D3.5 - Attracting institutional investors to low temperature DHC networks

Renewable and Waste Heat Recovery for Competitive District Heating and Cooling Networks

REWARDHeat

Project Title: Renewable and Waste Heat Recovery for Competitive District Heating and Cooling Networks

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Deliverable Title: Attracting institutional investors to low temperature DHC networks (HFT)

Lead beneficiary: HFT

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1 Summary

This deliverable focuses on the development of financing solutions which are attractive to potential investors for the district energy sector. District heating and cooling networks (DHCN) carry the advantage of representing a cost-efficient heating solution with little environmental impact and thus have a significant social and environmental value – leaving room for a variety of instruments to attract investors. Key benefits of REWARDHeat systems are their flexibility in terms of adapting to the usage of different types of heat sources, including renewable energy systems and even waste heat and their ability to balance electricity supply by also absorbing electricity.

The key question of task 3.5 is how to attract investors – as one key stakeholder group for upscaling DHCN – for financing DHCN. One core objective is to translate the results created in the demosites into the investment-decision-dimensions (risk, return, liquidity and sustainability) and the language of investors. D3.5 is closely linked with and builds upon the results of D3.1 PESTLE-Analysis, D3.2 Living Labs, D3.3 Bankability Assessment and D3.4 Business Models. The workflow of D3.3 D3.4 and D3.5 is iterative and based on interactive information flows between bankability, business model and financial instruments.

The overall purpose of this deliverable (3.5) is to develop solutions making the district heating sector attractive to investors. It will be shown that investments in DHCN networks do have a meaningful social and environmental impact because they enable cost efficient heating that has only small negative effects on the environment. One advantage of the RewardHeat systems is that they are equipped with the capability to integrate new heat sources such as RES and waste heat. Another advantage of this system design is that it is able to balance the electricity sector in absorbing electricity depending on the respective weather situation.

However, developing the district heating sector to become a “mass technology” makes it necessary to generate a new asset class which brings together several financing schemes and models focusing on funding sustainable technology that play a major role for meeting the EU’s climate goals. For this reason, one major goal of this deliverable is to show how potential investors can be attracted in the long-term, making modern district energy solutions a profitable investment opportunity.

The solutions that have been developed to attract investors to the DHCN can be summarized in in the following questions: (1) Which KPIs are important to investors in the decision-making process and in the evaluation of potentially investible DCHN business models? (2) Which financing instruments are suitable for creating the envisaged asset class (typology of financial instruments)? (3) What types of investors would be willing to invest in which financing schemes and instruments (typology of investors)? (4) Which financial instruments should be offered to which investor group (investor-financial instrument-matrix)? (5) How can the communication with investors be optimized in order to help them overcome uncertainties and recognize the benefits of proposed financing solutions (investor relations, networking with investors)? For this purpose, the identified and developed financing solutions will be presented to investors and their feedback gathered through interviews.

The ongoing changes in the EU’s regulatory environment on sustainable finance will be accounted for both in (bankability deliverable) and in this deliverable. A promising “vehicle” in the area of sustainable infrastructure finance is blended finance. Its goal is the effective implementation of critical, but hard-to -fund investment projects.

A case study analysis of different DHCN outside the REWARDHeat project, located in different European countries, has been conducted. Due to the early stage most of the projects are still in, in most cases publicly funded by the EU (e.g. Horizon 2020, European Structural & Investment Fund (ESIF)). This underpins the high importance of attracting investors via financial markets in order to provide a long-term funding for upscaling DHCN. The EU Green Deal and the EU Action Plan for Sustainable Growth are intended to help reorient financial flows towards sustainable investments and thus also facilitate the financing of DHCN projects.

2 Introduction

2.1. Background

Today, half of the EU's energy demand is designated to heating and cooling in buildings and industry. Almost 80% of the total energy consumption of EU households is used for heating and hot water. At the same time, climate change and rising temperatures are creating an increasing demand for cooling. Despite the increasing relevance of global warming, about 85% of heating and cooling is still produced with fossil fuels (Van der Veen et al. 2019)

DHC networks represent an efficient and innovative solution for the reduction of fossil fuels and consequently to meet the EU's climate and energy targets. They are suited to feed in a large variety of energy sources, such as solar thermal and geothermal heat, waste heat from industry and commercial buildings, heat from combined heat and power plants, and thus have the advantage of not making customers dependent on a single source of supply (Euroheat & Power)

Modern district energy solutions are already acknowledged as the best way to bring sustainable heating and cooling in dense urban environments by an increasing number of cities across the globe (Euroheat & Power). New, flexible business models are being developed as part of the REWARDHeat program and lay the ground for new investments. Still, potential investors perceive these approaches as very risky. To overcome the uncertainties, new financing and investment opportunities for district heating and cooling, as well as models and financing strategies are increasingly being developed (Carlsson et al. 2018)

Against the background of a significantly changing regulatory environment new opportunities for developing new approaches for financing DHC networks arise. Especially the EU Action Plan on Financing Sustainable Growth as well as the EU Green Deal provide for more favorable framework conditions, aiming at redirecting capital flows towards sustainable investments.

For our economy to function and to be stable in the long-term, a strong infrastructure, defined by (Fulmer 2009) as "the physical components of interrelated systems providing commodities and services essential to enable, sustain, or enhance societal living conditions", is vital. (Da Canas Costa and Popović 2020)

In metropolitan areas, (interconnected) infrastructure is a main enabler for a variety of essential services, such as cooling of buildings, cooking, commuting to work or school or even waste disposure, creating ever growing dependencies of urban citizens upon interconnected services. At the same time the global trends of climate change, economic development, population growth, urbanization and digitalization are putting urban infrastructure under unprecedented stress. (Da Canas Costa and Popović 2020)

The 2019 and 2020 edition of the annually published Global Risks Report by the World Economic Forum (World Economic Forum 2019a, 2020) confirm the immense scope of environmental risks to the world economy. Extreme-weather events and the failure of climate-change mitigation and adaptation build together the highest ranked risks globally in terms of likelihood, and are ranked second highest globally in terms of impact (second only to weapons of mass destruction) (World Economic Forum 2019a). (Da Canas Costa and Popović 2020)

The fact that the 2018 Aon's Weather, Climate & Catastrophe Report stated that the 394 top natural disasters generated USD 225 billion worth of economic losses (AON 2018), mainly in metropolitan areas, is yet another crucial indicator for the impact of climate change on the economy. (Da Canas Costa and Popović 2020)

Even though environmental risks are so prominent today, the great majority of future cities depend on outdated business models such as fossil fuels for energy generation or face uncertain and volatile water supply for drinking, irrigation and hygiene, due to the fact that the way infrastructure is being planned, built financed and operated does not fit future requirements and infrastructure assets tend to have a lifespan of 20-100 years. (Da Canas Costa and Popović 2020)

Nevertheless, a transformation of cities and urban areas into smart cities is taking place. Digital transformation plays a major role in this process, challenging cities even further by requiring significant investments in smart IT-driven technologies in all areas (Peris-Ortiz et al. 2017, S. 9–10). On the bright side, if this transformational process is successful it will create smart infrastructures that can serve as a basis for ecosystems for innovation. (Da Canas Costa and Popović 2020)

The decision-making process for the types of infrastructure projects to be implemented, is, to a large extend, shaped by financial markets and institutions (e.g. investment funds, insurance companies), due to their ability to channel huge sources of funding. In order to meet global sustainability agendas such as the Paris Climate Agreement or the UN's SDGs, a radical shift in infrastructure finance is vital (Da Canas Costa and Popović 2020)

The German Advisory Council on Global Change (WBGU) states in various expert reports e.g. (WBGU 2011) the need for investments to realize economic and societal decarbonization goals. For instance, an increase of annual investments in energy efficiency, renewable energy, etc. from US$ 1,100 billion in 2010 to US$ 3,500 billion in 2050 will be necessary to achieve the 2-degree climate target (WBGU 2012). According to the EU Commission by 2030 it can be expected that "clean energy" investments will account for up to EUR 11,200 billion (EU High Level Expert Group 2018: 10). Whilst large amounts of investments are required to meet the climate goals, many countries have high public debt levels which make the governments unable to raise these sums. Large economies like the United States report declining investments for infrastructure for several decades, leaving them today with a percentage of 1.5% of GDP (Stupak 2018). The lack of government investments in infrastructure reveals the need for innovative approaches to financing sustainable infrastructure which consider private capital as a critical factor. (Popovic 2018, p. 207). Approaches, like blended finance (the strategic use of public funds to mobilize private capital flows) can be of great use in this context (World Economic Forum 2019a, 2019b). (Da Canas Costa and Popović 2020)

Key Takeaway of Section 1:

One crucial question to deal with in this subtask is how to bridge this massive investment gap and how sustainable finance and investments can contribute to filling this funding gap.

2.2. Purpose, Research Questions and Structure of this Task

The significant environmental value of this technology and its dissemination across Europe requires the development of financing solutions, which are attractive to potential investors. DHCN carry the advantage of representing a cost-efficient heating solution with little environmental impact and this contributes to their high environmental and social value - leaving room for a variety of instruments to attract investors. Among the key benefits of REWARDHeat systems count their flexibility in terms of adapting to the usage of different types of heat sources, including renewable energy systems and even waste heat and also their ability to balance electricity supply by also absorbing electricity.

The three deliverables in WP3 are closely linked with one another. Those are the deliverables on business modelling (D3.4), bankability (D3.3) and attracting investors (D3.5). The work resulting in the three deliverables is iterative where information flows between bankability, business model and financial instruments.

One key stakeholder group for urban waste heat recovery expansion are investors. They need information on possible business cases, understand the kind of sector they invest in as well as identify the most suitable financing instrument for the investment.

In the study of bankability information is provided to the investor on the sector they invest in, ensuring that the perception of risk is reflecting reality. Input is collected from the particular demo sites and their business cases (D3.4) to support project promotors in their quest to attract investment. Investments in new fields might require capital incentives at early stages, such tools are identified for REWARDHeat solutions. The starting point is here the work done for four low temperature demo sites in sister project ReUseHeat where the proposed credit

The ongoing development in the EU on sustainable finance will be accounted for both in the study of debt and financing instruments (bankability deliverable) and in the financial instruments appearing to be suitable for investments like REWARDHeat demosites (D3.5).

The task (3.5) consists of three subtasks, which are subsequently laying the ground for the development of financing solutions for innovative technologies.

Subtask 3.5.1 – Financing schemes assessment:

Based on a knowledge base created within HFT about existing funding opportunities by the EU and international institutional, public and private investors (e.g. EIB, pension funds such as EEEF and ERP, crowd funding etc.), an analysis of potential public incentive schemes for energy efficiency (e.g. tax credit and white certificate) within all 8 demonstrator countries will be carried out. The overall goal is to elaborate innovative financing schemes base on public private collaboration and participative models and to execute a financial analysis which:

- Identifies a suitable governance structure to certify the advantages of adopting the proposed actions
- Defines a procedure to assess the bankability of proposed actions
- Identifies suitable models to demonstrate the functionality of the assessed financing schemes

Subtask 3.5.2 – Integrated Investment risk-, return- and sustainability-assessment – Sustainability Balanced Scorecard (SBSC):

The main purpose of this subtask is using the investors' perspective as a starting point for developing financing solutions for DHC networks. The "magic square", which combines the risk-, the return-, the liquidity- and the sustainability-perspective as most relevant dimensions for the investors' decision-making process will be used for analysing the DHC network business models (task 3.4). The resulting Sustainability Balanced Scorecard (SBSC) will analyse the individual business models of the REWARDHeat demosites and translate them – using KPIs – into the logic and language of investors (D3.4) in order to understand what the most feasible investment tools are. The SBSC will be strongly linked to the bankability assessment (task 3.3).

Acknowledged tools and methods from the Energy Efficiency Financial Institutions Group's DEEP or Underwriting Toolkit will be enhanced and adapted to the specific requirements of the innovative technologies to be developed in this project. As a result, an integrated financial and sustainability management instrument which enables the development of financing solutions for

innovative technologies, serves an instrument for the analysis of different investment scenarios along the entire value chain and provides measures for optimizing the different impacts, will be elaborated.

Subtask 3.5.3 – Networking with investors:

Through further literature-based and market-based analysis a typology of investors will be developed. In a second step, this typology will be used to identify potential investors and investor groups for DHCN. In a third step they will be linked systematically with suitable financing instruments that were identified and further developed in subtask 3.5.1. For this purpose and in order to identify specific financial instruments that would fit with the needs and objectives of the different types of investors an investors-financial instruments-matrix will be developed and filled (see below).

The division of labor between the different tasks of work package 3 as well as the related workflow is illustrated in Figure 1:

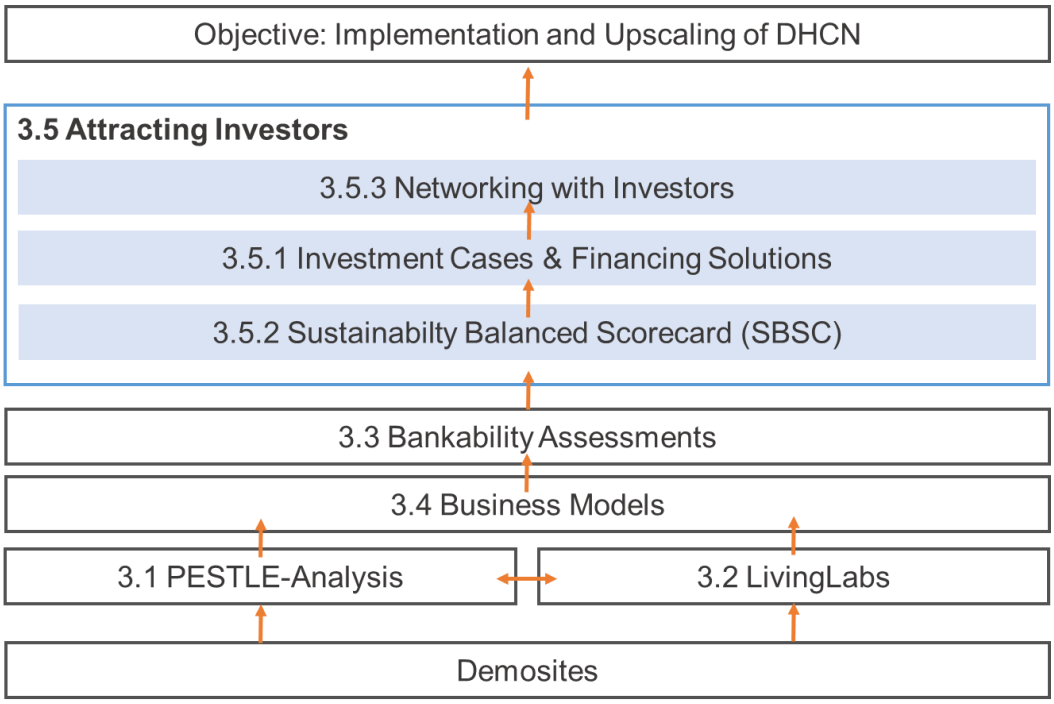

Figure 1: Task 3.5 within the context of the entire REWARDHeat-project (Source: Own illustration HFT)

Establishing DHCN as a mainstream technology and thereby meeting the EU's climate goals requires bringing together several financing schemes and models whose focus lies on the funding of sustainable technologies. It is therefore also necessary to outline modern district energy solutions as a profitable investment opportunity for potential investors.

The different kinds of asset classes are defined in Chapter 5.

A close examination of the relevant literature in the area of DHCN, interviews with investors, and the constant screening of the development of DHCN in other European countries has led to the identification of the following research questions:

- Which KPIs are important to investors in the decision-making process and in the evaluation of potentially investible DCHN business models?

- Which financing instruments are suitable for creating the envisaged asset class (typology of financial instruments)?
- What types of investors would be willing to invest in which financing schemes and instruments (typology of investors)?
- Which financial instruments should be offered to which investor group (investor-financial instrument-matrix)?
- How can the communication with investors be optimized in order to help them overcome uncertainties and recognize the benefits of proposed financing solutions (investor relations, networking with investors)? For this purpose, the identified and developed financing solutions will be presented to investors and their feedback gathered through interviews.
- This information is summarized in Figure 2:

	Equity	Mezzanine	Debt	Structured and Cashflow Based Finance	Grants / Subsidies / Subsidized Funding	Others
Private / Retail Investors						
Public Institutions						
Banks						
Investment Funds						
Pension Funds						
Insurance Companies						
International / Multilateral Financial Instutions						
Industrial Investors (e.g. Utilities)						

Figure 2: Investor-Financial-Instruments Matrix (based onPopovic 2013, p. 56)

Subsequently, the matrix will serve as a basis for contacting investors in order to start networking for the purpose to start a discussion process with them. By presenting the elaborated financing schemes to five different types of investors and complementing their feedback with information on national legislation that can hinder the possibility to bundle district heating schemes, conclusions on how policy impacts the option to bundle district heating investments. The foreseen types of investors are (as a preliminary selection):

- a municipal investor
- an investor with an explicit sustainable or green profile
- a conventional bank
- a pension fund and
- the European Investment Bank

Key Takeaway of Section 2:

A comprehensive approach is applied: Based on DHCN's business model investment cases are developed. These are analyzed from an investors' point of view using a sustainability balanced scorecard (SBSC). Investible cases will be matched with suitable financing solutions that are provided by different kinds of investors.

3 Methodology

The methodology provides a theoretical basis such as a literature analysis and the study of best practice examples. The practical basis of this approach is the cooperation with the demo sites in order to get the economic data as a basis for further action.

3.1 Literature Analysis

The literature analysis of this deliverable will not only encompass classic desk research but will also include term and project papers as well as bachelor and master theses from students enrolled in different study programs of HFT, providing for an interdisciplinary perspective on DHC network investments. This includes the Smart City Solutions master program at HFT which is focusing on the field of sustainable urban development. Furthermore, working towards the creation of a thoroughly researched knowledge base in the field of sustainable infrastructure finance and investments (as mentioned in 2.1) will ensure that relevant literature is reviewed. The search strings that have been used range from the technological requirements of modern DHCN to business models to investment cases and how these facilities had been planned and implemented in different countries.

Databases which have been reviewed: (This is a selection)

1. IEE Xplore
2. Web of Science
3. Scopus
4. JSTOR
5. Google Scholar
6. Science Direct
7. ProQuest
8. Citavi

3.2 Case Studies, Best Practice Examples

Case studies have been conducted throughout the project to analyze the development state of DHCN in different countries. These are described in detail in Chapter 6. The following list provides an overview:

1. Cool DH
2. Flexynets
3. TEMPO
4. HeatNetNWE
5. SmartReFlex
6. Life4HeatRecovery
7. DETEPA
8. Networks for Networks
9. Heat Pipe exchanger project Romania

Other case studies have also been used to complete this analysis. Some of these are described below:

1. Copenhagen, Denmark:

- Copenhagen's district heating system is one of the largest in the world that provides heating for 98% of the city's buildings. On the one hand, the system uses waste heat from power plants and industrial processes and on the other hand it makes use of renewable energy sources such as biomass. This has contributed significantly to the reduction of city's carbon footprint.
- The district heating system in Copenhagen outlines the advantages of large-scale district heating systems in urban areas. (Copenhagen Energy Ltd. 2009)

2. Stockholm, Sweden:
   - The city of Stockholm operates a district heating system providing large parts of the city with heating. The system is powered by a mix of biofuels, waste heat and natural gas. The recipients are residential and commercia buildings.
   - Implementing DHCN in Stockholm has made it possible for the city to reduce the consumption of fossil fuels and lower CO2-emissions. (Smart City Sweden)

3. Helsinki, Finland:
   - Helsinki has utilized one of the most advanced district heating systems in the world. This system is operated by a combination of waste heat from industrial processes, power plants and also renewable energy sources.
   - The DHCN in Helsinki made it possible for the city to replace fossil fuels by renewable energy sources and thereby reduce CO2-emissions. (Helsingin Energia 2011)

4. Vancouer, Canada:
   - Vancouver is using both district heating and cooling networks in order to reduce fossil fuels and to lower CO2-emissions. The Southeast False Creek Neighbourhood Energy Utility (NEU) is a district heating system in Vancouver that uses waste heat recovered from sewage to provide heating and hot waters to buildings.
   - This also made it possible to ensure the heat supply by simultaneously reducing the negative impacts of energy consumption. (City of Vancouver 2024)

These case studies show that DHCN is a globally recognized technology that makes it possible to provide heat and cooling by simultaneously reducing the negative effects of CO_2-emissions. The case studies outlined above are relevant to our study because they show that these systems have proven their applicability and are no longer in an experimental status. As such, they have the potential of reducing harmful CO_2-emissions by making use of renewable energy sources. Case studies can thus be used to display technological feasibility, the economic viability and the user acceptance of those projects to investors. These in turn are arguments for investors to invest.

Several case studies are planned to not only be conducted within the REWARDHeat project, but also as part of student projects within the Smart City Solutions Master Program. The objective is to gain further insights from DHC network projects already implemented, in order to learn more on suitable financing instruments already used in practice as well as on investors willing to provide the funding.

Potential case study projects will look into topics such as the decision-making process of potential investors, testing several financing schemes whilst assessing their risks and opportunities and their environmental impact. Instruments such as the Sustainability Balanced Scorecard (SBSC) – using the magic squares dimensions and the magic square will be an integral part of the case studies. The related KPIs will be used for deriving the investment story from different DHC networks business models.

3.3 Surveys and Interviews

Five Interviews with different types of investors and other representatives of financial services institutions were conducted in spring 2022. Conducting interviews counts among the research methods because it helps to gather information about a project's complexity, the uncertainty connected to it and also helps to mitigate these effects. (Tech R.P.G. 2018) The following table shows the interviews that have been conducted throughout the project:

Table 1: Interviews with different types of investors

	Interview partner	Organization	Date
1	Gebrail, Greg	EBRD	10.05.22
2	Anonymous	Anonymous	17.05.222
3	Dichtl, J.	UNEP FI	17.05.22
4	Inderst, G.	Inderst Advisory	23.05.22
5	Lautenschläger, S.	L-Bank	01.06.22

The interviews were conducted according to an interview guide which included a set of structured questions. The answers were recorded on tape, transcribed and afterwards they were analyzed with regard to the objective formulated below.

The goal of these interviews was to understand the perception of investors on elaborated financial solutions and district heating as an investment. An additional goal was to understand and to overcome potential obstacles which would keep investors away. The main motivation here was to get practical input to generate investor-centric financing solutions which are beneficial to the environment. The interview findings are described in section 0.

Additionally, interviews with each demo site were performed in the first months of 2023. The aim was to find out where the challenges of the demo sites are, especially in the case for financing and if the demo site could be a potential investment case. For this data was requested to calculate potential investment cases. This is described in section 4.4

3.4 Workshops

Workshops are a method that is applied across various fields. For instance, workshops enable active learning since they involve persons in the learning process. They also convey a hands-on-experience in containing practical activities, simulations or exercise that make it possible for the participants to apply the theoretical knowledge. Another advantage of workshops is that they enable problem solving in bringing together various perspectives and knowledge levels and in generating new innovative ideas. Moreover, workshops contribute to efficiency in that they promote interaction among the participants and discussion (Momirski 2019). The Design Thinking-method has been applied to develop the business model and to find out more about investors' paint points, needs and objectives.

Therefore, the method of workshops was chosen in order to work with representatives of financial services, institutions and investors. Workshops fulfil an important task in this work package. They

are a great opportunity to present results to potential investors and discuss prototyped financial instruments and investment solutions with them. The workshop results will be used to adjust and refine the solutions developed in this task.

A series of two workshops have been planned as part of this work package:

- The first workshop has been carried out in June 2021 and was conducted online. The goal of the first workshop was to find out how to attract investors to invest into DHC projects. For this purpose, they were presented basic information on DHC networks and their financial potential, as well as the potential of DHC networks as a sustainable investment solution. Furthermore, they had the opportunity to ask questions and were asked to give more information about their interests and needs.

The following Figure 3 shows the working process on how to attract investors in DHC:

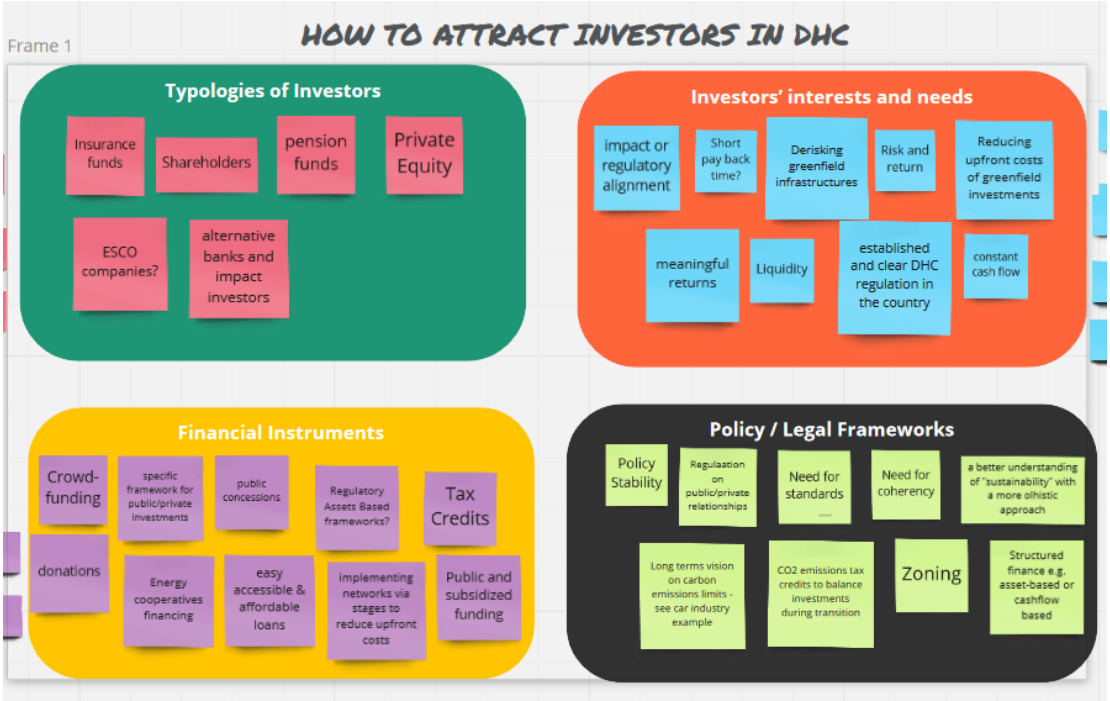

Figure 3: How to attract investors in DHC (source: screenshot from first investors workshop)

- The second workshop has been taken place in June 2022 in Sweden. The focus was set on finding out more about the way investors assess infrastructure investment opportunities. For this purpose, HFT presented the actual findings from the project, like KPIs and insights from the interviews. Representatives from two demo sides performed a pitch presentation which was assessed by the financial experts. The workshop findings are described in section 0.
- The Investment Case Workshop for Demo-sites took place on May 11th 2023 in Topusko at the 6. General Assembly Meeting of the REWARDHeat project. The focus of this workshop was to attract investors to District Heating and Cooling Networks (DHCN). Various demo sites talked about their future plans (extension, refurbishment etc.) and how these projects should be financed. HFT also offered a voluntary coaching session in order to put emphasize to the needs of investors.
- Demo-site Knowledge Sharing Workshop took place from November the 8th till November 11th 2023 in Milan at the 7. General Assembly Meeting of the REWARDHeat project. The goal of this workshop was to share the knowledge that had been attained throughout the project.

- On the 19th January 2024, the 3rd Investor Workshop with BVI (Competence Center for the German Funds Industry) and VKU (Representation of Municipal Companies) had been organized as an online-workshop. The goal of this workshop was to approach the question how investors can be encouraged to make investments into District Heating-networks and what efforts have to be made by the political decision-making process.
- From the 14th to 17th May 2024, the 4th Investor Workshop took place in Brussels. The topic was "Accelerating the European district heating rollout - Unlocking the potential of financial markets". The goal of this workshop was to present the results from within REWARDHeat to investors and to have an interactive roundtable on policy recommendations.

The purpose of these workshops was to present interim results and to discuss these results with the members of the Advisory Board.

3.5 Testing and Validation (Financial Advisory Board)

Once the aspired financing schemes are fully developed, they will be presented to a financial advisory board for evaluation. The advisory board will be composed of several stakeholders, including project partners, banks and investment funds representatives as well as energy cooperative associations.

Active financial boards play an important role in strategic decision-making by improving the quality of decisions. They make use of a framework that combines case-based reasoning and a new diversification strategy to create diverse and personalized investment portfolios by meeting the needs and constraints of investors. (Musto C. 2015)

The members of the Financial Advisory Board provided various insights in the presuppositions of investments in the district heating sector. This does not only include analyses and information of financial markets, but also investment strategies, risk management as well as financial planning and budgeting.

Moreover, financial Advisory Boards are also a possibility to put newly developed financing schemes to the test and this is mutually beneficial. Financial advisors are interested in new technologies because it helps them to renew and regain their competitive advantage. It also enables them to identify and business and technology drivers when implementing solutions. (Ceru D. 2004) Investors are aware of the fact that investments in new technology may lead to high benefits and the representatives of new technologies such as DHCN depend on these investments in order to scale-up and to enter the profit zone.

Expert advice on the newly developed financing mechanism and to arrive at a common ground with regard to the solutions elaborated are the benefits of working together with a Financial Advisory Board. The advantages for the project are obvious. The Financial Advisory Board's expert advice helps the demo-sites within this project to make risks assessable, to overcome obstacles and to provide information in the right way. The findings resulting from this working process will be tested for validation purposes via interviews with potential investors selected within the advisory board. This task will be executed in coordinate with the dissemination/communication activities to ensure the coherence of the project's message towards the outside world.

Key Takeaway of Chapter 3:

A wide range of different methods (e.g., literature analysis, case studies, interviews, workshops and the advice of a financial advisory board) were used to generate a knowledge base, to find out more about the investors' perspectives and goals, to develop financing schemes and to support the demosites in developing business models and investment cases

4 Attracting Investors by Developing Investment Cases for DHCN

4.1 Outlining the Technological Potential of District Heating

District heating and cooling systems have the potential to significantly increase energy efficiency and also contribute to a large extend to an increased decarbonization in urban areas. (Werner 2004) However, efficiency potentials have to be realized along the value chain. Regarding the climate change objectives of the EU, the efficiency gains through cogeneration will no longer be enough. The supply side of district heating must also address the problem of decarbonization to a higher degree. When comparing a solar-supported gas heating system with a natural gas-fired CHP plant the emission factor shows 294 gCO_2 p kWh at the break-even point. This is the point at which an equal amount of CO_2 emissions is allocated to the heat production of the CHP plant, as the solar-supported gas heating system would entail. (Welsch 2017)

The following example of Sweden shows that a well-balanced fuel mix can contribute to make district heating more climate-friendly.

Most urban areas depend on fuel- and electricity-imports. Fuels are imported from both near and far. In the case of biomass these are usually local but may also be imported from other countries depending on the logistical possibilities and prices. In Sweden, all fossil fuels are imported from other countries. Sweden itself produces roughly the same amount of electricity as it consumes. In the Nordic countries electricity production and consumption is integrated and electricity is supplied to a Swedish urban area. This, for example, can be defined as a mix of Nordic electricity production. A CHP plant in the DH system of an urban area will increase the amount of needed fuels by simultaneously decreasing the need for electricity. Energy conservation measures in the building stock will affect the DH system's heat load and thus the fuels and electricity flow through the system borders. (Lundström 2016) (see Figure 4):

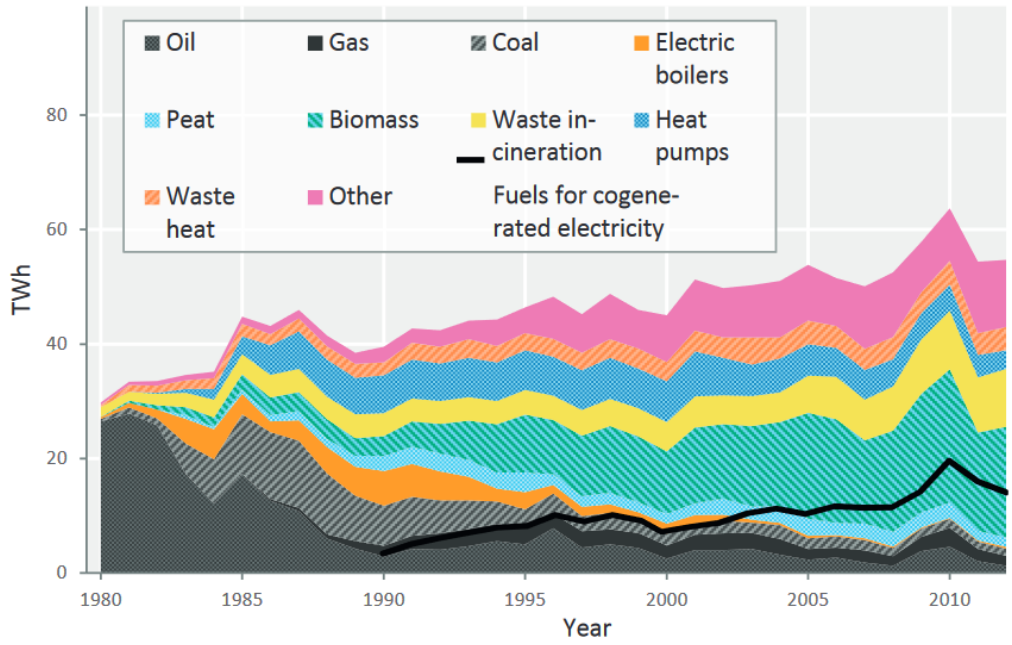

Figure 4: The fuel mix for the Swedish district heating sector 1980–2010, and amount of fuels for cogenerated electricity (black line) for 1990–2012. (Lundström 2016)

Holistic Consideration of Efficiency Gains Including all Stages of the Value Chain

As part of the heating network, production, transportation and the demand side depend on each other in the district heating sector. This also means that potential efficiency gains are present and realizable at all stages of the value chain – from the demand side to the supply side (power-to-heat ratio and integration of variable renewables by power-to-heat) as well as with district heating systems of the fourth generation. It is thus necessary to consider the synergetic effects when evaluating efficiency measures. (Welsch 2017)

Very often, DH can be coupled either with centralized heating stations and/or distributed heating units. Thus, numerous kinds of heat generation technologies (boilers, cogeneration plants, heat pumps etc.) and energy sources (fossil fuels, renewable energies, etc.) can be coupled. In Germany, combined heat and power (CHP) based DH systems are often seen as a key solution to meet the local heat demand in buildings and, therefore, these CHP units are frequently heat-driven. (Dahash et al. 2017) (see Figure 5)

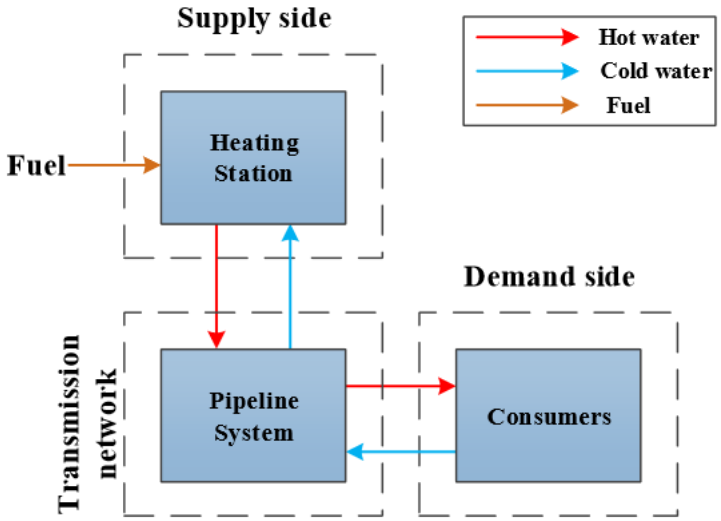

Figure 5: Generic block diagram of a district heating system (Dahash et al. 2017)

The transition to a smart DHC system should be conceptualized, developed and implemented.

Information and communication technologies (ICT) offer new opportunities to develop more effective and complex network solutions for production, distribution and demand. All parts of the system can benefit, e.g. from production through forming virtual power plants, to distribution by decoupling and integrating different temperature levels and to the demand side, where smart meters can be used in order to monitor and manager consumption. (Welsch 2017)

A system that is already used by district heating systems, cities and communities such as hospitals is E.ON ectogrid™. The smart grid solution is an intelligent decentralized energy system, which is able to share and reuse heating and cooling between buildings in a hospital area. Its task is to recycle energy for as long as possible and only adds new external energy after all existing internal energy streams have exhausted. In case of the hospital, it can decrease energy cost and thereby lower the environmental footprint.

In some cases it was also possible to reduce the need for external energy by 60% using E.ON ectogrid™. By lowering the temperatures in the system to the range of the earth's temperature, the safety in the hospital can be increased and since the system is bi-directional, there is only need

for two pipes in the ground, which takes less space in the densely built hospital areas. (E.ON Infrastructure Solutions) (see Figure 6)

Figure 6: E.ON ectogrid™ (E.ON Infrastructure Solutions)

This overview is intended to provide an insight into how diverse this technology is and the potential it offers for a "game changer" in the heat transition. Meanwhile, this technology has evolved to DHCN of the 5th generation, which are a promising technology for decarbonizing the heating and cooling sector. These modern systems are not only capable of reducing the heat loss, but are also able to integrate low-temperature waste heat sources. This is what makes them attractive for urban areas. (Rhein, J., Henze, G., Long, N. and Fu 2019)The reason why 5GDHCNs are still not suitable for the masses lies in the fact that only a few companies share the expertise on this technology and this means that there is a monopolistic system. One way to break up this monopoly is to promote the exploitation of local thermal energy sources and to adopt more decentralized "active" substations. This also requires the development of new business models for multi-utility companies. Another problem is that there are no guidelines for designing such systems and that there is knowledge base how 5GDHCN to be operated optimally and how to control them. (Rhein, J., Henze, G., Long, N. and Fu 2019)

The discussion of the technological potential of the district heating sector leads to the question how this technology can be made economically viable. Generally, the business model connects the technology to the economic use, but business models are more than that. They do not only display the connection between technology and firm performance, but also affect the development of the right technology through openness and user engagement.

