electricity prices), both authorities are working under the Finnish government. Authorities can make an intervention if they see that customer has been mistreated. Authorities base their actions on legislation (consumer protection, competition legislation, energy efficiency legislation). This supervising is also the steering background for good and transparent pricing and customer service in the field of district heating.

District heating is counted as determining market, as the investment costs are high and the investment is a long lasting investment. Once a building has been connected to district heating network, it's highly unlikely that the building will change it's heating system in next decades. Due to this, the requirements for reasonable pricing have been set and are supervised by supervising bodies.

Competition act is the main legislation that regulates district heating prices. Competition act determines as for example that the prices have to be: 1) reasonable, 2) cost correlated 3) and similar customers must have similar prices.

- Payment made on basis of heat meter (in majority)

Yes

Financial framework of DH systems – Germany

- VAT (general)
 - 19 %
- Network losses (operation)
 - 14 %
- Acknowledged supply and return temperature (operation & energy savings potential)
 - Supply winter: 110 °C, supply summer: 80 °C; return winter: 75-80 °C, return summer: 45-50%
- Financial aids
 - Feed-in tariff (operation)
 - depends strongly on the chosen technology and the date of first operation. The renewable energy act has been changed several times, but the tariff price has decreased everytime.
 - Feed-in premium (operation)
 - for non-coal fired CHP plants.
 - Determination of feed in tariff and premium
 - only biomass and biogas plants are eligible for the tariff to a capacity of 20 MWel. The tariff is paid for the fed-in electricity not the produced heat.
 - In addition there is an investment subsidy for renewable energy sources like solarthermal, smaller heat pumps, biomass plants.
 - Investment subsidy
- Responsible institution for granting & subsidies
 - The subsidy for RES and for CHP are developed by the ministry for economics and energy. The money is paid by the corresponding authority.
- Subsidy measure
 - N.N. (different)
- Amount of money spent on development of DH networks and boiler rooms over the last 5 years
 - In the CHP act there is 150 million euro allocated for building new piping and thermal storages. Within the last 5 years subsidies of 175 Mio. Euro were spent for new grids
- Determination of investment subsidies for DH companies
 - N.N. (but for example FW 703 but no general rule except of what is said in the GBER)
- Tax aids for DH companies
 - There is a tax aid for CHP, where energy tax on gas has not to be paid while using high efficient CHP plants.
 - In addition, small CHP plant operators up to 2 MWel can be exempted from electricity taxation for the electricity they distribute within the surrounding area around the plant (4.5 km radius)

- Other possible aids
 - There is an CHP act, that defines subsidies for fed-in electricity from high efficient CHP. Additionally, there are subsidies for DHC grids and heat storages.
- Taxes
 - Energy content tax
- Fuels under energy taxation
 - taxation for fuels is regulated by law "Energiesteuerergesetz", in English: German Energy Tax Act, §2):
 - the following fuels are under taxation: petrol, medium oils, gasoil, fuel oil, natural gas, other gaseous hydrocarbons, liquid gas, coal, petroleum coke, lubricating oil
 - natural gas: till 31.12.2023: 13,90 €/MWh, from 01.01.2024 until 31.12.2026 taxation will rise annually up to 27,33 €/MWh. exceptions and lower taxation are possible, if natural gas is used in "benefiting installations" or plants
 - coal: 0,33 €/GJ
 - fuel oil: 130,00 €/t
- taxation information in English available
- no
- other possible drivers of DH price
 - supply independent: investment costs, Inflation, labour costs
 - supply dependent: fuel costs, taxes and surcharges (emission fees, energy taxes)
- Calculation method for determining DH price
 - dh price consists of:
 - basic price, which covers all costs which are necessary for having a certain capacity available
 - commodity price, which covers output costs
 - transfer price, which covers costs for metering and invoicing
- If operator is not heat producer, how are costs and profits divided?
 - This is content of the contract between the two parties and is usually not transparent or published.
- Customer prices for DH incl. VAT
 - Residential
 - N.N.
 - Industrial
 - N.N.
 - Public sector
 - N.N.

- Other differentiation
 - prices do not include VAT, depending on output:
 - <= 15 kW: 74,68 €/MWh
 - <= 160 kW: 72,78 €/MWh
 - <= 600 kW: 70,68 €/MWh
- Why are there differences?
 - differences in prices for dh heat can occur because of differences in
 - type of generating plant (not an issue in same dh grid)
 - type of fuel / combustible (not an issue in same dh grid)
 - geological or urban conditions
 - overall connected load and dh consumption
 - depth of services which consumer is needing from producer
- Regulator of pricing
 - The prices are unregulated: There is competition between all kinds of heating technologies and district heating and cooling has to offer an interesting price for delivering heat.
- Payment made on basis of heat meter (in majority)
 - Yes, In addition to the heat meter, there is a demand rate for overhead costs.