Waste heat recovery from industrial processes

The recovery of waste heat plays a very important role in modern district heating networks. Achieving a recovery capacity equal to 10% of the peak load makes it possible to reduce fossil fuel use by 40%. (Arnaudo et al. 2021) This is how waste heat contributes to a successful heat transition in decarbonizing district heating systems. Waste heat can come from different processes (industrial and urban). Approximately 25% of the heat demand in Europe could be met by industrial waste heat recovery but only a fraction of the heat is recovered to date. An example of industrial waste heat recovery is found in the cooperation between voestalpine Tubulars GmbH & Co KG and the Bioenergie Group. (Moser S. and Jauschnik G. 2023). However, other sources of industrial waste heat, such as pulp and paper, the chemical industry, and also fuel refineries are used to a higher

percentage than the waste heat from metal ores. Nevertheless, all of these industrial branches can be used for the recovery of waste heat as they all make use of high-temperature heat in their industrial processes. (Lygnerud and Werner 2018) The following figure outlines the annual average industrial heat recoveries by taking into account the industrial branch (according to NACE classification and operational status during 2014 – still in operation or terminated). (Lygnerud and Werner 2018) (see Figure 7)

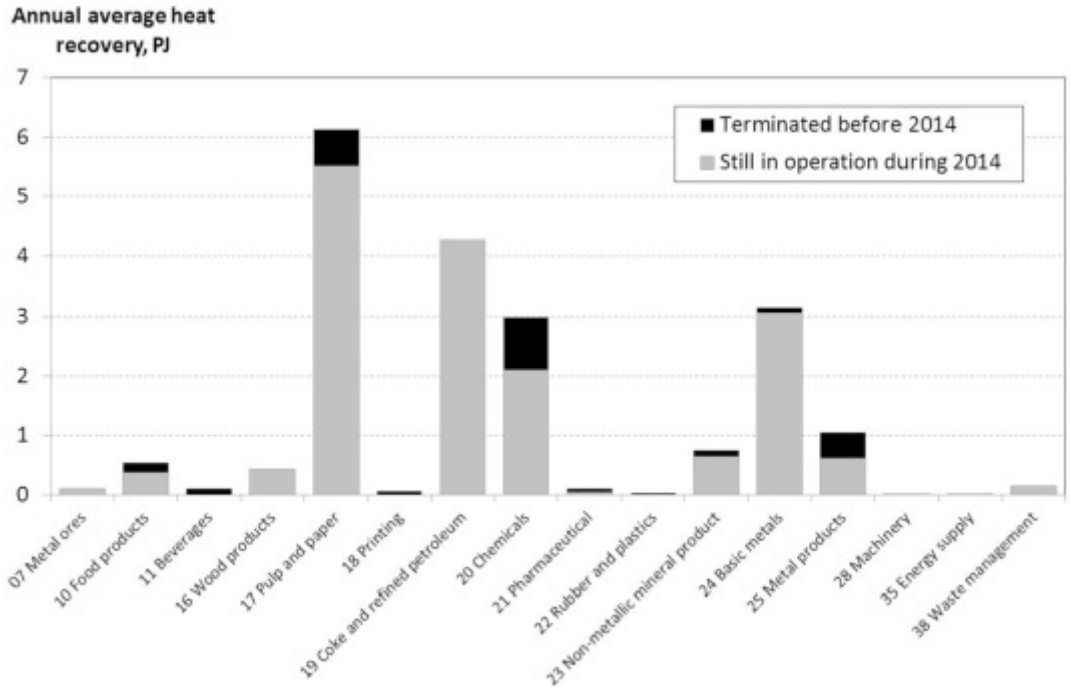

Figure 7: Annual average industrial heat recoveries focusing on the industrial branch (NACE classification, and operational status during 2014 (still in operation or terminated) (Lygnerud and Werner 2018)

4.2 DHCN Business Models, Infrastructure Project Structures & Investor Needs

4.2.1 Fundamentals

Value creation on major projects such as innovative DHCN business models is traditionally preceded by a strict financial analysis. If external money is needed investors have to be attracted in order to provide this money. This also includes risk minimization and requires the prior evaluation of a project's success. Years ago, investors reacted reluctant when projects did have a sustainability component, because the efforts connected to it were often seen as an additional cost, a negative line item on the project budget. Nevertheless, some investors were convinced that if managed properly, however, sustainability becomes a critical component of creating value out of the project. (Jain 2022)

4.2.2 DHCN Investment Process

Once the infrastructure of a district heating and cooling network (DHCN) is from a technological point of view available in business model can be developed. E.g. by using a business model canvas the value proposition can be derived, soaring as a basis for calculating revenue streams and cost structures. Both serve as a basis for deriving cash flows and the financial modelling. In a next step,

out of the business model the investment case as well as the investment story can be derived from an investors' perspective. In order to be able to take an investment decision, investors need key performance indicators (KPIs) alongside four dimensions, that are in particular importance to them: Return, risk, liquidity and sustainability. Sustainability comprises as sub-dimensions: Environment, Society and Governance (ESG). Tools like Sustainability Balanced Scorecard (SBSC) in section 0 can be used for conducting a comprehensive and combined financial, risk and sustainability analysis of the DHCN project, calculating the KPIs needed for taking the investment decision. In case of a positive outcome, investors can provide the funding needed through different financial instruments (e.g., Green and/or ESG-Linked Loans or Bonds) and the DHCN project can be realized (see Figure Figure 8):

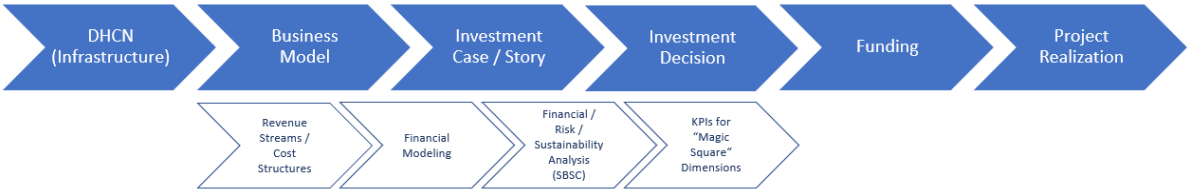

Figure 8: DHCN Investment Process (own representation)

4.2.3 Green Tech as Enabler of DHC Networks

An analysis of Boston Consulting Group has shown that renewable energy projects are scalable and that they are thus a good source for value creation. Nevertheless, these new markets are difficult. In order to create value players will have to think holistically. They have to consider long-term approaches to scale and have a close understanding of the different scale levers in order to be successful on this tough market (Cp. Jain 2022). There is also enough evidence to assume that strong market growth about renewable energy sources will continue (see Figure 9):

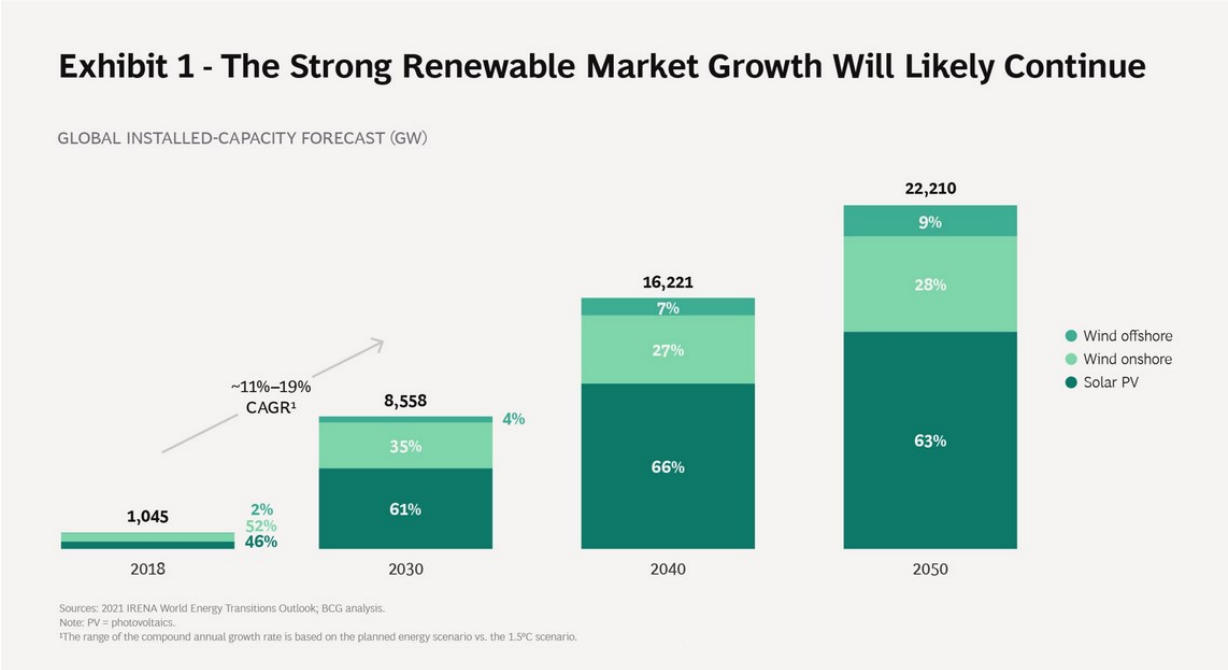

Figure 9: The Strong Renewable Market Growth Will Likely Continue (Jain 2022; Porsborg-Smith et al. 2021)

An enabler of innovative DHC networks is Green Tech, which is driven by an increasing adoption of IoT (Internet of Things), cloud computing, data platforms and analytical, digital twin, and blockchain-technology. The investment in Green Tech ranges from US$45-55 Billion every year and is assumed to grow at 25-30% annually over the next five years. Banks and investment firms have discovered the potential of these green solutions like climate risk-monitoring systems and customer-facing products like green mortgages, carbon-tracking credit cards, among others. In the retail market-industry the "big players" have begun to raise their investments significantly in transparency in ESG reporting, regenerative farming and e2e traceability solutions (farm to customer) for their products. (Cp. Jain 2022)

The aspired transition to net-zero greenhouse gas emissions requires companies and governments to change. What is also needed is an additional investment of as much as $20 trillion over the next two decades. In addition, strong fiscal policies, complemented by a broad range of regulatory and financial policies, will be necessary to facilitate the green transition. The world's $50 trillion investment fund industry, especially funds with a sustainability focus, can play an important role financing the transition to a greener economy and helping to avoid some of the most perilous effects of climate change, according to our recent analysis as part of the IMF's Global Financial Stability Report. (IMF 2021)

All these investments leave no doubt that sustainability is a growing market. Sustainability itself is a "driver" for it has the potential to …

- drive innovations that can reduce overall project costs.
- reduce the risk of project delays that can increase budgets and delay revenue generation from the finished project.
- help secure and maintain community support that can streamline approvals.
- reduce project risks, which can improve access to capital and lower financing costs.
- create a better, more attractive project that draws potential buyers and increases project valuation." (Mcphee and Dias 2020, pp. 1–2)

4.2.4 Infrastructure Project Structures and Stakeholders Involved

Fundamentals

One of the most important stakeholder groups supporting innovative DHCN business model are investors and buyers. In order to attract investors is to demonstrate how sustainability can have a positive impact on project financing. "This is true for industrial products that rely on stock, bonds, and debt financing, as well as government projects where financing could come from project-specific bonds, green bonds, or financing strategies like public private partnerships. (…) Buyers are required since many projects "(…) are developed with the intent of selling the asset once it has been built and commissioned. Whether the acquiring organization is a larger organization, a pension fund, or a stock market investor, the project will need to demonstrate that there is a strong community support for the project and that environmental and social risks are being managed effectively. (Cp. Mcphee and Dias 2020, pp. 2–3)

Process-Plant Projects

Process plants convert source materials (reactants) into merchantable products. These source materials may be gaseous, liquid or solid substances or even mixture of different states

(suspension, particulates etc.). Products may be intermediate or end products processes step by step. (Helmus 2008, p. 1)

Privatized and Private Sector Infrastructure

The formal agreement between authorities and private sector participants should be specified in terms of verifiable infrastructure services to be provided to the public on the basis of output or performance-based specifications. It should contain provisions regarding responsibilities and risk allocation in the case of unforeseen events. (OECD 2007, p. 23)

Public Private Partnerships (PPP)

PPP are long-term, contractual cooperation between the public and private sectors. Their primary goal is the economic execution of public tasks under which the necessary resources (e.g. expertise, equipment and facilities, capital, staff) are bundled in a joint organisational relationship. Any project risks are allocated appropriately to reflect the risk management expertise of the project partners. The term 'PPP' (Public Private Partnership) emerged in the US in the 1960s to refer to typical urban development projects involving private investors. From the US this concept spread across the world and has the following structure. Larger cities may have an increased interest in the involvement and assistance of private investors in order to develop brownfield and fallow sites for use. This adequately reflects the aims of urban planning while offering a commercial interest for the investors. (Cp. (Weber et al. 2016, p. 88)

Relevance of Special Purpose Vehicles (SPVs)

The SPV is an independent legal structure and has its own duties and responsibilities. The primary function of an SPV is to isolate financial risk. Having an own legal status means that the obligations within the SPV are secured even if the parent company goes bankrupt. This means that it is also independent of the legal status of the management company (formally or materially privatised) and the composition of its shareholders (public or private). Sometimes SPVs are also categorised as functional privatisations (Cp. Weber et al. 2016, p. 99). These newly-created project companies generally take the leading form of a limited-liability company. However, all rights and obligations arising from the project and thus the overall business responsibility remain with the (project) company. (Cp. Weber et al. 2016, p. 300)

4.2.5 Business Models

Fundamentals

The term "business model" outlines business-related activities that lead to value creation and is, therefore partly, self-explanatory. It is a concept for analysis and offers a systemic understanding of the factors that are considered to be important. The focus point of a business model is to explain how value is produced and harnessed by a firm. (Sandoff and Williamsson 2016)

In our project Business Model Canvas has been used in order to outline the business model. As an example, the Business model canvas (Report 3.4) for Topusko is shown below in Figure 10:

<table>
<tr><td rowspan="2">Key Partners
Municipality</td><td>Key activities
Monitor data
Save energy
Improved piping</td><td rowspan="2">Value Proposition
Heat and hot water
Improved indoor climate
Energy efficiency
Smart controls can reduce cost</td><td>Customer Relationship
Arm's length (not very close dialogue)</td><td rowspan="2">Customer segment
Private building owners, industry, city, Spa</td></tr>
<tr><td>Key Resources
New pipes
Monitoring equipment</td><td>Channels
Invoicing is the main communication channel</td></tr>
<tr><td colspan="3">Cost structure
Driven by fixed costs for distribution network, new pipes, monitoring equipment</td><td colspan="2">Revenue streams
Remains constant: energy price per kWh</td></tr>
</table>

Figure 10: Business model canvas for Topusko (Own representation based on Report 3.4)

- Value proposition

Heat and hot water are the values provided to all customers and for the Health Spa an additional value is the heating of pools to provide Thalasso Therapy treatments. The heating and hot water is supplied by green energy from geothermal wells and an additional customer value is the green value.

Increased control and monitoring of the system are implemented as part of the REWARDHeat project. Today controlling flow rates and temperatures is done manually. Smart control will improve the efficiency of the system and improve the indoor climate (now customers open a window if it is too warm since there is no other way to regulate the heat). Smart controls enable private customers to reduce their energy consumption and hence possible to reduce cost. Installing insulated pipes provided by Thermaflex will further increase efficiency.

- Customer segment, relationship and channels

The customer segments are mixed from own usage at the Health Spa site (hotel and Thalassotherapy), the city (heating of churches and public buildings: high school, elementary school, primary school, post office), industry and multifamily houses (both large ones and smaller ones: 6 apartment buildings).

- Key resources, activities and partners

The key resource is the existing district heating network and the energy centre around well 4 (the largest of the 4 geothermal heat sources). Added resources will be new pipes and monitoring equipment. Important partners are existing customers and then, in particular the city itself.

- Cost structure and revenue streams

The cost structure will change in terms of added assets and monitoring activity. However, as a result of REWARDHeat investment the costs will not need to be covered by increased price levels.

It is not until the project is over that the revenue streams will need to be adjusted (mentioned above).

- Importance of business models for infrastructure investors

Investors are looking for yields to meet their long-term liabilities faced with a seemingly continuing low-interest rate environment. These characteristic elements are provided by infrastructure investments (Cp. Weber et al. 2016, p. xvii). Usually, the investment decisions of investors are based on the current market development an on the information provided in the business model. This means that the business model has to be convincing.

The two key aspects for evaluating a business model are the revenue side (i.e. the available sources of revenue, the amount of revenue and the corresponding remuneration mechanisms) and the cost side. The following simplified discussion focuses only on the revenue side. In contrast to the cost side, which largely depends on the infrastructure services to be provided, the revenue side shows two fundamentally different, alternatively applicable sources of revenue that may be used for the same kind of infrastructure services: 'budget-financed' and 'user-financed'. In general, that means that the monetary output of the business model is based on direct user payments or the availability payments from the public budget or a combination of both (...). For 'user-financed' models, it is important to differentiate between 'direct user payments' (e.g. user toll) and 'user-driven payments' (e.g. shadow toll) payments. User-driven payments typically form a mixture of budget payments that are directly linked to the actual use of an asset even though the user does not notice it. As such, they increase the risk-return profile of the asset compared to pure budget (availability based) payment models. (Weber et al. 2016, pp. 102–103) (see Figure 11)

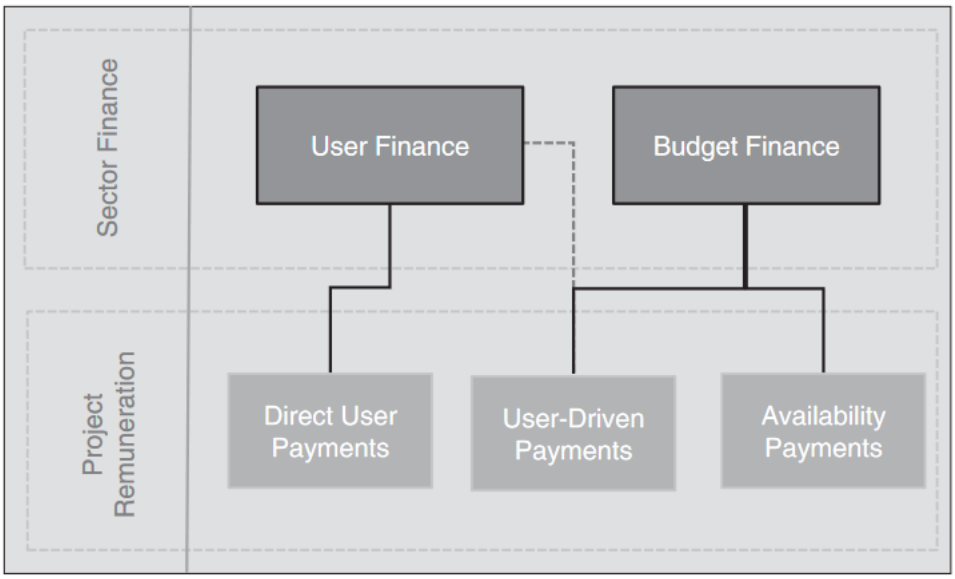

Figure 11: Business model – sources of revenue and remuneration structure (Weber et al. 2016, p. 102)

- Business Model of an advanced District Heating and Cooling Network (DHC)

In order to advance this energy changeover, the EU strongly supports expansion of efficient DHC and CHP [combined heat and power] systems to reduce primary energy consumption and emissions as well as to promote RES (Renewable Energy Sources) on the market. The Directive 2012/27/EU sets requirements and measures how to meet the famous 20–20–20 goal in terms of reduced primary energy consumption, emissions, as well as the share of RES. According to the Directive, each Member State shall set an indicative national EE [Energy Efficiency] target,

based on either primary or final energy consumption, primary or final energy savings, or energy intensity. Member States are asked to report those targets to the Commission. When setting up those targets, Member States must be aware of the fact, for instance, that efficient DHC means a system using at least 50% renewable energy, 50% waste heat, 75% cogenerated heat or 50% of a combination of such energy and heat.

Denmark and Finland are chosen as best practice countries from the EU because of their forerunner role in the field of renewable energy sources. Both countries have been ranked by the IEA Scorecards with the full five stars. However, the countries differ – whereas Denmark was the first country to maximize the DH based on regulations and Finland relying on free market forces. (Wiltshire 2016)

District heating (DH) systems were supplemented by district cooling systems (DCS) when there was a convergence of several factors—aging building (customer) equipment; high density of load that could be connected effectively through a piping network; and the desire for higher efficiencies from an energy consumption standpoint, as well as other operational factors, including maintenance and improved availability. Trailblazers were the United States, who applied these systems in locations, such as universities, airports, healthcare campuses and the central business districts of larger cities. (Wiltshire 2016)

Very important for the current project is also the question how economic value is created. The DH industry is characterized by the fact that the creation of customer value is based on a network logic. The task of the network is to link producers and consumers with complementary needs in a infrastructure-like network (...). In DH's case, the network links actors with a surplus of heat or alternatively, fuel that can be used for heat production, and operators with a heating need. In such a network, the success of the firm requires excellence in terms of both effectiveness and legitimacy. The core business is the management of contracts between the actors in the network and maintain and expanding the network itself. (Cp. Sandoff and Williamsson 2016, p. 298)

New Business Model for District Heating Firms Stabilizing the National Energy System with a future variable Electricity Production

District heating of the future will integrate both technologies that use electricity (heat from geothermal, seawater, wastewater, electric boilers, etc.) and technologies that produce electricity (e.g. energy utilization of local, sustainable biomass and of non-preventable waste, reused or recycled). (Cp. Richter 2022b)

Generally geothermal district heating offers the heat consumer the following:

- "Stable secure heat supply;
- Fixed, long term prices (for production and depreciation);
- Lower need for maintenance (compared to other conventional heat sources);
- Lower risks (when in operation);
- Ease and comfort for the end-user" (GeoDH 2014, p. 42)

GeoDH technology is known as a mature one, it is in use for 50 years and geoDH installations have proved to be competitive. However geothermal space and district heating systems are capital intensive, especially drilling the wells is elaborate. In comparison, operating expenses, nevertheless, are rather low and much lower than in conventional systems. Generating costs and selling prices are usually around 60€/MWh thermal, within a range of 20 to 80€/MWh thermal.

There are three frequently used financing models:

1. Firstly, public investment granted by the local or regional authority (usually at municipal level);

2. secondly, private sector investment holds the opportunity to sell the heat directly to the grid-connected subscribers over long duration (20 to 30 years contracts);

3. finally a 'mixed' solution, which entails the creation of companies dedicated to the development of the geothermal with capital investment shared by both public and private entities. (Cp. GeoDH 2014, p. 43)

Two business models can be given as an example:

1. The case of a DH company decarbonising its heat supply in close cooperation with energy service companies (ESCOs). Here the main marketing strategy would be a combination of sustainable heat supply (possibly with use of labels or certificates) and energy saving services so as to widen the scope of activity by simultaneously reducing the impact of the inevitable reduction in energy consumption.

2. The second case would concern a geoDH project developer (public or private) aiming at proposing a new DH system supplied by geothermal energy. The objective would be to convince heat users of the value of renewable energy sources which are stable and competitive.

Finally, specific attention should be paid to cascade uses. It is sometimes presented as an obvious solution for improving the economy of (notably) CHP, but it seems less and less easy to develop them. Today few examples exist all over Europe. (Cp. GeoDH 2014, p. 43) (Figure 12).

So far district heating has been characterized as a natural monopoly due to high fixed costs in the network infrastructure. (Cp. Liu et al. 2020b, p. 8) A single supplier can supply the entire market at a lower cost than several smaller suppliers because of economies of scale. Heat utility companies traditionally adopt a vertically integrated structure and this means that production, transmission, and distribution activities come from a single source. To some extent, a vertically integrated utility has the advantage of internalizing the energy efficiency benefits embedded within the system. However, the disadvantages of integrated utility models are that they have some trade-offs with local public debt capacity, lack of innovation, and monopoly behavior. (Cp. Liu et al. 2020b, p. 8)

Having only one large heat consumer may support the economy of a project greatly. On the one side, there are th local DH utilities with a need for renewable and flexible heat supply, and on the other side there are building owners with a need of heat supply. These are two interesting customer segments. (Cp. GeoDH 2014) However, by having a foot in the natural monopoly, municipalities can play a role in securing the heat market demand through regulations on the connection of existing and future buildings with a district heating system. (Cp. Liu et al. 2020b, p. 8)

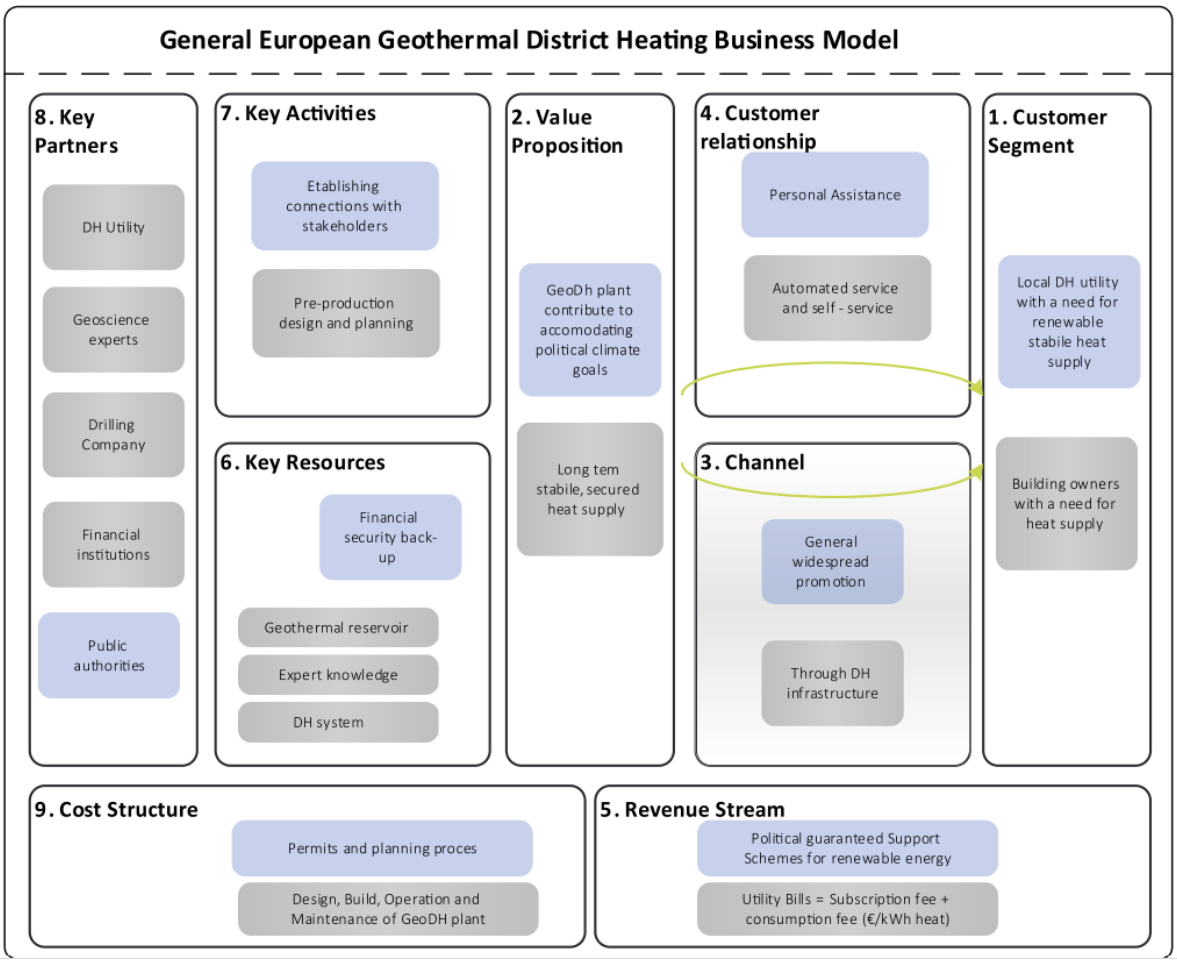

Figure 12: General European Geothermal District Heating Business Modell (GeoDH 2014, p. 43)

As monopolies may lead to a decrease in competition, which may also lead to a lack of innovation, and, there are intensive efforts to support competitive business models. In order to get there Liu et. al. propose utility-led models with third-party access between production and transmission (Cp. Liu et al. 2020b, p. 8). This means that a heat utility will have to negotiate an access agreement with excess heat producers. Since industrial excess heat provides a low marginal cost of heat supply, monopolistic heat utilities benefit from lowering its production cost in exchange for totally or partially financing investments associated with heat source connection and particularly also additional network costs. When the heat utilities begin to replace heat capacities as a result of the monopolistic position, the third-party must intervene by providing enough incentives for the market entry of new heat sources and incentivize utilities' capital expenditure on energy efficiency improvement. The third party can thus be seen as a regulation mechanism, reducing the negative impacts of monopolies. In this integrated business model, it is essential to provide third-party access to district heating networks in a non-discriminatory way. (Cp. Liu et al. 2020b, p. 8) (see Figure 13):

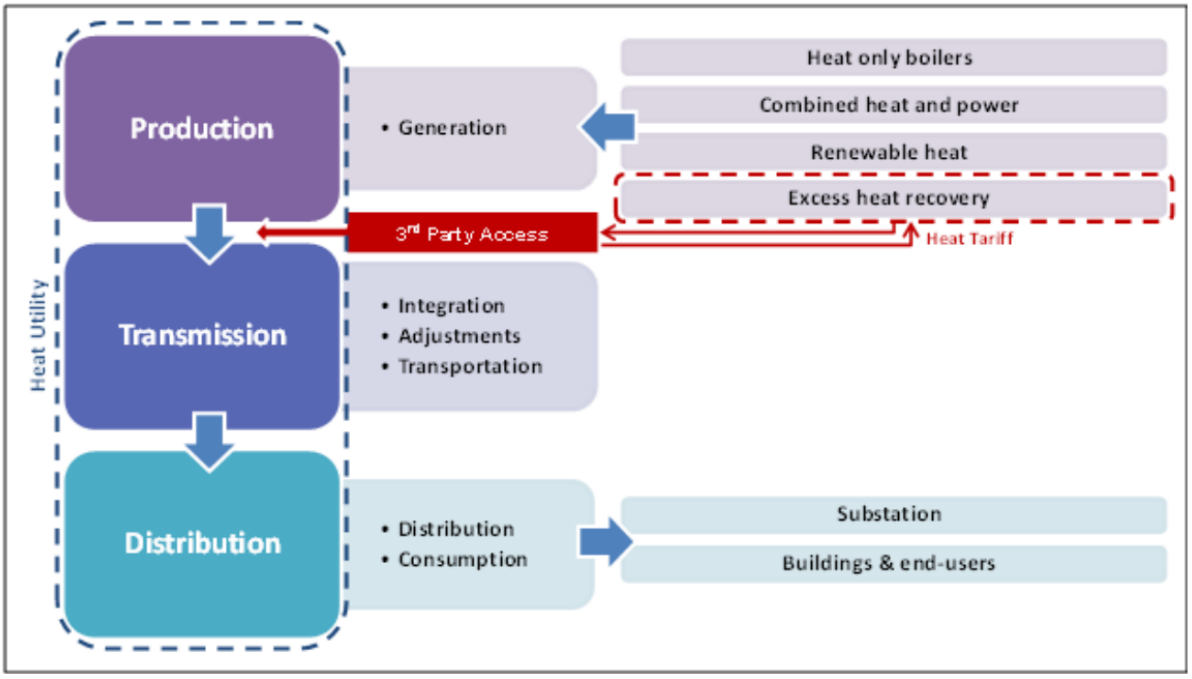

Figure 13: Utility-led Business Model with Third-party Access (Liu et al. 2020b, p. 9)

The example of Sweden's business model of district heating shows that the opening of the market has already begun with the DH act of 2008. Thereafter a number of investigations took place regarding how the market should be formed. In reaction of this new development, the industry began to set up measures such as the recently established "Price dialog," a significant focus on customer issues in the industry's strategic work and also research projects focusing on business models, customer issues and trust building mechanisms. (Cp. Sandoff and Williamsson 2016, p. 311). The following Figure 14 summarizes Sweden's development in three periods:

Time period	1960–1980	1980–2005	2005 to present
Focus area	Distribution	Production	Customer
Driving force for change	Housing program	Security of supply, the environment	Questioned legitimacy
Solution	Expansion	Renewable fuels	Customer value and costs
Main catalyst	Municipalities	Government (and EU)	The market

Figure 14: Business-related focus in Swedish district heating companies, 1960 to present (Sandoff and Williamsson 2016, p. 311)

In the first period (1960–1980), the focus was solely on distribution issues. The incentive to connect customers and build up and link together the distribution network was mainly driven by local municipalities. In the second period, the EU's and Sweden's strong fossil-fuel dependency were the focus of criticism. Among the measures to increase the market share of renewable fuels were tax rates, tax rules, as well as electricity certificates. During the period, the proportion of renewables increased from single digit percentages to nearly 70% by the end of the period (Swedish Energy Agency, 2013). This change has required significant knowledge development and investments in production equipment to be carried out. In the third period, voices have been stronger particularly from the customer collective but also from waste heat suppliers and from the Swedish Competition Authority which has challenged DH's legitimacy both nationally and locally." (Sandoff and Williamsson 2016, pp. 310–311)

4.3 Translating Business Models into the Investors' Perspective

4.3.1 Starting Point – Identifying Potential Risks & Benefits for Investors

Investment in infrastructure, such as DHCN, lead to economic, social and economic costs and benefits to various actors and thereby means a challenge to the traditional view of business models. In more precise terms, this means that DHCN, which can provide consumer with low carbon heat, will require significant levels of investment, co-ordination between public, private and regulatory actors. This again means that these actors will also be faced with a range of economic, social and environmental costs and benefits. (Foxon, T., Bale, C., Busch, J., Bush, R., Hall, S., & Roelich, K. 2015)

Most challenges for investors of DHCN infrastructure projects have their origin in the complex nature and characteristics of infrastructure projects.

Challenging characteristics are among others the following:

- Long time horizon,
- complexity, heterogeneity, large number of stakeholders involved (OECD 2015b, p. 8)
- lack of transparency objective, high quality data on infrastructure and clear and agreed benchmarks as well as key performance indicators (Della Croce, R., Yermo, J. 2013, pp. 28–29),
- information, knowledge and confidence gaps (Baietti et al. 2012, p. 14)
- uncertain intellectual property rights, esp. in terms of innovative technologies and their potential transfer (Baietti et al. 2012, p. 14)

In addition, quite a number of economic and financing related aspects contribute to challenges from an investors' point of view, e.g.:

- High capital intensity, implying substantial financing requirements and high risks, esp. in the predevelopment and construction phase (OECD 2015b, p. 8)
- High investment volumes, high upfront costs and long payback periods or amortization times (Baietti et al. 2012, p. 14)
- High costs of integrating clean energy sources into the system occur because of the higher upfront transmission costs, slow replacement cycles of existing energy assets, the intermittent nature of RE energy supply, and limited projects with acceptable risk-return profiles. (Baietti et al. 2012, p. 14)
- Residual value of existing assets that would need to be replaced (Baietti et al. 2012, p. 14)
- Revenue risks (Baietti et al. 2012, p. 14)
- High transaction costs for investors (Baietti et al. 2012, p. 14)
- Low fungibillity/liquidty of assets (OECD 2015b, p. 8)
- Lack of incentives for waste heat recovery combined with incentives for other technologies (Wheatcroft et al. 2020)
- Further impediments include: (1) Low carbon price, (2) fossil fuel subsidies, (3) (Baietti et al. 2012, pp. 13–15)
- Insufficient international participation, e.g. in terms of grants and concessional loans (Baietti et al. 2012, p. 14)

- Lack of appropriate financing instruments, esp. on local or domestic level, which seems in particular to apply to debt financing (Baietti et al. 2012, p. 14) (Della Croce, R., Yermo, J. 2013, pp. 28–29)

Furthermore, (institutional) investors are facing a number of complex risks related to investing in infrastructure projects, such as (Della Croce, R., Yermo, J. 2013, pp. 28–29; Baietti et al. 2012, pp. 13–15; OECD 2015b, pp. 8–9; Inderst 2010, pp. 73–74; Weber et al. 2016, pp. 259–295)

- Multiple risks (technological, political, legal, economic, financing)
- political and regulatory barriers and risks,
- inappropriate risk transfer,
- additional, particular challenges related to sustainable infrastructure, esp. risks related to environmental regulatory and policy uncertainty, risks of new technologies employed, etc.

On the contrary there are also a couple of benefits for investors if they allocate their funds towards infrastructure investments (Inderst 2010, p. 73):

- Potentially attractive returns
- Relatively low sensitivity to volatility in the economy and markets,
- Long term, stable and predictable cash flows,
- Advantages for portfolio diversification due to rather low correlation of returns with other asset classes
- Potentially a hedge against inflation
- Natural fit with long-lasting, often inflation-linked pension liabilities, which is in particular of importance for insurance companies and pension funds
- Relatively low default rates
- Good fit with trend and changing regulation towards sustainable investing

Both, the above discussed challenges and benefits will be used as starting point for the work packages of this task. They will serve for, on the one hand, identifying and further developing potential financing instruments for DHCN. On the other hand, they will be used for identifying potential investor groups and networking with them, in order to attract funding for DHCN.

Moreover, to identify these challenges and to attach a value to them is the basis of the “Magic Square”. On the one hand, this “Magic Square” serves as a “compass” for investors who are interested in infrastructure investments and who have to base their decision-making process on economic facts. On the other hand, this “compass” shall help to attract investors by making the risks accessible. The result of this process will be a well-founded decision on the side of the investors.

The “Magic Square” developed during this project is such a method to assess the DHC business model and to decide whether to invest.

4.3.2 Investor Decision-Making-Dimensions (“Magic Square”) and Related KPIs

Fundamentals

Investment and financing decisions in the areas of sustainable finance and investments are made with the help of a "magic target square". In addition to the three classic target dimensions of

financial management (return, risk and liquidity) investors additionally consider sustainability as a fourth dimension. This in turn is subdivided into the ESG-subdimensions. (Popovic 2013) Specific key performance indicators (KPIs) quantify the impact an investment contributes to the four dimensions and provide investors orientation in the investment decision making process.

In order to calculate the KPIs and in the end to present attractive investment cases to investors, it is necessary, as a precondition, that the demo sites deliver the raw data for these calculations. In addition, this data can also be used for modelling cash flows for the different business models. Both, the cash flow models as well as the KPIs along the four dimensions of the magic square serve with a basis for developing investment cases and investment stories, enabling investors to decide whether they want to invest into a specific DHCN-project or not. (see Figure 15):

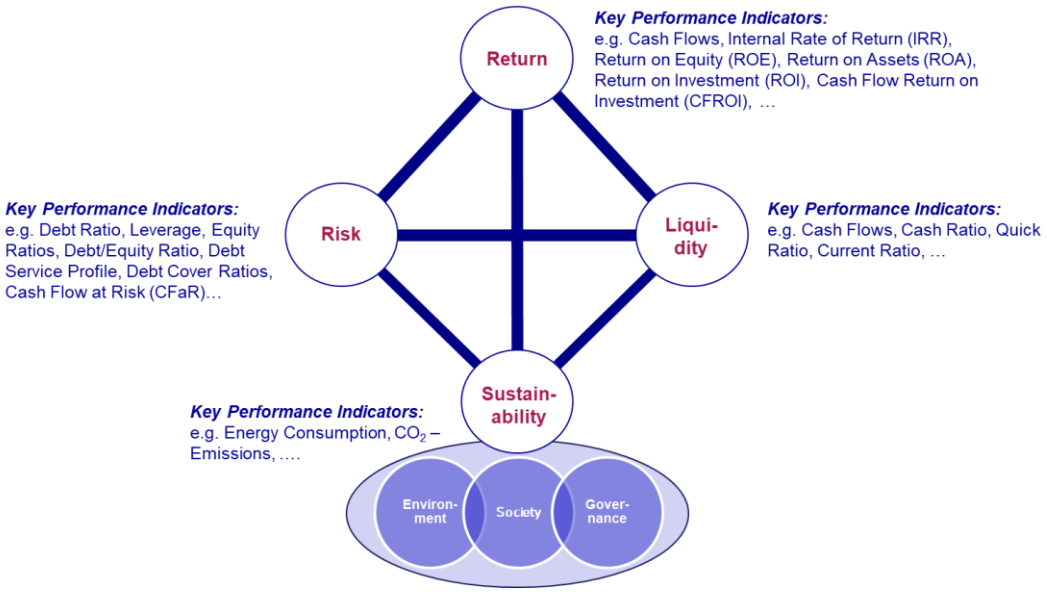

Figure 15: Investor Decision-Making-Dimensions ("Magic Square") and Related KPIs (based on Popovic 2012, p. 25)

Figure 16 shows the indicative risk-return profiles of potential infrastructure investors:

	Commercial banks	Infrastructure funds	Institutional investors (life insurers, pension funds)	Private equity
Capital	Debt	Equity	Debt, equity to a limited extent	Equity
Risk orientation	◑	◔	○	●
Investment horizon	< 5 years	5->8 years	>8-10 years	5->8 years
Average investment volume [EUR]	N/A	Unlisted infrastructure funds: EUR >5-10 m	At least EUR 1 m per fund	Unlisted infrastructure: EUR 100 m per asset
Return rate	Infrastructure credits: 2-5%	Direct investments: Early phase: 10-15%, later stage: 7-9%	Government: 3-7%, corporate: 4->10%	Brownfield (existing projects): 6-13%, greenfield (new projects): 13%+
Regulatory framework	Liquidity requirements in Basel III can limit risk taking	Limited restrictions, depending on fund's type	Liquidity requirements in Solvency II can limit risk taking	Limited restrictions, depending on type of involvement (equity share vs. fund)
Need for standardized structures	◔	◔	●	◔

Figure 16: Indicative Risk-Return-Profiles of Potential Infrastructure Investors (Ammermann 2015, p. 11)

4.3.3 Financing Models and Cashflow-Modelling

Business models define the way how value is delivered, they capture payments and affect the business strategy, innovation management and economic theory. (Teece 2010) Business models also inform about funding, which comes either from within (cash flow, equity) or from outside (debt). The business model must be supplemented with a cashflow-modelling which exercises control over the cashflow budget and the performance evaluation. (He, Y., Bai, R., & Dong, J. 2011) Cashflow-modelling is the presupposition for operating the "Magic Square".

A characteristic element of payment models is the involvement of the public sector assuming 100% of demand risk and the reliance on KPIs for ensuring optimal performance during operation and maintenance. (Lawther, W., & Martin, L. 2014)

Availability Payment Models

In the case of availability payment models, the private partner receives a fixed remuneration that is generally budget financed and payable by the principal at regular intervals, based on specific task and service level agreements. Examples are:

- Performance-based payments corresponding to the services set out in the specifications or list of services;
- Availability-based payments corresponding only to the availability of premises, areas, facilities, equipment, etc.;

Whereas volume-based payments correspond to the consumption of water, electricity, gas, etc. results-based payments correspond to contractually agreed (optimisation) targets. Fixed remuneration is used mainly in the area of social infrastructure. The following sections provide examples of typical budget-financed business models. (Cp. Weber et al. 2016, p. 103)

User-Driven Payment Models

User-driven payment models include budget and user finance. The revenue that is required to cover the investment and operating costs is paid from the public budget, but directly linked to the user demand. User demand is the respective assets or services. The public payment of these models is typically based on: Usage-based payments, which can be further broken down into:

Frequency of use, such as the shadow toll for roads or fees that reflect the number of users of a swimming pool, a sports hall or another public facility;

Intensity of use, such as in the case of shadow tolls, whereby diverging 'shadow rates' apply based on axle loads or emissions.

The advantage of all user-driven payment models is that the demand risk is softened because the consumption behaviour of the users is not influenced by (changes in) price. The users do not even know the price. They are not charged directly on usage but the public contract partner pays the bill 'in the background'. This means that the price risk stays with the principal who also negotiates the price with the operator in the first place. (Weber et al. 2016, p. 105)

Direct-User Payment Models

Direct-user payment models get the revenue required to cover the investment and current operating costs directly from user fees. This can be tolls, charges, entrance fees or rents. The market risk in this model is determined by the level of demand, which in turn varies with the

willingness of the prospective users to pay a certain fee. The amount of the fee depends to a large extent on the level of competition in the respective usage situation. Differentiation is made with regard to: Compulsory usage, e.g. compulsory connection to the water network, where users have no choice but to cover their water supply from the local provider (monopoly situation). A (Quasi-)compulsory usage is pertained where there are no alternatives to using the services offered or the available alternatives are unattractive; typical examples are bridges over or tunnels under rivers that cannot be crossed in another manner within an acceptable distance (quasi-monopoly situation).Free choice of usage in a competitive environment means that the user can choose between several telephone providers or a shorter toll road compared with one or more longer non-toll roads within an acceptable distance. (Weber et al. 2016, p. 106)

Value Stream and Key Performance Indicators (KPIs)

The district heating and cooling network (DHCN) can either use fossil (gas, coal) or renewable energy sources (geothermal energy, waste heat from data centers, industrial facilities or supermarkets as heat sources. The electricity that is needed for working the pumps, heat pumps or the heat exchangers can either be bought or produced by wind, PV or biomass. Using fossil energy sources represents a not insignificant cost factor. Normally, the costs of the whole system are contained in the price for heating and cooling. Sometimes, subsidies make it possible to charge only the price for the fossil energy sources and the electricity used for the system. So, the DHCN sells heating or cooling to the customer and there it receives payment that is represented in the revenue stream. The revenues are either covering the costs, there is an over-/ or under-absorption. (see Figure 17):

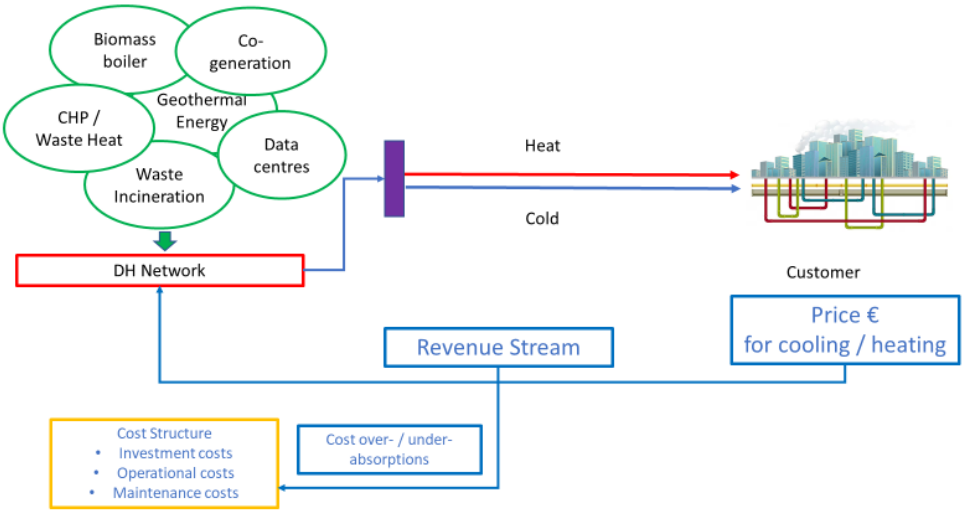

Figure 17: Value Stream of a DHCN that integrates a wide range of energy sources (own representation)

Extensive infrastructure projects such as DHCN do need financial capital – either for their realization, their extension, or for the renewal or renovation of specific parts. As a rule, investments with such a long time-horizon are only interesting for specific investors that are looking for long-time investments, such as pension funds or insurance or investment companies. The following economic data can be used as a basis for making investment decisions. Economic data are requested in the questionnaire and are the foundation for calculating the KPIs:

1. Organization

There are a number of models for delivering district heating financing schemes. Choosing the right model will depend on the

- opportunity,
- strategic objectives and
- risk tolerance

Delivery models include:

- corporate joint ventures,
- wholly owned companies
- possibility of utilizing Teckal exemptions[1]
- design, build, operate and maintain contractual approaches, i.e. contractual joint ventures.

Each of these approaches enables the organization to calibrate its approach to risk and assess its requirements regarding financial returns. (TLT) (see Figure 18):

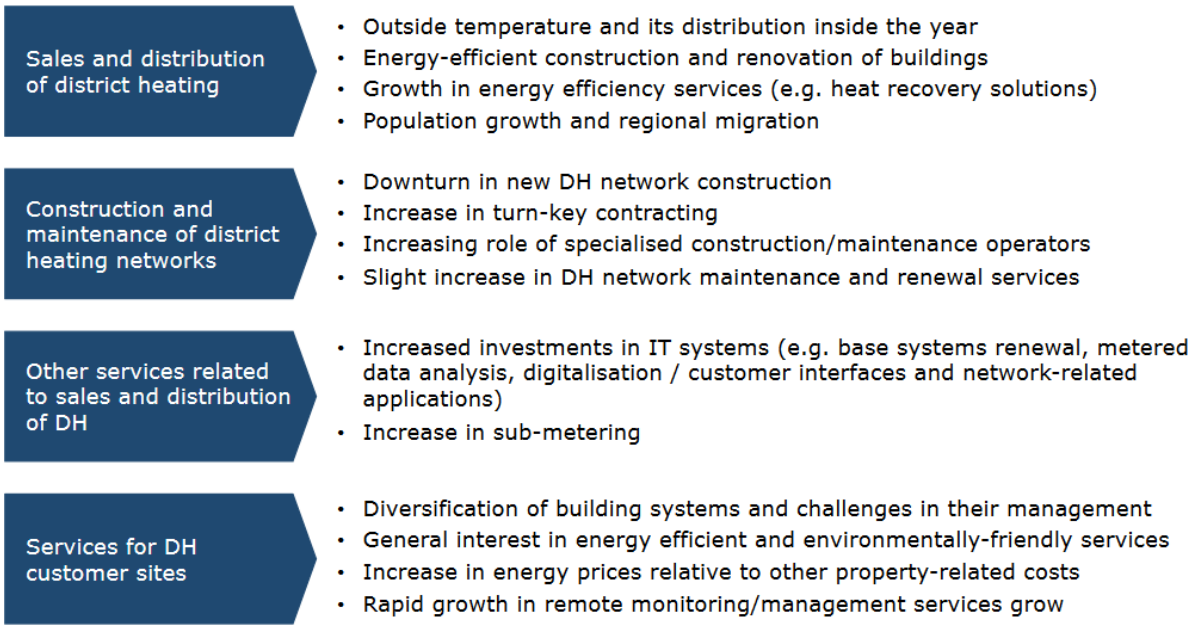

Figure 18: Value creation within the DH Value Chain (Finnish Energy Industries 2015)

[1] "In the 1999 judgment of Teckal (C-107/98) the ECJ established an exemption from public procurement for the award of contracts by a public authority to a separate entity provided certain requirements were met. Those requirements were that: (1) The contracting authority must exercise sufficient control over the separate entity (with the test applied being that the control should be similar to that which the contracting authority exercises over its own departments); and (2) The separate legal entity must carry out the essential part of its activities for its owner authority/ies ("the essential activity test"). This exemption, widely known as the "Teckal exemption", was formally codified into the 2014 EU Procurement Directive (Article 12), and therefore our Public Contracts Regulations 2015 (Regulation 12), which also clarified that the requirement that the separate entity carried out the essential part of its activities for the owner authority meant that at least 80% of its activity must be for that authority. Regulation 12 also confirmed the principle established in case law that there can be more than one contracting authority owner." Musselwhite 2017.

2. Cost Structure and Sources of Revenue - Cost Structure

The cost structure of the DHCN can be outlined as follows. The following figures shows the individual post and what are their components:

(1) Production costs (see Figure 19)
(2) Heat network costs (see Figure 20)
(3) Energy system costs (see Figure 21)

(1) Production costs:

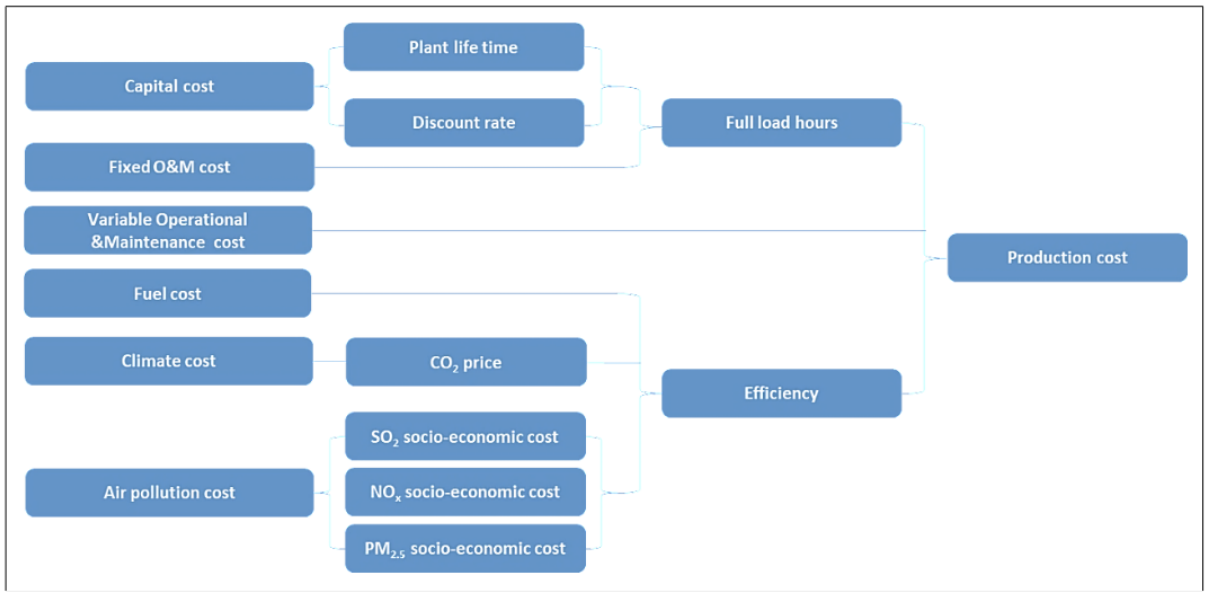

Figure 19: Production cost (Liu et al. 2020a)

(2) Heat network costs:

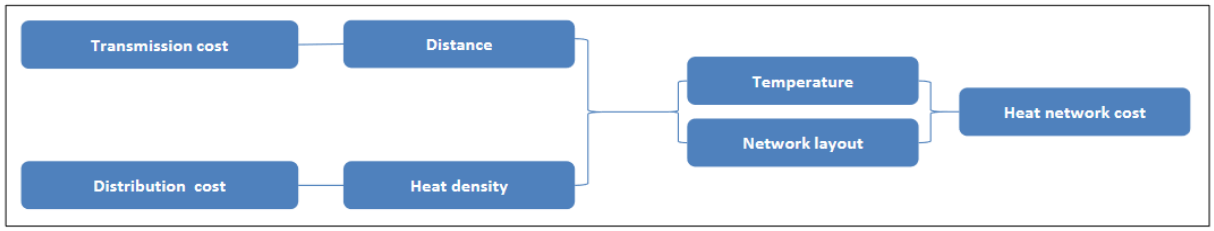

Figure 20: Heat network cost (Liu et al. 2020a)

(3) Energy system costs

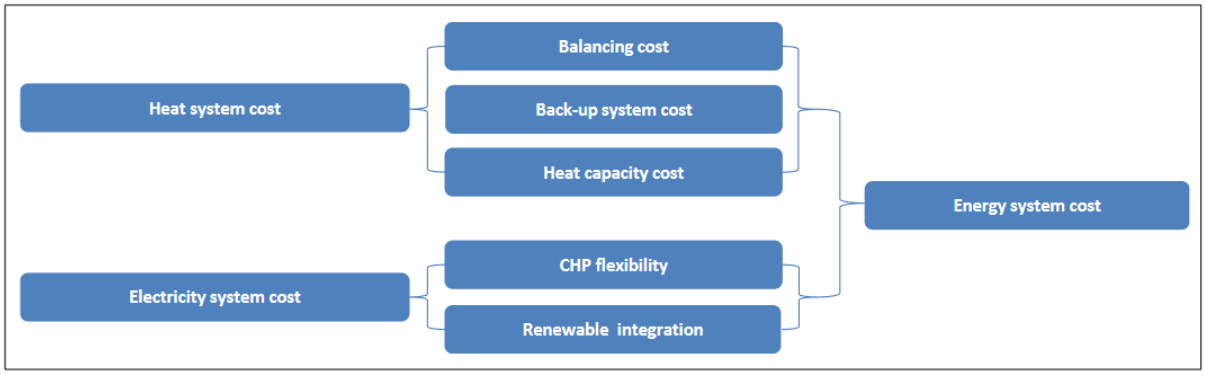

Figure 21: Energy system cost (Liu et al. 2020a)

Revenue Stream

Currently, the revenue streams of conventional power plant types are aimed at satisfying the standard supply and demand from generation to end consumer. The business model for district energy system varies according to each project. It is important to make sure that the design ensures that all players – among them investors, owners, operators, and utilities/suppliers to consumers – are able to benefit from direct profits as well as the greater sustainability gains that are economic, environmental, and social). (Welsch 2017)

Value proposition through DH system by way of waste heat

The heat distribution network in Albertslund is planning to use the waste heat from two suppliers – a datacentre and a supermarket. Since waste heat is difficult to measure – not at least because of seasonal variations – the energy company must keep its conditions transparent. And this transparency must also be captured by the contract. The fact that the producers of waste heat – the datacentre and the supermarket – do not rely on energy as their core business makes the evaluation of waste heat difficult. (Fransson et al. 2022)

Ownership of the facilities

A municipality can aim to be the owner of the customer's substation. This makes it possible to guarantee an optimized operation of the DH system. The customers on the one side take advantage of the service which includes the renting of the substation in combination with the heat supply. On the other side, the DH company is in control of the system. Albertslund is following this business model and this is connected to an increase in risk. The municipality is recommended to control as much of the supply chain as possible and to aim at increasing the share of rental customers in the future. (Fransson et al. 2022)

Open DHC business model (Prosumer model)

In 2012, the Finnish energy company Fortum launched the Open DHC business model in Stockholm (Sweden). The goal was to utilize the most efficient energy sources available and to enhance profitability of the DHC system by decreasing the costs related to heat supply. This can be accomplished by opening the network to a wide range of energy sources (Cp. Figure 23). This business model benefits from the large excess heat produced by the city's large data centres, which is brought in the district heating network. The surplus heat is compensated by way of three types of rates. Generally, this classification depends upon the line through which heat is being delivered:

- Open spot market price for heating (through feed lines);
- Open returned heating price (through return lines);
- Open residual heating price (through district cooling return lines during winter).

Customer are thereby encouraged to become prosumers in recovering their excess heat and in becoming supplier. This in turn relates to an unexploited resource by touching the use of local waste heat. This system offers a market price for additional heat from the consumer and it also contributes to the goal of sustainability reducing their heat demand through improved demand-side management or thermal storage. (Welsch 2017)

In addition, prosumers on the heat market can be defined as follows:

- Small producers of heat
- They do not have a professional organization for delivering heat
- It is not their primary business nor do they have know-how in the heating business
- If they are too small to handle with separate "deals" for each customer, they can use a standard business offer instead (Celsius Wiki 2019)

Overall assessment & Outlook

Innovative technologies, such as low-temperature networks, integrate a wide range of renewable energy sources and can thus be considered as a "key driver" of the heat transition in Europe. In order to become a mainstream technology not only technological innovations such as digital twins are necessary, but also innovative business models.

An optimal solution would be a business model which becomes attractive to the end consumer because of its flexibility. Here, blockchain technology could be a viable solution. In order to put this new blockchain technology to the test real laboratories could be play an important function. (TransUrban.NRW 2021)

Sustainability Factors for Direct Real Estate Investments – A Four-level Approach

Integrating sustainability practices into real estate investment helps to alleviate the risks associated with environmental, social and risks associated with environmental, social and governance factors. This also means to increase financial returns through energy efficiency and marketability. It also fulfils a high measure of social responsibility by promoting healthier, more attractive living spaces and helps to meet the expectations of stakeholders. The development of a sustainability strategy requires the careful consideration of numerous factors. Starting from regulatory requirements and stakeholder expectations through to social needs and net zero emission net-zero emissions targets. (Archer-Svoboda and Kimmerle 2023) (see Figure 22)

Figure 22: Four-stage approach for the consideration of sustainability factors in direct real estate investments (Archer-Svoboda and Kimmerle 2023)

The following Table 2: Development of strategy and evaluation of portfolio (Archer-Svoboda and Kimmerle 2023) shows the development of strategy and the evaluation of the portfolio:

Table 2: Development of strategy and evaluation of portfolio (Archer-Svoboda and Kimmerle 2023)

	Measure	Action
1	Definition of a sustainability strategy	Evaluation of the the current ESG profile of the real estate portfolio • Get an overview of the data available for the individual buildings and obtain further relevant information from stakeholders e.g. on environmental aspects (energy efficiency, water consumption), social aspects (well-being of tenants, impact on the community), governance (compliance with regulations, stakeholder commitment) • For life cycle planning, you should know all the important characteristics of your real estate (year of construction and relevant renovation years, building parameters)
2	Definition of a concrete action plan (for the whole portfolio on the basis of the defined strategy und evaluation of the portfolio	• Make sure that the action plan is realistic by analysing the financial implications impact, the resources required for implementation, the risk aspects, the regulatory requirements and the demands of the stakeholders and prioritize time- and resource-intensive measures.
3	Monitor the infrastructure (on the basis of defined indicators and selected instruments. Make sure at portfolio level that the strategic objectives and the objectives of the plans are achieved)	• Build up a reliable and timely data history for the entire life cycle of the individual buildings and the entire portfolio
4	Communication	• Create regular reports on the sustainability-relevant data of the entire real estate portfolio to ensure

		transparency towards stakeholders, including investors and tenants

Specific Characteristics

District energy systems provide heating and cooling generated in a centralized location. Distribution is usually accomplished via underground piping to residential and commercial consumer. Often the heat is obtained from a cogeneration plant burning fossil fuels. Moreover, there is increasing usage of renewable energies as central plant energy source. Among the renewable energies are biomass, geothermal heating, and central solar heating. (Cp. DuFrene 2017)

District energy systems can earn revenues from several sources: Heating and cooling, power, ancillary services, connection charges and various other sources of (smaller) revenues.

- Heating and cooling – sales are determined by the absolute demand and load profiles of buildings connected to the system. A diversification of consumers as well as of thermal storage may smooth the aggregated load profile, ensuring attractive heating or cooling offerings. Prices for either service may be regulated or be part of a somewhat liberalised market. Often, the rates have two elements: a capacity charge and a consumption charge.
- Power – district energy systems will generally include one or more CHP plants, generating electricity along with heat. The power is typically fed into the distribution or transmission grid and sold on the market at market prices via long-term PPAs or on the spot. In case regulatory support schemes apply (e.g. FITs), these will change the revenue profile.
- Ancillary services – one possibility to generate additional revenue is to use capacity premiums located in a stressed power grid as well as balancing services to the transmission or distribution grid.
- Connection charges – to connect to well-maintained grid users make either a one-off payment or pay a fixed annual/monthly charge.
- Various of sources – district energy systems operators may also be able to generate additional revenue from subsidies, e.g. for renewable/CHP heat or electricity or from carbon trading.

District energy systems help to reduce CO_2 emissions and increase local energy security. They do so through improved efficiency and system flexibility that allows for the bridging of, and support of balancing, electricity and thermal systems and the ability to integrate a wide diversity of energy sources. (Cp. Weber et al. 2016, p. 244)

4.3.4 Bankability

The banks are usually concerned about the return of their investment. For our project this means that it has to be proved to the bank that DHCN provide a sufficient and economic energy supply over decades. Report 3.3 “Bankability” defines a range of barriers for a targeted financial support for developing innovative DHCN-networks (see 3.3. “Bankability”). Long-time investments are always a projection in the future – with an unforeseeable outcome. However, investors such as banks make their investment-decision based on their current level of information. Report 3.3. sees a barrier in the lack of awareness and understanding about the technological concept among politicians and decision makers. This is why more knowledge has to be generated. Additional barriers can be seen in competing heat solutions, lacking technological maturity, an outdated

infrastructure, no support for such systems and reluctant customers lacking understanding. It is thus important to fill this "knowledge gap" on various levels and to identify the key sectors that are shifting money towards sustainable sectors (Cp. Scott Cato 2022, p. 21). Investors such as Pensions and insurance companies are the "key players" in the establishment of this new technology. It is their long time-horizon that gives them a reason to take sustainability seriously (Cp. Scott Cato 2022, p. 22). Cato gives a powerful example: "[I]f we are aiming for net-zero by 2050 that means any investments made in fossil fuel companies will not pay returns to pension holders after that date. Less obviously, but also of key importance, if we continue to erode and undermine our soils with excessive use of pesticides, or lose essential pollinators, of if some prime farming areas become arid and no longer productive, investments made in agribusiness in those areas will not yield a return. This explains why some of the world's leading pensions providers are also key advocates for sustainable finance." (Scott Cato 2022, pp. 22–23)

Cash Flow Modelling and Valuation

The business model outlined in 4.2.5 (Business Model Canvas) defines local DH utilities with a need for renewable, stable heat supply of building owners with a need for heat supply as *Customer Segment*. The *Revenue Stream*, i.e. how income is realized, is a mixture of public expenses and utility bills paid by the customers. According to this business model potential investors may thus have a secure basis for their investment and also return on investment as long as there are enough municipal (building owners) as well as commercial customers (producing companies).

The "green focus" of this project may attract investors looking for green investments. The goal is the EU-wide implementation of DHCNs in order to replace as much fossil energy sources with the goal of CO2-reduction. Since fossil fuels have been revealed as the main "drivers" for global warming, it is therefore in the public interest to support this new technology. It is a known fact that global warming affects the earth' temperature equilibrium in a negative way and this has far-reaching effects for mankind, humanity and the global economy. For example, the melting of the glaciers and the polar caps will lead to rising sea levels and this again will lead to the fact that islands and coastal areas may become uninhabitable. Another also important issue are the vast economic costs connected to climate damage. "It is difficult to make a reliable estimate of the increasing costs of climate damage (…). (Scott Cato 2022, p. 23) So far "the systemic complexity of climate change has helped to conceal the vast economic costs until it may be too late. (…) The European Environment Agency provides regular updates on the economic losses from climate-related extremes, although does not attempt to assign these to anthropogenic climate change. Their estimates are that between 1980 and 2019, the loss amounted to €446bn in the EEA [European Economic Area]" (Scott Cato 2022, p. 23)

One way to slow down or even stop the process of global warming is to develop new technologies for heating and cooling that help to reduce fossil fuels and thus reduce CO2-emissions. The DHCN-approach outlined in this project can make a difference by using waste heat from supermarkets or servers etc. or by integrating various renewable energy sources in the system, such as geothermal energy, solar energy, wind power and biogas.

Building new kinds of these decentralized power plants at a larger scale as well as supplementing old power plants with new technology is an important step in the ongoing process of a successful energy transition and thus a promising way to CO2 neutrality.

Risk Assessment & Rating

Potential investors (e.g. insurance companies, pension funds etc.) who are willing to invest capital in long-term projects such as infrastructure, naturally have a huge interest to assess the risk of the investment as precisely as possible. These risks are connected to DHCN's in planning and to those already existing looking for external capital provided by investors. The latter means that potential investors might have problems to estimate the quality of the underground infrastructure consisting of buried district heating pipes difficult to inspect. A good example can be seen in the 23 000 kilometres of district heating pipes in Sweden which has an estimated value of 12 billion Euros in Sweden alone. This shows the value such infrastructure constitutes (Sernhed and Jönsson 2017) In order to make risks assessable risk matrices can be used to uncover these risks: (see Figure 23)

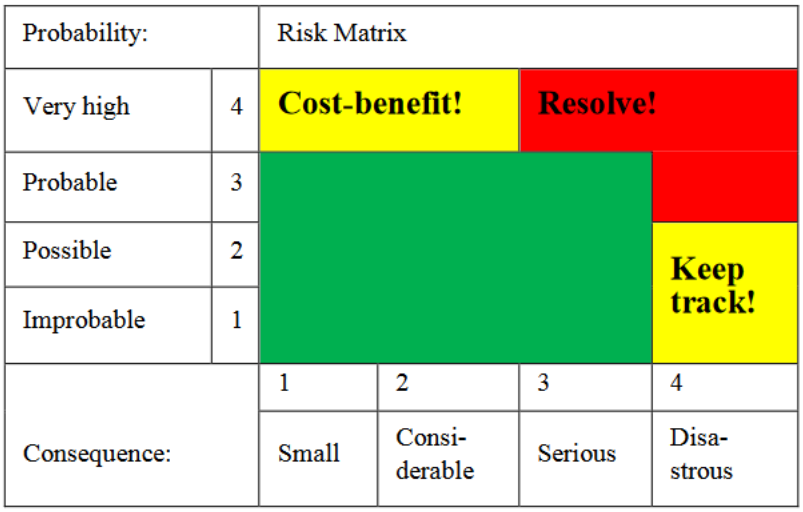

Figure 23: Risk Matrix (Sernhed and Jönsson 2017)

Parameters such as "Age", "Type of pipe", "Pipe dimension" etc. can be considered parameters for the rating of probable failures and the impact from a breakdown in a district heating network. (Sernhed and Jönsson 2017)

Sustainability Balanced Scorecard (SBSC) and Key Performance Indicators (KPIs)

Over the last few years different institutions have developed a number standards and tools for more precisely defining, measuring and assessing the sustainability related aspects and impacts of infrastructure projects (Da Canas Costa and Popović 2020, p. 237). Originally, they were primarily developed by multilateral development banks e.g. the International Finance Corporation's (IFC) Performance Standards (PS) (Da Canas Costa and Popović 2020, p. 237). More recently, tools like the ENVISION® tool or the GRESB infrastructure assessment tool have been brought to market by private third-party providers. Most tools focus and different aspects (e.g. the planning and design phase of infrastructure projects) (Da Canas Costa and Popović 2020, p. 237). The Global Infrastructure Basel foundation in collaboration with Natixis Bank developed the SuRe®-standard, which is a voluntary, third-party verified certification scheme for infrastructure assets (Da Canas Costa and Popović 2020, p. 237). The tool examines 14 themes using 61 criteria across the environment, social and governance factors. It is its objective to create a worldwide language for governments, planners and financial institutions to better understand and influence the sustainability related impacts of infrastructure projects. The SuRe® Standard can be used for analyzing projects from different infrastructure sub-sectors, such as energy, transport or

wastewater. The projects are awarded – depending on their outcome a gold, silver and bronze certification (Global Infrastructure Basel 2019).

For this project an own assessment tool was developed by HFT: a sustainability balanced scorecard (SBSC).

The aim is to provide a template to assess a district heating and cooling network or a DHC company to support investment decisions. In a broader sense, it is based on the concept of the Balanced Scorecard (BSC) introduced in the 1990s by Kaplan and Norton (Kaplan and Norton 1992) which was later extended by the sustainability dimension, when this topic became more important, and named sustainability balanced scorecard.

Following the logic of the "Magic Square" the SBSC is designed to make the investment decision-making-process for investors easier, providing them with specific key performance indicators (KPIs) on the return-, the risk-, the liquidity- and the sustainability-dimension. It translates the technical infrastructure data as well as the business model into numbers investors are interested in. The scorecard is a tool to measure performance in these areas using a set of KPIs. In order to develop the scorecard, it was first necessary to find out which KPIs investors are looking for.

One pillar of generating relevant KPIs was through the accumulation of economic data by way of literature research (Zhang 2022) (Gudmundsson et al. 2013) and case studies of low temperature district heating systems (Celsius Wiki 2020). The other pillar – a more practical approach of gathering information are the interviews with the demo sites and the investor's workshop. The relevant KPI' are based on these scientific findings: (see Figure 24)

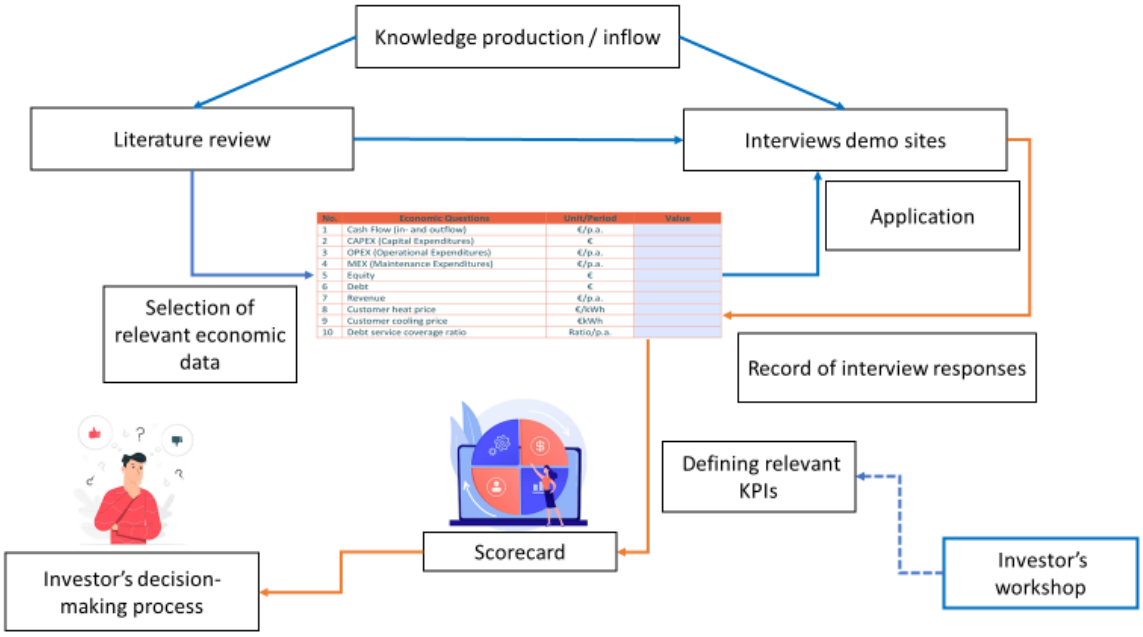

Figure 24: Flowchart overview of the process of generating relevant KPIs (own representation)

The scorecard is designed in such a way that it can and must be adapted to the needs of the individual companies and investors. Target values must be defined for the individual KPIs so that performance can be measured for these KPIs. The scorecard can then be fed with data to provide a quick overview of the performance of the network or investment. For example, it can be seen whether the sustainability requirements or target values for cash flows or similar are being met. It is also planned to integrate a Taxonomy check, so that can be checked if the networks fit the EU

Taxonomy requirements to be a sustainable Taxonomy. The scorecard can therefore also be used by DHC companies for management accounting purposes or preparing for investors pitches.

For the REWARDHeat project it is planned to use the scorecard to calculate potential investment cases for the demonstration networks. At the time of the draft submission, however, no data was available from the demonstrator networks, so this will be done in the further course of the project. (see Figure 25):

Sustainability Balanced Scorecard

Perspective	Performance
Return	55%
Risk	79%
Liquidity	83%
Sustainability	48%
Overall Performance	66%

Perspective / KPI	Value	unit	Target value	unit	weight (0 to 2)	Reciprocal value (Yes/no)	Performance
Return							
Cash Flow	5	%	8	%	1	no	63%
Internal Rate of Return	4	%	7	%	1	no	57%
Return on Equity	2	%	5	%	1	no	40%
Return on Investment	6	%	10	%	1	no	60%
Total group performance							55%
Risk							
Debt Ratio	15	%	10	%	1	yes	67%
Equity Ratio	40	%	50	%	1	no	80%
Leverage	7	%	10	%	1	no	70%
Debt Service	10	Mio. €/year	10	Mio. €/year	1	no	100%
Cahs Flow at Risk	15	%	10	%	1	yes	67%
Total group performance							79%
Liquidity							
Cash Flow	5	%	8	%	1	no	63%
Cash Ratio	85	%	100	%	1		85%
Quick Ratio	1		1	0	1		100%
Total group performance							83%
Sustianablility							
Share of renewable energy	45	%	100	%	1		45%
CO2-Emissions	500	tCO2e	200	tCO2e	1	yes	40%
Total Primary Energy Savings	25	MWh	30	MWh	1		83%
Used Waste Heat	25	%	100	%	1		25%
Total group performance							48%
Total Performance of Sustainability Balanced Scorecard							66%

Figure 25: Sustainable Balanced Scorecard (SBSC) (own representation)

The Sustainable Balanced Scorecard (SBSC) is a still uncomplete Tool that will be refined in the next month. The SBSC follows the same purpose as the DEEP-Tool and yet it differs from it. While using the Deep-Tool is very informative but also elaborate, the SBSC offers a “quick check” for investors along the four dimensions of the “Magic Square”. Each dimension of the “Magic Square” contains KPIs and if these KPIs are put into relation to each other, they give a quick survey whether an investment could be considered as promising or not. As such the SBSC can be understood as a reasonable complement to the DEEP-Tool.

SBSC – In the Application

The further developed SBSC compares various values with each other. For example, in the column "Value" the figure achieved is shown. This figure represents the starting point and is compared with a "Target Value" that can be determined by the individual investor. The column "Limit" shows the target outline in the literature (see table in the Appendix). The column "Performance" shows the individual percentage that has been achieved. If the desired number has been reached the output will be marked "green" and if the desired number has not been reached the output will be marked "red". The "Total group performance" will give a percentage value of the whole performance (see Figure 26):

Perspective / KPI	Value	Unit	Target Value	Unit	Weight (0 to 2)	Reciprocal value (Yes/no)	Performance*	Limit	Valid/Invalid
Return									
Cash Flow	2.000.000 €	€	2.500.000 €	€	1	no	80%		
Net present value	68.696 €	€	65.000 €	€	1	no	106%	>0	
Internal Rate of Return	4,4%	%	65	%	1	no	0%	66.8%	
Return on Equity	8,00%	%	15%	%	1	no	53%	11%-30%	
Return on Investment	4,5%	%	10%	%	1	no	45%	7% - >10%	
Total group performance							57%		
Risk									
Debt Ratio	1%	%	38%	%	1	yes	63%	38,40%	
Equity Ratio	1%	%	34%	%	1	no	2%	34%	
Leverage	5%	%	5%	%	1	no	100%	4%-5%	
Debt Service	20.000 €	€/year	20.000 €	€/year	1	no	100%		
Cahs Flow at Risk	10%	%	10%	%	1	yes	100%		
Total group performance							76%		
Liquidity									
Cash Flow	2.000.000 €	€	3.000.000 €	€	1	no	67%	>0%	
Cash Ratio	4%	%	40%	%	1	no	9%	>30%	
Quick Ratio	20,00%	%	120%	%	1	no	17%	>100%	
Current Ratio	20%	%	170	%	1	no	0%	>120%	
Total group performance							23%		
Sustainability									
Share of renewable energy	45	%	100	%	1		45%		
CO2-Emissions	500	tCO2e	200	tCO2e	1	yes	40%	200tCO2e	Invalid
Total Primary Energy Savings	25	MWh	30	MWh	1		83%		
Used Waste Heat	25	%	100	%	1		25%		
GHG SAVINGS	75	[ton CO2eq / (m:	100	[ton CO2eq /	1		75%		

Figure 26: Sustainability Scorecard (SBSC) in application

De-risk-Energy Efficiency Platform: DEEP

The European Commission-Directorate General for Energy (DG Energy) and United Nations Environment Program Finance Initiative (UNEP FI) founded the Energy Efficiency Financial Institutions Group (EEFIG) in 2013. Its purpose was to create an open dialogue and to serve as a work platform for public and private financial institutions, industry representatives and sector experts whose task it is to identify the barriers to long-term financing for energy efficiency and propose policy and market solutions to them. EEFIG includes 120 active participants from 100 organisations to represent this issue. (Wendt 2019)

The core of the De-risking Energy Platform (DEEP) is a web-based platform that holds information energy-efficiency measures as well as savings. This database will show the benefits and financial risks of energy-efficiency measures. In order to use this database, the users have to get registered. The database mainly holds the data of the European, but the USA, Canada, Great Britain and Turkey are also considered. It contains data for the building sector as well as industry. The data are provided by different actors such as financial institutions, energy consultants and public authorities.

In February 2015, EEFIG submitted its main report – Energy Efficiency – The First Fuel for the EU Economy: How to Drive New Finance for Energy Efficiency Investments. This report can be acknowledged as a significant advance in the understanding and knowledge of the issue of energy-efficiency financing. The findings of the EEFIG-report have led to actions such as the G20 Commitments. Moreover, the European Commission has taken die EEFIG Report has become a guideline for energy-efficiency- related policies. Currently, the sector industry can rely on a database of 9,400 energy-efficiency projects (Ebersold 2022) (Glenting 2021)

In order to continue the findings of EEFIG 2015, the De-risking Energy Efficiency Project Consortium, consisting of COWI, BPIE, EnergyPro, NTUA, Fraunhofer ISI and Climate Strategy & Partners, was formed in order to support EEFIG during 2016-2017. One intention of this Consortium was to address the fundamentals of energy-efficiency investments in the buildings and corporate sectors through two major work streams – the creation of an open source database for energy efficiency informing about the quality of the investment.

The De-risk Energy Efficiency-Platform (Deep) is an open-source database for the performance monitoring and the benchmarking of investments in the field of energy efficiency. Meanwhile, the database contains data on more than 17.000 energy-efficiency project in buildings and the industry of more than 30 data providers. Nevertheless, the investments in the energetic restoration are below the level necessary for Europe to reach its climate goals. The platform tries to compensate the lack of evidence concerning the performance of EE-investments complicating the evaluation of their benefit and financial risk. In the EEFIG-report of 2015, this was named as a main obstacle for the extension of financing of energy efficiency measures. (Glenting 2021)

DEEP 2.0

At the end of June, the upgraded platform Deep 2.0 was introduced. The updated platform has a new visual identity and several improvements based on the user's feedback. It has a new structure and more information can be obtained directly from the Landing Page. A registration is no longer necessary. There are new date fields for building integrated EE and fields considering the new EU-Taxonomy. Furthermore, there is an improved Benchmarking-Tool enabling the users to compare their own portfolio with the DEEP-data as well as to carry out a benchmarking among user-defined partial quantities, to consider more advanced risk indicators (skew, kurtosis and value-at-risk) and to a have an easier access to the DEEP-Analysis via API with practical examples. (Glenting 2021)(see Figure 27)

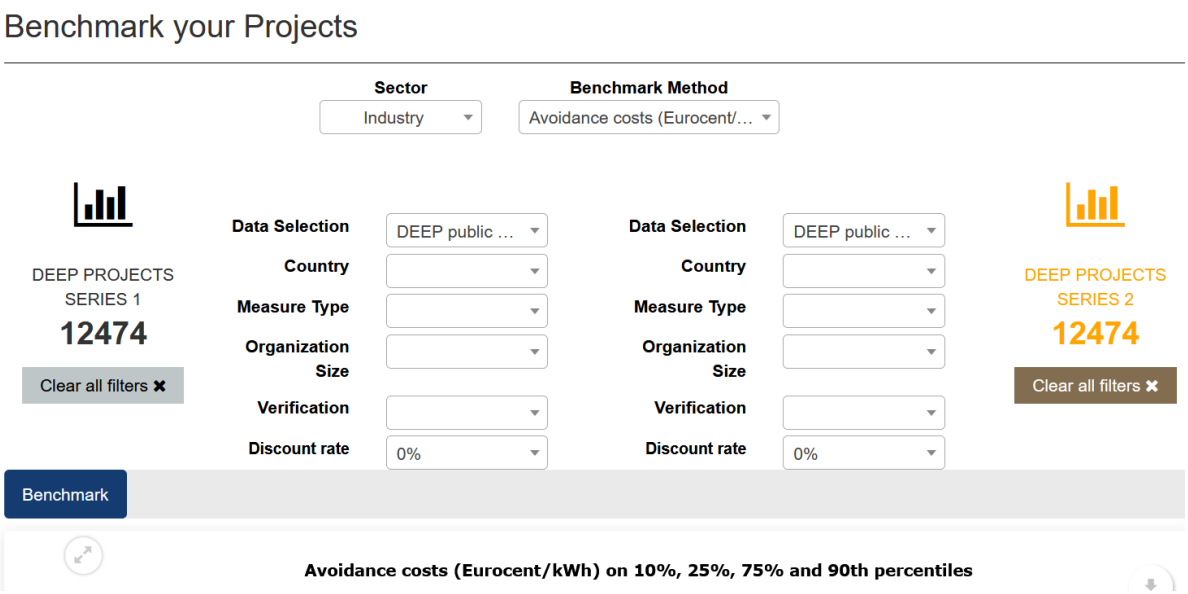

Figure 27: Benchmark your Projects (DEEP - De-Risking Energy Efficiency Platform)

Figure 28 shows the Chart Data of the DEEP-Platform:

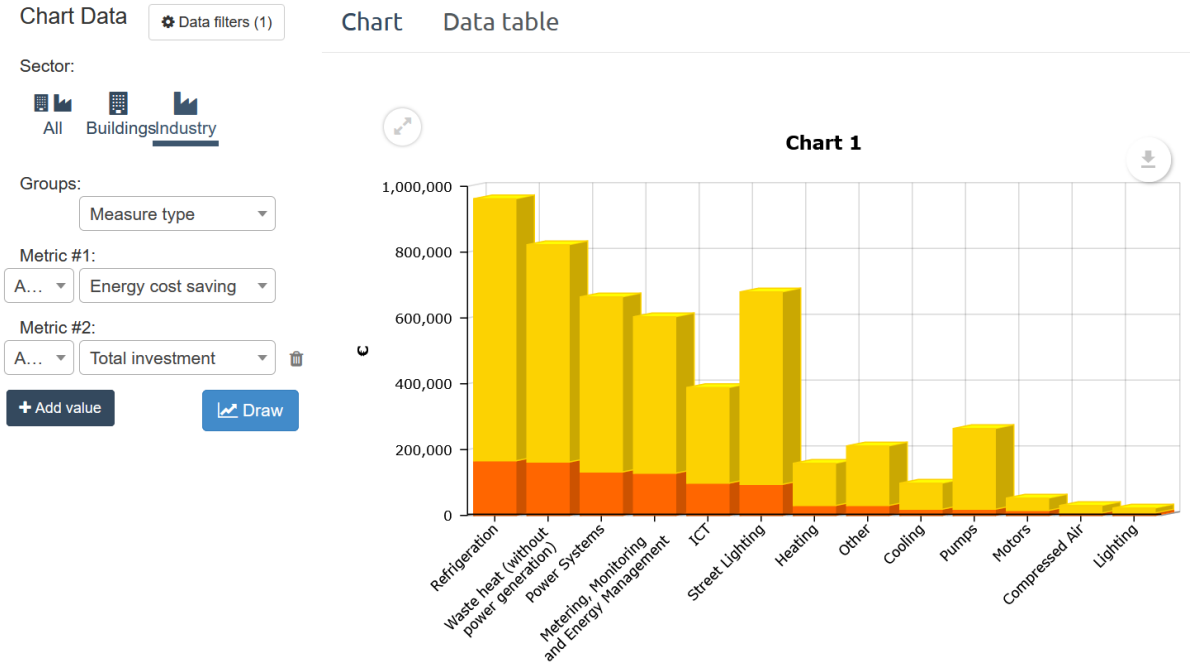

Figure 28: Chart Data (DEEP - De-Risking Energy Efficiency Platform)

EEFIG- Underwriting -Toolkit

In June 2017, the EEFIG Underwriting Toolkit was set up. It was produced to fulfil the following objectives:

- Helping, originators, analysts and risk departments within financial institutions to better understand the nature of energy efficiency investments and be better prepared to evaluate both their value and the risks connected to them
- Providing a common framework that makes it possible to evaluate energy efficiency investments and to analyse the risks. This again makes it possible to allow training and to build up capacity around standardised processes and understanding
- Helping developers and owners to attract external capital for energy efficiency projects and to develop projects that better addresses the needs of financial institutions
- Fostering a common language between project developers, project owners and financial institutions

The Toolkit provides all the reasons why financial institutions should be interested in:

- energy efficiency
- ways of financing efficiency
- the project life cycle
- the assessment of value and risks of energy-efficiency projects

By including an online segment, it provides background information on energy-efficiency technologies, contracts, organisations as well as additional case studies.

While the EEFIG DEEP database is helps to evaluate the risk of energy efficiency projects, the Underwriting Toolkit is a capacity-building tool for financial institutions looking to expand their investments in the field of energy efficiency. (Cp. Wendt 2019, pp. 87-88)

The DEEP-Tool Related to Investment Decisions of Public Investors

In the project we have developed an own toolkit – a Sustainable Balanced Scorecard (SBSC) – for investor's decision making. The following table shows a comparison between the DEEP-Tool and the SBSC. Similar to the DEEP-Tool, the purpose of the SBSC is to inform potential investors and to encourage investment decisions.

Although the SBSC is not a web-based and pan-European tool and does not hold as much data as the DEEP-platform with regard to the industry sector, the SBSC has distinct advantages. When being compared to the Deep-Platform it turns out that it gives a measurement of the CO2-emission savings connected to the investment. Moreover, the connection of different dimensions reveals the interrelation between them in the "Magic Square". This makes it possible to project the investment into the future and it creates a knowledge base that may attract investors. Another advantage can be seen in the fact that the SBSC-tool gives a quick overview of a potential investment decision. What is also decisive for attracting investors is the assessment that the investment case is compliant with the regulations of the EU Taxonomy. This will be another field to explore. The following Table 3 shows a comparison between the DEEP-Tool 2.0 and the SBSC:

Table 3: Comparison DEEP-Tool 2.0 and SBSC (own representation)

DEEP-Tool and DEEP-Tool 2.0	SBSC
• Publicly available: web-based database (registration necessary) • Database shows the benefits and the financial risks of efficiency measures • Database contains data for the industry and building sector • Data are provided for financial institutions, energy consultants and public authorities • Data of 9.400 energy-efficiency-projects useable as comparative data • Charts • Data for building-integrated EE • New EU-taxonomy considered • Improved Benchmarking-Tool – enabling users to compare their own portfolio with the DEEP-database • Benchmarking among user-defined partial quantities • Advanced risk indicators (skew, kurtosis, value at risk)	• Not publicly available: not web-based (no registration) • Investors are contacted and are shown the KPI's contained in the SBSC • Database shows the benefits and the financial risks of efficiency measures • Database contains data for the industry sector • KPIs, have been recorded to specific investor's needs (e.g. investors are insurance companies etc.), semi-professional investors and private investors (angel investors, venture capitalists, private-equity firms etc.) • No charts (so far) Distinguishing features: • Measurement of CO_2-emssions of the investment goods. Gives an overview of the CO_2-savings connected to the investment • "Magic Square" shows the relation between the four relevant dimensions and the Key Performance Indicators (KPIs) of "Return", "Risk", "Sustainability" and "Liquidity" by also including EU Taxonomy ➔ this makes it possible to project investment decisions into the future and to give a prediction about their likely success / failure.

4.4 Investment Cases & Investment Stories

Very often investment stories are presented in the form of a pitch and this pitch should be as short as possible. A pitch should be a document that conveys a core message to its readers. This message should be easy to grasp and should have an (emotional) impact on them. A good guideline for preparing a pitch is the 10-20-30 rule from Guy Kawasaki recommending to use 10 slides in 20 minutes with not more than 30 points. These slides should be presented in the following order (see Figure 29):

- What is the problem?
- What is the solution to this problem?
- How does the business model look like?
- Make a demonstration of your product / service.