Financial framework of DH systems – Latvia

- VAT (general)
 - 21 %
- Network losses (operation)
 - Riga 12%; sparsely populated areas 20-30% if grid reconstruction has not been done
- Acknowledged supply and return temperature (operation & energy savings potential)
 - Supply: 60-90 °C; return: 40-70 % (summer-winter)
- Financial aids
 - Feed-in tariff (operation)
 - No, there is a feed-in tariff for electricity produced in CHP plants. Therefore, the feed-in tariff is not applicable on the produced heat.
 - Green certificates
 - But not yet introduced in Latvia
- Responsible institution for granting & subsidies
- Ministry of Economic affairs and Central Finance and Contracting Agency coordinates the grants from European Structural and Investment funds
- Subsidy measure

N.N.

- Amount of money spent on development of DH networks and boiler rooms over the last 5 years
Allocated 60 million Euro for DH companies
 - Determination of investment subsidies for DH companies
Support is provided to promote energy efficiency and the use of local RES in district heating. Within this measure, the following is supported:
 - heat energy conversion to increase energy efficiency and switch to the use of RES in central heating, incl. purchase and installation of technological equipment;
 - increase of energy efficiency of the heat energy transmission and distribution system;
 - conversion of a cogeneration plant to a heat source
 The investment subsidies can cover 40% of total project costs.
 - Tax aids for DH companies
None
 - Other possible aids
When using the alternative energy sources, DH company does not pay the natural resource tax
 - Taxes
 - Carbon dioxide tax
 - Energy content tax (called: natural resource tax)
 - Fuels under energy taxation
Energy tax (In Latvia: natural resource tax) for natural gas is 1,83 EUR/MWh; Coal 8,54 EUR/MWh; Oils Shale (5,79 EUR/MWh);
Therefore there is tax on particular emissions.
 - CO₂ emission tax 3,5 Euro/t .
 - Nitrogen oxides and other anorganic nitrogen compounds, normalised to NO₂ quantities (0,08537 Euro/kg);
 - Sulphur-tax (0,08537 Euro/kg); CO (0,0077 Euro/kg);
 - PM excluding heavy metals and heavy metal compounds 0,075 Euro/kg;
 - Heavy metals and heavy metal compounds (1,1383 Euro/kg))
 - taxation information in English available
yes and no, Natural resource law: <https://likumi.lv/ta/en/en/id/124707-natural-resources-tax-law>
Law on Pollution: <https://likumi.lv/ta/en/en/id/6075-on-pollution>
 - other possible drivers of DH price
As the main component in heat tariff is production costs, the energy source is main driver for heat price. Therefore, the heat price is strongly impacted by local conditions (number of inhabitants, heat density, availability of energy sources etc.)

- Calculation method for determining DH price

The tariff is calculated for each heat supply stage separately in accordance with the decision of the Council of the Public Utilities Commission No. 1/7. The tariff calculation consists of the sum of the three heat supply stages : production tariff, EUR/MWh; transmission tariff, EUR/MWh; realization tariff, EUR/MWh.

In production tariff maintenance and running costs are included which consists of both labor and administration salaries, as well as repairs and other additional expenses. One of the most important controllable costs is investment, and repayment of the associated credit.

In the transmission tariff the same as in the production tariff. In the transmission section, the costs of heat loss, as well as the electricity consumption for running the pump, which is directly related to the transmission of heat, appears on the variable costs.

Realization tariff is made from cost attributed to heat transferred to the users. The realization tariff retains part of the other elements in the tariffs, but the share of electricity and heat losses is eliminated.

- Customer prices for DH incl. VAT

- Residential
42-70 €/MWh
- Industrial
Same
- Public sector
Same

- Why are there differences?

No differences. The regulation in country does not allow different tariffs for different consumer groups. Therefore, most of large industrial companies has own heat plants and mainly does not buys the heat from DH.