(Janeczko 2020)

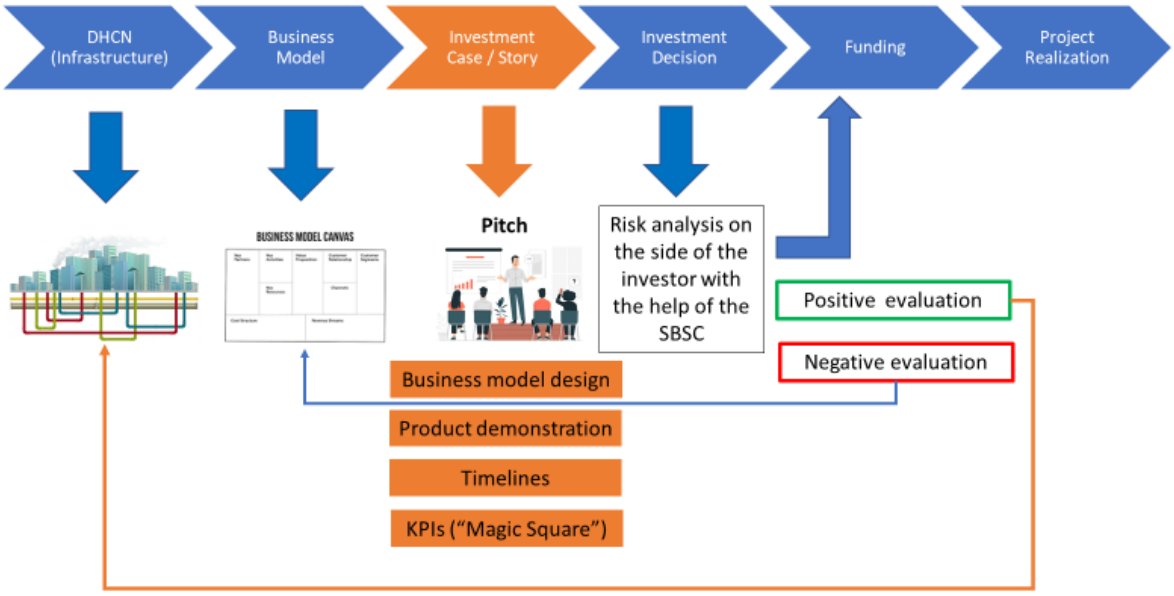

Figure 29: Investment case / story in the overall context (own representation based on Popovic (2023)

As a matter of fact, a greater implementation of DHC systems across the European Union is prevented by a lack of funding. Heat recovery requires not only additional equipment, but also higher upfront investments. Both are necessary for the implementation of cogeneration technologies compared to conventional power plants. Significant investments are also required for building up the necessary distribution infrastructure from generating heat or cold to consumers. (Welsch 2017)

4.5 Lifecycle Stages of Investment Projects

Investment cases depend on the lifecycle stage of the projects. Traditionally, in earlier stages the uncertainty of the project is higher and an investor has to take higher risks. But this usually comes with a higher risk premium and this may also mean a higher return for the investor.

Infrastructure development goes along with various risks becoming obvious at different states of a project's life cycle. Among these risks are construction, completion, currency, revenue stability, environmental, and demand fluctuation.

Other risks emerge as a result of the jurisdiction, macroeconomy as well as the political and regulatory environment. Whether or not infrastructure can work as asset class depends upon the addressing of these risks. Another task that has to be dealt with is the mitigation and allocation of

these risks to relevant stakeholders. It is also important to deal with the foreign exchange risks of infrastructure projects since infrastructure revenues are normally denominated in local currency. This may lead to mismatches when foreign equity and debt are used in project financing.

Moreover, adequate and effective legal, regulatory, tax, governance and accounting frameworks also play a decisive role in attracting investment in infrastructure. Well-functioning markets for infrastructure financing, the protection of investors and the guarantee of efficiency, transparency and stability depend on the design of these frameworks. Also, this framework has to promote integrity and anti-corruption and simultaneously it has to minimize unnecessary regulatory burdens. (OECD) In the following figure the lifecycle status of the REWARDHeat demo sites shown (see Figure 30):

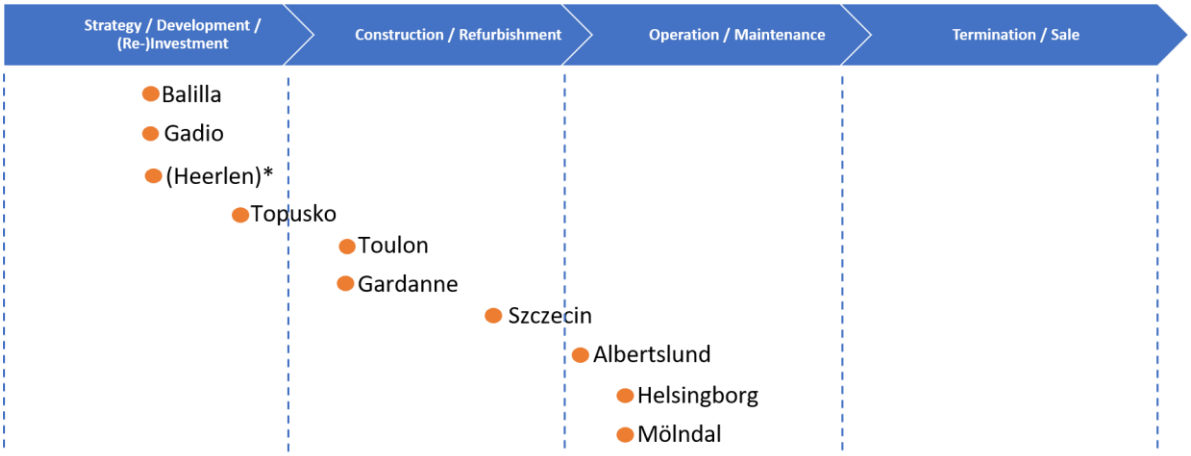

Figure 30: Mapping REWARDHeat demosites to the infrastructure finance lifecycle, Source: (Popović 2022b) (Own representation based on (Radford et. al. 2019); (OECD 2015b), (Ehlers 2014).

The following points show how the demo-sites were used and how they were integrated into the process.

(1) Analysis of the demo sites according to their current lifecycle position

Prior analysis of the demo-sites participating in the RewardHeat-project has delivered valuable insights about their current position in the lifecycle. In the further course of the project it is planned to analyse the demo sites more thoroughly and this also means that their current position in the lifecycle will be determined again.

This position makes it possible to determine the current status and to ask decisive questions concerning the financial requirements of these installations. This again leads to the decision how they can be supported or financially stabilized so they can make necessary investments in the future. The goal of allocating financial aid is to achieve financial stability in the long run. To act profit-oriented gives them the opportunity to prosper and they can be a role model for other places in Europe or elsewhere.

The following table shows the evaluation of the interviews with the operators of the demo sites. The goal of these interviews was to offer financial support according to their current position within the lifecycle. The colours used – red, yellow and green – give a quick overview over their intention to rely on external financial capital. “Red” means that there is no willingness to rely on external

financial capital or it is not possible because of the demo sites financial situation (lack of profitability) or organizational structure (e.g. it is non-profit). "Yellow" means that there is the intention to carefully examine such an investment and "green" means there is the will to accept the inflow of external capital:

(2) Interviews

During the interview the operators of the demo sites were asked the following questions:

- What is the status of your demo site? What kinds of problems do you have?
- Are you planning extensions or renovations?
- Does EU-Taxonomy play a role for you?
- Do you need financing? Have you considered a buy-out in order to generate liquidity?
- How can we support you?

The results of the analysis of the interviews have led to the following results that can be grouped into three generic parts:

- demo sites are not interested in external financial capital because they
  - rely on subsidies
  - are non-profit
  - are not intended to make a profit
  - are run by the municipalities (which means that their funding is a component of the municipality's overall budget)

- demo sites lack rentability* because
  - fixed costs are high and cannot be compensated because
  - the selling price for heat / cold is not the result of a cost calculation, but rather skewed by subsidies
  - the technology is not anchored in the population because cheaper heat sources e.g. wood are preferred and the connection of the installation to the houses would be elaborate (structural) and expensive

- demo sites do not grasp the potential of external capital
  - for renovation
  - financial stability
  - further development of the installations

*lack of rentability is a thesis based on the impression the interviewers had during the interview. This thesis has to verified on the basis of the Key Performance Indicators (KPIs) we will derive from the economic data contained in the questionnaire handed out to the demo sites.

[DS 2 and DS 6 have to be defined as preliminary investment cases*: A viable investment story has to be based on KPI's which we hope to learn from the questionnaires as soon as possible.]

(3) Collection of General Data and KPIs (Questionnaire)

Key performance indicators (KPIs) are crucial for organizations to evaluate and to improve their sales performance. This means that they effect organizational success by addressing the

company's performance in a multidimensional way. Essential are strong theoretical rationales and the appropriate combination of measures. (Richard, P., Devinney, T., Yip, G., & Johnson, G. 2009)

A second more detailed questionnaire has been issued to supplement the subject of finance with the subject of taxonomy and technology. This extended questionnaire is the result of an increase in knowledge gained through expert interviews, workshops and a continuous exchange with the test facilities (demo-sites) on the one hand and investors on the other hand. The structure of the questionnaire and its explanations follow scientific principles (see Figure 31):

No 1.1.	Opening questions		Yes/No
1	Are you collecting data for GWP – emissions? (Scope3?)	Yes / No	• If Yes, could you share this information with us?	
2	Are you doing LCA?	Yes / No	• If Yes, would you share your plan (GaBi, Umberto, Excel-file etc.) with us? • If Yes, are the points 9 to 16 a in the table below represented in your LCA / file?	
3	Would it be possible for you to make available the business reports of the last three years?	Yes / No	• If No, give a short explanation why this is not possible?	

The first part of the questionnaire gives an overview of GWP (Global Warming Potential) and the requirement of Scope 3 as well as LCA (Lifecycle Assessment). The term Global Warming Potential (GWP) is used to describe the relative potency on the basis of molecules of a greenhouse gas such as CO_2 or other non-fluorinated gases (CH_4, N_2O). (European Environment Agency 2023) With

regard to DHCNs it is possible to say that modern district heating system based on renewable technologies can be a carbon-free and sustainable solution for urban heating. (Mazhar, A., Liu, S. and Shukla 2018) Scope 3 tries to capture all the indirect emissions that occur in the value chain of a company. These emissions are a consequence of the company's value chain including all upstream and downstream emissions. It may also result from sources the company does not own or control. (Greenhouse Gas Protocol) This applies to electricity-driven heat pumps or other pumps within the system. For example, it is a known fact that especially 5th-generation DHCNs utilizing low-temperature heat sources require higher pumping energy consumption than traditional district heating. (Rhein, J., Henze, G., Long, N. and Fu 2019)

The advantage LCA is that it captures all the emissions and resource requirements of a production system. With regard to the production of district-heat this means that the effects of all the activities within the system, such as extraction, refining, transport and use of the fuels are considered. For example, it can be shown in a LCA-analysis that the combustion of biofuel in a CHP is more environmentally friendly than waste incineration and natural gas. (Eriksson, O., Finnveden, G., Ekvall, T., & Björklund, A. 2007)

No. 1.2.	Setting / Technical and Environmental Questions	Unit	Value
1	Number of houses	Number	
2	Type of houses (e.g. single-family houses / apartment block / communal buildings)	Description only	
3	Principle energy sources	Description only	
3	Year of construction	Date	
4	New development / renovation	Date	
5	Total heated area	m^2	
6	Supply temperature	Celsius	
7	Return temperature	Celsius	
8	Distribution losses	%	
9	What are your primary heat sources?	Description only	

10	What is the average life span of your instalment? [from cradle to grave]	years	
	Thermal efficiency		
11	Total Output	MWh/year	Year 1 | Year 2 | Year 3 | | |
12	Distribution loss	MWh/year	Year 1 | Year 2 | Year 3 | | |
	CO_2-load		
13	CO_2 – emission factor (cooling)	kg/MWh	
14	CO_2 – emission factor (heating)	kg/MWh	
15	CO_2 – emission factor (total)	kg/MWh	
16	Is your plant a CHP- plant?	Yes/No	
16a	If yes (What is/are your heat sources?)	Description only	
17	Does your CO_2-emission factor include all upstream emissions?	Yes/No	
18	Do you recycle equipment?	Yes/No	
19	Do you have boiler capacities somewhere else?	Yes/No	
20	Are you using heat pumps?	Yes/No • If yes, please	

		answer also 16a	
20a	What is the global warming potential of the refrigerant?	Kg/MWh	
21	Does your company make use of CO2-certificates?	Yes/No	

The CO2-load provides information to potential investors whether a system has a high or low environmental impact. EU-taxonomy has defined limit values for each energy source. The following table contains the principles of "Do no significant harm" ("DNSH") raised by the EU-taxonomy that also applies to district heating / cooling distribution. (EU Commission 2021) Both the reported CO2-load and the DNSH-principles provide information to investors whether a system is in alignment with EU-taxonomy or not.

No. 1.3.	Questions relating to Taxonomy		
	Please describe your contribution to the six climate and environmental objectives		Action(s)
		Example	
1	Climate change mitigation	Using RES LT-technology	
2	Climate change adaptation	Using RES LT-technology	
3	Sustainable use and protection of water and marine resources	Closed loop cooling systems	
4	Transition to a circular economy	Recycling of spare parts or heat pumps	
5	Pollution prevention and control	Making use of RES	
6	Protection and restoration of biodiversity and ecosystems	Adopting advanced emission	

		control systems	

At an early phase in their lifecycle large-scale infrastructure projects, such as DHCNs, are normally connected to various risks that may lead to the cancellation of the whole project, serious delay, and cost overruns. (Lam 1999) It is therefore in the interest of investors to demand identification and mitigation of risks. Among these risks are commercial, political, legal, environmental, and also social risks. (Rezaee 2016)

No. 1.3	Risk Evaluation		
	Determination of risk on the basis of risk categories	Likelihood (from 1 to 5)	Impact (from 1 to 5)
	Technological		
	Please name the most important technological risk from your perspective and give them an evaluation		
	Risk of new technology employed		
	Stable secure heat supply		
	IT-infrastructure breakdown (e.g. cyberattack)		
	Economic		
1	Long time horizon		
2	Revenue risks (e.g. drop in sales)		
3	High transaction costs for investors		
4	Low liquidity of assets		

5	Lack of incentives for waste heat recovery combined with incentives for other technologies		
6	Further impediments: • Low carbon price • Fossil fuel subsidies		
7	Lack of appropriate financing systems		
8	Long-term, stable and predictable cash flows		
	Environmental		
9	Climate physical risks (e.g. hurricanes, floods, droughts) leading to the plants' destruction, lower firms' productive capacity and output		
	Political		
10	Political uncertainty (e.g. Change of government)		
11	Political and regulatory barrier and risks		
12	Insufficient international participation (e.g. terms, concessional loans etc.)		
13	Climate transition risk (e.g. due to a disorderly transition to a low-carbon creating a situation in which climate policies (e.g. carbon tax) and regulations are implemented late with regard to the		

	climate targets and cannot be fully anticipated by investors.		

For investors planning to invest in a large-scale infrastructure project, such as DHCN, during maintenance, it is helpful to have profound knowledge of the financial structure because this influences the level of investment and the efficiency of the company's capital allocation. (Stiglitz 1988)

No. 1.4	S	Financial Structure	
1	Please describe your general funding structure in detail (e.g. sources, financing instruments, etc.)?		
2	Is your site funded by public entities (e.g. multilateral institutions, EU, national government, state municipality?		
3	Do you receive subsidies?	Yes/No	
3a	If yes, please specify!		
4	What are the most important financial instruments you are using?		
5	Is blended finance implemented on your site?	Yes/No	
5a	If no, are you planning to utilize it?	Yes/No	
6	Would European Long-Term Investment Funds (ELTIF) be an option?	Yes/No	
6a	If no, why not?		
7	Which investor groups are providing funding for your site (e.g. banks, promotional banks, investment funds, multilateral institutions, (re-)insurance-companies, etc.)?		
8	Are you planning to attract new investors?	Yes/No	

8a	If yes, which kind of investors are you targeting at or do you want to attract?		
9	Are ESG-linked bonds/loans part of your financial structure?	Yes/No	
10	Are Green bonds/Loans part of your financial structure?	Yes/No • If Yes? Which ones? (state, bank?)	

Past economic performance provides information about a company's ability to innovate and this presupposes a dynamic direction of financial flows. (Cozzarin 2006) In general, investors want to know about economic performance because they act unlike those in economic models by impacting wealth an risk. (Lindblom, T., Mavruk, T., Sjögren, S. 2017)

No. 1.5	Economic Performance	Unit/Period	Value
1	Cash Flow (in- and outflow)	€/p.a.	
2	CAPEX (Capital Expenditures)	€	
3	OPEX (Operational Expenditures)	€/p.a.	
4	MEX (Maintenance Expenditures)	€/p.a.	
5	Equity	€	
6	Debt	€	
7	Revenue	€/p.a.	
8	Customer heat price	€/kWh	
9	Customer cooling price	€kWh	
10	Debt service coverage ratio (DSCR)	Ratio/p.a.	
11	Return on invested capital (ROIC)	Ratio/p.a.	
12	Internal rate of return (IRR)	Ratio/p.a.	
13	Sales Revenues	€ (2022)	
14	Cost of Sales	€ (2022)	
15	Taxes	€ (2022)	

16	Depreciation	€ (2022)	
17	Additions to Networking Capital (= Cash and cash equivalents; e.g. Working Capital, Receivables, Bank balances etc.)	€ (2022)	

Figure 31: Second (extended) questionnaire

The questionnaire is the basis of the "Magic Square" in delivering the necessary KPIs. The "Magic Square" in turn serves as basis for the decision-making process of investors by covering the dimensions "Risk", "Return", "Liquidity" and "Sustainability".

(4) Criteria for Market Maturity

Financing the energy transition demands a large-scale mobilization of private capital. The financial means for large infrastructure projects in the field of clean energy cannot only be provided by political institutions but must also be made available by the private sector. This makes it necessary to provide specific criteria for determining the market maturity of large infrastructure investments. (Tasic N. and Valev N. 2008)

This means that the public and the private sector have to cooperate in order to provide financial means that are

(1) adequate in terms of volume
(2) appropriate and relative cheap terms
(3) diversified and is able to cover a broad range of market readiness levels, needs and target beneficiaries/clients (EU Commission 2024b)

Based on these considerations the European Commission has developed a framework in order to assess the maturity of markets in the field of clean energy finance that is based on three dimensions. The following table summarizes the framework to assess the three dimensions: (EU Commission 2024b) (see Table 4):

Table 4: Approach to assessing market maturity (EU Commission 2024b)

Market maturity characteristics	Description *Why we have chosen this characteristic*	Key metric / indicators *How we will measure it*
Abundant supply of finance, primarily from the private sector, with the public sector intervening in underserved markets	The deployment of renewable H&C technologies to mitigate carbon emissions typically requires high upfront investments Across countries the availability of financial capital contributes to investments in more capital-intensive energy	To evaluate the supply of finance, we will use the following indicators: The availability of private finance in each Member State, measured through: • Banking debt of corporates

	technologies. For high-income countries, financial capital supports transitions towards more capital-intensive energy technologies. If both public and private H&C financing is needed, they should play different roles in financing the energy sector. • Public money should be used to finance underserved markets, emerging technologies, for the addressing of market failures and investments in riskier fields. • Private sector finance should be used to provide the supply of debt and equity finance needed in the market. It is used to cover a wide range of levels of technology maturity with a diverse offer of instruments.	• Stock market capitalisation • Green bond market The availability of public finance to finance H&C in each Member State
Low cost of capital - WACC	One of the most important financial variables for evaluating infrastructure is the weighted average cost of capital (WACC). The realization of low-carbon infrastructure such as H&C is capital-intensive and connected to high upfront costs. WACC incorporates various information such as • level of interest rates	Evaluating the cost of capital demands the calculation of WACC for renewable energy projects in each Member State.

	• country risks (regulatory, economic, political and legal) WACC also provides information about technological advancements and increased experience in the energy financing sector informing about the level of maturity. Low values of WACC point to mature energy finance markets and a low country risk.	
Various financial instruments including bonds and equity as well as a low use of grants for mature technologies	Normally, H&C projects are financed with project-level conventional (i.e., non-concessional) debt. This accounts for 32% of the RE investment in 2017-2018 on average. Availability of grants may point to many early-stage technologies in the market. The excessive usage of grants points to a low maturity of the energy finance market too dependent on free public support. If grants are used for mature technologies capable of accessing private financial markets is a reason for concern. Mature markets have a balanced mix of financial instruments including also bonds and equity. It has to be considered that markets relying only on grants and loans must be defined as less mature.	There is no comprehensive data on the instruments that can be used for making investments in renewable energy. In order to evaluate the diversity and comprehensiveness of financial data available in each country, the following indicators can be used: • How diverse the financing instruments for H&C are can be measured through a modified usage of the Herfindahl-Hirschman-Index (HHI) • Outlining a number of categories of financial instruments (bonds, equity) offered in the respective Member State. • Grants for projects in the implementation

		phase as a % of grant instruments.

(5) Investment Stories

Investment stories do not only inform potential investors about KPI's, but also about the demo sites business model, their financial situation etc. The KPIs will be integrated in the SBSC and thus make it possible to find out whether these demo sites are viable investment cases. The investment story of the most likely cases – based on the later evaluation of the KPIs – can be described as possible. It is important to understand that storytelling plays a role in the exchange between a salesperson and buyer and in this way it also has an impact on the decision-making process of investors. (Gilliam, D., & Flaherty, K. 2015)

(6) Investment cases

Among the key components of a successful investment case count continuous research, the understand how the market works, the detecting and exploiting of opportunities in order to achieve excess returns at reasonable risk. (Jacobs, B., & Levy, K. 2014).The following section gives a theoretical overview of investor relations.

4.6 Investor Relations

Investor relations is a part of strategic management. It integrates finance, communication, marketing and securities law compliance. Its goal is to enable the most effective two-way communication between a company, the financial community and other constituencies. They all contribute ultimately to a company's securities achieving fair valuation. The investor relations department is aware of the fact that the whole company is run in the interest of the shareholder. (DuFrene 2010, p. 3) If shareholder value-driven companies commit themselves to material sustainability opportunities, they need to build the understanding and support of their shareholders. Investors are increasingly interested in sustainable investments. A survey of Principles for Responsible Investments (PRI) signatory investors of 2015 found out that 84% of respondents would allocate capital to investments supporting the Sustainable Development Goals (SDGs), and 89% have even declared themselves to support regulatory reforms that promote the SDGs. Investors have begun to look at the SDGs as a way to address growth opportunities and to manage risks. In order to help institutional investors to measure their alignment with the SDGs new tools are being developed such as the MSCI ACWI Sustainable Impact Index. The cost to achieve the SDGs in developing countries alone are estimated § 3-5 trillion per year. Investors and companies are thus expected to invest capital in a way that delivers both financial returns and contributes to public-goods. (Cp. United Nations Global Compact) So far, this has not been an issue when working with the demo sites:

Key Takeaway of Chapter 4:

Based on DHCN's technological infrastructure business models are derived which in turn serve as a basis for investment cases. In order to facilitate investors' decision-making processes, it is crucial to present investment cases with specific KPIs in the following dimensions: return, risk, liquidity and sustainability (focus: CO2-emissions), resulting from a sustainability balanced scorecard (SBSC). Esp. with respect to the risk-return-relationship it is of particular importance to integrate the lifecycle-stage in which a DHCN-site is located. Since DHCN-projects have a long-term time horizon investor relations-management is of high importance.

5 DHCN as new Asset Class on Financial Markets

Infrastructure has become a key driver of economic growth and prosperity. The G20 has recognized the importance of infrastructure for growth and development and they have understood that it is necessary to compensate investment shortfalls as a way of lifting growth, job creation and productivity. Policies, framework and mechanisms have been established in order to increase investments – also through initiatives such as the long-term investment financing by institutional investors, investment strategies, based on the diversification of instruments and incentives for infrastructure financing. (OECD)

5.1. Fundamentals on Asset Classes

An asset class can be defined as a group of similar investment vehicles. Different classes, or types, of investment assets, e.g. fixed income investments, can be grouped together because they share a similar financial structure. Typically, they are traded in the same financial markets and they underlie the same rules and regulations. There are also different kinds of asset classes.

Key facts:

- Asset classes are the main building blocks in order to generate a diversified portfolio and to reduce your overall investment risk;
- They are very broad categories including assets with similar characteristics and risk levels;
- Those assets most common are cash and cash equivalents, equity, fixed-income securities, as well as real estate. There are still more advanced asset classes. (Schucht 2022)

The following Table 5 gives an overview over some of the different asset classes (Park 2023):

Table 5: Understanding different asset classes (Park 2023)

Asset Class	Description
Stocks or equites	Equities are shares of ownership issued by publicly-traded companies in order to produce liquidity. They are traded on stock exchanges such as the NYSE or NASDAQ. Shareholders can potentially profit from equities either through a rise in the share price or by receiving dividends. The asset class of equities is often subdivided by market capitalization into small-cap, mid-cap, and large-cap stocks.
Bonds or other fixed-income investments	Bonds or fixed-income investments are investments in debt securities Their rate of return are interests. The risk connected to such investments is generally considered to be less risky than the investment in equities or other asset classes.
Cash or cash equivalents, such as money market funds	Cash or cash equivalent investments are very popular because of their liquidity. Capital that is held in the form of cash or cash equivalents can be easily accessed at any time.
Real estate or other tangible assets	Asset classes can also be real estate and other physical assets are considered an asset class that offers protection against inflation. The tangible nature of such assets also leads to them being considered

	as more of a "real" asset. In that respect, they differ from assets that exist only in the form of financial instruments, such as derivatives.
Forex, futures and other derivatives	This category includes futures contracts, spot and forward foreign exchange, options, and an expanding array of financial derivatives. Figure 32Derivatives are financial instruments based on - or derived – from an underlying asset. For example, stock options are a derivative of stocks.

The following Figure 32 shows the different asset classes:

Figure 32: Asset Classes (Schucht 2022)

Sustainable finance in the broader sense[2] focusses on how sustainable development can be financed, and particularly on the question of how to finance the (major) transformative process towards a sustainable economy (Popovic 2018, p. 206). Sustainable finance in the narrower sense is divided into the following sub-areas, where sustainable infrastructure is one of these sub-areas (see Figure 33):

[2] For a more detailed, literature-based derivation of the Sustainable Finance and Sustainable Investments dates, see Popovic 2013.

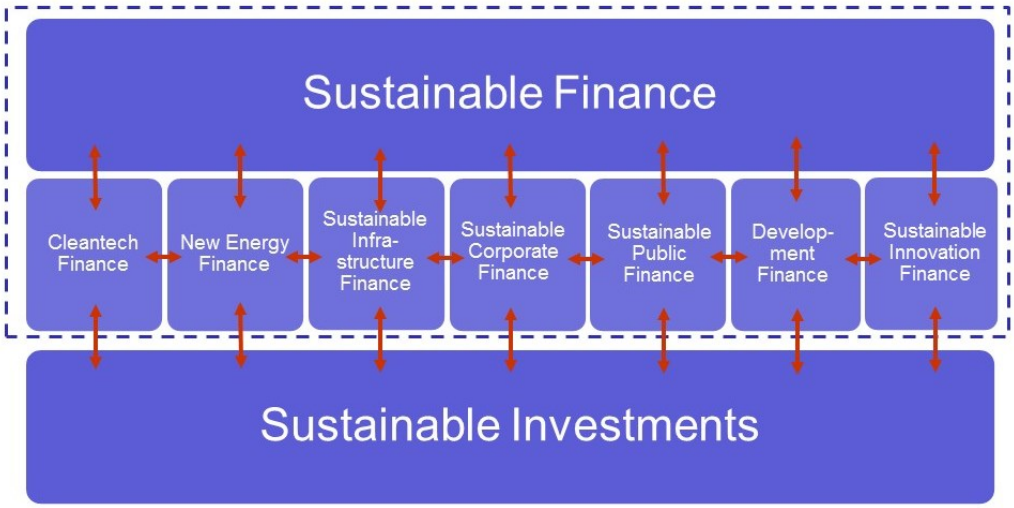

Figure 33: Taxonomy of Sustainable Finance (Popovic 2018, p. 206)

The counterpart of sustainable finance is sustainable investments. Financial markets link both areas in order to facilitate to channel the capital flows sustainable finance and sustainable investments. Private and institutional investors – as surplus units – provide the capital supply via sustainable investments. The funds provided service as source of funding for sustainability-focused projects and corporations. (Popovic 2018, p. 207).

The Sustainable Finance Disclosure (SFDR) specifies the requirements for investment companies, pension funds, insurance companies and banks that provide investment services. It commits companies and financial institutions to make a declaration of how they consider the environmental or social impacts of their investments. Any firm marketing its financial products as "sustainable" faces even stricter disclosure requirements to prevent greenwashing.

Financial products are now measured according to their level of pro-sustainability performance. The following paragraphs of the EU regulation define them: (Scott Cato 2022) (see Figure 34):

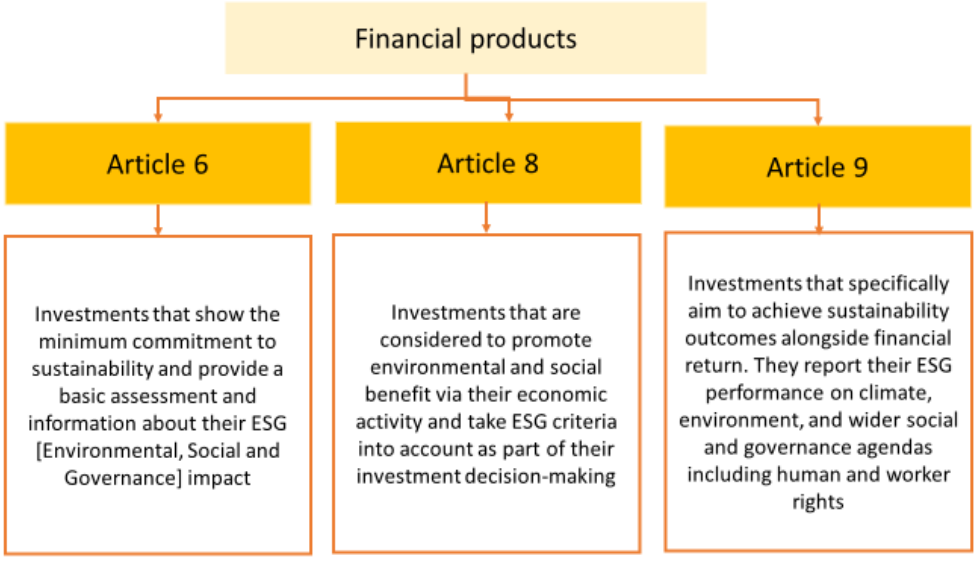

Figure 34: Financial products defined by EU regulation (Own representation based (Scott Cato 2022))

These new rules may have a beacon function for they could have far-reaching consequences for asset managers – not just in Europe but around the world as investment firms are forced to demonstrate they are serious about sustainability. Another advantage of these rules is that they will also influence the decisions of listed companies which will find themselves under pressure to focus more on ESG issues when they are confronted with losing investor capital. (Scott Cato 2022)

Sustainable Real Estate Finance and Sustainable Infrastructure Finance are sub-areas of Sustainable Finance. Sustainable Real Estate Finance focuses on the question of how sustainable buildings (e.g. green buildings) or renovation work (e.g. energy refurbishments) can be financed. Sustainable Infrastructure Finance is dedicated to the question of how sustainable infrastructures (e.g. energy, (waste) water, digital infrastructures) can be financed and how investors can be won for this.

In the context of sustainable development, the aspect of climate neutrality only deals with a sub-area within the environmental sustainability dimension. (Popović 2022b). The focus on climate neutrality in this paper results from the urgency of effectively combating anthropogenic climate change (World Economic Forum 2022, pp. 8–9).

Sustainable investments have been one of the fastest-growing asset classes worldwide since the mid-2000s. In Europe sustainable investments grew from EUR 184 billion in 2002 to EUR 10,151 billion in 2015 (+5,400%) (Eurosif 2016, p. 25). Large asset managers and sovereign wealth funds have been acting as a driving force for investments from CO2-intensive sectors (e.g. mineral oil industry) to less CO2-intensive sectors (e.g. renewable energy) (Fouche 2017; Carrington 2015; BlackRock 2017; The Economist 2019), contributing by that to the decarbonisation process of the economy. This dynamic growth trend of sustainable investments provides an opportunity for also in particular mobilising resources for financing sustainable infrastructures. The success of this rechannelling of capital flows strongly depends, though, on how policymakers design the corresponding framework conditions (Popovic 2018, p. 208; Da Canas Costa and Popović 2020, p. 234)

5.1.1 Specific aspects for DHCN[3]

DHC networks require significant investment, which is why municipalities and countries rely on several financial measures to support their planning, implementation and operation. DHC networks should eventually pay for themselves, but the upfront costs of projects are significant. It can take up to 10 years to recoup the initial design and construction costs and even make a profit. Thus, district heating projects need investors who are more interested in a relatively secure long-term income stream. In the following, the common financing models for DHC according to (Sunko et al. 2017), among others, are discussed. These include: equity, loans, grants, bonds revolving funds and land-value capture strategies (Sunko et al. 2017).

The figure below shows the financial instruments mentioned and their distribution in DHC projects. This also indicates the importance of the respective instruments (see Figure 35).

[3] This paragraph contains results of a term-paper project in the Smart Sustainable Finance-module (Prof. Dr. Tobias Popovic) as part of HFT Stuttgart's Master's programme Smart City Solutions in 2020 compiled by Abeo Trotter, Halimeh Abu Ayyasch, Taha Al-Taie, Olga Timofeeva. Thematically the term paper-assignment was linked to REWARDHeat.

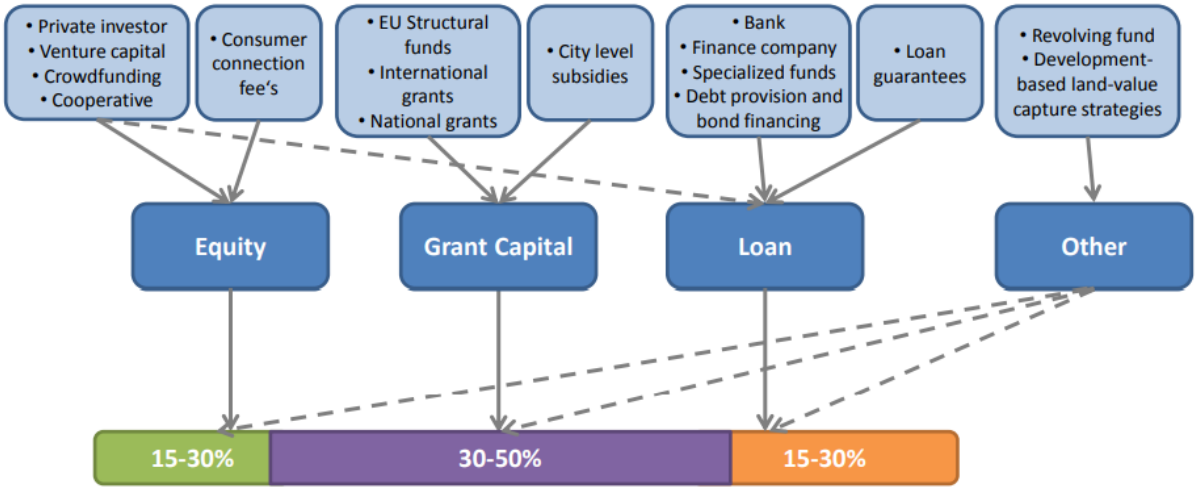

Figure 35: Financing structure of DHC-Projects (Sunko et al. 2017)

Furthermore, Energy Performance Contracting (EPC), as well as equipment finance are analysed for their suitability to finance DHC-networks (see Figure 36).

Figure 36: Regulatory trends increase attractiveness for DHCN as a sustainable asset class. Sources: own illustration. Images: UN, UN PRI, European Commission, Volkswagen AG, CECE.

5.2 Sustainable Infrastructure Finance and DHCN as an Asset Class

Sustainable infrastructure finance contains innovative approaches and it also contains analyses that encourage sustainable development as well as the creation of new eco-financial assets. (González-Ruiz, J., Botero-Botero, S., & Peña, A. 2022) By making use of renewable energy sources district heating does have the potential of bringing about large reductions in fuel consumption and due to ongoing regulation of the EU becomes more and more attractive as a new asset class. Another advantage and incentive for investors is the flexibility of district heating systems, which makes it possible to use them to provide additional services such as electric power generation. This means that investors can also make profits by utilizing the arbitrage in multiple markets. (Tan et al. 2022)

The following figure shows that the investments in renewable energies are a growth market and that this will also have an effect on the recognition of renewable energy technologies, such as DHCNs, as an attractive asset class (see Figure 37):

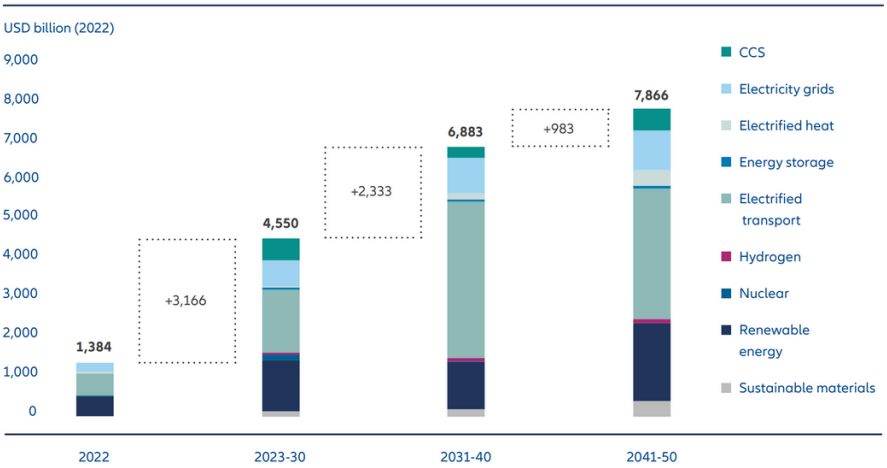

Figure 37: Comparing the 2022 energy transition and grid investment versus required annual investment in 2023-30, 2031-40 and 2041-50 in a net-zero scenario. (BloombergNEF 2024)

5.3 Political and Regulatory Framework

5.3.1 UN SDGs and Paris Agreement

The 2030 Agenda for Sustainable Development has been adopted by all United Nations Member States in 2015. It provides a shared blueprint for peace and prosperity for people and the planet - now and into the future. The core of this Agenda is the 17 Sustainable Development Goals (SDGs), which can be understood as an urgent call for action by all developed and developing countries in a global partnership.

All Member States have recognized that ending poverty and other deprivations must go hand-in-hand with strategies that lead to an improvement of health and education, to the reduction of inequality, and to a scaling-up of economic growth. All this has to happen while bringing about climate change and working to preserve our oceans and forests. (United Nation's Secretariat Department of Economic and Social Affairs)

The Paris Agreement is a legally binding international treaty on climate change. Adopted by 196 Parties at COP 21 in Paris, on 12 December 2015, it entered into force on 4 November 2016. Its primary goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels.

In order to achieve this long-term temperature goal, countries are demanded to reach global peaking of greenhouse gas emissions as soon as possible. The goal is to achieve a climate neutral world by mid-century. The Paris Agreement has to be understood as a landmark in the multilateral climate change process. For the first time, a binding agreement has united all nations into a common cause to undertake ambitious efforts to fight against climate change and adapt to its effects. (United Nations Framework Convention on Climate Change)

5.3.2 UNEP FI

The United Nations Environment Programme Finance Initiative (UNEP FI) is a partnership between UNEP and the global financial sector. Its foremost goal is to mobilize private sector finance for sustainable development. UNEP FI works together with more than 400 banks, insurers, and investors and over 100 supporting institutions. The primary goal is to help create a financial sector that serves people and the planet while delivering positive impacts. Our goal is to inspire, inform and enable financial institutions to improve the quality of people's life without endangering the basis of existence of future generations. By leveraging the UN's role, UNEP FI accelerates sustainable finance. (United Nations Environment Programme - Finance Initiative)

5.3.3 EU Action Plan on Financing Sustainable Growth[4]

The widespread implementation of DHC requires substantial near-future investments, with projections indicating costs of at least EUR 120 billion across the EU by 2030 (Euroheat & Power 2023a) Given the high levels of public debt, it is improbable that governments can single-handedly provide the requisite funding. Thus, a pivotal question arises regarding the potential role of financial markets in bridging the escalating funding gap. In principle, regulatory frameworks like the EU Action Plan on Financing Sustainable Growth provide tailwind for accessing financial markets to attract institutional and retail investors. The Action Plan's foremost objective is to reorient capital flows towards sustainability[5]. A detailed EU Taxonomy is supposed to serve as a classification system for sustainable activities[6], integrating technical screening criteria with specific CO_2 thresholds for more than 100 business activities that are considered as climate sensitive. (Stroleny M. et al. 2024)

With the adoption of the Paris Agreement on Climate Change and the UN 2030 Agenda for Sustainable Development in 2015, governments from all over the world decided to take a more sustainable path for the planet and the economy. The goal is to adapt to climate change, better protect ourselves from its impacts and reduce global warming to a much lower level, well below 2°C. Increasing resource scarcity and unpredictable consequences of climate change call for urgent action. Policies need to be adapted to the new reality. The financial system plays a key role in this. As we increasingly face the catastrophic and unpredictable consequences of climate change and resource depletion, urgent action is needed to adapt policies to this new reality. The financial system has a key role to play in this. On the one hand, improving the contribution of the financial sector to sustainable and inclusive growth by financing society's long-term needs, and on the other hand, strengthening financial stability by taking into account environmental, social and governance (ESG) factors in investment decisions (European Commission 2018b).

To counteract these problems, the EU Action Plan and EU Green Deal were developed. In the following, both the Action Plan and the Green Deal are examined and analysed in terms of their impact on the financing of DHC projects.

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[4] This paragraph contains results of a term-paper project in the Smart Sustainable Finance-module (Prof. Dr. Tobias Popovic) as part of HFT Stuttgart's Master's programme Smart City Solutions in 2020 compiled by Mireille Jean and Vipul Sarnot. Thematically the term paper-assignment was linked to REWARDHeat.