- Regulator of pricing

The heat tariffs are regulated and confirmed by the Council of the Public Utilities Commission. There have not be major changes in tariff regulation during last years

- Payment made on basis of heat meter (in majority)

Yes

Financial framework of DH systems – Lithuania

- VAT (general)
21 %
- Network losses (operation)
15 %
- Acknowledged supply and return temperature (operation & energy savings potential)

Minimum temperature is given by Ministry of Economy

1. in a case of closed heat supply system, at least 65 degrees C;
2. in the case of an open-source heat supply system, at least 60 degrees temp. C;

- Financial aids
 - Investment subsidies (though not ticked)
- Responsible institution for granting & subsidies
N.N.
- Subsidy measure
See down below
- Amount of money spent on development of DH networks and boiler rooms over the last 5 years
 1. During the years 2007-2013 EU structural assistance period about 12% of total DHT pipelines in length were modernized;
 2. During 2014-2020 funding period it is planned to allocate funding for:
 - 2.1. Measure "Modernization and development of heat supply networks", 69.5 mln. Eur;
 - 2.2. Measure "Promotion of high-efficiency cogeneration in Vilnius city" (share of biofuels: 154 MWh and 70 MWe) - 96.6 million;
 - 2.3. Measure "Changing of heating plants that use biomass", 10 mln. Eur;
 - 2.4. Measure "Development of municipal waste incineration capacities" (Vilnius CHP power plant (53 MW and 18 MWe), 67.4 million EUR; Kaunas Cogeneration Plant (measure not approved yet) Planned: (71 MWh and 24 MWe); 69 million Eur;
 - 2.5. Measure "Modernization of fossil fuel boilers" 15.0 mln. Eur.
- Determination of investment subsidies for DH companies
N.N.
- Tax aids for DH companies
N.N.
- Other possible aids
N.N.
- Taxes
N.N.
- Fuels under energy taxation

The heat supplier, which sells at least 10 GWh of heat per year, in accordance with the methodology for the determination of heat prices and, having regard to the comments of the municipal authority and the National Control Commission for Prices and Energy, develops and submits a heat base price project to the National Control Commission for Prices and Energy and the municipal authority.

The municipality authority submits to the National Control Commission for Prices and Energy the basic documents for harmonization of the price and / or substantiated comments. The National Control Commission for Prices and Energy sets the price for the heat base. The National Control Commission for Prices and Energy determines the price of the basic heating price on its website for each heat supplier: <http://www.regula.lt/siluma/Puslapiai/silumos-zemelapis/silumos-zemelapis.aspx>;

- taxation information in English available
no

- other possible drivers of DH price

The base price for heat consists of two parts: constant and variable. The constant and the variable are recalculated once a year, and the monthly price for consumers is adjusted for the price of the purchased fuel. Fixed costs include wages, depreciation, profits, repairs, material and other costs. The constant costs incurred by companies are independent of the amount of heat produced and supplied to consumers. These costs are monitored and monitored by the National Control Commission for Prices and Energy to avoid unreasonable and unreasonably high costs incurred in the heat price. Variable costs include the production of fuel for heat production, the purchase of heat from independent heat producers, electricity generation and preparation of heating water. Costs vary depending on the amount of heat needed to produce and supply to the heat transfer networks. Fuel consumption is 40 to 80 percent of the heat price. Fuel prices are not regulated by the Commission.

- Calculation method for determining DH price
N.N.

- Customer prices for DH incl. VAT
 - Residential
N.N.
 - Industrial
N.N.
 - Public sector
N.N.

- Why are there differences?
N.N.

- Regulator of pricing

In the heat energy sector, the Commission regulates heat energy prices for those heat suppliers whose sales of heat exceed 10 GWh / year (smaller heat suppliers) the prices of heat supplied are regulated by the municipal authorities.

Map of the heat prices:

<http://www.vkekk.lt/siluma/Puslapiai/silumos-zemelapis/silumos-zemelapis.aspx>

- Payment made on basis of heat meter (in majority)
N.N.

Financial framework of DH systems – Poland

- VAT (general)
23 %
- Network losses (operation)
N.N.
- Acknowledged supply and return temperature (operation & energy savings potential)
According to ENGIE (owner of Pomeranian heating company ENGIE EC Slupsk) the maximum temperature of the heating medium during the heating season is 119 °C, minimum – 68 °C, and in summer – 68 °C.
- Financial aids
 - Green certificates
9,12 €/MWh, supervised by Energy Regulatory Office (URE)

The green certificate system was introduced in Poland on October 1, 2005 on the basis of the amended Energy Law (replaced in 2015 by the auction system), but they act as an element of the support system only for electricity from RES, they do not concern the production of thermal energy. The price of green certificates given above is the weighted average price for the entire 2017, however in June 2018 it was 16.93 EUR/MWh and in July 2018, when the possibility of buying certificates to fulfill the obligation of renewable energy sources for 2017 disappeared, the price of certificates continued to increase to the average level of 21.01 EUR/MWh. However, there are Property rights to Certificates of Origin confirming the production of electricity and heat in high-efficiency cogeneration.
- Tax aid
 - Other
There are Property rights to Certificates of Origin (violet certificates) confirming the production of electricity and heat in high-efficiency cogeneration in sources referred to Energy Law (e.g. fired with gas obtained from biomass processing).
- Responsible institution for granting & subsidies
N.N.
- Subsidy measure
N.N.
- Amount of money spent on development of DH networks and boiler rooms over the last 5 years
N.N.

- Determination of investment subsidies for DH companies
N.N.
- Tax aids for DH companies
N.N.
- Other possible aids
N.N.
- Taxes
 - Carbon dioxide tax
- Fuels under energy taxation
Every fuels and electricity are under taxation in Poland – excise duty:
 - natural gas 1.28 PLN/GJ i.e. 1.074 EUR/MWh,
 - coal 1.28 PLN/GJ i.e. 1.074 EUR/MWh,
 - light fuel oil 0.232 PLN/l i.e. 5.438 EUR/MWh,
 - electricity 20 PLN/MWh i.e. 4.662 EUR/MWh
- taxation information in English available
no
- other possible drivers of DH price
N.N.
- Calculation method for determining DH price
N.N.
- Customer prices for DH incl. VAT
 - Residential
66.18 €/MWh
 - Industrial
N.N.
 - Public sector
66.18 €/MWh
- Why are there differences?
N.N.
- Regulator of pricing
Energy Regulatory Office (URE) is the regulator of the pricing of energy, including heat.
- Payment made on basis of heat meter (in majority)
Yes

Financial framework of DH systems – Russia

- VAT (general)
 - 18 %
- Network losses (operation)
 - 20% on average, 12-16% in larger cities
- Acknowledged supply and return temperature (operation & energy savings potential)
 - Quality control plans: 150/70, 120/70, 95/70 with the temperature of a heating medium of 70 degrees for hot water supply
- Financial aids
 - none
- Responsible institution for granting & subsidies
 - none
- Subsidy measure
 - none
- Amount of money spent on development of DH networks and boiler rooms over the last 5 years
 - none
- Determination of investment subsidies for DH companies
 - none
- Tax aids for DH companies
 - None
- Other possible aids
 - none
- Taxes
 - None, just VAT
- Fuels under energy taxation
 - All types of fuel are subject to VAT
- taxation information in English available
 - no
- other possible drivers of DH price
 - Electricity tariffs, cost of natural gas, materials and equipment, etc
- Calculation method for determining DH price
 - The price is calculated based on the basic principles for pricing. The tariff is approved by the State committee for rates and prices of the Republic of Karelia based on the tariff application and proofs of costs in previous periods.

- Customer prices for DH incl. VAT
 - Residential
35 €/MWh
 - Industrial
35 €/MWh
 - Public sector
n/a
- Why are there differences?
The pricing for all consumer groups is the same.
Fuel - 40%, electricity - 10 %, salary fund -20 %, investment+ production company– 10 %, other - 20%. [author's note: this answer partially answers the question for calculation method for determining DH price, see above]
- Regulator of pricing
The State committee for rates and prices of the Republic of Karelia
- Payment made on basis of heat meter (in majority)
No, about 50% of customers have metering skids

Financial framework of DH systems – Sweden

- VAT (general)
25 %
- Network losses (operation)
8 % overall
- Acknowledged supply and return temperature (operation & energy savings potential)
Supply: 80-90 °C; return: 50-60 %
- Financial aids
 - Feed-in premium (operation)
if electricity is produced in a process of efficient cogeneration by biomass except condensation plants.
 - Green certificates: 16 €/MWh, no organization named which is the supervisor of these certificates
- Description green certificates for DH companies
Electricity certificates are distributed to producers of renewable electricity for a maximum of 15 years. This means that CHP plants fed by bio energy and younger than 15 years are eligible to receive the certificates.

The prices have been varying extremely in the last few years and have been much lower than expected. In early 2017 they dipped to 4 euro/MWh. During the summer 2018 they have again

risen to reasonable levels. In 2018, the average has been 16 EUR.

- Responsible institution for granting & subsidies

The national authority Swedish Environmental Protection Agency distributes an investment support called Klimatklivet (The climate leap), which is a support for the most climate friendly investments per invested SEK. It is not possible to apply for techniques that have separate support schemes (like PV installations).

There are four calls a year and each time the submitted applications are weighed against each other based on how much CO₂ emissions are reduced per invested sum. This fund is open for district heating and LTDH, even though large investments in pipes in trenches can make the investment too large to compete. LTDH with cheaper pipe infrastructure should have a good chance though.

- Subsidy measure

Klimatklivet

- Amount of money spent on development of DH networks and boiler rooms over the last 5 years

n/a

- Determination of investment subsidies for DH companies

The entire cost for the system can be included in the application and the competition is decided on reduced CO₂ emission/cost unit (Swedish krona)

- Tax aids for DH companies

None

- Other possible aids

No directed aids.