[5] C. https://finance.ec.europa.eu/publications/renewed-sustainable-finance-strategy-and-implementation-action-plan-financing-sustainable-growth_en

[6] C. https://finance.ec.europa.eu/publications/renewed-sustainable-finance-strategy-and-implementation-action-plan-financing-sustainable-growth_en

The "Action Plan on Financing Sustainable Growth" published by the European Commission in March 2018 presents a strategy for sustainable finance in the EU. In the context of sustainable economic and social development, the plan links financial issues and specific needs of the European and global economy to ensure a fair, crisis-resistant society and a healthy planet. As shown in the figure below, the three main objectives of the EU Action Plan are to redirect capital flows towards sustainable investments, to integrate sustainability into risk management, and to promote long-termism and transparency (European Commission 2018a) (see Figure 38):

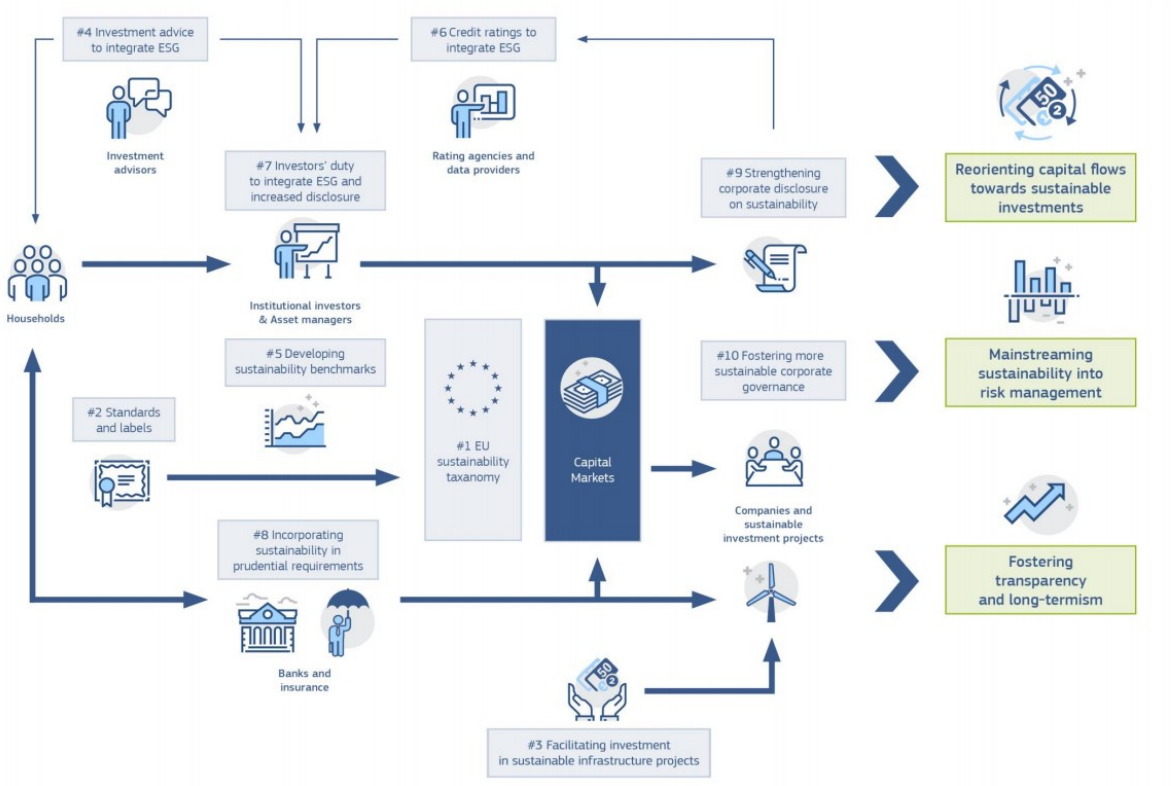

Figure 38: EU Action Plan on Financing Sustainable Growth – Overview (European Commission 2018a)

The DHC network projects, with their undeniable and easily demonstrable environmental benefits, are a fitting response to the objectives of the EU-APFSG plan. By directly targeting most of the measures identified by the EU-APFSG, the DHC network projects become attractive for public financial support and for private investors, thus increasing the opportunities for financing DHC projects. (European Commission 2020b)

5.3.4 EU-Taxonomy

The EU-Taxonomy is part of the EU action plan on financing sustainable growth codified in Regulation 2020/852 (Taxonomy Regulation). One goal of the action plan is to reorienting capital flows towards sustainable investments. To reach this goal, it is necessary to have an understanding what can be defined as "sustainable" economic activity and have criteria how to measure this. The Taxonomy is intended to define exactly which companies or activities are sustainable. Operating sustainable or environmentally friendly should lead to more investments for such companies and reward "green" behaviour. The Taxonomy has six environmental objectives:

1. Climate change mitigation

2. Climate change adaptation
3. Sustainable use and protection of water and marine resources
4. Transition to a circular economy
5. Pollution prevention and control
6. Protection and restoration of biodiversity and ecosystems

To be classified as sustainable economic activity a four-step decision making process is followed. First, an activity has to contribute to one of the six environmental objectives. Second, it has to "do no significant harm" (DNSH) to any of the other environmental objectives. Third, the activity meets minimum social safeguard like the UN Guiding Principles on Business and Human Rights. Last, the activity is following the technical screening criteria which are developed by the EU Technical Expert Group (see Figure 39):

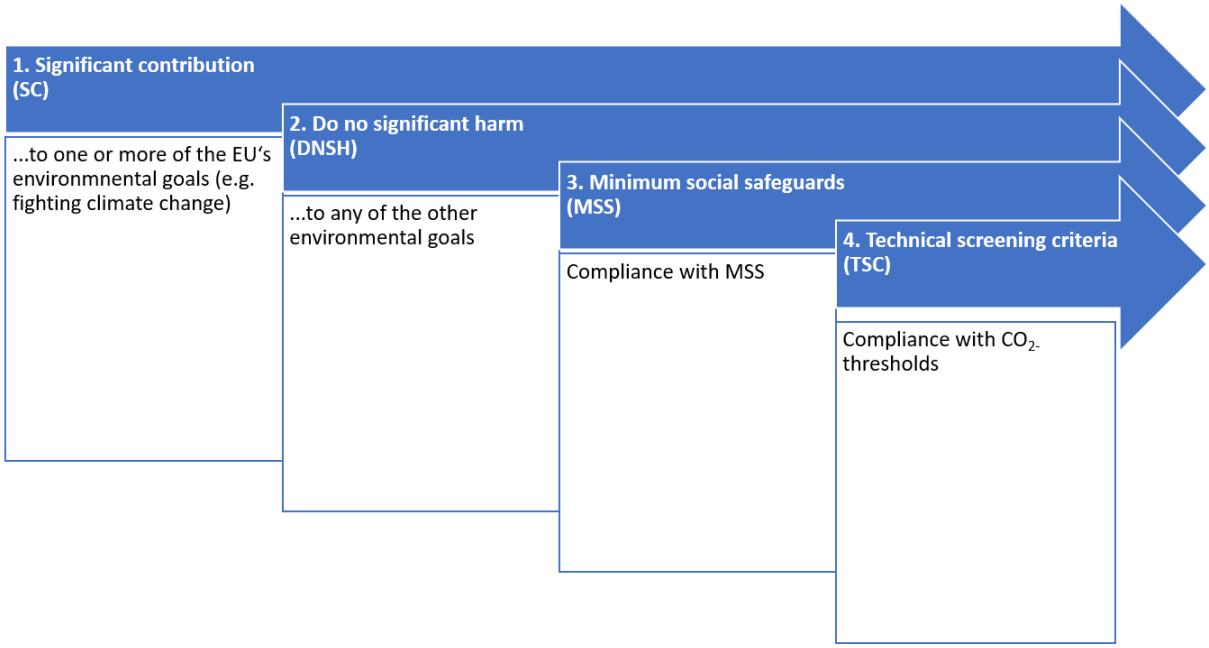

Figure 39: Decision making process for Taxonomy-aligned investments financing need (own illustration based on (European Commission 2021b))

5.3.5 Energy Efficiency Directive (EED)

The goal of the Energy Efficiency Directive (EED) is to encourage energy efficiency across the European Union (EU) and to achieve the EU's energy and climate goals it requires from district heating and cooling systems to meet efficiency criteria. This includes the use of renewables as well as waste heat. Especially the utilization of waste heat from industrial processes and other sources (e.g. data centres, supermarkets etc.) plays a major role in modern district heating and cooling systems. New buildings and buildings which have to be renovated must consider the requirements of existing or planned district heating and cooling networks. The application of renewables and the utilization of waste heat aims to improve the efficiency of district heating and cooling systems. This is part of the overall energy efficiency targets of the EU.(Stroleny M. et al. 2024)

The revised EED also contains positive changes and additions in which it recognises waste heat as a valuable source for decarbonising heating systems. For example, Article 26 tries to commit the MS to implement waste heat recovery from data centres if they have a total rated energy input

exceeding 1MW. This can only be circumvented if it turns out to be technologically or economically impossible. (Stroleny M. et al. 2024)

The Energy Efficiency Directive (EED) thus plays an important role in increasing the efficiency of district heating networks by reducing their CO_2-emissions and this contributes to the EU's broader climate goals. According to the EU's requirements low-temperature district heating networks, including the contributions of prosumers, can be defined as efficient when they help to reduce CO2-emssions between 30% and 40% by 2030 and 80% by 2050. (Ancona et al. 2021) Moreover, the utilization of low-grade waste heat from energy-intensive industries such as pulp and paper also makes it possible to decrease the output of CO_2-emissions. (Cioccolanti et al. 2021) A district heating system of the 4th generation (4GDH) reduces CO_2-emission to such a high degree that it grossly supports the transition to a zero emission system. (Ziemele et al. 2017)

5.3.6 The Renewable Energy Directive (RED II)

The key message of the Renewable Energy Directive II (RED II) is to increase the share of renewable energy sources within the European Union (EU). This can be achieved by the adoption of mature and market-ready technologies making it possible to use renewables in the heating and cooling sector. For example, Article 23 (1) defines a clear and binding baseline for the use of renewable energy sources in heating and cooling by 0,8% annually from 2021-2025 and 1,1% from 2026-2030. The recovery of waste heat and cold recovery can support these targets with a sizeable share of 0,4%. This target should be defined more ambitious because the growth rate 30% renewables is not high enough to reach the binding target of 42,5% (and the planned target of 45%) by 2030. (Stroleny M. et al. 2024)

Evolving technical innovation enables the stakeholders in different sectors to identify new ways of collaboration and this possibility should be promoted by a supportive regulatory framework. This also includes the development of new business models containing the value that is added by the flexible use of renewable and waste heat in DHC networks. Simultaneously, electric grids should be developed and standardised. A supportive approach can be seen in an energy community model, which could create a constructive environment with the goal of promoting collaboration. (Stroleny M. et al. 2024)

The Renewable Energy Directive (RED II) promotes the utilization of renewables in district heating systems and this plays an important role in the reduction of CO_2-emissions. This makes a contribution to decarbonization and helps to achieve the EU's broader climate goals.

5.3.7 EU Green Deal[7]

The European Green Deal is designed to make the EU economy sustainable. The EU Green Deal establishes a plan to ensure the efficient use of resources through the transition to a clean, circular economy and to ensure the reduction of pollution. (European Commission 2019a). Achieving the goal of being climate neutral in 2050 requires action in all sectors of our economy. There is also a particular focus on decarbonising the energy sector, investing in green technologies and ensuring energy-efficient buildings. The following chart illustrates the different elements of the EU deal.

[7] This paragraph contains results of a term-paper project in the Smart Sustainable Finance-module (Prof. Dr. Tobias Popovic) as part of HFT Stuttgart's Master's programme Smart City Solutions in 2020 compiled by Abeo Trotter, Halimeh Abu Ayyasch, Taha Al-Taie, Olga Timofeeva. Thematically the term paper-assignment was linked to REWARDHeat.

The idea of a Green New Deal has been an issue for more than a decade, since a group of green economist and policy-makers launched it in London based on Colin Hine's work with the New Economics Foundation. From an economic perspective it proposed a triple win:

- investment in the green transition,
- jobs for the workless,
- and stimulus for the economy. (Scott Cato 2022)

The European Commission understands the European Green Deal as Europe's lifeline out of the COVID-19 pandemic. One third of the €1.8 trillion investments from the NextGenerationEU Recovery Plan, and the EU's seven-year budget will finance the European Green Deal. Moreover, the European Commission has adopted a set of proposals to make the EU's climate, energy, transport and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. (European Commission) The European Green Deal set the blueprint for this transformational change. All 27 EU Member States committed to turning the EU into the first climate neutral continent by 2050. To get there, they pledged to reduce emissions by at least 55% by 2030, compared to 1990 levels. (European Commission) This will create the new opportunities described below (see Figure 40):

Figure 40: Elements of the EU-Green Deal (European Commission 2019a)

The European Deal is connected to the following goals (see Figure 41):

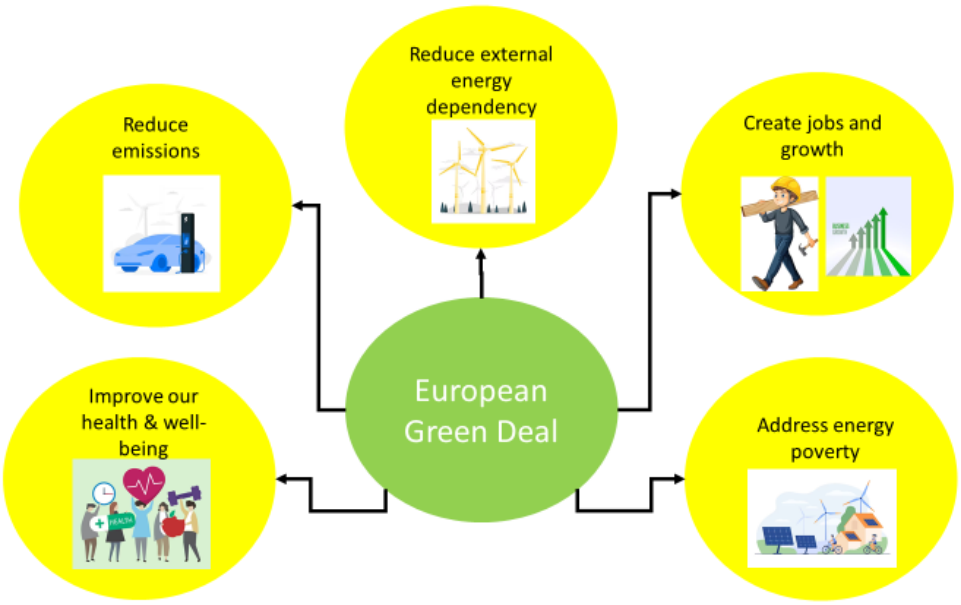

Figure 41: Goals related to the European Green Deal (Own representation based on (European Commission)) (www.freepik.com)

NextGenerationEU

The goal of NextGenerationEU is to work as a temporary recovery instrument. More than €800 billion have been spend to support Europe's recovery from the pandemic and this shall be used in order to make Europe a greener, more digital and more resilient continent. The EU will raise the capital from the capital between mid-2021 and end-2026.

Around 30% of the funds are being raised via NextGenerationEU green bonds – as part of the NextGenerationEU green bond framework. In parallel to NextGenerationEU, the Commission runs several back-to-back funding programmes to finance specific needs of the EU's Member States and third countries." (European Commission 2022a)

Carbon Pricing

Carbon pricing is a market-based instrument that deals with the external costs of greenhouse gas (GHG) emissions. These are the costs of emissions the public has to pay. Among these costs are damage to crops, health care costs from heat waves and droughts, and loss of property from flooding and sea level rise. These catastrophes are connected to a price and this price is usually connected to the carbon dioxide (CO_2) emitted. To set a price on carbon shall make it possible to transfer the burden for the damage from GHG emissions back to those who have caused it and who are also in the position to avoid these consequences. Setting a carbon price is no accusation, rather it provides an economic signal to those emitting CO_2. The CO_2-emitters are two action options: they can either decide to change their processes and lower their emissions, or they can decide to pay a compensation for their emissions. In this way, the overall environmental goal is achieved in a flexible and financial way. Finding an adequate price on GHG emissions is fundamentally relevant to internalize the external cost of climate change. This is done by influencing economic decision making and by simultaneously setting economic incentives for clean

development. It may also help mobilizing financial investments that can be used to promote clean technology and market innovation. The goal is to arrive at low-carbon drivers of economic growth. (World Bank Group)

One lever to reach this goal is the Emission Trading System (ETS). The ETS reform and extension of scope to cover all GHG emissions from fossil fuels, used in residential and commercial buildings, is important. Setting a CO_2 price on all fossil fuels is an essential aspect of the decarbonisation of the energy system. At present, the majority of generated district heat is covered by the existing ETS, whereas individual fossil fuel solutions are not. The ETS2 price cap of 45 EUR/ton of CO_2 emitted is much lower than the CO_2 price applied to DHC solutions under ETS1, which may lead to unfair competition in the heating and cooling sector. This situation calls for a uniform CO_2 price across the heating and cooling sector to ensure a level playing field and drive decarbonisation. In the DHC sector, such a uniform price would ensure greater efficiency and integration of renewables, making it more competitive, decarbonised, and prevalent. Using CO_2 credits not only to foster investments but also to reduce taxes and levies on renewable heat would be highly beneficial, as it would directly narrow price gaps. (Stroleny M. et al. 2024)

To tackle all installations below 20 MW that are not subject to the EU ETS, the chosen mechanism should be as easy to implement as possible, with a clear scope to limit the administrative burden. Until a level playing field is established, the DHC sector would continue to need free allocations. (Stroleny M. et al. 2024)

A well-functioning and well-designed combination of an ETS2 and the use of its revenues in the Social Climate Fund (SCF) would contribute to achieving the decarbonisation target for buildings without risking increased rates of fuel poverty or other negative social impacts. CO_2 pricing and the SCF are essential building blocks of the policy framework of the European Green Deal. Without an adequate and targeted CO_2 pricing system covering fuels used for heating and cooling, the EU will not be able to achieve its own emissions reduction targets, nor the targets for renewable heating and cooling. (Stroleny M. et al. 2024)

The policy alternatives can be considered complementary, but cannot replace a CO_2 price, as they do not create their own revenue streams. If executed correctly, the proposed ETS2 will accelerate the green transition and reduce the risk of energy poverty, as our current dependency on fossil energy will be greatly reduced. (Stroleny M. et al. 2024)

National Legislation Hindering or Supporting the Possibility to Bundle DHCN

In September 2022 the German federal Government launched the „Bundesförderung für effiziente Wärmenetze (BEW)"(engl. federal support for efficient heating networks). Until 2026 subsidies of around 3 billion Euros are available in order to support the construction of new heating grids with at least 75 % renewable energies and waste heat and also the decarbonisation of existing grids by modernisation. Funding has already been made available for feasibility studies for new networks and also for plans helping to transform the conversion of existing grids to renewable energies and waste heat. Investments in generation plants and possible operating costs as result of implementation can be promoted up to maximum 40% on the investment costs. The intention of the support programme is to promote an average of up to 681 megawatts of renewable heat generation capacity per year by 2030. Another goal is the stimulation of investments of an average of around 1174 million euros per year. Applications for funding are possible on the website of the Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA (engl. Federal Office of Economics and Export Control). (Federal Ministry for Economic Affairs and Climate Action 9/15/2022) A problem

that is slowing down progress can be seen in the fact that the demand for the subsidy is so strong that in the first few months the authority cannot keep up with the processing of applications. As a result, already planned heating networks could be delayed because construction cannot begin until funding is approved. (Janzing 2023)

Further Regulatory and Political Aspects

The heating and cooling sector is responsible for about 50% of the total European final energy consumption (Heat Road Map Europe 2017). The decarbonisation of heating and cooling is important for achieving net-zero greenhouse gas emissions by 2050. It is a matter of fact that district heating (DH) networks will play a significant role in the decarbonisation process of the heating sector. One decisive goal is to enable the integration of renewable and waste heat on a larger and more centralized scale. For this reason, the European Commission promotes the transformation of DH and commits the Member States of the European Union to increase their share of renewable and waste heat in DH-systems or to enable third party renewable or waste heat generators to access DH. In contrast to the gas and electricity markets, no European market standardisation and liberalisation has been carried out for DH. (Billerbeck and et al. 2023).

5.3.8 Political regulatory Instruments for the transformation of district heating

An expert opinion from "Hamburg Institut" commissioned by AGFW[8] states that the heat transition can only be successful if significant changes are implemented:

(1) There must be a significant growth in heating networks over the next few years which are capable of exceeding by far the expansion rates of recent years.
(2) Existing heating systems must be fundamentally restructured in order to make possible the rapid decarbonization of district heating. (Thamling et al. 2020)

A change of direction can be achieved with the following regulatory means:

1. Sharpening the price signals

- An essential element in the process of decarbonizing the heat supply through renewable heat networks are greenhouse gas-related price signals in the heating market. The goal of the Fuel Emissions Trading Act (BEHG), which will come into force next year, is to compensate the structural disadvantage of district heating compared to decentralized heat generation. The reason for this lies in the fact that fossil heat generators with a rated thermal input of over 20 MW fall under the TEHG, unlike decentralized heating systems. As soon as the CO_2 price in national emissions trading on the basis of the BEHG is higher than the CO_2 price in the TEHG, this structural disadvantage of district heating will be eliminated. (Thamling et al. 2020)

2. Heat planning as a key strategic instrument - two important points have emerged in this process:

[8] AGFW stands for Energieeffizienzverband für Wärme, Kälte und KWK e. V. (https://www.hamburg-institut.com/wp-content/uploads/2021/06/AGFW_Perspektive_der_Fernwaerme_2030_final.pdf)

- Local authorities and planners must not be left alone with the implementation of heat planning. For example, these guidelines apply to the question of the extent to which biomass and synthetic fuels should be used in the heating market in the future.
  Without corresponding specifications of the federal government, it is to be expected that local authorities will stick to these supposedly simple solutions. What is needed is a strategic heat planning at the federal, state (or regional) and local authority levels and the municipalities as well as uniform, binding specifications. (Thamling et al. 2020)

- Heat planning should be designed as an implementation-oriented instrument.
  Until now most municipalities and federal states understood heat planning primarily as an informational instrument whose major task is the gathering of different data and which also provides conceptual options for analyzing conceptual options. The lack of legal requirements gave heat planning the form of an optional – not externally binding – concept. In order to achieve a dynamic development for heating networks, heat planning must be lifted on a binding, implementation-oriented and planning conceptual level. (Thamling et al. 2020)

5.3.9 Fields of action for a climate-neutral heat supply

Germany aims at becoming climate-neutral by 2045. In order to reach this ambitious goal, the transformation of the heat supply system must be significantly accelerated. This also applies to the heating market and the associated infrastructure, which both must be converted faster towards climate neutrality. It is thus necessary to support the heating transition with additional measures.

It is absolutely necessary to design the economic and regulatory framework in such a way that the best solution, i.e. the most efficient, reliable and cost-effective climate-neutral technologies prevail on the market. Dead ends (lock-ins) have to avoided and innovations have to be triggered. (Bundesministerium für Wirtschaft und Energie 2021)

Defining the preconditions for a successful heat transition

A successful heat transition could have the following preconditions:

- There is neither a single technology nor is there an individual single energy source that is capable of covering the heat demand in Germany alone. The goal – a climate-neutral heat supply in Germany – can only be reached with a mix of different renewable energy carriers, waste heat and different conversion technologies. Different heating infrastructures can be considered depending on the application area and temperature level.
- The significant reduction in the amount of energy in the heat production is the basis for meeting the remaining energy demand with imported renewable energies – in different forms – and also waste heat.
- The proportion of electricity-based heat generation such as heat pumps will lead to a considerable increase. For the process industry this means that electricity-based fuels such as green hydrogen are needed.
- The heating networks have to be expanded and decarbonized.
- Biomass will play a more prominent role in the generation of industrial process heat.

- The regulatory framework must be changed fundamentally in order to enable new business models. This includes in particular the reduction of the high burdens on renewable electricity and the removal of obstacles to the establishment of customer-based business models.
- It is an obvious fact that there is no "all electric" approach for the entire heating sector (buildings and process heat). There was a broad consensus that green gases are also necessary for the success of the heat transition. However, there was much controversy regarding the amount of time in which CO_2-free hydrogen will be available to support climate neutrality in the heating sector – especially in buildings. (Bundesministerium für Wirtschaft und Energie 2021)

Defining fields of action

The fields of action outlined in Figure 41 below have been identified during the dialogue in order to achieve a climate-neutral heat supply by 2045: (Bundesministerium für Wirtschaft und Energie 2021) (see Figure 42)

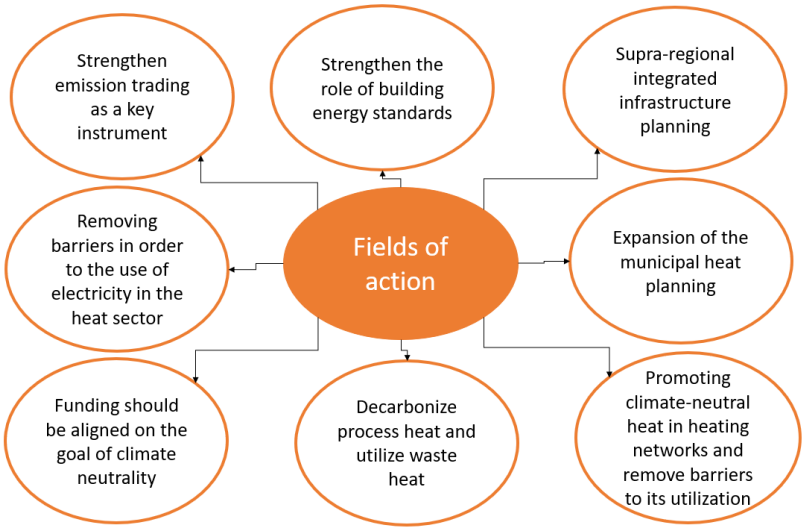

Figure 42: Fields of Action (Own representation based on (Bundesministerium für Wirtschaft und Energie 2021))

Interim conclusion

It is a matter of fact that most of the technological solutions for achieving climate neutrality are capital-intensive and coupled with political and economic uncertainties. This does not only apply to renewable energies, but also to electrification of transport and heating, district heating expansion and the hydrogen economy in equal measure, even with varying degrees of intensity.

An important lever are the capital costs which are a decisive cost factor in the energy transition. The EU is trying to counteract this by steering capital flows in the direction of sustainable business. However, this plan has not yet led to a significant reduction in the cost of capital for sustainable investments. The reasons for that can be found in a changed interest rate environment and the risks associated with financing, e.g. from the deterioration in financial ratios in view of increasing investments. Another point are the considerable process and bureaucratic costs incurred by banks which are a direct result of EU regulations. (Deloitte 2023)

To address these problems, the following should be examined: (Deloitte 2023)

- What possibilities are there for stimulating bank financing on a political level. One possibility could be to lower the capital adequacy requirements for investments in the energy transition or an expansion of state risk protection
- Another possibility for risk sharing or refinancing of energy transition loans are corresponding capital market instruments such as the accumulation of individual loans and subsequent on-lending via capital market instruments such as securitizations, promissory securitizations and promissory bill loans.
- Making use of various financing options creates new opportunities for energy companies. While the capital market is relevant for all companies, the capital market is currently relevant only for the larger companies.
- Where public funds are also used for the energy transition, there are various additional opportunities for mixed financing forms – such as public and private funding sources (= blended finance instruments). These points are discussed in the following sections:

A major problem can be seen in the fact that there are lots of EU Directives leading to the following problems. The following problems of the EU-Taxonomy became evident at the investor workshop in Brussels: (See: 4th Investor Workshop in Brussels):

Complexity: The EU-Taxonomy defines complex criteria for making sure that economic activities fulfil the requirements of economic sustainability.

Dynamic nature: The EU-Taxonomy is based on an open concept and this means that its criteria can be updated if necessary. This leads to uncertainty for investors and companies with regard to long-term planning.

Inconsistency: Different levels of readiness and also different interpretations of the EU-Taxonomy's various regulations are contributing to uncertainty and are also promoting non-transparency.

The complexity of the EU-Taxonomy is illustrated in Figure 43, which outlines the EU Directives and Initiatives relating to DHCN:

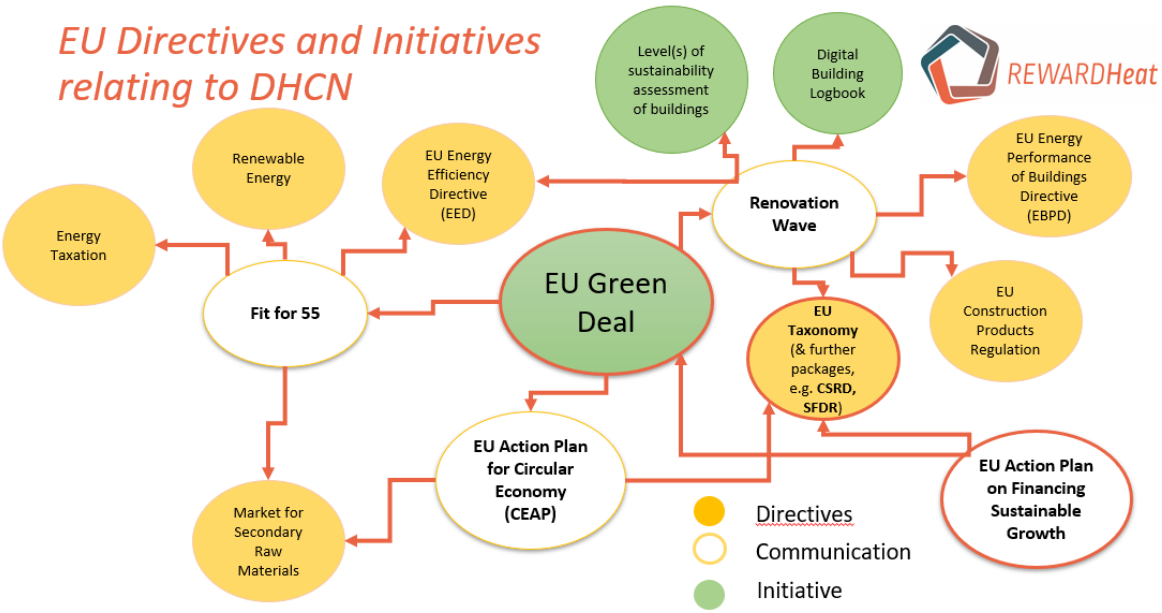

Figure 43: EU Directives and Initiatives relating to DHCN (Own representation based on (Archer-Svoboda and Kimmerle 2023))

5.4 Typology of Investors[9]

5.4.1 Financial Markets Oriented Funding

There are a number of financial institutions that have implemented special instruments for the financing of DHC projects and ensure the flow of funds from the surplus unit to the deficit unit. Project promoters need to use the services of institutions to access capital for their projects and thus constitute the deficit unit. A distinction is made between deposit-keeping and non-deposit-keeping institutions. Deposit-taking institutions are efficient intermediaries as they have more information on sources of capital, can assess their creditworthiness and repackage the deposited funds in the desired sizes and maturities. Commercial banks, savings banks and credit unions belong to the deposit-taking institutions. However, to supply the funds needed, they require non-depository institutions as buyers of their securities. These institutions include financial companies, pension funds and insurance companies. In the following, named financial institutions are examined for their suitability to provide DHC networks with financial resources.

Money market funds and investment firms will not provide financing for DHC networks as they either buy short-term securities or serve as a financial intermediary (e.g. a brokerage firm). Financing a DHC project is not part of their business model (see Figure 44):

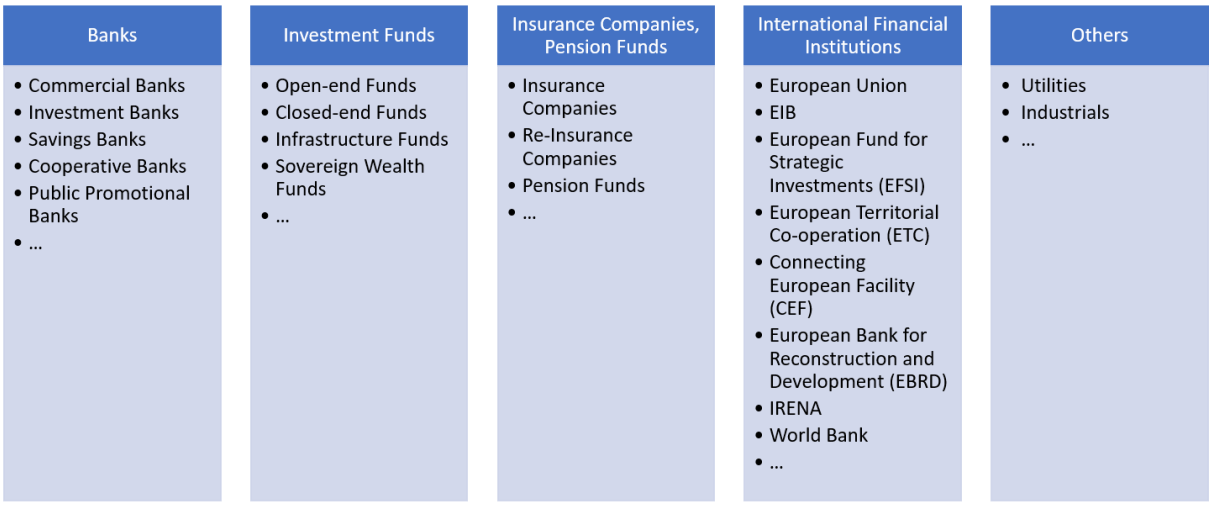

Figure 44: (Institutional) investor groups, identify their needs and objectives (Popovic 2021)

[9] This paragraph contains results of a term-paper project in the Smart Sustainable Finance-module (Prof. Dr. Tobias Popovic) as part of HFT Stuttgart's Master's programme Smart City Solutions in 2020 compiled by Mireille Jean and Vipul Sarnot, Achim von Neefe, Asmita Rawool. Thematically the term paper-assignment was linked to REWARDHeat.

Commercial Banks[10]

Commercial banks generate their funds mainly from households. These funds are used to purchase government and corporate securities and to lend to households and businesses. Thus, there is a possibility that the project may receive a loan from this financial institution. Commercial financing provided by banks such as HSBC, LBBW is much more flexible than that provided by multi- and bi-lateral organisations. However, according to (Reeep.org 2019), it becomes difficult for project developers to secure financing as market conditions influence the repayment period and interest rates applied. Ethical banks such as Triodos Bank and Co-operatives place a higher value on projects that are sustainable and democratically run.

Investment Banks

A key difference between investment banks and commercial banks is that investment banks act as intermediaries in large and complex financial transactions. They are banks that deal with the needs and interests of companies, governments or financial institutions. This includes, for example, IPOs, mergers and acquisitions or the financing of infrastructure projects (Friedrich 2018). Accordingly, they play a highly specialised role in the banking and financial system and manage business clients and their access to capital markets and provide various advisory and support services.

Savings Banks[11]

Savings institutions offer their customers a variety of savings accounts to make deposits, mainly from the general public. This type of financial institution specialises in investing in shares, stocks and government bonds. The financial instruments offered by these institutions are not suitable for the DHCN.

Cooperative Banks

Cooperative banks are credit institutions that are run in the legal form of a registered cooperative. Their main objective is the economic promotion of their members. Customers can buy shares in the cooperative and thereby become members. For their membership they are provided with the co-determination rights and a direct share in the profits generated. Accordingly, a cooperative bank has to align its business policy towards the interests of its members. Cooperative banks account for up to 61% of the industry market share in various European countries (Italy 61%, Germany 51%, Spain 31%, Austria 29%). They are also responsible for high percentages of loans to small and medium-sized enterprises. This makes them important players in local economic development. In terms of asset size, however, they are generally smaller than the average commercial bank (Clark et al. 2018).

[10] This paragraph contains results of a term-paper project in the Smart Sustainable Finance-module (Prof. Dr. Tobias Popovic) as part of HFT Stuttgart's Master's programme Smart City Solutions in 2020 compiled by Abeo Trotter, Halimeh AbuAyyash, Mireille Jean and Vipul Sarnot. Thematically the term paper-assignment was linked to REWARDHeat.

[11] This paragraph contains results of a term-paper project in the Smart Sustainable Finance-module (Prof. Dr. Tobias Popovic) as part of HFT Stuttgart's Master's programme Smart City Solutions in 2020 compiled by Mireille Jean and Vipul Sarnot. Thematically the term paper-assignment was linked to REWARDHeat.

Investment or mutual funds get their financial resources from the sale of shares to households, companies and government agencies. They use the money in the funds in order to buy long-term government and corporate securities. There is also the possibility that long-term bonds are issued, which are bought by the mutual fund. Mutual funds pursuing a sustainable investment objective may be particularly interested. This provides access to stable capital, but does not affect the liquidity of the project, which increases the project's chances of success. Mutual funds that pursue a sustainable investment objective may be particularly interested. Thus, mutual funds are a suitable source of financing.

Closed-End Funds

Closed-end funds are public funds that are generally open to everyone and in which private investors can also invest. The shares are usually corporate investments. Money is collected for a defined project and a fund volume is set. Once this volume has been reached, no further purchases are possible and the fund is closed. Such funds make sense for investors who want to invest for the long term, as investors have no right to redemption of the share by the issuer during the term. Fund units can be sold to other investors or third parties via the secondary market, but this is usually associated with high discounts due to low trading volumes (FAZ n. d.; BaFin 2021).

5.4.2 Listed and Unlisted Infrastructure Equity Funds

Listed private equity firms tend to lower their abnormal accruals, do have a faster loss recognition and higher post-IPO stock returns compared to unlisted private equity firms. (Goktan and Muslu 2015) In contrast, unlisted infrastructure in Australia has shown a better risk performance and portfolio diversification benefits during the global financial crisis. (Newell, G., Peng, H., & Francesco, A. 2011) The combination of listed and unlisted infrastructure can have advantages for investors because it offers better returns and diversification, while reducing risks and improving portfolio diversification. (Moss 2015) (see Figure 45)

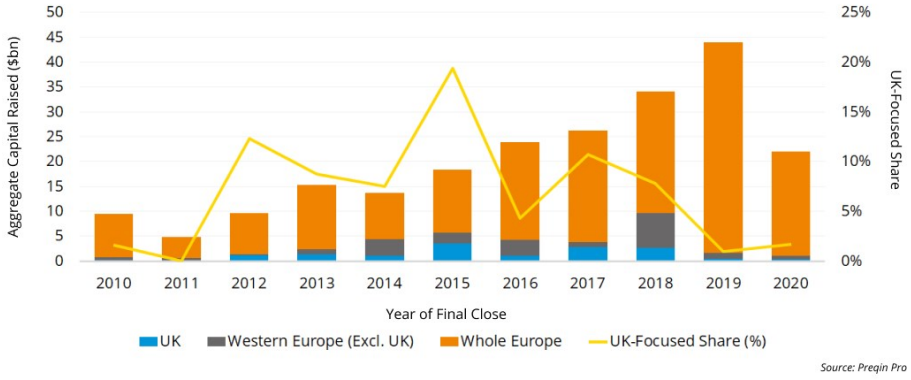

Figure 45: Aggregate Capital Raised by UK- vs. Europe Focused Unlisted Infrastructure Funds (2010-2020) (Murray 2021) (Data Source: Preqin)

The following Figure 46 gives an overview of how (Asian) Fund Manager predicting the primary drivers of private capital investments in infrastructure over the next ten years. The Figure shows that the "Transitioning to Decarbonized Energy Generation" is assumed to be the strongest field:

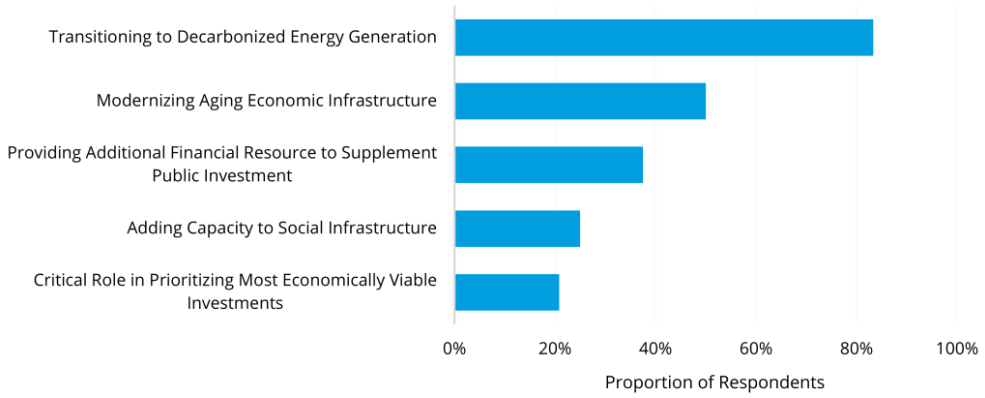

Figure 46: Views of (Asian) Fund Managers on the Primary Drivers of Private Capital Investments in Infrastructure over the Next 10 Years (Lee 2021) (Data Source: Preqin)

Real Estate Investment Trusts (REITs)

A REIT is a publicly listed company that operates in the real estate industry. The predominant business purposes of REITs can be the acquisition and disposal, rental or leasing or pure financing of real estate. REITs have become an attractive investment opportunity for investors as they can hold shares in real estate through the purchase of shares and benefit from the corresponding advantages and opportunities of investing in direct real estate without having to overcome the high entry costs into this market. Another advantage are special tax benefits, depending on the tax legislation of the respective home country of the REIT corporation. In return, the companies have to fulfil some governmental requirements, such as the parts of the income that have to be distributed to the shareholders (Lesame et al. 2021; Waldron 2018).

Infrastructure Investment Trusts (IITs)

IITs are investment opportunities similar to mutual funds or REITs. However, with IITs, the money raised is invested in real infrastructure assets such as roads, pipelines or power plants. The principle is similar to REITs in that IITs allow investors to invest in revenue-generating infrastructure assets without actually owning them or entering the market themselves. These assets have long-term contracts so that steady and predictable cash flows are generated which are then distributed to the unitholders. To mitigate the risks of under-construction infrastructure, at least 80% of the investments must be invested in completed and revenue-generating projects (Shah 2021). IITs also enjoy favourable tax treatment such as exemption from dividend distribution tax and relaxation of capital gains (Sinha 2017; Pawha et al. 2014).

Master Limited Partnerships (MLPs)

An MLP is a limited partnership or a limited liability company, where some or all of the limited partners' interests, or the limited liability company, are publicly traded. These shares are analogous to ordinary shares in a company. A key feature of an MLP is its classification as a partnership for federal income tax purposes, which allows its income to be treated for tax purposes by pass-through. This provides the unit holders with a tax-sheltered income. As long as at least 90% of the income represents "qualifying income", this treatment is available to any MLP. This "qualifying income" includes, among other things, income from the exploration, development, mining or extraction, processing, refining or transportation of minerals or natural resources. This includes

crude oil, natural gas liquids, natural gas, as well as rents and income related to related real property. Because of the tax advantages for companies that operate energy businesses, many MLPs mostly own pipelines or other infrastructure assets such as propane distribution networks or exploration or transportation facilities (Goodgame 2012). Accordingly, the tax advantages of a private partnership are combined with the liquidity of a publicity traded company.