- Taxes

- Carbon dioxide tax (only if fossil fuels are used)

- Energy content tax

- Fuels under energy taxation

- Fossil fuels have CO₂ tax and energy tax. 1 EUR = 10 SEK (to make it easy)

- Coal: energy tax 661 SEK (~ 66.1 €) per 1000 kg and CO₂ tax 2865 SEK (~ 286.5 €) per 1000 kg = 3 526 SEK (~ 352.6 € per 1000 kg)

- Natural gas has different tax depending if it is used for vehicles or in boilers. For boilers: 3 425 SEK/ 1000 m³ (~ 342.5 €/1000 m³)

- Oil for heating: 4161 SEK/m³ (~416.1 €/m³)

- taxation information in English available

no, but: Energy taxes: <https://www.skatteverket.se/foretagochorganisationer/skatter/punktskatter/energiskatter/skattesatserochvax-elkurser.4.77dbc041438070e0395e96.html> It is in Swedish, but a table that is quite easy to

read

- other possible drivers of DH price

After a big storm in Sweden in 2005 when electricity distribution was severely effected, a new law came that all electric cables should be dug down and thereby climate protected. This has meant big costs for the utilities distributing electricity. When it comes to DH, the pipes are already dug down, but with risk for flooding and earth slides following heavy rains, it could theoretically mean the DH companies will have to evaluate their distribution.

Looking at a more current issue, DH is under heavy pressure from other heat sources like heat pumps, which has the benefit of a low electricity price that has lasted for a few years. This also means the CHP plants receive less income from their old cash cow, the electricity production, which affects the overall balance.

- Calculation method for determining DH price

Difficult to answer, business secret

- If the grid is owned by a different operator than the heat producer, how are the costs/profits divided?

No fixed model. It is negotiated separately in every single case.

- Customer prices for DH incl. VAT

- Residential

85 €/MWh

- Industrial

Not public

- Public sector

?

- Why are there differences?

The production industry have discount on the energy tax.

Big consumers can extra for peak load, which households do not pay.

There is often a monthly fee, which is more significant for households who uses less kWh.

Public sector can lift all VAT on everything they purchase within the country.

- Regulator of pricing

Every district heating company decide their own prices, but there is a national authority, Energimarknadsinspektionen, overseeing the pricing to make sure they are not increased unrealistically.

- Payment made on basis of heat meter (in majority)

Yes

II Filled out questionnaire for testing developed calculation tool from Gulbene municipality



11.04.2019

Testing of excel based tool for calculating funding gaps within lowTEMP's pilot energy strategies

Guideline and questionnaire for testing phase 1

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1 Introduction

Actions like the reduction of primary energy consumption, the introduction of efficient district heating systems with cogeneration plants, the integration of renewable energy supply, the increase of the system flexibility and the reduction of final energy consumption are realized in EU municipalities mostly as specific local investments and not on a large scale. The reason for this is, that looking at these actions under short-term market-oriented aspects, such investments need large upfront capital and may lack profitability and have a **funding gap**. However, with regard to climate protection targets, the promotion of climate-relevant projects, which do not have sufficient economic viability, is still absolutely sensible and necessary.

Funding gaps, or sometimes called unprofitable costs or economic viability gap, represent that part of an investment that cannot be covered by revenues within the usual amortization period. They represent the difference between all costs, including those for investment, operating and maintaining, and all expected revenues. As the term indicates, funding is an option to fill in these gaps.

When applying for funding, proof of the economic viability gap can be required by funding authorities. For this, a transparent, objective and practical calculation method is needed. This method will be one of two outputs of GoA 5.1 within lowTEMP. The first draft of this is shown in this questionnaire.

2 First draft of excel based tool for calculating funding gaps

2.1 Background and origin of the excel based tool

The method shown here is based on a working paper from project partner AGFW (pp 19), the so-called AGFW FW 703 working paper. The working paper describes how the economic viability gap within urban development projects in terms of energy efficiency can be calculated. Together with this working paper, an excel based tool is provided, which was developed by project partner BTU Cottbus-Senftenberg, Chair of Urban Technical Infrastructure (pp 2). The tool itself is available in German only but for free on AGFW's website¹. It is used when applying for funding and only for calculating the unprofitable costs. Usually, target groups are applicants and funding authorities. This method is objective, transparent and practicable and was proven in several applications in Germany.

In January 2019, a workshop was held in Berlin to show project partners of GoA 5.1 the first draft of this excel based tool (translated to English) and to discuss its practicability and further adjustments². However, to provide a suitable method for calculating funding gaps as an output of GoA 5.1, the method needs to be tested and reviewed by stakeholders. In lowTEMP, stakeholders are all partners with pilot energy strategies (PES): Gulbene (LV), Holbaek (DK) and Ilmajoki (FI). At this stage of de-

¹ Online available at <https://www.fw703.de/hauptmenue/kalkulationsprogramm/>, German only

² Documents of this workshop, e.g. presentations, tool and minutes, can be found on LinA: 4_LowTEMP Content → WP 5 → GoA 5.1 → workshop economic efficiency & funding gaps

velopment, it is now time to send this draft to all project partners involved with the PES as an attachment of this questionnaire.

2.2 Structure of the tool

The tool consists of five visible spreadsheets. Hidden spreadsheets are currently existing but will be removed during further adjustments as they are not necessary for lowTEMP. The following visible spreadsheets are:

- Input data: this spreadsheet asks for general information on what kind of development project is planned (development of a generating plant, a grid or both), on the costs for fuel(s), operating and maintaining the system, expected revenues and some general data on the system.
- Recalc. of construction costs (recalculation of construction costs): this spreadsheet asks for all investments which are needed for building the system, e.g. costs for pipes, generating plants, entry/exit points.
- Add. Calc. (additional calculation): this spreadsheet works automatically and does not ask for any information. It is currently written in German but will be translated to English soon. It shows additional calculations which are needed for calculating the unprofitable costs, e.g. the expected fuel energy needed over the whole period under review³.
- Results: this spreadsheet shows the main results of all calculations. As the tool considers the investment over a period of 20 years, it calculates the present net value of all costs, revenues, and the funding gap. It asks for additional information, whether other incomes like special funding opportunities are used and when.
- Version: this spreadsheet does not ask for any information but tells the user general information on the tool.

Calculations on general indicators for economic efficiency will be added soon.

3 Questionnaire

PP 2 is asking all project partners working on PES to test the excel tool. However, using the tool for the first time might not end up in plausible results. That is why PP 2 suggests filling out the following questionnaire BEFORE using the excel based tool. Additional questions may be asked in this questionnaire as well.

³This is set to 20 years.

3.1 General questions

1. Please describe the investment of your pilot energy strategy. For example: Are you going to set up a new district heating grid with generating plants? Are you going to modify an existing grid/generating plant?

Gulbene municipality as a LowTEMP project partner have following investment:

- Construction of new DH grid, new house heat controlling rooms and new boiler house in Belava village
- Smart metering systems implementation and monitoring till September, 2020
- Purchase of 3 mobile indoor data climate centers
- Strategy development for LTDH implementation in other regions

2. Has the project and the investment already started? If not, when will the project/investment start?

The investment have already started.

3.2 Spreadsheet "input data"

3. Please choose the type of investment:

- Generating plant with grid
- Grid only
- Generating plant only
- Other

Generating plant with grid.

4. If generating plants shall be part of the investment, what kind of generating plant(s) are planned? What kind of fuel do they need? How much does 1 MWh of fuel cost? Is there any annual increase in costs expected and if so, how much will this be? (For example boiler with natural gas, 47 € per MWh of natural gas with no expected annual cost increase)

Boiler with wood pellets, 40 EUR without VAT per MWh of wood pellets with approximately 3% annual cost increase

5. *If investments in the grid are the only measures taken in this project, how much does 1 MWh of heat cost? Is there any annual increase expected and if so, how much?*

Heat costs 63,26 EUR/MWh without VAT with 2% annual increase.

6. *Maintenance: how much money will be needed for maintaining the system (either percentage of the investment or a lump sum)? When does maintenance should be taken into account? Is there any annual increase expected and if so, how much?*

Approximately 500,00 EUR annually

7. *How much money will be spent on operating the system (either percentage of the investment or a lump sum. Fuel costs are not included here)? Operating includes electricity which is needed for operating, costs for insurance(s), imputed tax and staff costs*

3905,09 EUR annually without VAT

8. *How much money [€/MWh] are you expecting to generate by selling district heat? Is there any annual increase expected and if so, how much?*

0 EUR

9. *If CHP-plants are part of the system: how much money [€/MWh] are you expecting to generate by selling electricity? Is there any annual increase expected and if so, how much?*

-

10. *How many hours per year is the district heating system running (number of full utilization hours)?*

4258,6 h

11. *How high [%] are average heat losses of the district heating grid?*

5

12. If more than one generating plant is running or one or more generating plant(s) are starting to produce heat gradually: when and to what extent are generating plants added to the system? For example, one CHP-plant with max. 5 MW_{thermal} is added to the system in 2020 but starts with 3 MW in 2020 and will start running with 5 MW in 2022. Another example, the annual increase in heat production amounts to 2000 MWh in 2020 and to 1500 MWh in 2021.