European Long-Term Investment Fund (ELTIF)

The European Long-Term Investment Fund (ELTIF), harbours a new type of collective investment framework. The goal is to make financial markets more transparent, more stable and also more interconnected. (SCOPE 2022)This makes it possible for investors to invest money in companies and projects needing long-term capital. Its target group are investment fund managers wanting to offer long-term investment opportunities to institutional and private investors across Europe funding infrastructure projects. The range of this investment funds, e.g. in infrastructure projects, makes it necessary to define rules in order to safeguard all the parties – the investors and the companies – as well as the projects. (EU Commission 2015)

The goal of ELTIFS is to make available more non-bank finance for companies willing to invest in the real economy of the European Union. Since there is no consistency among the funding vehicles in the member states of the European Union there has to be action on the European level. Very often it is not clear that such funds are really focused on investments with a long-time horizon such as infrastructure projects. The disadvantage of existing funds is that they are limited to the respective member country and such a fragmentation means a limitation to the growth of funds. (EU Commission 2015)

Meanwhile, there are different asset classes for ELTIFS like: (FondsDISCOUNT.de 2023)

- Private equity,
- Private credit (debt financing),
- Infrastructure,
- Multi Asset

The following Table 6 shows the different kinds of ELTIFS on the Market:

Table 6: Different Kinds of ELTIFS on the Market (FondsDISCOUNT.de 2023)

Different Kinds of ELTIFS on the Market	
BlackRock Private Equity ELTIF	The BlackRock Private Equity ELTIF (ISIN: LU2575673624) is the first ELTIF of the US invest company. With its minimum deposit of €30,000 it is also addressing private investors. As part of the Umbrella-Fonds BlackRock Alternative FUNDS II ELTIF SICAV will build up a portfolio with 25 to 30 co-investments within the next two years. The holding period is eight years and obligatory. ⇨ For risk averse-investors this ELTIF is rather unsuitable.
Schroders Capital Private Equity ELTIF 2023	This ELTIF (ISIN: LU2523383904), which has been put on stock in 2023, makes it possible for private investors to make

	broadly diversified investments in unlisted companies and projects from an investment sum of €10,000. This ELTIF is focused on family-owned companies or companies run by founders. The holding period is eight years and obligatory. ⇨ The fund falls under the product category according to Article 8 SFDR and invests 15 percent in SFDR sustainable investments.
Aquila Capital ELTIF	The sustainability-focused asset manager Aquila Capital plans to put its first ELTIF on stock in the third quarter of this year. As an impact fund, the ELTIF is intended to take up all aspects of the planned energy transition. Is range extend from the generation of renewable energies to storage and efficiency enhancement, as well as the development of a corresponding infrastructure. The target return of the infrastructure fund is six to eight percent p. a.
Union Investment	The first draft ELTIF was stopped last year because of a lacking investor interest. Union Investment, the fund provider of the cooperative banks, plans to launch its first ELTIF in the fourth quarter of this year. More information on the infrastructure fund can be announced after the revised ELTIF regulation has been published.

The following figure show that ELTIFs can hold new opportunities for private customers (see Figure 47):

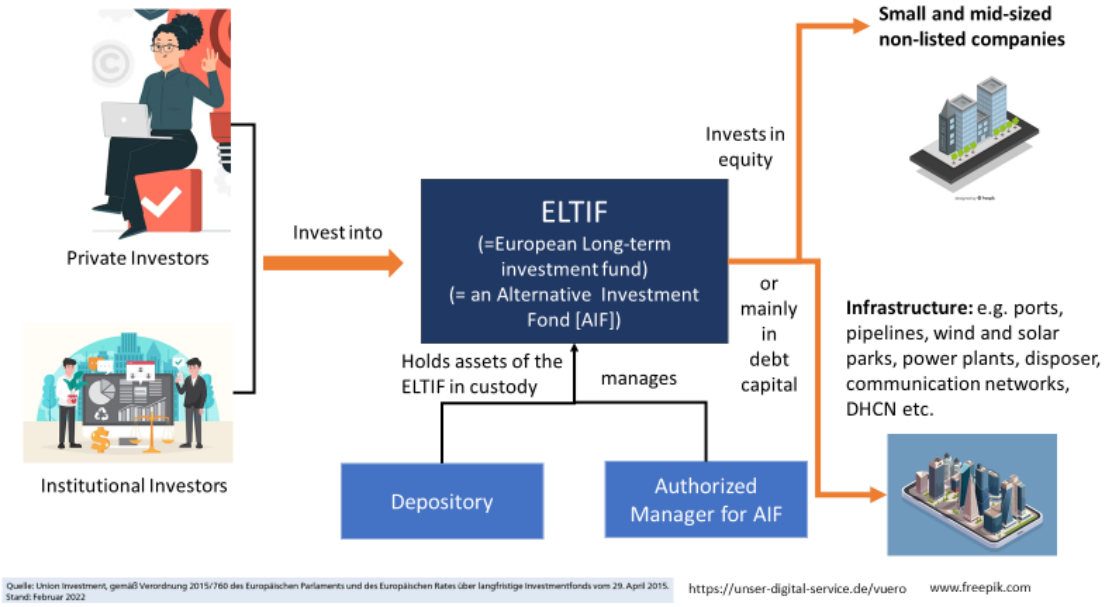

Figure 47: ElTIFS – new opportunities for private customers (Own representation based on Union Investment 2022) (Union Investment 2022)

The following Table 7 shows a summary of the chances and risks connected to ELTIFS for investors:

Table 7: Some opportunities and risks of ELTIFs for investors (Union Investment 2022)

Chances	Risks
• Chance to achieve earnings and value increases from Private Market Investments • Broad risk diversification across numerous countries, branches and asset classes as well as within the asset classes • Independence from short-term capital market movements • Insolvency protection of fund assets through special assets	• Investor capital is subject to fluctuations in value and return and no guarantee of return or preservation of value is given • Long-term investment without regular redemption option during the term • Valuation risk due to lack of stock market prices of the target investments • Credit risks such as creditworthiness risk • Construction and development risks in infrastructure projects • Increase in insolvency risk due to leverage of target companies • Possible difficulties in the acquisition of selected target investments

The following figure shows that despite of its risks the number of ELTIFs have increased between 2015 and 2021 (see Figure 48):

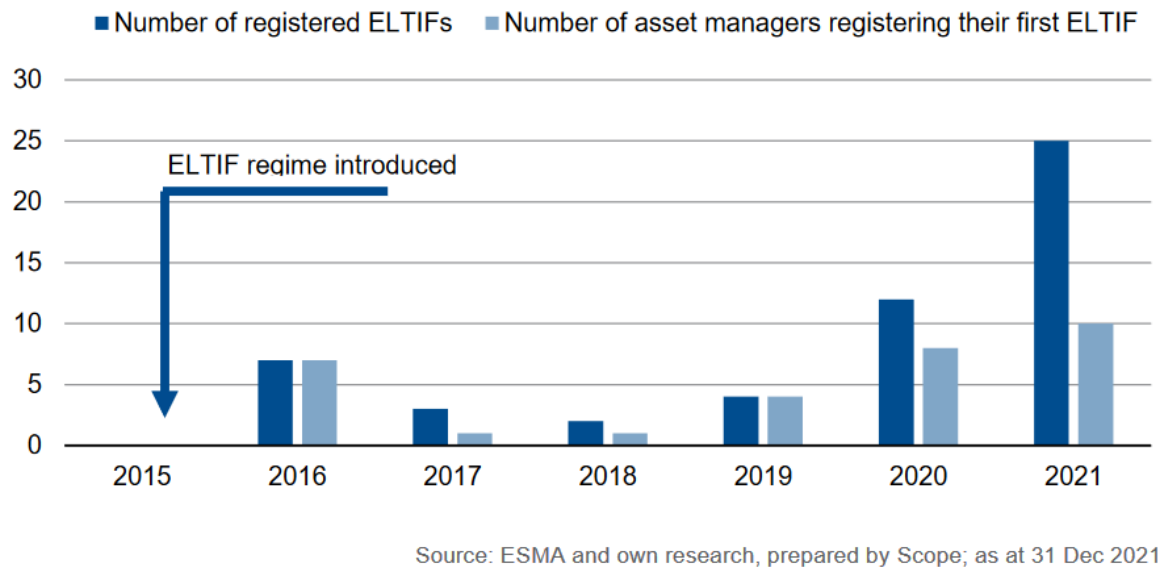

Figure 48: Development of ELTIFS between 2015 and 2021 (SCOPE 2022)

The following Figure 49 demonstrates what ELTIFs could look like.

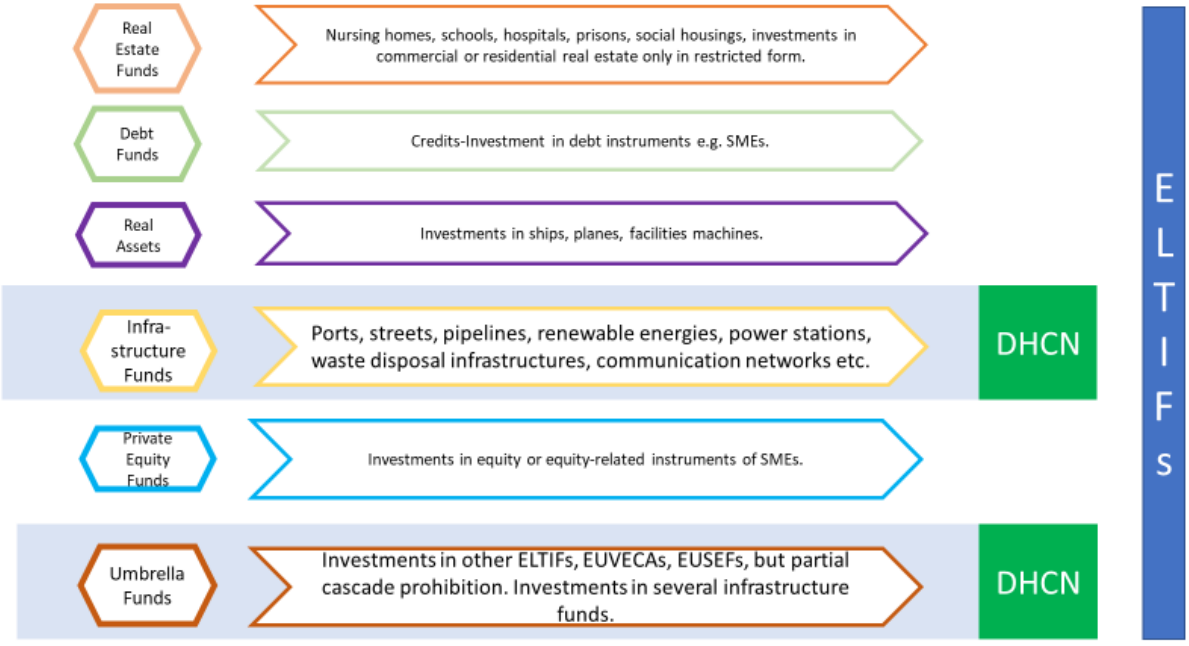

Figure 49: What could ELTIFs look like? (Own representation based on (alfi 2015))

The following Table 8 shows the difference between cooperative shares and ELTIFS:

Table 8: The Difference between cooperative shares and ELTIFs

Cooperative Shares	Definition	ELTIFs	Definition
What are cooperative shares?	Cooperative shares are business shares. Cooperatives give people the possibility to join together for the purpose of doing beneficial business for all members. E.g. the purpose of housing cooperatives is to provide their members with affordable housing. (Holthoff 2023)	What are ELTIFs?	ELTIFS (= European Long-Term Investment Fund) are a new type of investment class making it possible for investors to invest into companies / projects needing long-term capital. Its target group are investment fund managers as well as private investors across the EU. (EU Commission 2015)
What do cooperative shares cost?	The Federal Association of German Housing and Real Estate Companies (Gdw) offers shares that are in existence for some time between €500 and €3,000. New cooperatives demand higher costs for they have not enough capital at the beginning. This means according to Gdw that five-digit sums are a normal price.(Holthoff 2023)	How do I buy ELTIFs?	See providers in Table 4 Because of the still high advisory requirements, most ELTIFs are not yet available digitally for private investors. Only for Germany's largest ELTIF klimaVest exists the possibility to buy it online.(FondsDISCOUNT.de 2023)
How are shares distributed in a cooperative?	It is possible that people within the same legal property own different shares of this legal property depending on its quality (size, floor etc.). A bigger portion of shares means more maintenance fees, but to give up shares to reduce those fees means losing voting power.(Guzov 2023)	How are ELTIFs managed and what are their target groups?	ELTIFS must be managed by authorised Alternative Investment Fund Managers (AIFMs) and they have to meet minimum suitable asset and diversification requirements.(alfi 2015) Among the investors of ELTIFS are the following groups: Institutional (including small and medium-sized enterprises) investors for a long-term fund regime;

			high-net worth and retail investors looking for investments into e.g. long-term typically illiquid assets and the protection of a dedicated regime; (alfi 2015)
How to buy cooperative shares?	The members of a cooperative have to subscribe the cooperative shares. This is an obligatory presupposition for becoming a member. Each cooperative can determine the amounts of shares. Very often this depends on the size of the apartment.(Wohnungsbaugenonssenschaft Deutschland e.V.)	How to buy ELTIFS?	ELTIFS can be bought by authorised Managers. Vice versa: the ELTIF legitimates managers of private equity, infrastructure and real estate funds to offer a well-regulated European product that serves the demands of investors and also benefits the European economy.(alfi 2015)
Distribution	Nation-wide		Cross-border funds: The ELTIF makes it easier to develop European cross-border long-term funds which: invest in various countries; are distributed to investors on a cross-border basis eligibility with regard to retail investors(alfi 2015)

Pension Funds

Pension funds are occupational pension schemes in which employees participate in the opportunities and risks of the stock market. Pension funds are legally independent pension institutions and, in contrast to insurance companies, can take a greater risk in investing assets and invest the savings capital in listed investments such as shares or equity funds. As a rule, savings in a pension fund are made through so-called (gross) deferred compensation, whereby the employee uses a portion of his or her monthly gross salary for old-age provision. Normally, the employee is guaranteed the amount paid in and only the employer bears the risk of loss. Pension funds are important cornerstones for the income of European households in retirement. Pension funds also play a role in the financial markets as institutional investors (European Central Bank n. d.). According to pension-related assets tend to be among the most important household assets (accounting for around 20% of euro area household net financial assets), especially in countries where occupational pension provision is widespread. Pension fund assets in the euro area have almost doubled in size since 2008, reaching almost €3 trillion in 2019. The most common asset

types held by pension funds in the euro area are investment fund shares, followed by debt securities. (European Central Bank n. d.)

Insurance Companies

The task of an insurance company is to ensure its customers against certain risks, such as the risk of having a car accident or the risk of having a house burned down. In return for this insurance, their customers pay them regular insurance premiums. These premiums are managed by making suitable investments and this means that they also functioning as financial intermediaries between customers and the channels that receive their money. For instance, insurance companies may invest the money in commercial real estate and bonds.

It is important to note that the insurance companies invest and manage the moneys they receive from their customers to make profit for themselves. The liabilities of insurance companies are based on certain insured events. Their customers can receive a payout if an event against which they are insured happens, e.g. such as their house is burning down. Otherwise, they don't have a claim on the insurance company.

Since it is unlikely that a very large number of people will want their money at the same time, as happens in the case of a run on the bank, insurance companies are in a better position to manage their risk. (Thangavelu 2021) It is a matter of fact that the insurance industry can take over a leading role in the sustainable finance agenda since 2012. In this same year the UN Environment Programme Finance Initiative launched its Principles for Sustainable Insurance. A report issued in 2021 emphasizes the importance of the insurance industry to the process of bearing the risks of the climate crisis and having the financial force to accelerate climate issues.

With more than USD 6 trillion in world premium volume and US$36trn in assets under management the insurance industry is one of the largest global industries. This also means that the insurers are in possession of a significant portion of economic assets and liabilities on their balance sheets. In the role of risk managers, insurers and investors, the insurance industry can take over a leadership role when it comes to building climate-resilient communities and in accelerating the transition to a net-zero emissions economy. (Scott Cato 2022)

Family Offices

Family offices are private wealth management advisory firms serving ultra-high-net-worth individuals (HNWI). Unlike to traditional wealth management shops they offer a total outsourced solution to managing the financial investments of an affluent individual or family. For example, while many family offices offer budgeting, insurance, charitable giving, wealth transfer, and tax services, a family office offers a wide range of services for the specific needs of HNWIs. Among these services are investment management to charitable giving advice. Family offices may can also offer a dedicated team of specialists to service these clients. (Hayes 2021)

Especially the family-run businesses may require structures for succession planning. This can either be the setting up of trusts or a foundation for the family assets. As these situations are often very complex, clients may utilize a family office to help manage the assets and align interests. Family office are also able to handle non-financial issues, such as private schooling, travel arrangements, and miscellaneous household arrangements. (Hayes 2021)

It is important to note that the range of family offices differs widely. One client may need sophisticated advice from a range of experts, while another may need a family office to organize their lifestyle needs. (Hayes 2021)

International Financial Institutions

Climate change is a major challenge of today's world, requiring research and innovation to meet the challenge. Therefore, there are several funding schemes that support DHC-projects at international, national and regional level. In the following, different funding programmes are presented for each of these levels.

European Investment Bank (EIB)

The EIB's objective is to rapidly transform energy systems to achieve net zero emissions and minimise the negative impact of human activity on the climate. The EIB has stopped financing fossil fuel projects, including natural gas, and has added DHC networks to the investment portfolio. Long-term loans are granted either as direct loans if the investment costs exceed EUR 20-25 million or as bridging loans if the investment costs are lower.

The EIB also issued green bonds and since the first green bond was issued this market has experienced exponential growth. (Scott Cato 2022)

The Green Deal was promising at least a budget of €1 trn for green stimulus. €503 bn should be paid directly by the EU budget. This remainder was a result of the InvestEU programme – a combination of public and private funding with national match-funding. This will support riskier lending by the EIB, which is now called Europe's "climate bank". (Scott Cato 2022)

In the years before the EIB has faced some criticism over its investment decisions. Some of them have locked fossil fuels into the European Economy. One example is the €1.5 bn loan for the Trans-Adriatic Pipeline (TAP) crossing Northern Greece, Albania, and the Adriatic Sea before arriving in Southern Italiy where it connects to the Italian natural gas network. (Scott Cato 2022)

European Fund for Strategic Investments (EFSI)

The EFSI is a collaborative initiative between the EIB Group - European Investment Bank and European Investment Fund - and the European Commission to overcome the current investment weakness in the EU. The EFSI is one of the three pillars of the Investment Plan for Europe, which aims to revitalise investment in the EU and kick-start strategic projects in the real economy. The EFSI aims to mobilise EUR 500 billion in additional investment to close the investment gap created by the crisis. Through EFSI, the EIB Group provides funding for commercially viable projects that are typically riskier than standard EIB financing. The EFSI focuses on sectors that are key to the European economy. These include, for example, strategic infrastructure, including digital networks, transport and energy (EIB 2021).

European Territorial Co-operation (ETC)

ETC is part of the European Union's structural and investment policy. For many years, it has supported cross-border cooperation between regions and cities that affect daily life, for example

in transport, the labour market and environmental protection. Countries and regions work together in 79 programmes in different ways to address challenges in areas including innovation, research, sustainable energy and climate adaptation. Projects must involve partners from at least three countries, of which at least two must be EU Member States (Van der Veen et al. 2019). A new seven-year EU funding period begins in 2021. Discussions are currently taking place on the financial resources and the design of the future cohesion policy. The decisions on long-term EU budget planning and the new regulations of the European Structural and Investment Funds (ESIF) will lay the foundations for future transnational cooperation from 2020 (Interreg n.d.).

Connecting Europe Facility (CEF)

The Connecting Europe Facility (CEF) is an important EU financial instrument for promoting growth, employment and competitiveness. This is implemented through targeted infrastructure investments at European level. It supports the development of sustainable, high-performance and efficiently interconnected trans-European networks in transport, energy and digital services by supporting projects, in addition to grants, through innovative financial instruments such as guarantees and project bonds. These instruments are intended to act as a catalyst to attract further funding from the private sector and other public sector actors. For the period 2014-2020, a total budget of EUR 5.35 billion will be made available for energy infrastructure projects. 4.6 billion will be in the form of grants managed by the Innovation and Networks Executive Agency (INEA) (European Commission 2021a).

European Bank for Reconstruction and Development (EBRD)

The European Bank for Reconstruction and Development is an international financial institution that uses investment as a tool to build market economies. The EBRD's vision is a partnership between industry, government and consumers to provide the basic energy needs of societies sustainably, reliably and at the lowest possible cost. It offers a wide range of financial instruments and helps structure financial products through a flexible approach. Loans, equity and guarantees are among the EBRD's main forms of direct financing. Up to 35% of the total project costs for a greenfield project or 35% of the long-term capitalisation of an established company are covered by the EBRD. This requires additional funding from sponsors and other co-financiers. The EBRD can help identify additional funds through its syndication programme. (ERBD n.d.).

IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that helps countries implement sustainable energy. IRENA serves as the main platform for international cooperation, a centre of excellence and a repository of knowledge on renewable energy policy, technology, resources and finance. The organisation promotes the widespread adoption of renewable energy in all forms. These include, for example, bioenergy, geothermal, hydropower, marine, solar and wind energy. The goals are sustainable development, energy access, energy security and low-carbon economic growth and prosperity. IRENA is involved in various DHC networks and has published several research papers on the topic. It has a funding arm, the Abu Dhabi Fund for Development (ADFD), which provides accessible finance for renewable energy projects in developing countries. However, the ADFD has not yet financed any DHC projects (IRENA 2021).

World Bank

The World Bank is an international financial institution that provides loans and grants to the governments of poorer countries to implement capital projects. It supports projects that aim to provide access to affordable, reliable and sustainable energy. These projects are vital to achieving all other UN Sustainable Development Goals and are essential for many countries to meet their climate targets. More than 12,000 development projects have been financed by traditional loans, interest-free loans and grants from the World Bank since 1947 (World Bank n.d.).

5.5 Typology of Financial Instruments

Over the course of the following (sub-)chapters the conventional infrastructure financing instruments will be successively modified and developed further by integrating sustainability related aspects, such as the carbon footprint.

5.5.1 Introduction & Overview

In general infrastructure projects can be financed by a variety of different financing instruments, each of them being part of a particular asset categories, such as equity, fixed income or a mixture of both. The letters also described as mixed or mezzanine. The following table provides a taxonomy of (conventional) infrastructure financing instruments, also linking them – on the one hand – to different kinds of projects and – on the other hand – to market vehicles or capital providing the funds needed (see Figure 50):

<table>
<tr><th colspan="2">Modes</th><th colspan="2">Infrastructure Finance Instruments</th><th>Market Vehicles</th></tr>
<tr><th>Asset Category</th><th>Instrument</th><th>Infrastructure Project</th><th>Corporate Balance Sheet / Other Entities</th><th>Capital Pool</th></tr>
<tr><td rowspan="5">Fixed Income</td><td rowspan="3">Bonds</td><td>Project Bonds</td><td rowspan="2">Corporate Bonds, Green Bonds</td><td rowspan="3">Bond Indices, Bond Funds, ETFs</td></tr>
<tr><td>Municipal, Sub-sovereign bonds</td></tr>
<tr><td>Green Bonds, Sukuk</td><td>Subordinated Bonds</td></tr>
<tr><td rowspan="2">Loans</td><td rowspan="2">Direct/Co-Investment lending to Infrastructure project, Syndicated Project Loans</td><td>Direct/Co-investment lending to infrastructure corporate</td><td>Debt Funds (GPs)</td></tr>
<tr><td>Syndicated Loans, Securitized Loans (ABS), CLOs</td><td>Loan Indices, Loan Funds</td></tr>
<tr><td>Mixed</td><td>Hybrid</td><td>Subordinated Loans/Bonds, Mezzanine Finance</td><td>Subordinated Bonds, Convertible Bonds, Preferred Stock</td><td>Mezzanine Debt Funds (GPs), Hybrid Debt Funds</td></tr>
<tr><td rowspan="2">Equity</td><td>Listed</td><td>YieldCos</td><td>Listed infrastructure & utilities stocks, Closed-end Funds, REITs, IITs, MLPs</td><td>Listed Infrastructure Equity Funds, Indices, trusts, ETFs</td></tr>
<tr><td>Unlisted</td><td>Direct/Co-Investment in infrastructure project equity, PPP</td><td>Direct/Co-Investment in infrastructure corporate equity</td><td>Unlisted Infrastructure Funds</td></tr>
</table>

Figure 50: Taxonomy of (conventional) infrastructure financing instruments (OECD 2015b, p. 15)

From an investor's point view different asset categories and financing instruments are exposed to different amounts of risk. Since equity is used for compensating losses, once they occur, is it is exposed to the highest risk. On the contrary, debt usually has a lower risk exposure, since it is not used as a risk bearing capacity in case of losses. Mezzanine finance –as a hybrid form between equity and debt, consequently (depending on the contractual specific conditions) has a risk exposure between equity and debt. The higher the risk of a financing instrument, the higher are the returns expected by potential investors. Expected returns from the investor's perspective are – from an infrastructure project's point of view –, the financing costs of the particular financing instrument. The following illustration provides an overview of risk-return-profiles of different innovative financing instruments from an investor's point of view (see Figure 51):

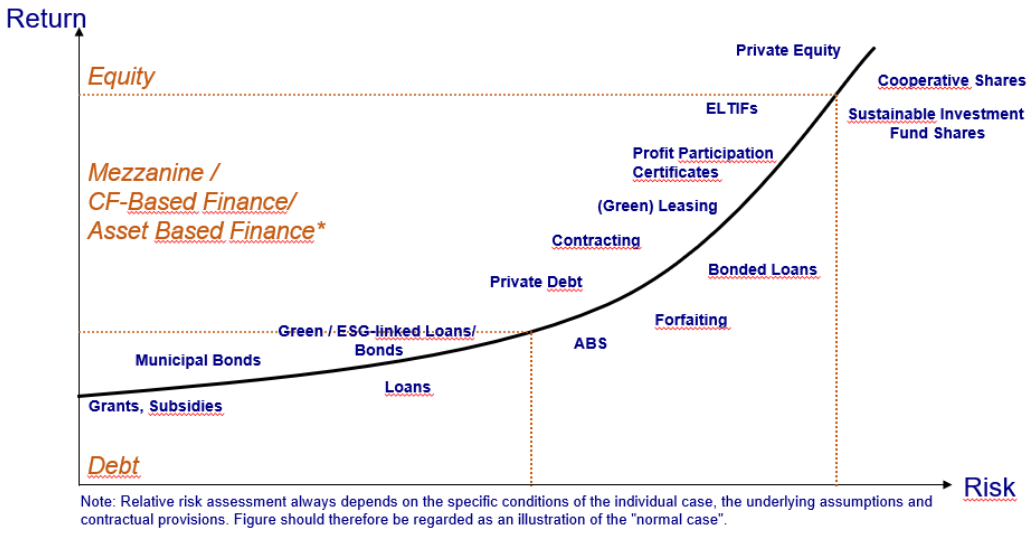

Figure 51: Risk-return profiles of different innovative financing instruments from the perspective of investors (conceptual/indicative)Risk-return profiles of different innovative financing instruments from the perspective of investors (conceptual/indicative) (Source: Based on Popovic (2013); (Kaserer 2006, p. 161)

More specifically, the following illustration links the risk-return-relationships to different kinds of infrastructure projects and also indicates which kind of asset category might be suitable (see Figure 52):

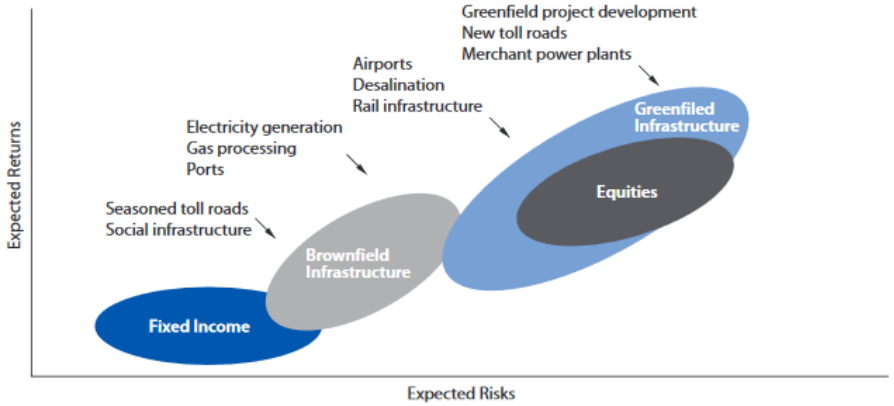

Figure 52: Illustrative Risk-Return-Relationships of Selected Types of Infrastructure Projects (Inderst 2010, p. 79)

Since the EU is increasingly obliging financial service providers to take CO_2 limits into account in their investment and financing decisions along the EU taxonomy as part of the EU Action Plan, financing instruments are likely to gain in importance in the future in which the CO_2 footprint or the corresponding reduction potential during the term influence the financing conditions in the sense of the "magic quadrilateral". (Da Canas Costa and Popović 2020, pp. 233–239). These include ESG-linked bonds or loans, for which the interest rate decreases depending on the CO_2 reduction achieved, depending on the structure. This creates a concrete financial incentive for the creditor to reduce CO_2 emissions. (Popović 2022a). The same applies to transition and target-linked bonds. (Pratsch 2022) The relevance of green loans and bonds that are used exclusively to finance decidedly sustainable investments is also likely to increase (cf. the following table) (see Figure 53):

	Green Bonds	Green Loans	Green Bonded Loans (GSSD)	ESG-linked Bonds	ESG-linked Loans	ESG-linked Bonded Loans
Definition	• Environmentally oriented bonds	• Environmentally oriented loans	• Environmentally oriented SSD	• ESG-oriented bonds	• ESG-oriented loans	• ESG-oriented SSD
Market relevance	• high	• high	• increasingly	• increasingly	• increasingly	• increasingly
(Binding) regulations	• Green Bond Principles (ICMA*) • EU Green Bond Principles • EU Action Plan / EU Taxonomy	• Gren Loan Principles (LMA*) • EU Action Plan / EU Taxonomy	• No, but usually orientation towards Green Bond Principles • EU Action Plan / EU Taxonomy	• Sustainability-Linked Bond Principles (ICMA) • EU Action Plan / EU Taxonomy	• Sustainability Linked Loan Principles (SLLP) (LMA*) • EU Action Plan / EU Taxonomy	• (Orientation Sustainability Linked Loan Principles (SLLP)) (LMA*) • EU Action Plan / EU Taxonomy
Second Party Opinion (SPO)	• Yes, e.g. by rating agency	• Yes, e.g. by rating agency	• (Yes, e.g. by rating agency)	• Yes, e.g. by rating agency	• Yes, e.g. by rating agency	• (Yes, e.g. by rating agency)
ESG rating	• meaningful	• meaningful	• meaningful	• meaningful	• meaningful	• meaningful
ESG KPIs/SPTs**	• meaningful	• meaningful	• meaningful	• necessary	• necessary	• necessary
Use of Proceeds-Reporting	• yes	• yes	• (yes)	• (yes)	• (yes)	• increasingly
Examples (each exemplary)	• BayWa • EnBW • KfW • EBRD • EIB • State of BaWü • E.ON • BASF • Numerous other companies	• Philips • Danone • Handle • Indorama Ventures	• Nordex (• Man + Bumblebee • Porsche • Schaeffler • Nassauische Heimstätte (Green & Social) • enercityt AG	• Enel • Association • Hapag-Lloyd • Handle • Pfleiderer GmbH	• Continental • Handle • Lanxess • German Stock Exchange • Dürr • Voith • Teléfonica Germany	• Jenoptik AG, • RHI Magnesita • Faber-Castell AG • Faurecia SE

*ICMA = International Capital Markets Association, LMA = Loan Market Associaton ** Key Performance Indicators, SPT = Sustainability Performance Targets

Figure 53: Analytical comparison of different debt instruments in the context of Sustainable Infrastructure Finance; (Popović 2022a)

Depending on the specific area of application of these innovative financing instruments, issuers (e.g. energy suppliers) must take specific criteria and requirements into account (Popović 2022a). These include, for example, how high the capital market relevance of the respective instruments is, to what extent (binding) regulations must be observed, whether an independent review by an external body (Second Party Opinion, SPO) must or should take place, to what extent an ESG rating must be commissioned, whether specific information regarding the concrete sustainability effects (Key Performance Indicators, KPI; Sustainability Performance Targets, SPT) must be provided and to what extent investors must be informed about the actual use of the funds raised (Use of Proceeds Reporting) (Popović 2022a).

The exponential rise in global issuance volumes of sustainability-oriented bonds (e.g. green bonds, ESG-linked bonds) from USD 11 billion in 2013 to over 800 billion in 2020 (Hypovereinsbank 2022)

underscores the dynamic increase in investor interest and thus the potential that exists in the more intensive use of these instruments for financing the heat transition in the context of sustainable real estate and sustainable infrastructure finance. This momentum must be used in a targeted manner to accelerate the heat transition (Popović 2022a).

For example, Berlin Hyp has also renewed its EU Taxonomy-aligned Green Bond Framework and has actively entered this new market. On 31 December 2021 the Green Finance Portfolio provided financing for a total of 312 properties. 62% of this portfolio corresponding to €4,499 million is part of Berlin Hyp's mortgage cover pool. The overall development can be understood in the table and chart below: (Berlin Hyp 2021) (see Figure 54):

	Total	Number of buildings
Total by 31 December 2020	5,984	238
New business for green buildings	1,015	43
Difference between subsequently identified green buildings and repayments	284	31
Total by 31 December 2021	7,283	312

Figure 54: Overall development – number of buildings (Berlin Hyp 2021)

Figure 55 shows that the proportion of green investments have increased between 2015 und 2021:

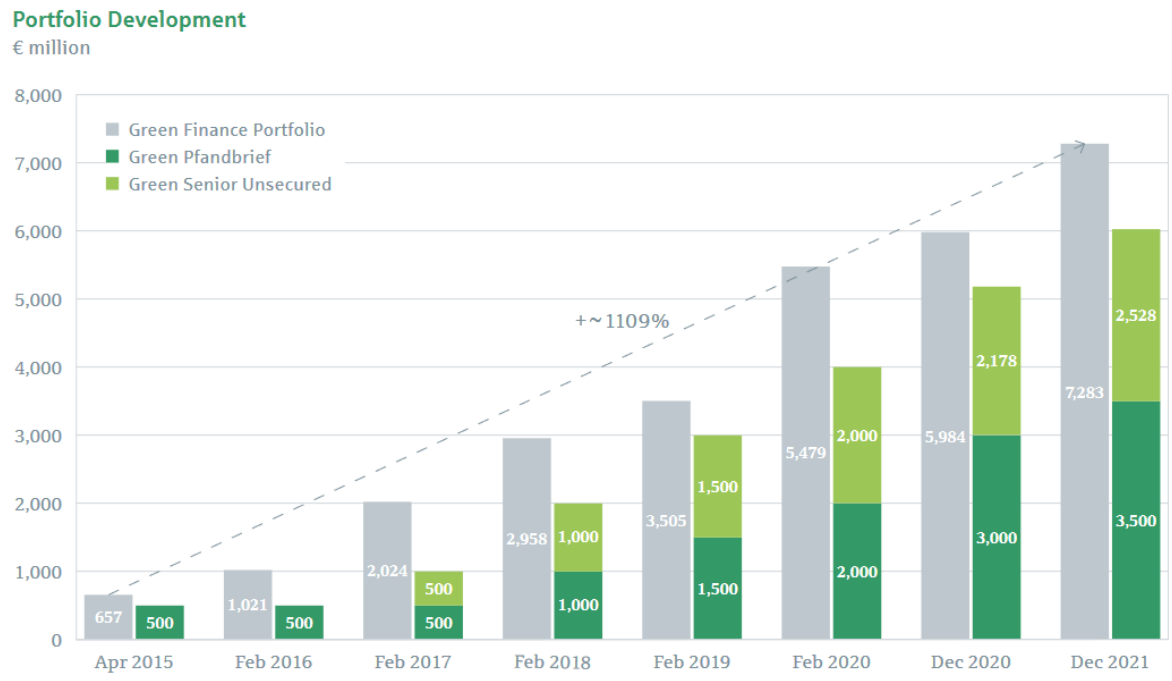

Figure 55: Portfolio development (Berlin Hyp 2021)

5.5.2 Debt

Loans

Fundamentals

Loans are characterized by the fact that the investors of debt capital do not become co-owners of a company and are merely creditors. Usually, there is a contractually fixed annual percentage interest rate and the loan amount must be repaid within a certain period of time inclusive of this interest.

Improved access to loans helps mobilise finance for energy projects, including DHC projects. There is an increasing trend of financial institutions to lend to renewable energy based and sustainable district heating and cooling projects. The advantages are high security and exceptionally low interest rates. International lenders also offer generous loan amounts. However, borrowers must adhere very strictly to the payment schedule, as if payments are late or the borrower defaults, it becomes difficult for the borrower to obtain further funds in the future (Reeep, 2017). Loans can thus be suitable funding for a DHC project. Nevertheless, it should be noted that the negotiated conditions could be very restrictive for the project promoters.

Syndicated Loans

“A syndicated loan, also known as a syndicated bank facility, is financing offered by a group of lenders [...] who work together to provide funds for a single borrower. The borrower can be a corporation, a large project, or a sovereign government. The loan can involve a fixed amount of funds, a credit line, or a combination of the two.” (Segal 2020)

Syndicated Project Loans

“Project finance is a form of financing based on a standalone entity created by the sponsors, with highly levered capital structures and concentrated equity and debt ownerships. Due to its contractual idiosyncrasies it is also used to segregate the credit risk of the project from those of its sponsors so that lenders, investors, and other parties will appraise the project strictly on its own economic merits.” (Pinto and Alves 2016)

Syndicated Corporate Loans

“Corporate loans are loans made to businesses for a specific business purpose. There are many types of corporate loans, and lenders change interest rates for these loans based on risk and market conditions, just like individual loans. Without these loans, most companies would not have enough funding for basic business activities. While there are many varieties, several corporate loans are more popular than others.” (Lacoma 2017) In summary, corporate loans can be roughly divided into working capital, real estate, venture capital, credit line and equipment. (Lacoma 2017)

Securitized Loans and Asset Backed Securities (ABS)

"Securitization is the process of transformation of non-tradable assets into tradable securities. It is a structured finance process that distributes risk by aggregating debt instruments in a pool and issues new securities backed by the pool.

When a bank or financial institution requires additional capital to finance a new facility, to raise the fund, instead of selling the assets, the financial institution decides to sell the portion of the loan to a Trustee named as Special Purpose Vehicle (SPV) and collect the fund up front and remove the loan asset from the balance sheet of the institution. SPV holds the asset as collateral in balance sheet and issues bonds to the investors. It uses the proceeds from those bond sales to pay the originator for the assets." (Oracle)

"Asset-backed securities (ABS) are securities derived from a pool of underlying assets. To create asset-backed securities, financial institutions pool multiple loans into a single security that is then sold to investors. The pools can include many types of loans, such as mortgages, credit card debt, student loans, and auto loans. As many of the loans cannot be sold separately, securitizing them into asset-backed securities provides investors with further investment opportunities, and allows financial institutions to remove risky assets from their balance sheets." (CFI Education Inc. 2022b)

Collateralized Loan Obligations (CLOs)

CLOs are very similar to corporate bonds as they are securitized corporate loans (Wahrenburg et al. 2020). The loans are usually granted by the investor and serve as collateral for the issued bonds and certificates. However, there are also participants outside the banking sector who issue CLOs with the motivation to spread arbitrage. However, there are also participants outside the banking sector that issue CLOs with the motivation of distributing arbitrage, through the fact that it is a mixture of high-yield and distressed loans. In the case of bank CLOs, the motivation is to reduce capital requirements and fund low-yielding assets. The collateral consists mostly of investment-grade and some non-investment-grade corporate loans. There are usually multiple tranches of rated securities to which the risk is redistributed, through prioritization of cash flows and the layered structure. Similarly, there is usually a non-rated equity tranche that remains with the bank, with this and the most subordinated tranche absorbing the first losses in the event of default. This means the most senior tranche has the lowest credit risk and a higher rating (Howard and Merritt 1997). This securitization of loans is an important source of funding for the corporate loan market. Unlike other securitization markets, the CLO market has now fully recovered from the 2008 financial crisis and has become the dominant institutional investor in syndicated loans (Gallo and Park 2022).

Direct and Co-Investment Lending

Direct Lending

Direct lenders are non-bank creditors making loans to businesses without using an intermediary, such as an investment bank. Direct lending is a subset of private debt which most commonly refers to first lien loans made to middle-market companies (i.e., those that report between $50 million and $1 billion in annual revenue). (Oaktree Capital 2021).

Co-Investment Lending

Co-lending is an arrangement where banks and non-banks (NBFCs) can form agreements and engage in priority sector lending. (Mayank 2021)

Green Loans

Green loans are a form of financing that allows borrowers to use the proceeds exclusively to finance projects that make a significant contribution to an environmental goal. A green loan is similar to a green bond, but green loans are usually private transactions and smaller in volume. Green loans follow the principles of the Green Loan Principles of the International Capital Market Association (ICMA). Green loans are becoming increasingly important as they help balance lending and environmental goals. They also help borrowers communicate the greening of their operations and supply chains (World Bank 2021).

To be designated as a green loan, a loan should be structured according to green loan principles, consisting of four core components.

1. Use of Proceeds: the project should provide a clear environmental benefit that is assessed and reported by the borrower.

2. Process for Project Evaluation and Selection: The borrower should communicate several factors to the lender. For example, the evaluation and selection of projects that will be financed and how the environmental and social risks of the project will be managed.

3. Management of Proceeds: proceeds should be credited to a dedicated account or tracked by the borrower so that transparency is maintained and the integrity of the project is promoted.

4. Reporting: should be based on qualitative performance indicators and, if possible, supported by quantitative indicators (reduced greenhouse gas emissions, energy capacity, etc.) (ICMA et al. 2018).

ESG-Linked-Loans

ESG-linked financing loans are intended for corporate financing activities that focus on sustainability in terms of ESG criteria (Environmental, Social & Governance). In this context, the companies undertake to operate more sustainably on the basis of verifiable criteria and are rewarded with lower interest rates if the previously agreed ESG-related KPIs are achieved (Watson Farley & Williams 2022). Also, like green loans, ESG-linked loans send strong signals to all stakeholders that the issue of sustainability is of great importance to the borrower. In addition, these loans offer greater flexibility as different criteria, measurements and ratings can be considered. These are also individually agreed between lender and borrower (Eckardt n. d.). A Bloomberg estimate in 2021 stated that ESG assets were on track to exceed $53 trillion by 2025, accounting for more than one-third of total assets under management worldwide (Platform on Sustainable Finance 2022).

Green Mortgages Green mortgages play a role when it comes to building a new home/building or renovating an existing one. In order to obtain a green mortgage, the lender submits a recognized

sustainability certificate in the case of new construction or undertakes to renovate an existing building in such a way as to improve its environmental performance. Accordingly, a green mortgage is specifically aimed at green buildings (World Green Building Council n. d.). The major Swiss bank UBS has been offering green mortgages on its UBS Atrium real estate platform since May 2021. The borrower submits property documents together with a sustainability certificate. These are checked and then marked as green mortgages so that investors can invest in them if they are interested. If the deal is closed, the closing fee is not charged to the borrower. But it is not only the borrowers who benefit. Due to the ever-increasing requirements for institutional investors to invest their money in sustainable investments, interest in convincing sustainable products is increasing and time-consuming checks are no longer necessary in the case of UBS Atrium (UBS 2021; nzz 2021). The importance of green mortgages and the need for change in buildings becomes clear when looking at the figures: In the EU, buildings are responsible for 40% of final energy consumption and for 36% of CO2 emissions. Likewise, the energy consumption of private households in the EU worsened in the last decade. The reason for these figures is, among others, the age of the buildings in the EU, as more than 40% of the buildings were built before 1960 and 90% before 1990. As mortgages represent the largest part of the assets of EU banks (around 30%), it is important in the future that green mortgages are increasingly offered and perceived (Esposito et al. 2022).

Bonds

Bonds in General

Bonds are large loans broken down into partial amounts, with the debtor (issuer) promising repayment and interest on predefined terms. Bonds are offered for subscription to the public or to a specific group of investors also be listed on the stock exchange. In addition to states other local authorities, such as federal states or cities, can also be considered as issuers, as can international organizations. The difference between bonds and loans usually means higher fixed issue costs for companies, but bonds usually allow longer-term financing at lower costs than loans. Likewise, high financing requirements can usually be secured more easily via bond issues. Therefore, companies sell bonds to finance ongoing operations, new projects or acquisitions. Governments sell bonds for funding purposes and also to supplement tax revenues. (Guserl and Pernsteiner 2015). In recent years, there has been a rise in bond financing, changing the landscape of corporate borrowing in the euro area. The composition of bond issuers has also changed, with many smaller and riskier issuers now joining in recent years. In addition, new issuers are investing and growing instead of just repaying bank loans (Darmouni and Papoutsi 2022).

Municipal Bonds (Munis)

“Municipal bonds (or “munis” for short) are debt securities issued by states, cities, counties and other governmental entities to fund day-to-day obligations and to finance capital projects such as building schools, highways or sewer systems. By purchasing municipal bonds, you are in effect lending money to the bond issuer in exchange for a promise of regular interest payments, usually semi-annually, and the return of the original investment, or “principal.” A municipal bond’s maturity date [...] may be years in the future. Short-term bonds mature in one to three years, while long-term bonds won’t mature for more than a decade.” (Investor.gov and SEC n. d.). Defaults in the municipal bond market are extremely rare, and most municipal bonds are exempt from federal

and state taxes, which is why they have gained popularity and attracted retail investors in particular (Schwert 2017).

Bonds and Green Bonds

Green bonds, like conventional bonds, are fixed-income securities in which the borrower assures the lender that the funds will be used to finance environmentally sustainable project investments under certain criteria. Between 2013 and 2020, the market for Green bonds has grown to the equivalent of 266 billion euros. The share of green bonds in total issuance increased from 0.4 percent (2013) to over 4.5 percent in 2020. Slightly more than half of new global issuance occurred in the EU in 2020. While the total volume of new loans and bonds stagnated worldwide, the market for green bonds grew steadily, particularly in the EU - from €6 billion to €134 billion between 2013 and 2020. The growth of green bonds, even in times of crisis, shows that in addition to the short-term return expectations the long-term risks of climate change - through physical damage, regulatory changes or technological innovation pressure - are increasingly playing a role among investors. While development banks were among the first green bond major issuers energy and non-financial companies steadily increased their project financing using green bonds, especially from 2015 onwards, before state actors in the EU entered the market since 2017 (Friedrich and Wendland 2021). The EU Taxonomy Regulation has given rise to the European Green Bond Standard, which places the issuance of bonds under the following requirements: 1: Significant contribution to the achievement of one or more environmental objectives defined in the taxonomy. 2: No negative impact on the other environmental objectives. 3. Compliance with minimum social standards. 4: Compliance with technical evaluation criteria for each environmental objective. In addition, there are various requirements for a European green bond that must be met: 1: There is a restriction on the use of the proceeds of the issue, as these may only be used to finance an environmentally sustainable activity that meets the requirements of the EU taxonomy. 2: There are disclosure requirements of a "European Green Bond Factsheet" before or at issuance. In addition, annual reporting on the use of proceeds and an impact report on the issuer's environmental strategy are mandatory. 3: Verification of the factsheet by a third party, as well as external audit of the annual report on the use of proceeds (EBS Universität für Wirtschaft und Recht and EBS Real Estate Management Institute 2021; Meyer 2021; European Commission 2020a).

Green bonds are playing an increasingly important role in financing assets needed for the low-carbon transition. However, there is no uniform standard for green bonds within the EU. Under the European Green Deal Investment Plan of January 2020, an EU Green Bond Standard (GBS) will be introduced (European Commission 2020a).

The green bond market has registered exponential growth since the first green bond was issued by the European Investment Bank in 2007. By December 2020 it reached an important milestone. The total value of green bonds issues reached US$1 trn. Another important milestone in terms of creditability was by November 2013 when the first corporate green bond was issued by Swedish property company Vasakronan. Other large corporate issuers include SNCF, Berlin Hyp, Apple, Engie, ICBC, and Credit Agricole. (Cp. Scott Cato 2022, p. 28)

Naturally, when investors choose to invest their money they are interested in the default property of the assets. By 2012 the OECD already emphasized the need for an objective evaluation of green projects. The recommended governments to support the constitution of rating agencies to

approve, certify or rate green projects (e.g. green bonds, green funds etc.) to make sure funds are used for justifiably green investments (Inderst et. al. 2012, p. 10).

The International Capital Markets Association formulated voluntary principles for those actors issuing green bonds in 2018: (Scott Cato 2022)

Use of Proceeds: These must contain clear environmental benefits and they should be quantified by the issuer. The sectors in question include renewable energy, energy efficiency, prevention of pollution and control, sustainable land management, biodiversity conservation, sustainable transport, adaptation to climate change, change production to a circular economy and promoting green buildings.

A process for Project Evaluation and Selection: those issuing the bond have to make the environmental sustainability objectives clear to investors, and how these are measured

Management of Proceeds: in order to avoid the failure of missions the management of the portfolio of green bond proceeds need to be separated from the management company's other accounts.

Reporting: the issuers of green bonds have to provide relevant and timely information about the impact of their investments to investors.

Since the first bond was issued by the European Investment Bank in 2007 the market with green bonds has experienced exponential growth. By December 2020 the total value of green bonds issued reached US$1trn. In November 2013 the first corporate green bond was issued by the Swedish property company Vasakronan. Other large corporate issuers include SNCF, Berlin Hyp, Apple, Engie ICBC, and Credit Agricole. (Scott Cato 2022)

The growing demand of "Green Buildings" has led to the implementation of some building certification systems which are valid worldwide. Among the most popular rating systems in Germany count DGNB, LEED, as well as BREEAM. Which product requirements need to be fulfilled by sustainable building projects in order to be placed in sustainable building projects? (Building Material Scout 2019)

"Additional / alternative eligibility criteria include the following sustainability certificates. (...) LEED, BREEAM, DGNB and HQE issue sustainability certificates for buildings. Buildings financed by Berlin Hyp following the issue of the Green Pfandbrief on 27 April 2015 must achieve a score of at least 50 percent in the energy efficiency category of the green building certificate if the building does not already qualify through its energy requirements and consumption." (Berlin Hyp 2021) (see Table 9).

The Green Deal Investment Plan aims to mobilise at least EUR 1 trillion in sustainable public and private investment over the next ten years to drive the transition to a climate-neutral and competitive economy. This is the so-called Just Transition Mechanism. Yet public money will not be enough. That is why the EU is trying to incentivise private capital flowing into green projects through a tough law (European Commission 2019b). However, one can not only assume a strong promotion of DHC projects from the public side, but also an increased interest from the private sector due to the guaranteed financial support. Consequently, a development of technologies and scalable solutions for energy efficiency projects and their dissemination can be expected.

Table 9: Sustainability Certificates (Berlin Hyp 2021)

Sustainability Certificates		
Description	Definition	Evaluation
LEED	Leadership in Energy and Environmental Design	Gold status or higher
BREEAM	Building Research Establishment Environmental Assessment Methodology	Very good status or higher
DGNB	Deutsche Gesellschaft für Nachhaltiges Bauen	Gold status or higher
HQE	Haute Qualité Environnementale	Excellent status or higher

Climate change and a deteriorating environment are an existential threat – not only to Europe but also to the world. In order to cope with these challenges, the European Green Deal will transform the EU into a modern, resource-efficient and competitive economy, by ensuring

- the abolishment of net emissions of greenhouse gases by 2050
- the decoupling of economic growth from resource use
- that no person and no place is left behind (European Commission 2019a)

ESG-Linked-Bonds

While green bonds are an investment in green projects or initiatives, ESG bonds are about companies and their overall achievement of goals in environmental and social areas. They are therefore not limited to environmental activities alone. In the case of ESG bonds, the issuer of the bond undertakes to pay an additional premium on the interest coupon if a set sustainability target is not achieved. In this way, the issuer confirms its willingness to operate more sustainably in the future (Kent 2020; Deutsche Bundesbank 2021). For central bank eligibility, the bond must meet all relevant requirements for marketable securities (minimum rating, listing, custody, etc.). The issuer's set targets (Sustainability Performance Targets - SPT) must be assigned to at least one UN Sustainability Development Goal or at least one of the targets of the EU taxonomy. This is not only a matter of the issuer's own assignment in a document, but also of confirmation by a qualified independent entity. The achievement of the goals is also monitored (Deutsche Bundesbank 2021). ESG-linked bonds or sustainable bonds are therefore suitable for DHC projects and companies that specialize in them.

5.5.3 Equity

Shares

Shares are units of equity ownership in a corporation. Investors buying the shares can receive income in the form of dividends and they can gain potential capital gains if the shares increase in value. Selling shares means to give up control in return for funds (Scott Cato 2022)

Direct- and Co-Investments in Infrastructure Equity

Direct investments into infrastructure assets require the longest time horizon for an investor since infrastructure assets have long lives. Sometimes their average lifetime is up to 60 years –

sometimes these investments also last 99 years. Because of the physical nature of these assets, direct investments cannot easily be sold and though they high risks to liquidity. Since infrastructure assets are generally very capital-intensive, they require large sumes. Furthermore, placing a large amount of capital over a long period of time into a single-infrastructure asset means a high political and regulatory risk for the investor. It is also important to note that only a few investors such as insurance companies or pension funds are capable of making such investments. There are also special forms of direct infrastructure investments. Very often used are Public Private Partnerships (PPPs) or project finance structures. (Bitsch et al. 2013)

An equity co-investment is a minority investment in a company made by investors in participation with a private equity fund manager or venture capital (VC) firm. Such equity co-investment make it possible for investors to invest in potentially highly profitable investments without paying the usual high fees charged by a private equity fund.

Normally, equity co-investment opportunities are restricted to large institutional investors who already have an existing relationship with the private equity fund manager and they are often not available to smaller or retail investors. (Chen 2021)

Private Equity

Private equity is a term for a financial instrument in which equity is provided by project initiators or financial investors over a medium or long-term period. The funds can either be provided in the form of ownership or a loan from external investors. If there are specialised private equity investors, which are already active in the field of DHC networks, they can bring in additional knowledge and experience. As such they are able to support the investment with their expertise. Efficient partnership financing means to finance the projects by sharing the costs between several organisations. This is also referred to as public-private partnerships. A public-private partnership (PPP) is a partnership between the public sector and private sector companies. Whereas the private entity assumes responsibility for the efficient production of a service required by the public sector, the public entity assumes responsibility for the public welfare orientation of the cooperation. (Carlsson et al. 2018) A good example is the EU LIFE programme, which has brought forward the Private Finance for Energy Efficiency (PF4EE) instrument – a joint agreement between the European Investment Bank and the European Commission. This financial instrument can be applied well to DHC projects.

Venture Capital

Venture capital is a sub form of private equity and typically provided by investors to start-up companies and small businesses that are believed to have long-term growth potential. Venture capital usually comes from wealthy investors, investment banks and other financial institutions that bundle similar partnerships or investments and invest in industry focuses. Since venture capital usually works with high-risk projects, it is easier for innovative, complex DHC projects to obtain funding from targeted investors (Sunko et al. 2017).

Public Private Partnerships (PPP)

Public Private Partnerships (PPPs) are contracts between public entities and private investors. The goal is to deliver public services. They contain calls for tender by a public institution to build and/

or manage public infrastructure. The successful bidder is allowed to absorb the initial investment and to make returns by charging the delivery of the public service. (Eurosif and Kyoko 2021, p. 25)

PPPs have a potential for unlocking sustainable investment opportunities. This makes it possible to guide investment in regions where financing the transition is needed very urgently. Funding projects with PPP and thereby also showing its viability is an important signal to send to the private sector for it could stimulate the funding of similar projects. The scope of a PPP can therefore be much broader than just for the financed project. (Eurosif and Kyoko 2021)

YieldCos

YieldCos are an emerging asset class of publicly traded companies that are focused on returning cash flows generated from renewable energy assets to shareholders. These assets consist mostly of solar and wind farms having entered into long-term energy delivery contracts with customers. Many YieldCos are known for distributing high percentages of their cash flows by utilizing tax incentives to minimize tax liabilities. (Global X Research Team 2016)

(Energy and District-) Cooperatives

There is no official definition for energy cooperatives, but energy cooperatives are understood as legally registered cooperatives that manage activities along the energy value chain. By providing technological services, by producing energy and by being in charge of energy distribution, they operate their respective infrastructure, market and sell energy or offer energy demand and supply services. (Debor 2018)

Energy cooperatives are democratic model organizations since they hold up the principle of "one share-one-vote" and their goal is to promote all members economic development equally. As a rule, cooperatives bring social benefits to their respective community or region. (Friedrich-Ebert Stiftung 2022) and they support the energy transition by encouraging people to switch from traditional fossil energy to renewable energy. (Viardot 2013)

Nevertheless, cooperatives are perceived quite differently and it is also important to note that the political framework conditions for cooperatives differ considerably in the individual states. The main reason for this can be seen in the non-identical implementation of RED II (the Renewable Energy Directive). This directive has been launched by the European Commission and it specifies that all member states are required to ensure to assess the existing barriers and potentials for the development of renewable energy communities in their territories. (Friedrich-Ebert Stiftung 2022)

The following three examples of successful energy communities are in line with the EU law and the definition of an Energy Cooperative (EC): (European Commission - Rural Energy Community Advisory Hub)

- Energiegenossenschaft Odenwald eG: this community was founded in 2009 and how has over 3000 members from the Odenwaldkreis – a district in the south of the Federal State Hesse. Until today, there has been an investment of €50 million into 83 solar plants mainly installed on rooftops and in fields. The regional development they advance also includes the building of energy-efficient properties and community spaces.

- Climate Community Saerbeck: this community relies on a decentralized energy grid since 2012 owned by the community and their goal is to achieve 100% renewable energy production for their 7200 inhabitants by 2030. The energy of this community is generated from:
- Photovoltaic investments by the citizen energy cooperative and projects of private households.
- Investments in wind-energy by the community-owned company and a cooperative of citizen.
- Farmers rely on biomass and biowaste plants, having made it one of the most advanced organic waste processing plants in Europe. The electricity produced by the Biogas facilities is fed into the grid and heat is supplied to all public buildings in their high school and sports hall.

Listed Infrastructure and Utilities Shares

Investments in infrastructure assets class have become an increasingly important topic for investors over the past decade. The attractive investment properties and the high diversification potential make the infrastructure asset class not only suitable for efficient portfolio optimization but also for an extension of the investment opportunity set by an investor. One reason for the increased interest in infrastructure assets has led to the emergence of numerous established listed infrastructure facilities in the last decades. Today, the access of investors to these companies is simplified because they only have to buy shares. (LPX AG)

Mezzanine Finance

Mezzanine Finance general

Companies with a high liquidity can use mezzanine finance to fund further growth through expansion projects; acquisitions; recapitalizations; and management and leveraged buyouts. Mezzanine finance (or the use of hybrid debt and equity securities, which is also known as mezzanine debt) can have different forms. What all mezzanine instruments and products have in common is that they offer a risk/return profile that lies between debt and equity. Mezzanine finance is used as an equity substitute to increase the financial leverage of transactions (the ratio of debt to equity). One presupposition is that the senior debt capacity has been maximized and a company's cash flow has sufficient capacity for additional long-term borrowings.

Mezzanine debt can also be used in conjunction with senior debt where it reduces the amount of equity required in a business. Equity is the most expensive form of capital. And since the use of lower cost mezzanine debt in connection with traditional senior debt lowers a company's cost of capital, it makes an impact by the shareholder return on equity. (Silbernagel and Vaitkunas n.d.)

Subordinated Loans

Subordinated loans are debts that are only paid off after all primary loans are paid off. One presupposition is that there is money left. Subordinated loans are also known as subordinated debt, junior debt or a junior security, while primary loans are also known as senior or unsubordinated debt. In comparison, primary loans first have to get paid back if a company faces bankruptcy. Since they are often secured, they are more likely to be paid back. Subordinated loans

are not secured and more of a risk. A subordinated loan can also refer to a second mortgage. (Fisher 2019)

Subordinated Bonds

In case of a debtor's bankruptcy subordinated bonds are paid after the payment of other higher priority bonds, the so-called senior unsubordinated bonds. As subordinated bonds are unsecured they are therefore riskier than older ones.

When facing bankruptcy defaults occur on all of the company's obligations. "The bankruptcy court assigns the company's debts according to the priority of payments and requires the company to pay off existing debt according to the available assets. First, payments are due to holders of preferred shares, then payments will be made for senior unsubordinated bonds and tax arrears. Then come payments on subordinated bonds, if funds remain for this. Holders of ordinary shares receive payments last. Based on the priority of payments, subordinated bonds are also subdivided into senior subordinated, subordinated and junior subordinated bonds. Holders of a subordinated bond may receive a higher interest rate to offset possible losses." (Cbonds)

Convertible Bonds

Convertible bonds give the holder the option to convert or exchange it for a predetermined number of shares from the issuing company. As soon as they are issued, they act just like regular corporate bonds, although with a slightly lower interest rate.

Because convertibles can be changed into stock and, thus, benefit from a rise in the price of the underlying stock, companies offer lower yields on convertibles. If the stock underperforms, there is no conversion and an investor is stuck with the bond's sub-par return—below what a non-convertible corporate bond would get. There is always a tradeoff between risk and return. (Lioudis 2021)

Mezzanine and Hybrid Debt Funds

By way of mezzanine financing companies are able to raise funds for specific projects or to aid with an acquisition through a hybrid of debt and equity financing.

Mezzanine lending is also used in mezzanine funds. These are pooled investments, similar to mutual funds, offering mezzanine financial to highly qualified businesses. (Silbernagel and Vaitkunas n.d.)

Structured Finance

Cash Flow Based Finance

Principles

Cash flow financing describes a form of financing in which a loan made to a company is backed by a company's future cash flows. Cash flow is the amount of cash that flows in and out of a business in a specific period.

Cash flow financing—or a cash flow loan—uses the generated cash flow as a means to pay back the loan. Cash flow financing is helpful to companies that generate significant amounts of cash from their sales but don't have a lot of physical assets, such as equipment, that would typically be used as collateral for a loan. (Kenton 2021)

Land Value Capture

Land Value Capture is a method of financing infrastructure improvements that recaptures all or part of the increase in property value generated by public infrastructure investments. The challenges cities face in raising public funds can be mitigated through this method. At the same time, it offers benefits for private sector partners. The confiscation of rural land enables the development of new residential zones and increases the value of the land. The new infrastructure is financed by future and ongoing revenues from the sale or lease of land in certain zones and the collection of taxes from new landowners. The confiscation of rural land enables the development of new residential zones and increases the value of the land. The new infrastructure is financed by future and ongoing revenues from the sale or lease of land in certain zones and the collection of taxes from new landowners. This principle demonstrates an integrated approach to district heating. By integrating urban planning with transport and district heating planning, the financing of optimal and well-planned district heating projects can be achieved (Sunko et al. 2017).

Asset Based Finance

Fundamentals

Asset-based finance (ABF) finances the acquisition of equipment, machinery, and vehicles by businesses (but also non-businesses such as households and vehicle finance). All the capital raised is used for this purpose. ABF differs from traditional lending and stands on its own as an alternative form of financing. The financed assets secure the payment obligation of the borrower over the term of the contract. In this context, the asset is the collateral, as the financing company retains legal ownership or a prior claim to the asset until the customer has paid it in full. Therefore, the credit decision depends heavily on the customer's cash flow. Financing approval depends on whether a company or customer generates sufficient cash flow from the financed equipment to be able to make the payment or generally has sufficient cash flow to be able to make the payment (Powell 2020).

[Green] Leasing

Since buildings are responsible for a large share of CO_2 emissions, the topic of green leasing is present among stakeholders in the real estate industry. Due to the goals of the EU to become climate neutral by 2050 as well as the EU taxonomy that has come into force, changes have to be made in the area of real estate. Green Lease is about sustainable leases, whereby a property is certified to encourage the tenant to use the property as sustainably as possible and the landlord to manage the property as sustainably as possible. This involves regulations such as cleaning and waste, as well as the infrastructural integration of the leased property and the mobility of the users. Also important is the energy consumption and emissions in the building operation by the tenant and the promotion of sustainable energy sources (KPMG Law n. d.; Deka n. d.).

Sale- and leaseback

With the sale of an object from the fixed assets, the company can release tied up capital and thus provide additional liquidity. If the property is sold as part of the sale-and-lease-back process, it can still be used, for example, to continue producing or delivering goods. Sale-leaseback have to be understood as an important opportunity for a corporate real estate portfolio strategy. Recent changes in debt and equity markets may impact rental rates and may also lead to a lowering of financing costs. (Bryan 2004)

Asset Backed Securities (ABS)

Asset-backed securities are essentially "pools" of smaller assets held by various financial institutions, such as banks, credit unions, and other lenders. Most of the assets are loans provided to individuals in the form of mortgages, credit card debt, or auto loans. Since the loans provide the lender with interest and principal payments, they are assets on the lender's balance sheet.

However, the assets are often small and illiquid and cannot be sold to investors individually. Therefore, financial institutions will pool multiple assets together through a process known as securitization. The process results in new securities with a diversified risk profile, as each security only contains a fraction of the total pool of underlying assets. The interest and principal payments on the assets are also passed on to the investor, as well as the risk.

To create asset-backed securities, loans and other forms of debt are pooled together in a process known as securitization. Securitization can take place with many types of loans, such as commercial and residential mortgages, auto loans, consumer credit card debt, and student loans.

The original interest and principal payments are passed on to the investors, while the risk of default is minimized as each asset-backed security only contains a fraction of each underlying asset. Each pool is separated based on the level of risk, as well as the return. Lower-risk assets can result in lower interest payments, while riskier assets may provide a higher yield. (CFI Education Inc. 2022a)

Derivatives

Forwards and Futures

The following Table 10 puts emphasize to the major differences between Forward and Future contracts.

Options

The term option describes a financial instrument based on the value of underlying securities such as stocks. An options contract gives the buyer the opportunity to buy or sell. This again depends on the type of contract they hold—the underlying asset. The holder is not required to buy or sell the asset if they decide against it. Each contract will have a specific expiration date by which the holder must exercise their option. The stated price on an option is known as the strike price. Options are typically bought and sold through online or retail brokers.

Options belong to the versatile financial products. They need a buyer and seller. The buyer pays a premium for the rights granted by the contract. Call options make it possible for the holder to buy the asset at a stated price within a specific timeframe. Put options, on the other hand, allow the holder to sell the asset at a stated price within a specific timeframe. Each call option has a bullish buyer and a bearish seller while put options have a bearish buyer and a bullish seller.

Options are bought and sold by traders and investor for several reasons. Options speculation allows a trader to hold a leveraged position in an asset at a lower cost than buying shares of the asset. Options are normally used by investors to hedge or reduce the risk exposure of their portfolios. (Chen 2022)

Table 10: Forwards and Futures (Key Differences 2017)

Basis for Comparison	Forward Contract	Futures Contract
Meaning	A forward contract describes an agreement between parties to buy and sell the underlying asset at a specified date and agreed rate in the future.	In a futures-contract the parties agree to exchange the asset for cash at a fixed price and at a specified date in the future.
What is it?	A tailor-made contract	A standardized contract.
Risk?	High	Low
Default	Relatively high because they are based on a private agreement.	Probability does not exist
Where is it traded?	Over the counter, which means that there is no secondary market.	Organized stock exchange.
When is it settled?	On maturity date.	On a daily basis.
Size of contract	Depends on the terms of the contract.	Fixed
Liquidity	Low	High
Collateral	Not required	Initial margin required
Maturity	According to the terms of the contract	Predetermined date
Regulation	Regulated by itself.	Regulated by stock exchange.

Swaps

A swap allows two parties to exchange sequences of cash flows for a predefined timeframe. Usually, at the time the contract is initiated, at least one of these series of cash flows is determined by a random or uncertain variable, such as an interest rate, foreign exchange rate, equity price, or commodity price.

A swap can be considered as either a portfolio of forward contracts or as a long position in one bond coupled with a short position in another bond. (Mccarffrey 2022)

Others

Contracting

EPC is an innovative form of financing energy efficiency measures. It refers to cash flow-based financing instruments and shifts the costs and part of the benefits of energy efficiency investments to an external contractor, which is called an Energy Service Company (ESCO). The ESCO takes care of the energy efficiency investments, guarantees a lower energy bill and can even finance the investments upfront. A pre-negotiated percentage of the savings on the energy bill goes to the ESCO for a fixed contract period. This covers investments and the ESCO's potential profit. After the contract period, the customer will benefit from a significantly lower energy bill. The advantages of Energy Performance Contracting are that both the energy performance risk and, if applicable, the financial investment lie with the ESCO. In addition, proposed energy savings can be achieved due to the expertise and financial interest of the ESCOs. The energy service provider has every incentive to achieve the agreed savings through the design of the energy performance contract (Sunko et al. 2017).

Energy Performance Contracting (EPC)

Business models can either be based on Energy Performance Contracting (EPC) such as ESCO or on Energy-as-a-Service (EaaS) business models. The latter could include, for example, the supply and maintenance of the user substation and helps to ensure the high-performance operation of the system. The investor can be an ESCO and this means that it also bears the responsible for the design, the installation, the management of the network and also the energy consumption billing. The contract existing between the ESCO and the users helps to limit the maximum costs to the ones equivalent to the use of individual gas boilers for heating purpose. (Buffa et al. 2019) Moreover, the cost that can be saved from the energy efficiency improvement is the source of the ESCO's revenue. This money is needed for repaying the project investment. The business structure below shows that the ESCO needs to negotiate with industrial excess heat producers, the heat utility, and potential third-party financiers. (Liu et al. 2020a) (see Figure 56)

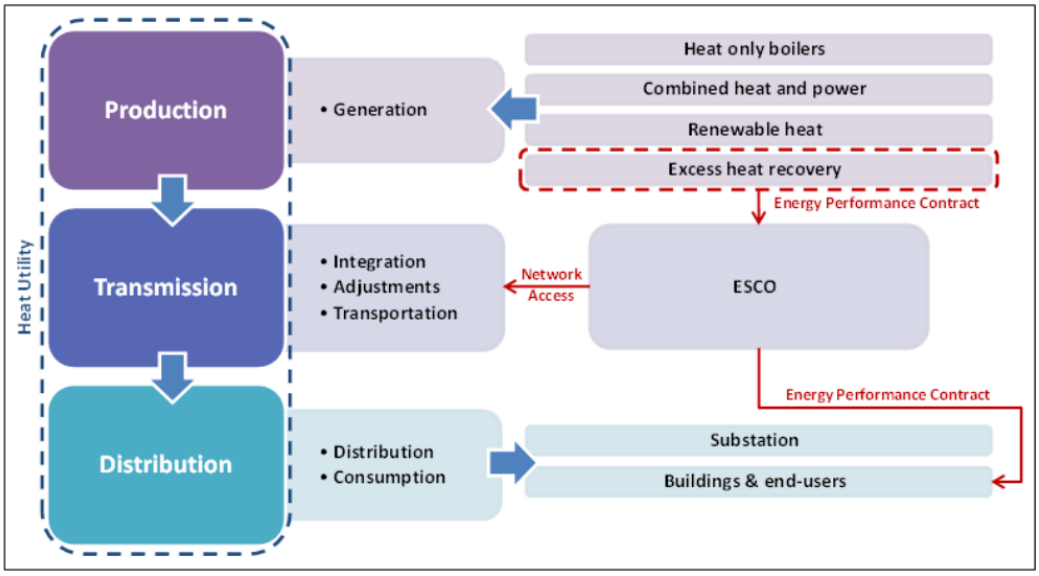

Figure 56: Energy Performance Contracting (ESCO) (Liu et al. 2020a)

Equipment Finance

Equipment finance is the ability of a company to obtain machinery, vehicles or other equipment on a lease or rental basis. This allows the business to operate effectively in a short period of time without having to invest capital in the equipment. Equipment financing is suitable for businesses that have difficulty obtaining financing. The equipment is used as collateral and is taken away in case of default, as ownership is in the hands of the financial institution or leasing company. Equipment finance can also offer tax and accounting advantages. This finance could be a supplement to other funds and could be especially helpful in the early stages (FinanceCorp n.d.).

Crowdfunding

Crowdfunding is a form of alternative finance, which allows to fund a project or venture by raising small amounts of money from a large number of people, via web-based platforms. There are different types of crowdfunding that can potentially be applied in the district heating and cooling sector. However, lending has over time become the preferred crowdfunding instrument. In this type of crowdfunding, the crowd gives a loan and expects an interest-bearing repayment. Lending projects are more prevalent in terms of numbers and have raised the highest volume of funding. Crowdfunding is a fast, flexible and cost-effective financial instrument as there are no intermediaries. However, this instrument is only effective if the project can appeal to a broad mass of potential investors (Euroheat & Power 2018).

N°	Opportunity	Business as usual	Problematic	Blockchain solution	Dependence	Complexity	Blokchain Added Value
a	Communication protocol for IOT services / Pour la communication en particulier je pense qu'il faut trouver la VA ailleurs, car les protocoles actuels sont fiables.	• Data fom communicating devices are centralized • IOT devices are linked to one solution / Platform	• IOT devices can be hacked • Devices are note interoperable • Devices does not communicate with each other	• Secure the communication protocol and interoperability of connected devices • Allow to detect more effectively counterfeits • Allow devices to communicate with each other			
b	Quality of metering and maintenance tasks	• Data is collected by the operator • Data is stored in a local solution or an excel file • Information stays at the operator level	• Data is managed by one entity, it can be modified, lost or erased • If abnormal information is stored, problem to control and transmit the information.	• Data verified • Immutable information • Automation of task in function of data collected • Historical data	a		
c	Manage the billing	• The operator consolidates data (meters, setpoints...) • The operator analyses data and interprets the commitment	• The operator is judge and jury • No one can compare, challenge the information of the billing with the data collected	• Integrity of on-chain data and transparent for every stakeholder (same record of data) • Commitments are automated by the use of smart contracts • Invoice can't be questionned by the consumer	a,b		
d	Optimize Renewables Energies	In a central solution, the operator manages directly the introduction of renewable energy in the mix of heat and cold production	In a decentralized system, it is complicated or impossible to manage the strategies of every contributor	• Strategies (production, consumption, storage in functions of criteria as price, source of energy ...) are implemented in smart contracts. Need to define what is on-chain and off-chain.	a		
e	Enhance Flexibility	• The operator decides to stop a substation • He sends an email to the client or call him • He stops the station remotely	• The client has no visibility on the operation performed (gain, duration, ...) • The operation is manual	• Transparency of every operation • Control of prices fairness • Control win-win operation for producer and consumer	a,c,d		
f	Multi producers loop	not applicable	Heating and cooling district are centralized	• Decentralization of the production • Management of different stakeholders (operator, producers, consumers, ...) and contributors (financing companies, Storage provider...)	a,c		
g	Open market place	not applicable		• Reconciliation of the offer and the demand • Tracing of trades • Justification of the energy origin	a,c,d,f		

Figure 57: Synthesis of Blockchain opportunities in 5GDHC (Faugeras 2019, p. 37)

Blockchain based Financing Instruments

Blockchain based financing instruments are financial products which use the blockchain technology in order to make transactions, contracts and assets more transparent. The advantages of these instruments are an increased security, improved capital and information flow, reduced costs and an improved transparency. (Du et al. 2020) Blockchains can bring significant benefits and innovations to the energy sector when they can be combined with smart contracts. (Andoni et al. 2019) With regard to renewable energy blockchain technology plays an important role in that it offers a decentralized system and also an alternative approach to how the energy market is currently organized: (Budiarto et al. 2022). Figure 57 shows a synthesis of blockchain opportunities in 5GDHC:

5.5.4 Finding New Funding Options for DHCN

In order to bring forth carbon neutrality and to put an end to the EU dependence on fossil fuels, fossil fuel consumption for heating purposes has to be reduced. One option is the further development of district heating and cooling systems and their integration in the energy planning of municipalities and cities. This includes the modernisation of district heating systems as well as the renovation of older instalments. (EU Commission 2023)

This ambitious goal makes it necessary to find new funding options – on the level of subsidies as well as on the financial market:

Public & Subsidized Funding, Grant Capital and Subsidies[12]

The term "public funds" refers to loans and credits that are subsidized by the public sector, i.e. the EU, the state or the province. Public funds are grants from the state that are intended to achieve specific political and economic goals. Subsidies are therefore not simple gifts of money; the recipient is obliged to fulfil the criteria of the subsidy program. Looking at the energy sectors, total investments are expected to grow by more than 4% per year, increasingly moving towards non-fossil and decarbonization technologies. Business models in a highly decarbonized system are also expected to remain uncertain, and these will likely rely on adjustments to market design, subsidies, and other support mechanisms (McKinsey & Company 2022). The EU Taxonomy and the Green Deal Investment Plan are supportive in this area, including an increase in public (and private) funding for sustainable investment to over €1 trillion by 2030 (Friedrich and Wendland 2021). District Heating projects sometimes purchase electricity with certificates of origin, which provide access to financial support, such as renewable energy investment subsidies (European Commission 2022b)

Grant Capital

Grants from public and multilateral institutions make up the largest share (approx. 30-50 %) in the financing structure of DHC projects. DHC projects are often municipally owned or supported.

[12] This paragraph contains results of a term-paper project in the Smart Sustainable Finance-module (Prof. Dr. Tobias Popovic) as part of HFT Stuttgart's Master's programme Smart City Solutions in 2020. Thematically the term paper-assignment was linked to REWARDHeat.

Grants are a key element in the financing of DHC projects, as they reduce investment costs and thus enable competitive consumer prices for heating and cooling. It also allows municipalities to make better use of their project funds if they participate more in the business model. If the project is not bankable on its own or has specific risks that private investors or lenders cannot handle, government support through subsidies/grants, equity participation and/or debt is particularly useful. However, it must equally be considered that obtaining grants is extremely costly, complicated and competitive. Moreover, according to Skryl et al. (2017), subsidized projects can delay the process of energy efficiency commercialisation. Nevertheless, subsidies are a popular and suitable option in the financial structures of DHC projects, as they do not require repayment.

Subsidies

Subsidies are financial government grants that are not linked to a direct service in return. They flow directly (financial aid) or indirectly (tax concessions), whereby recipients of subsidies can be (other) states, companies or also private households. (At least in Germany) Subsidies can be distinguished between adjustment aid, maintenance aid and productivity aid. Adjustment subsidies serve to change existing structures of enterprises and economic sectors. This is intended to provide relief during structural change and to promote adjustment processes. Maintenance aid traditionally comprises the largest item within subsidy policy. The aim is to promote certain sectors whose preservation is socially and politically desirable. Agriculture plays a major role here. For DHC projects, productivity support is an interesting point. These are intended to promote the productivity progress of enterprises and economic sectors, especially in new forward-looking and growth-promising industries such as energy and environmental technology (Buhr n. d.). In the EU, fossil fuel subsidies have decreased in 2020, while renewable energy subsidies and energy efficiency subsidies have increased (European Commission 2021c).

Guarantees

Financial guarantee contracts, or credit insurance contracts, require the guarantor to make specified payments to reimburse the guaranteed party for losses it incurs as a result of a specified debtor's failure to make payments due in accordance with the original or modified terms of a debt instrument. Some financial guarantee contracts result in a transfer of significant insurance risk and therefore meet the definition of an insurance contract' in IFRS 4 Insurance Contracts (Deloitte n. d.).

European Union (EU)

Horizon 2020 is the European Union's Framework Programme for Research and Innovation, announced by the European Commission to run from 2014 to 2020. It covers the entire innovation chain and offers a wide range of funding and support measures at European level. Horizon 2020 is open to any legal entity from an EU Member State, an Associated State or a third country. Legal entities can be natural persons or legal persons (i.e. private or public bodies). In principle, a research project must involve at least three independent institutions from three different EU member or associated states. In most cases, however, the number of partner institutions in successful project proposals is above this minimum requirement. Additional requirements for participation are anchored in the respective work programme. (Horizont 2020 2021).

The total budget in constant prices is EUR 70.2 billion. However, considering the increase in inflation, the amount available to the programme since 2014 is almost EUR 80 billion. The following chart shows which areas are covered by the Horizon 2020 budget and to what extent (European Commission 2013) (see Figure 58):

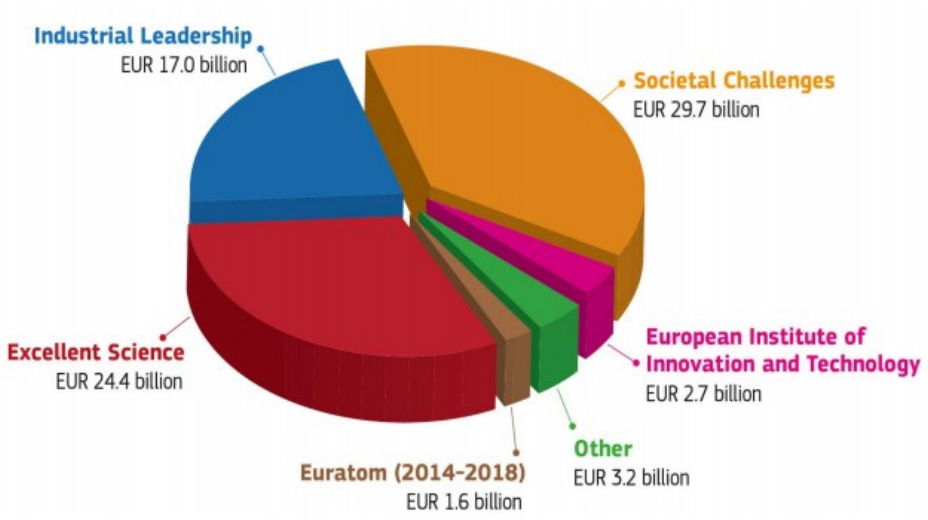

Figure 58: Division of the HORIZON 2020 Budget in current prices (European Commission 2013)

In addition to the classic cooperation projects, individual funding is also possible in some programme areas. Horizon 2020 provides targeted funding for small and medium-sized enterprises (SMEs). Support is provided to individual companies up to market launch with grants and optional risk financing (Horizont 2020 2021).

Instruments to support RES heat and cooling

To reduce the energy demand in the heating and cooling sector is a goal of the EU. For example, energy demand can be reduced by energetic building renovation and by employing more efficient energy conversion technologies. Moreover, it is also a matter of fact that innovation in the heating and cooling sector can also accelerate the transition to more efficient energy systems. (van der Veen and Kooijman Esmee 2019) (see Table 11):

Table 11: Relevant support program instruments for DHCN (Van der Veen et al. 2019)

Program	Description	DHCN
CEF Energy	The program supports demonstration projects that increase energy security of supply, it integrates the EU internal energy market and that also integrates renewable energy sources into the network. The development of smart grids and CO_2 networks. Energy ➔ Energy-related solutions, such as district heating and cooling networks, could be supported under CEF Energy.	X
ELENA	The development of energy related solutions for energy efficiency, such as district heating and cooling can be	X

	(co)financed under ELENA. In order to make the mobilisation of funds for investments in sustainable energy at local level easier, ELENA supports beneficiaries in the preparation process of large sustainable energy investment programmes in cities and regions. These project development activities include all solutions for increasing energy efficiency or savings: among them are thermal insulation, efficient air conditioning and ventilation or efficient lighting; Integration of renewable energy sources (RES) into the built environment – e.g. solar photovoltaic (PV), solar thermal collectors and biomass; Investments into renovating, extending or building new district heating/cooling networks, based on highly efficient combined heat and power (CHP) or renewable energy sources and also decentralised CHP systems (building or neighbourhood level)	
PDA	The program supports technical, economic and legal expertise needed for the project development and leads the way to the launch of concrete investments. These are the final aim and deliverable of the project. This includes not only the development of energy efficiency projects in existing public and private buildings, industry and service, transport and existing infrastructure, but includes also district heating and cooling project preparations.	X
URBACT II	The goal of the program is to supports urban sustainable policies and practices in general. Thereby it focuses on knowledge and capacity building. Energy related solutions could be a topic under this, although projects implementing solutions are not eligible.	X
UIA	The program supports pilot projects for identification and testing of new solutions addressing issues related to sustainable urban development. Energy related solutions could be part of this, as long as it does not focus on the technical implementation of solutions, but includes also innovation and participatory approaches.	X
NER 300	The program supports innovative low-carbon energy demonstration projects in the area of RES and CCS technology. Energy related solutions, such as smart energy grids, could be supported under the presupposition that these projects are innovative and impactful. This means that these projects either have to 1) demonstrate a cost-effective low-carbon technology that has so far not been sufficiently demonstrated at pilot scale or 2) implement technologies that are already (largely) proven but largely not in commercial application yet. District heating	X

	and cooling networks could meet these requirements.	

Subsidies

Investment subsidies: for demonstration and market introduction.

Investment subsidies are believed to be more effective at the demonstration and market introduction phase, than during the deployment phase with a larger emphasis on stimulating production of renewable energy. Investment grants could be converted in equity (government participation) or debt after successful commissioning of a project. Doing so the effect on the government budget can be kept to a minimum.

5.5.5 National

Kreditanstalt für Wiederaufbau (KfW)

The "Kreditanstalt für Wiederaufbau" is a state-owned development bank based in Frankfurt. It promotes investments in CHP plants and heating systems that are powered by renewable energies. KfW's funding products are available in two different forms - as a directly paid grant or as a loan. A loan with a repayment subsidy, where the loan amount does not have to be repaid in full, is an additional special form. Through these programmes, project promoters receive long-term financing at low interest rates and can receive a repayment subsidy of up to 50% (KfW 2021).

Germany's Ministry for Economic Affairs and Energy (BMWi)

The Federal Ministry for Economic Affairs and Energy (BMWi) launched a new funding programme for "District Heating Pilot Projects 4.0" on 1 July 2017. The realisation of the networks can be funded with up to 50 % of the project costs. For other activities related to the project, such as consumer advice and participation of local research institutions, there is the possibility of 100% funding. To be eligible for funding, district heating networks must cover at least 50 % of annual heat consumption from renewable energy sources or waste heat. However, no more than half of the renewable heat supply may be generated from biomass. The support scheme also includes low-temperature networks - a focus of the EU REWARDHeat project (BMWI n.d.).

[Exkursus – Canada: Low Carbon Economy Fund (LCEF)]

The Fund supports the 'Clean Growth and Climate Change' framework by leveraging investments in projects that generate clean growth, reduce greenhouse gas emissions and help meet or exceed Canada's commitments under the Paris Agreement. The fund will also help create jobs, support investment and reduce energy bills. The fund is composed of the 'Low Carbon Economy Leadership Fund' and 'Low Carbon Economy Challenge'. The Low Carbon Economy Leadership Fund provides up to $1.4 billion to provinces and territories that have adopted the framework. Provinces and territories can receive funding up to $30 million each plus funding based on population size. The Low Carbon Economy Challenge provides a total of around 500 million dollars for suitable projects (Canada.ca n.d.).

5.5.6 Regional/Municipal

Climate and Environment Pact [KLUP] – Salzburg, Austria

The KLUP (Climate and Environment Pact) promotes projects for the increased application of new technologies in climate protection and air pollution control. The KLUP is intended as a supplement to the funding opportunities offered by domestic environmental funding and klima:aktiv mobil. The funding amounts are based on the CO2 savings achieved (KLUP 2021).

The support programme provides some subsidies for DHCs. Two of the programmes are the "District Heating Offensive" and the "District Heating Network Expansion". The subsidies paid out by these two programmes are relatively small. The maximum for the "District Heating Offensive" programme is 20,000 euros per project, while the maximum for the network expansion programme is 50,000 euros (Fazeni 2015).