No plants will be added to system.

13. Please write down the thermal efficiency [%] of every generating plant that is part of the district heating system. If CHP-plants are included, please write down the electrical efficiency as well [%].

90%

3.3 Spreadsheet “recalc. construction costs”

14. Please list all components of the investment to calculate construction costs. For example, 100 m of DN 25 pipes, 400 m of DN 50 pipes, 1 CHP-plant with 5 MW_{thermal}, 3 entry/exit points for small residential buildings (20 kW), etc. Please list for each component its unit price, quantity and the year of investment.

year	component	Dimension/size [DN, m, kW, etc.]	Quantity [pieces, kW, m, etc.]	Unit price [€/m, €/kW, etc.]	Total costs [€]
2018	Thermal plant with all components	199 kW _{thermal}	1 set	66363,54	66363,54
2018	Residential building heat entry point	88 kW	1 set	4309,45	4309,45

	with heat exchanger and all components (LT)				
2018	Culture centre building heat entry point with heat exchanger and all components (LT)	31 kW	1 set	4164,59	4164,59
2018	Local government building heat entry point with heat exchanger and all components	53 kW	1 set	4164,59	4164,59
2018	Local shop building heat entry point with heat exchanger and all components	12 kW	1 set	3958,95	3958,95
2018	Building heat entry point with heat exchanger and all components	16 kW	1 set	3947,20	3947,20
2018	Manifactory insulated heat pipes	D76/D160	12 m	42,52	510,24
2018	Manifactory insulated heat pipes	D60/D140	54 m	38,00	2052,00
2018	Manifactory insulated heat pipes	D48/D125	222 m	34,39	7634,58
2018	Manifactory insulated heat pipes	D33/D110	192 m	33,00	6336,00
2018	Heat pipe and heat grid construction components	varies	1 set	34781,17	34781,17

3.4 Spreadsheet "results"

15. *If possible, needed and you already know, please write down whether some kind of funding will be granted certainly. For example, the planned district heating system includes 1 CHP-plant and it is certain that funding for this CHP-plant will be granted. Please tell us, when you will receive additional funding.*

The funding is granted.

3.5 Questions, further remarks and feedback

16. *Please tell us, if this questionnaire was clear to you or if there are any questions on this which need to be clarified for you. If you have any remarks or feedback on this questionnaire, the excel based tool or the calculation method itself, please write it down as it will help the author with optimizing the output of GoA 5.1.*

III Evaluation sheet of testing developed calculation tool



11.07.2019

Testing of excel based tool for determining economic efficiency & funding gaps within Gulbene's pilot measure

Evaluation of responses in testing phase 1

BTU Cottbus-Senftenberg

Chair of Urban Technical Infrastructure

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1 General

- Regarding response / PES from:
 - Gulbene municipality
- Response was given by
 - 03.05.2019, Baiba Kalmene and Sandis Kalnins
- Did the respondent give any further and important information in the E-Mail (beyond the filled out questionnaire and the tool)?
 - yes
- If so, what is the information?
 - "In Your forms we indicated just direct costs of the estimate (without the overheads and profits and without the VAT (value added tax), but including the employer's social tax fee which in Latvia is 24.09% and according to Latvian laws should be included in direct cost of the estimate).

The real construction costs were 157 645.51 EUR + VAT 21 %. Plus there were also costs on construction supervision 968.00EUR+ VAT 21% and construction project costs 4920.00 + VAT 21%.

After the reconstruction object officially passed on exploitation on 21st of December, 2018."
- Does this information lead to further questions?
 - Yes, namely:
 - The total amount for construction costs in excel is 138 222 €, whereas the sum in the E-Mail amounts to 157 645.51 € + VAT. Where does the difference of nearly 19 500 € come from?
 - What are construction project costs (4920 €)?

2 Questionnaire

- Did the respondent answer every question of the questionnaire?
 - no
- If the respondent did not answer every question, which answer is missing?
 - Answer to question 16 "questions, further remarks and feedback" was not given
- Are there any answers which lead to further questions or are not understandable?
 - Answer #1: what are "house heat controlling rooms"? Is it a room with a distribution point, entry/exit point, etc?

- Answer #1: smart metering systems: are the costs for these systems already included in the construction costs and if not, why?
- Answer #1: are the costs for "3 mobile indoor data climate centers" not part of the investment? Why are these costs not given in the "recalc. Construction costs" spreadsheet?
- Answer #5: answer is not "vaild" as this question needs to be answered only when investment is just a grid and not a grid with generating plants. The price given here (63,26 €/MWh) might be the heat selling price (the answer might be given correctly in the excel tool)
- Answer #8: in the excel tool, the expected revenue from selling heat was estimated to 63,26 € per kWh whereas, in the questionnaire, 0 €/MWh are expected by selling DH → ensure that there are any revenues by selling heat, otherwise the end result will be crushing
- Answer #15: answer is "funding is granted". what does the respondent mean with that? What kind of funding is granted, what does the funding cover or for what part of the investment is the funding granted? How much money will be funded and for what?

3 Tool

- Did the respondent fill in every cell of the tool which is needed for calculation?
 - yes
- If the respondent did not fill in every needed cell, which information is missing?
- Is there any information that leads to further questions or is not understandable?
 - No, questions arising from the tool have already arisen from the questionnaire and can be seen above
- Based on the answers given in the response – is the calculation of a funding gap possible?
 - No, as reviewer's recalculation of construction costs is missing and necessary for calculating funding gap → this point has to be changed in order to offer all project partners a tool which they can use directly and on their own without a reviewer's assistance
 - In order to check whether the given information leads to plausible results, PP 02 has done the reviewing process. During this process, the following steps were necessary:
 - The whole excel file was set to 'unprotected'
 - In spreadsheet 'recalculation of construction costs', the columns B-I got unhidden and deleted

- Construction costs were typed into reviewer's columns
 - After construction costs had been reviewed, there was still no plausible result. In the spreadsheet 'results', the "amount of investment not covered by discounted annuals results" on the upper part of the spreadsheet was "DIV/o". Therefore, the reason for this calculation error had to be found and was found, in short: translation mistake lead to "DIV/o" in preconnected spreadsheets.
 - The respondent accidentally typed in an increase in heat capacity of 398 MWh/a whereas there is no such increase in heat consumption. During a short query, the respondent said the increase of 398 MWh/a only happened in year 1 of the measure. This was changed in the input data mask.
 - Besides that, the author has found some discrepancies between the increase in heat capacity in MWh/a and kW: the boiler has a thermal capacity of 199 kW. With full hours of utilization of 4258.6 h/a this makes an increase in heat capacity up to 847 MWh/a and not 398 MWh/a. As the latter seems too little for such a system, the author has changed the increase in heat capacity to 199 kW.
 - After that, the calculation was possible.
- If so, is the result plausible?
 - Yes

4 Conclusion

- Based on the answers given in the response - Is the usage of the tool viable for the PES?
 - The main idea of the tool is to determine whether a district heating infrastructure project is economic efficient after a period of 20 years. The tool is generally used before any investments start. As the pilot measure in Gulbene has already started in 2018, the tool's results can not be used as an estimation for this. However, the results might be helpful for the following time of the investment (e.g. as a check-up or controlling tool)
- Were there any misunderstandings by the project partner who filled out the questionnaire and the tool? What has to be done to resolve them?
 - Yes
 - misunderstandings regarding the difference between heat subscription price (costs) and mixed price for district heat (imputed revenues) in the questionnaire → highlight difference
 - misunderstandings regarding investment costs that actually incurred (e.g. no costs for smart metering systems, new house heat controlling rooms, 3m-bile data climate centers) and what are part of the accounting boundaries.

- The respondent also refers to different costs in total than there were given in the spreadsheet "recalc. Construction costs". → show accounting boundaries
- typing mistakes in "recalc. Construction costs" → delete this spreadsheet and insert a cell in "input data" where user has to type in the sum of the whole investment that is within the accounting
 - granted funding was not specified however has to be given as any kind of granted funding during the investment period counts as (other) income → highlight funding as optional income
- Based on the answers given in the response – is the pilot measure obvious?
 - yes
 - Can it be summarised in own words?
 - Gulbene is building a local / DH network in Belava village (part of Gulbene municipality)
 - Within this network, 5 buildings will be connected to the grid and provided with district heat (residential building, culture centre, local government building, local shop building, and another building)
 - The heat will be generated by a wood pellet boiler with 199 kW
 - The main investment covers the cost for the generating plant, pipes, heat entry/exit points and construction components
 - It is unsure whether other components like smart metering systems are part of the investment as well as they are mentioned in the questionnaire but not in the tool
 - Are there any questions and remarks from the respondent regarding the tool?
 - no
 - Further remarks from the author
 - Change ',' and '.' separator issue with numbers

Annex

The following annexes belong to this work:

- Excel based calculation tool *LowTEMP_economic efficiency and funding gaps LTDH_Vo-9*
- Manual *LowTEMP_Manual for determining economic efficiency and funding gaps of LTDH projects*

Both of them are uploaded together with this work on the projects internal document library LinA.

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