KommuneKredit – Denmark

KommuneKredit is a non-profit organisation whose membership is limited to Danish municipalities and regions. KommuneKredit's mission is to ensure cost-efficient financing for its clients. Among its clients are Danish municipalities, regions and other entities that benefit from a 100 per cent municipal guarantee. It offers low-cost long-term loans with an interest rate currently around 1 % (KommuneKredit 2021).

EU Modernisation Fund

The core of the Modernisation Fund is a funding programme to support 10-lower-income Member States of the EU to drive the transition to climate neutrality. The main approach is to help renewing their energy system and to improve their energy efficiency. The Member States benefitting from this programme are Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania and Slovakia. (European Commission) (see Figure 59)

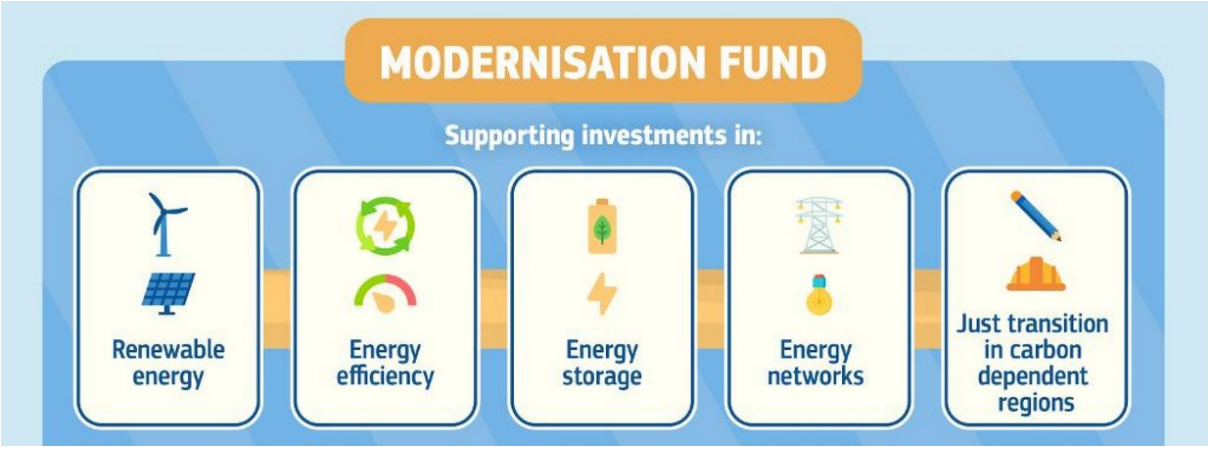

Figure 59: Investments of the Modernisation Fund (European Commission)

The Modernisation Fund is part of the European Green Deal Investment Plan and is one of the key funding instruments for implementing the goals of the European Green Deal. The total revenues of the Modernisation Fund are €48 billion starting from 2021 to 2030 (at € 75 / tCO2). This is linked to the carbon price. Around €28 billion come from the allowances of beneficiary Member States

which have been agreed to finance the Modernisation Fund from their resources under Article 102(b) and 10(c) and around €20 billion results from the auctioning of 2% of the total EU ETS allowances from 2021 to 2030. (European Commission)

In order to prevent loopholes in the current set-up bearing the danger of leading to a continued usage of fossil fuels a number of principles and requirements have been set up:

Projects have to compatible with the objectives of the Green Deal that is climate neutrality, zero pollution and implementation of transition objectives preventing the further use of fossil fuels.

The Modernisation Fund is a driver for the just transition of the economy without promoting fossil fuels. As such it corresponds to the EU's commitments under the Paris Agreement. (EEB-European Environmental Bureau 2021)

Life Clean Energy Transition Call 2023

The EU Programme for Environment and Climate Action is called LIFE Programme. It is one of the key instruments of the Green Deal directed at the following points: (CINEA 2023)

Transformation of the EU to a fair and successful society including a modern, resource-efficient and competitive economy without net emissions of greenhouse gases in 2050. Economic growth will be separated from resource use and

protection, conservation and enhancement of the EU's natural capital as well as protection of the health and well-being of citizens from effects caused by environment and climate related risks.

The LIFE Programme is structured in two fields and four sub-programmes:

- Environment: (CINEA 2023)

sub-programme: Nature and Biodiversity

- sub-programme: Circular Economy and Quality of Life
- Climate Action:
- sub-programme: Climate Change Mitigation and Adaptation
- sub-programme: Clean Energy Transition

"The Multiannual Financial Framework (MFF) is not ready yet, so this information is based on conferences, proposals. It is not sure that the programme will remain as the proposed regulation." (OCTA 2020) (see Figure 60):

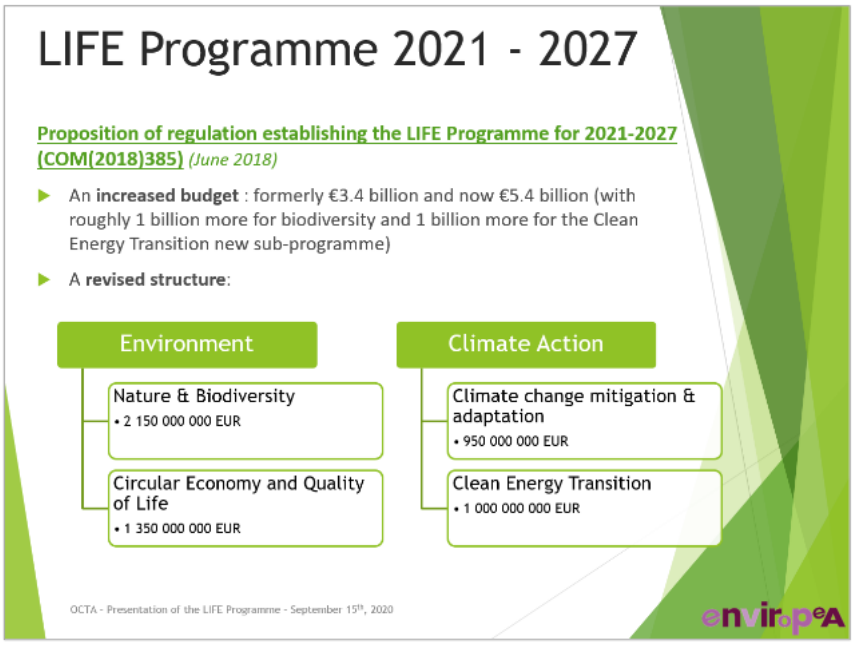

Figure 60: LIFE Programme (OCTA 2020)

CET Partnership Joint Call 2023

The CETPartnership Joint Call 2023 is the second annual co-funded call under the CET Partnership Joint Call 2023. 12 Call Modules have been brought into being to cover different topics and RDI types. The topics dealt with in this Modules are different energy technologies and/or systems as well as both research and innovation-oriented approaches on various Technology Readiness Levels (TRLs), complementing and completing each other. These Modules also contain subjects such as "Heating and cooling technologies" (Call Module CM2023-06). (CET Partnership 2023) (see Figure 61)

Figure 61: CM2023-06: Heating and cooling technologies (CET Partnership 2023)

Moreover, the CETPartnership Joint Call 2023 is divided into a regional and international part. (CET Partnership 2023)

State Aid Corner: New Dutch Funding Scheme for District Heating

This new state aid holds a budget of €150 million of subsidies for this year and its goal is to support the implementation of efficient heating networks substituting heating based on fossil fuels such as natural-gas. Until now it is not decided if this subsidy programme will be increased for the coming years. It is still time to submit applications until December 16, 2023. (Euroheat & Power 2023b)

State Aid Corner is a subsidy scheme whose goal it is to accelerate investment in heating networks. This investment in infrastructure is a cornerstone in reaching the Dutch government's climate goals

to reduce CO2-emissions by 49% by 2030. As such it is directed at future investment and to accelerate the implementation of projects already decided. (Euroheat & Power 2023b)

5.5.7 Investors and their Investment Characteristics

Today, sustainability has become a major concern for infrastructure investors and lenders and is seen as an attractive business opportunity. Despite their increasing interest in sustainability infrastructure, many investors lack the tools and skills to properly assess ESG risks within their portfolio and thus aren't able to exhaust the benefits related to sustainable infrastructure investments. In a 2014 survey conducted by Novethic (Caisse de Depots) with over 185 infrastructure asset owners across Europe, over 65% of respondents stated to have an ESG analysis as part of their investment selection process (Kamelgarn and Blanc 2014), leaving plenty of room for growth. (Da Canas Costa and Popović 2020)

The following Table 12 will give an overview of the key investor constraints keeping distinct investors groups such as life insurers and pension funds:

Table 12: Investors and their investment characteristics (Tonkonogy et al. 2018)

Investor group	Investor Constraints	Explanation
Institutional investors	Investor requirements do not fit to liquidity, risk, and the profile of an energy project	The majority of institutional investors and pension funds in particular, which often are pro-clean energy projects) normally invest in traditional, typically liquid assets (cash, bonds, publicly traded stocks and asset backed securities). In 2014, of all investments only 15% were invested in illiquid assets (real estate, mortgages, private equity, hedge funds and infrastructure. This knowledge base was established by an OECD-study screening the asset allocation of pension funds in 34 countries.(OECD 2015a) There are less investments in clean energy belonging to the infrastructure asset class.(Tonkonogy et al. 2018)
	The capacity of institutional investors and the investment profile of the project do not fit	Most institutional investors lack the capacity of directly investing in unlisted energy assets. The largest institutions left aside, there are smaller institutions which are prevented from investing directly because of high transaction costs, large minimum ticked sizes[13] and the costs keeping requisite deal teams.(Tonkonogy et al. 2018)

[13] To contextualize this, the average range of pension fund and insurance company investment into private equity (as a proxy for direct investment) is $13-$53
million. SWF range from $46-118 million (see WEF, 2013). Tonkonogy et al. 2018.

Commercial Banks	Commercial banks are known for being critical investors in all states of the project lifecycle. They are faced with some barriers that may prevent them from investing in clean energy projects.	Basel III regulatory requirements demand greater liquidity and lower leverage. The goal is the reduction of risk and to prevent unintended consequences. ⇨ This may lead to a limitation of long-term investment by international commercial banks.(Tonkonogy et al. 2018)

5.6 Risk Analysis, Mitigation and Management

One major challenge of the transformation of the heating sector is the increase in decentralized heat generation. The decarbonization of the heat supply makes it necessary to integrate more renewable sources into the grids and to make greater use of the locally available waste heat potential from so-called prosumers. This integrates companies into the system which not only draw heat from the grid, but also feed heat in, e.g. this can be waste heat from industrial processes. The ongoing and necessary decentralization of heating networks relying on volatile, distributed feed-in can no longer be managed by classic operating routines used by central heat sources. (Mohring J. 2024)

A decentralized high-quality infrastructure is viable for a successful heat transition and it is also the basis for a sustainable socio-economic development. Although infrastructure is one of the most important investment targets, it suffers globally from an investment gap of USD 2.5-3 trillion p.a. Even before the pandemic there has been agreement that this deficit cannot be compensated by the public sector alone. The pandemic has only pointed to the necessity of mobilizing private capital more urgently. In order to mitigate the risks connected to these investments, the financial institutions are actively using de-risking and other interventions in order to mobilize private capital more urgent. (OECD 2021)

Financial de-risking instruments

Financial instruments can contribute to the mitigation of (regulatory) risks in private infrastructure investment. In the same way can investment strategies help to reduce financial risk. (Jamison et al. 2005)

There are different de-risking instruments of which some shall be picked out and explained: (see Figure 62)

De-risking Instruments	
NAME	**DESCRIPTION**
Co-investment (Project Equity)	Public actor(s) provide equity alongside private investor(s) directly at the project level. Equity stake of public actor(s) may be equal or lower than that of private investor(s).
Co-investment (Equity Fund)	Public actor(s) co-capitalise an unlisted fund alongside private investor(s) (as a limited partner). The fund provides equity to projects.
Co-investment (Debt Fund)	Public actor(s) co-capitalise an unlisted fund alongside private investor(s) (as a limited partner). The fund extends debt to projects.
Co-financing	Debt provision by a public actor(s) alongside other private financiers, directly at the project level.

Figure 62: De-risking instruments (OECD 2021)

Different risks occurring in infrastructure projects differ from life-cycle stage to life cycle stage. Therefore, also the risk transfer and mitigation instruments need to be specifically adapted to the individual risks. The following illustration provides an overview on which instruments might be suitable for which stage. (see Figure 63):

	Strategy / Development / (Re-)Investment	Construction / Refurbishment	Operation / Maintenance	Termination / Sale
Risks (focus on cash flows)	• High investment volume • Lack of suffiicient funding • Inflation/interest rates • Long time horizon • Project complexity/feasibility • Technological • Regulatory • Environmental • Etc.	• Governance • Permits/contracts • Construction delays • Inflation/interest rates • High cash ouflows due to CAPEX	• Governance • Qualitative deficit of infrastructure /services • Stakeholder (esp. customer) acceptance • Demand volatility • Inflation/interest rates • Refinancing/liqudity • Counterparty default	• Contract duration • Decommissioning risk • Asset transfer
Risk transfer & mitigation	• (State) guarantees • Insurance • Derivatives	• (State) guarantees • Insurance • Derivatives	• (State) guarantees • Insurance • Derivatives	• (State) guarantees • Insurance • Derivatives

Figure 63: DHCN in the context of the infrastructure finance lifecycle risks and risk transfer. Source: (Popović 2022b) based on (Radford et. al. 2019), (Ehlers 2014); (OECD 2015b)

Since investors vary in their risk appetite, not every type of investor is willing to invest in all stages of the infrastructure lifecycle.

The renewable energy projects lifecycle typically includes three stages of development: The development stage, the construction stage and the operational stage. Normally, the risk is decreasing while the project is moving towards operation. Due to the changing risk and return profiles throughout the project lifecycle, there are different types of equity and debt investors involved in the different stages of the project and they tend to use those vehicles that matches with their risk appetite. (Tonkonogy et al. 2018) The following figure shows the typical participants at each stage of the project lifecycle: (see Figure 64)

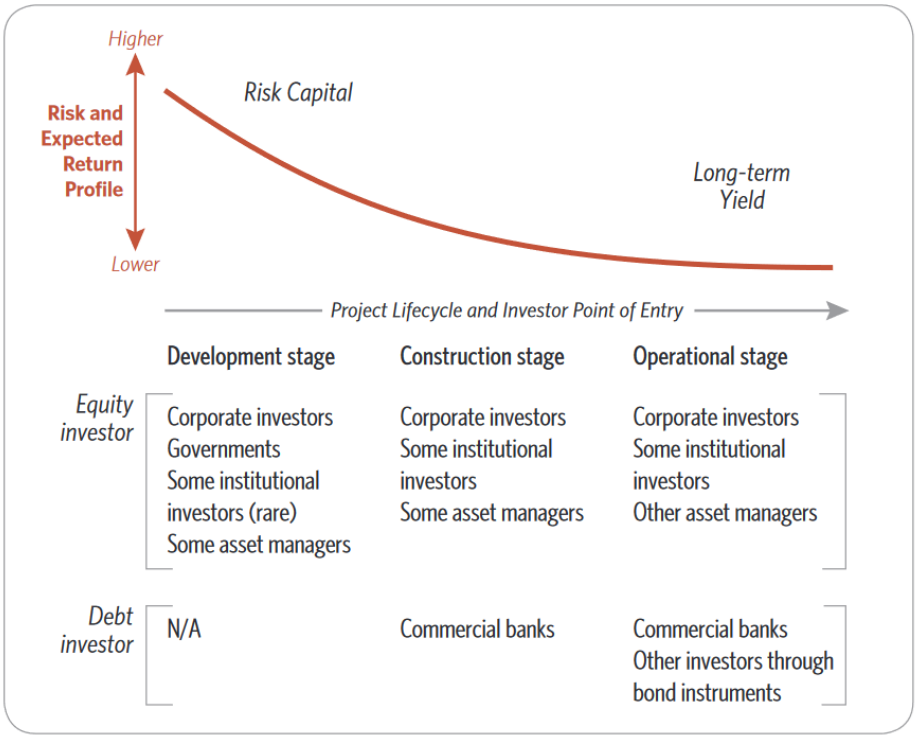

Figure 64: Risk return requirements at each renewable energy project stage (Tonkonogy et al. 2018)

The same is true for the applicability of financing instruments. They also vary from one life cycle stage to the other and are linked to be investors' interests. The following illustration gives an indication on the potential availability of financing instruments and investors across the different life-cycle stages. (see Figure 65)

	Strategy / Development / (Re-)Investment	Construction / Refurbishment	Operation / Maintenance	Termination / Sale
Investors	• **Equity sponsors**, e.g. - Utilities - Governments/ municipalities/ multilateral institutions - Infrastructure funds - Private equity - Pension funds? • **Debt investors**: - Promotional banks - Multilateral institutions (e.g. EIB) - Bank syndicates	• **Equity sponsors**, e.g. - Utilities - Governments/ municipalities/ multilateral institutions - Infrastructure funds - Private equity - Pension funds? • **Debt investors**: - Promotional banks - Multilateral institutions (e.g. EIB) - Bank syndicates	• Investment funds • Infrastucture funds • Pension funds • Sovereign Wealth funds • (Re-)Insurance Companies	• Investment funds • Infrastucture funds • Pension funds • Sovereign Wealth funds • (Re-)Insurance Companies
Financing Instruments	• Subsidies • Blended finance/PPP • (Private) Equity • Debt: - Promotional loans - (Syndicated) (Green) Loans, ESG-linked Loans - (Green) Bonds, ESG-linked bonds?	• Subsidies • Blended finance/PPP • (Private) Equity • Mezzanine • Debt: - Promotional loans - (Syndicated) (Green) Loans, ESG-linked loans - (Green) Bonds, ESG-linked Bonds?	• (Green) Bonds • (Green) Loans • ESG-linked Bonds • ESG-linked Loans	• Leveraged finance • M&A-transaction • Trade sale • Initial public offering (IPO)

Figure 65: DHCN in the context of the infrastructure finance lifecycle Source: (Popović 2022b) based on (Radford et. al. 2019), (Ehlers 2014), (OECD 2015b)

5.6.1 Investor-Financial-Instruments-Matrix

Once the owners and/or operators of a DHCN have identified their particular financing needs and the corresponding financing instruments, it is crucial to find investors that would be willing to provide the funding through these instruments. The following table provides an indication on what kind of investor potentially would be willing to invest in a DHCN-project through which financing instruments. (see Figure 66)

	Equity	Mezzanine	Debt	Structured and Cashflow Based Finance	Grants / Subsidies / Subsidized Funding	Blended Finance	Others, e.g., Contracting
Public Institutions	+	-	o	+	+	+	o
Banks	-	o	+	-	o	+	-
Investment Funds	+	o	+	-	-	o	-
Pension Funds	+	-	+	-	-	o	-
Insurance Companies	+	o	+	-	-	o	-
International/ Multilateral Financial Institutions	-	-	+	+	+	+	-
Industrial Investors (e.g. Utilities)	+	o	-	-	-	o	o
Legend: + applicable, o partly applicable, - not applicable							

Figure 66: Investor-Financial-Instruments Matrix (based onPopovic 2013, p. 56)

5.7 Blended Finance

5.7.1 Definition

Blended finance is a financing concept in the area of sustainable infrastructure finance aiming effectively at implementing critical, but hard-to-fund investment projects. (Bank of America 2023) Moreover, blended finance projects are based on the commitment of public funds at below-market rates – this can either be public institutions or third-party donors. The strength of this concept is that governments, local entities, or development banks can become co-investor, or act as guarantors so that the risk of the project can be diminished. This increases trust and helps drawing in private investors. The lifecycle of clean energy projects typically includes three stages: the development stage, the construction stage and the operational stage. Normally, the risks connected to the project tend to decrease once the project moves towards operation. The changing risks and return profiles during the lifecycle attract different types of equity and debt investors and this means that different investor types are active in different stages of the project through vehicles matching their risk willingness to take risks. (Tonkonogy et al. 2018) (Popovic, T., Lygnerud, K et al. 2023)

5.7.2 Objective

The objective of blended finance is related to the Sustainable Development Goals and the Paris Agreement, which both support two separate – but related – objectives:

1.) The achievement of universal energy access by 2030 and
2.) To keep global warming below 2°C by implementing decarbonization

Both objectives have important differences that affect investment and the need for blended finance instruments. (Tonkonogy et al. 2018)

Blended finance is defined as the strategic use of development finance in order to mobilize additional finance towards sustainable development in developing countries. (OECD n.d.) Blended finance projects "involve the commitment of public funds at below-market rates, e.g. by a public institution or third-party donors. With governments, local entities, or development banks co-investing, or acting as guarantors, the cost of the project decreases, and the risk-return profile improves, thus drawing in private investors that would otherwise be unwilling to invest, as they would consider project as either too risky, or unprofitable. If projects are cheaper and less risky, they are also more bankable, meaning that private investors can access bank loans more easily, or issue sustainable bonds to cover their costs. Figure 6 shows the four-stage life cycle of typical blended finance projects." (Eurosif and Kyoko 2021, p. 25)

It is therefore possible to say that blended finance is an effective way to address market distortions occurring from policy failures in pricing-in externalities. It allows the utilization of catalytic capital from public or philanthropic sources and this makes it possible to create societal or environmental benefits that cannot be realized otherwise. At the same time, it creates a way for improved risk-adjusted returns for private investors. Blended finance also helps to balance risk-return profiles for investment opportunities and can thus help to promote investments in climate solutions and future technologies in both developed and emerging markets. (UN-convened Net-Zero Asset Owner Alliance 2021)

If projects are cheaper and less risky, they are also more bankable, meaning that private investors can access bank loans more easily, or issue sustainable bonds to cover their costs. (Eurosif and Kyoko 2021) The key idea of blended finance structure is, that one party, preferably a public institution (e.g., a municipality, a publicly-owned utility) takes the highest risks, for example by investing equity, providing grants or guarantees, or by taking the first loss piece. For private investors on financial markets this reduces the investment risk, which makes the risk-return-relationship of the investment favourable for them. This increases the investment's attractiveness creating incentives for private investors to decide for an investment. The objective of this de-risking approach is to mobilise as much as possible private capital from financial markets. (Bank of America 2023)
Another advantage of blended finance is the splitting. This makes it possible to choose among different risk tolerances. Investors willing to take higher risks (e.g., public institutions) can act as a "capital cushion" for investors who need to take less risk (e.g., commercial investors). Blended finance has been increasingly implemented in emerging markets and developing countries, but has largely been neglected in the context of the heat transition in industrial countries. (Global Impact Investing Network 2023; Bank of America 2023; Popovic 2023) (see Figure 67).

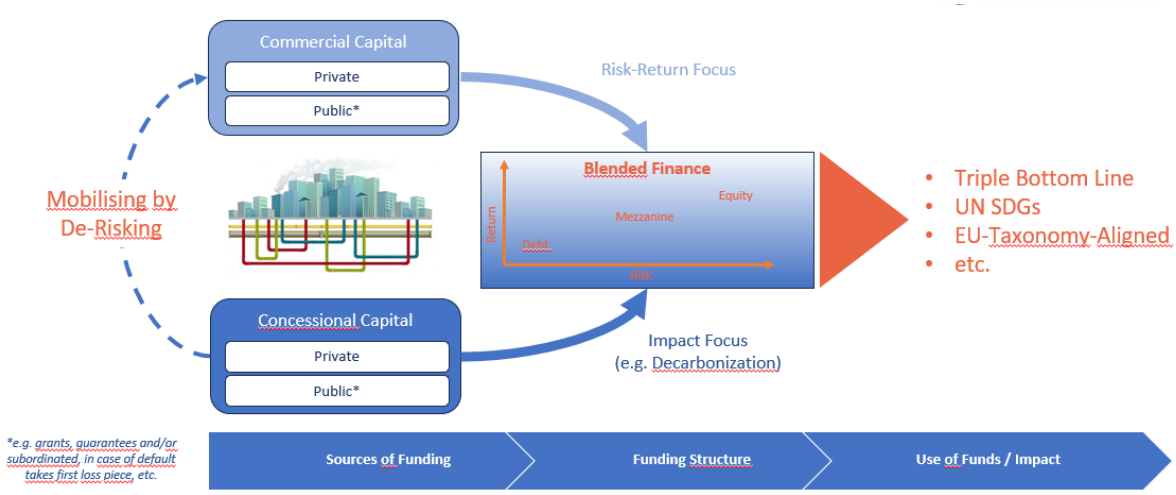

Figure 67: Blended Finance – a Conceptual Overview (Popovic 2023; responsability 2020; OECD 2018)

Instruments like blended finance can be a help in mobilizing commercial investment towards clean energy projects. The provision of private financing makes it possible to compensate the lack of public resources in this field. A most prominent example of government funding blended with private capital is Germany's CO_2 Building Rehabilitation Programme (CBRP). The KfW – Germany's state bank – provides loans to households arranged through commercial banks. (Brown D. et al. 2019)

Supporting hybrid financing schemes

To attract investors, innovative financial instruments such as blended finance should be leveraged, emphasising impact-oriented financing, insurance, and subsidised financing. As part of sustainable infrastructure finance, blended finance is a concept designed to facilitate the implementation of critical, yet challenging-to-fund investment projects. This approach hinges on the utilisation of public funds at rates below the market standard. The distinctive strength of blended finance lies in its capacity to engage governments, local entities, or development banks as co-investors or guarantors, resulting in a reduction in project costs and an improvement in the risk-return profile. This mechanism attracts private investors whose higher investment risk compared to other sectors is mitigated in this way, to an extent that it makes the risk-return relationship favourable. Private investors, such as investment funds, can benefit from a sustainable investment opportunity in DHC infrastructure, ideally aligned with the EU Taxonomy. (EU Commission 2024b)

In order to unleash blended finance's full potential, a regulatory framework at EU-level is needed. A more flexible regulatory-(tax)-framework for investment funds is considered necessary. Furthermore, establishing national financing agencies/platforms for municipalities, modelled after successful initiatives, e.g., in Denmark and France, is posited as a potential mechanism to streamline and bolster financial support for sustainable infrastructure projects. Conversely, utilities, mostly small-size municipal ones, are encouraged to view financial markets and institutions as important partners, in successfully navigating the complexities of the clean energy transition. (EU Commission 2024b)

Against the backdrop of the multitude and heterogeneity of the different regulatory frameworks, many stakeholders see the risk of a regulatory "overkill". In particular, Taxonomy regulations are considered to be too complex and too bureaucratic in their application. With respect to the SFDR, an increasing number of investment funds seem to avoid classifying their investments accordingly.

Thus, more simplification and standardisation are needed. In this context the integration and harmonisation of various regulatory frameworks is crucial, with a particular emphasis on harmonising the EU Taxonomy with EPBD, EED, and RED.

Although the most common types of blended finance are concessional capital and credit enhancement (risk insurance), blended finance is also very often combined with grants including technical assistance. This contains not only capacity building, but also knowledge-sharing with the beneficiary. The goal is to enhance its commercial viability and to provide help with the transaction preparations. (EU Commission 2024b)

Creating an Ecosystem for Blended Finance

Governance and investor relations as a basis for blended finance

The precondition of an attractive investment environment are governance and investor relations: (NGFS 2023) In a blended finance context, governance and investor relations can be defined as follows:

- In a blended finance context, the focus of governance lies on managing and evaluating blending operations. It addresses management and organizational challenges and makes sure that evaluations help to improve the knowledge base on blended operations. (Andersen et al. 2019)
- In this context investor relations involve strategies to manage the relationships between organizations and financial stakeholders. They also play a role in a coordinated communication strategy. (Dolphin 2003)

Both has to rely on an appropriate institutional, legal and policy framework to which climate policies belong. A high measure of regulatory clarity is also necessary when regarding the complexity of some blended finance structures. This also includes securitization vehicles. Moreover, very important is a strategy on climate information, which includes reliable and comparable climate data, internationally interoperable taxonomies/classifications and also climate disclosures. It is also important to assess price, management risks and opportunities. (NGFS 2023)

Technical Assistance

Technical assistance includes different types of services which are directed towards financial beneficiaries and/or financial intermediaries. The overall goal is to improve the skills of these actors in supporting them with the performance of business modelling, financial planning, report and risk assessment, etc. Technical assistance is not only relevant for a trouble-free planning and preparation capacity of the project promoters, but also to improve their ability of benefiting from financial instruments. The schemes of technical assistance are often connected to loans or grants to SMEs (Small and medium-sized Enterprises), Midcaps or public sector entities. Mostly they refer to environmental impact assessments, feasibility studies or they help to support regulatory and policy matters. (EU Commission 2024b)

The development of technical assistance schemes may support project promoters with their financial planning and business modelling so that they can submit solid plans to investors and financial institutions. This signalizes the investment readiness of the projects and represents the

basis for accessing other external financing options. The combination of technical assistance with financial instruments such as loans or grants makes it easier to acquire and implement those instruments and this again helps to support well-defined and more mature project proposals. (EU Commission 2024b)

Potential for Clean Energy Investing

What makes Blended Financing instruments so interesting for clean energy investing is the use of "concessional" capital from various sources. These can be public sources, such as climate funds, but also philanthropic sources like foundations.

1.) Blended finance instruments help to shift the risk from the private sector to the public sector

Different tools make it possible to shift different risks that mean obstacles to investments into clean energy.

2.) Blended finance can address perceived risks as well as real risks

Very often the source of perceived risks is a lack of understanding of the technology used, the design of the business model, the team, the investment strategy or the asset class. Blended finance initiatives are aimed at reducing risks through its implementation. In contrast, real risks are those kinds of risks and obstacles that cannot be reduced by a blended finance initiative. These risks are often macro-economic risks like currency risks or risk such as a lack of trustworthiness that cannot be overcome. The only way to overcome this risk is to shift it to another party at the project level through the use of blended finance tools. (Tonkonogy et al. 2018). The following table gives an overview of Blended finance instruments:

INSTRUMENT TYPE	DESCRIPTION	EXAMPLES	ADDRESSES WHICH SPECIFIC RISKS/ BARRIERS
Direct Investment	Debt or equity instruments with direct contribution into a blended finance vehicle (e.g., project or fund)	Junior/ subordinated capital (e.g., concessional equity & debt)	Multiple risks including off-taker risks, construction risks, revenues attractiveness, etc.
		Commercial capital (catalytic when used for demonstration effect, also known as "anchor capital")	Access to capital
Guarantees	Generally, three party agreements, where a third party provides an extra layer of protection for the beneficiary of a service, e.g. debt service, in case the entity who would normally provide a service fails to do so	Loan guarantees	Access to capital, counterparty / off-taker / credit risk
		Performance guarantees	Technical risk
Hedging instruments, swaps, and derivatives	Contractual instruments to help manage different types of risks faced by an investor or borrower	Local currency hedges/swaps	Currency risk
		Securitization	Liquidity/time horizon, scale, counterparty / off-taker / credit risk
Insurance	Two party contracts between the insurer and the policy holder. The insurance provider promises to provide financial compensation in the instance of an event that results in a financial loss	Political risk insurance	Political and social risks
		Performance insurance	Construction risks, operation and output risks Upstream resource-related risks
Commercially oriented preparation support	Grant or concessional funding specifically to address early stage development risks	Project preparation funding or technical assistance	Administrative risks, Access to capital, capacity at local level

Figure 68: Blended finance instruments (Tonkonogy et al. 2018)

One way to pool public, private and donor funds for investments in clean energy projects are public private partnerships (PPPs). If well-designed PPPs can be a promising way to raise the funding for clean energy investment on an international level. (Hilmarsson 2018)

Blended Finance and Public Private Partnerships (PPPs)

Cooperation between investors and public institutions is an important component for directing private capital flows towards the segments where transition finance is essential for decarbonizing the economy. In its roadmap to net-zero from 2021, the International Energy Agency (IEA) confirmed that the mobilization of capital is needed to support a successful and affordable transformation towards clean energy. A successful transformation requires a close cooperation between governments, public finance institutions, investors and also developers. Public Private Partnerships and blended finance can serve as "mechanisms" to push forward this transformation by attracting the interest of investors. The goal is to arrive at decreasing risks and to lower the costs of large-scale projects. Such projects also include the low-carbon transformation in the energy sector. The electrification of transport as well as to make buildings fulfill the requirements of energy efficiency. (Eurosif and Kyoko 2021)

However, there is a difference between blended finance and PPPs with how they make use of market mechanisms. PPPs are contracts between public entities and private investors with the goal of delivering public services. The process is as follows. A public institution issues an invitation to tender for the building and/or managing of a public infrastructure. As a result, the successful bidder can absorb the initial investment and generate returns by raising fees for the delivery of the public service. In contrast, blended finance projects are based on the commitment of public funds at below-market rates. Normally, these are public institutions or third-party donors. Governments, local entities or development banks can become co-investors or thy can act as guarantors. The advantage of this is the decrease of the project cost, the improvement of the risk-return profile as well as the attracting of investors who would refrain from such an investment because it is considered as too risky or unprofitable. Cheaper and low-risk projects are more bankable and this means that bank loans are more easily accessible by private investors. Another financing option for private investors is to issue sustainable bonds. (Eurosif and Kyoko 2021)

The following Table 13 gives a structured overview of the differences between PPPs and blended finance:

Table 13: Differentiating blended finance and PPPs (Own representation based on (Eurosif and Kyoko 2021))

	PPPs	Blended Finance
Definition	Contracts between public entities and private investors	Based on the commitment of public funds at below-market rates Public institutions or third-party donors
Participants	Public entities Private investors	Public institutions Third party donors

		Governments, local entities or development banks can become co-investors or they can act as guarantors
Goal	Delivering public services	decrease of the project cost improvement of the risk-return profile attracting of investors
Process	A public institution issues an invitation to tender for the building and/or managing of a public infrastructure	See Figure 49
Result	The successful bidder can absorb the initial investment and generate returns by raising fees for the delivery of the public service	Cheaper and low-risk projects are more bankable and this means that bank loans are more easily accessible by private investors.

The following figure shows the lifecycle of blended finance projects (see Figure 69):

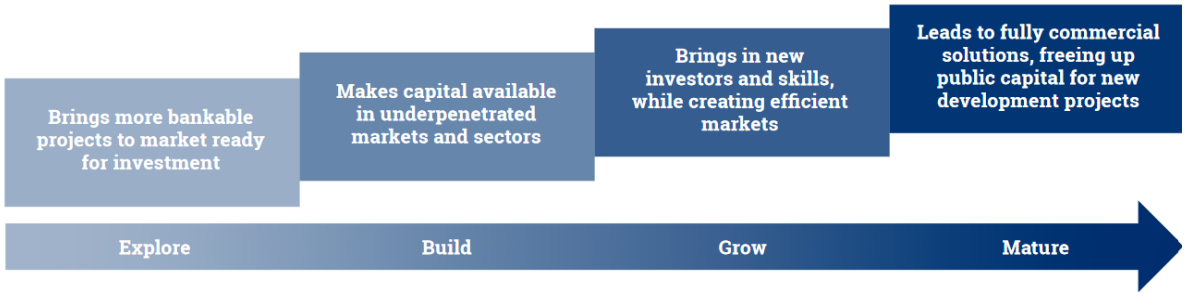

Figure 69: Life cycle of blended finance projects (Eurosif and Kyoko 2021)

Exploiting the potential of PPPs and blended finance – the European Energy Efficiency Fund (eeef)

The European market already makes use of PPPs and blended finance. The European Commission and the European Investment Bank (EIB) has been supporting the use of PPPs since 2011. In 2011, the European Energy Efficiency Fund (eeef) founded a joined initiative among several partners – the European Commission, the EIB, the Italian public financial institution Cassa Depositi e Prestiti (CDP) and DWS Group. The asset, which is managed by Deutsche Bank Group, makes assessible a market for PPP for commercially viable projects in the market for energy efficiency and renewable energy sources. The eeef supports not only European municipalities, local and regional authorities, but also funds utilities, public transport providers, social housing associations and the energy service companies (ESCOs) of private and public investors. The fund offers financing instruments such as debt, mezzanine, equity and leasing as well as maturities (up to 15-18 years for debt). By 2020 the fund managed to mobilize €150 million of committed capital. (Eurosif and Kyoko 2021).

European Energy Efficiency Fund (eeef)

The following figure gives an overview of the investment structure of the European Energy Efficiency Fund (eeef) (see Figure 70):

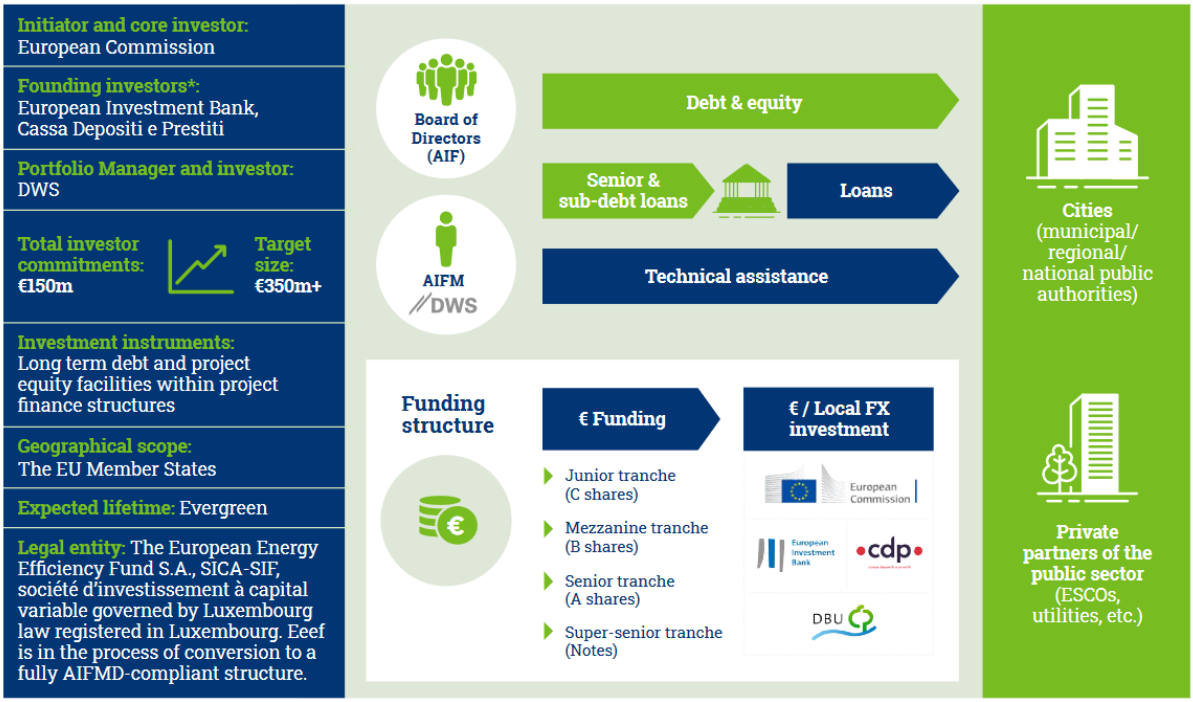

Figure 70: The eeef investment structure (Eurosif and Kyoko 2021)

5.7.3 Effectiveness of financial instruments

How effective financial instruments are, depends on the fact whether their objectives and targets can be met. The following table gives an overview of the main factors that have been identified as key for effectiveness: (EU Commission 2024a) (see Table 14):

Table 14: Evaluating the effectiveness of financial instruments (EU Commission 2024a)

Parameter	Problem	Measure
Ticked Size	Some investment ticket sizes required for DHCN-projects are too small for institutional investors and thus unattractive.	Bigger ticket size (Aggregation of multiple projects in order to create more attractive ticked sizes for investors. Private investors do have a higher incentive to invest when projects have a certain size. This is why the aggregation of multiple smaller projects is preferred (such as individual heat pumps, or DHC for few residential units). This is one way of de-risking their portfolio.

Low bureaucratic requirements	Complex procedures and requirements are an obstacle because they deter investors or lead to a delay of investments in DHNC	A technological neutral and open sector instrument profile was assumed as useful to support the effectiveness of instruments. Moreover, it contributes to widening its scope and the funding opportunities for projects and potential recipients. Simpler specifications can promote the deployment in broad sectors such as energy investments.
Long-term support	Planning phase is not long enough	Regulatory certainty, consistency and predictability are the key factors for securing private capital in DHCN-projects. The more visible the long-term conditions are on which the project will be implemented, the more adequately can the business model and the financial models be adapted. A constant problem is that every change in the application requirements, eligibility criteria, or instrument functioning can jeopardize the project preparation.
Accessibility (easy, periodic and rapid application process)	Application process and elaborate monitoring	Application process which are based on too many requirements or instruments which are too complex to monitor and strict reporting requirements will be perceived as less attractive to project promotors.

The following figure points to the number of times investment barriers were identified and "addressed" or "partially addressed" by the mapped instruments. The decisive factor is the type of barrier (see Figure 71)

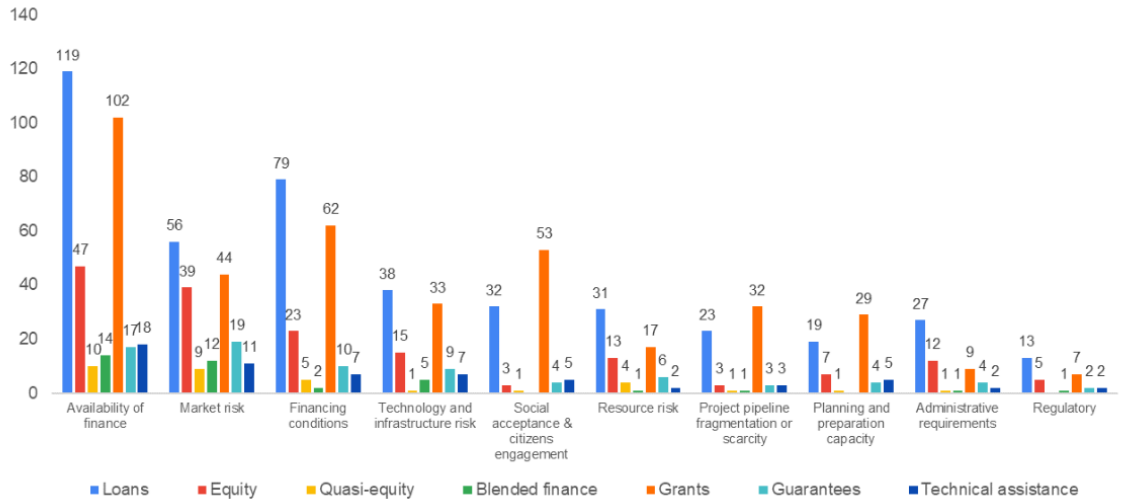

Figure 71: Number of times investment barrier were identified, addressed, partially addressed by financial instruments (EU Commission 2024b)

5.8 Testing and Validation Results (Advisory Board)

- 1st Investors Workshop (With Bloomberg) (June 2021), Online
- 2nd Investors Workshop at the Decarbonize Heat Conference (June 2022), Helsingborg
- Investment Case Workshop for Demo-sites in (May 2023), Topusko
- Demo-site Knowledge Sharing Workshop – Investment Case Preparation (November 2023), Milan
- 3rd Investors Workshop (Online) January 19th 2024 in cooperation with BVI and VKU
- 4th Investors Workshop in Brussels´, May 14th, 2024

The purpose of these workshops was to present interim results and to discuss these results with the members of the Advisory Board.

Key Takeaway of Chapter 5:

DCHN are a separate asset class on financial markets with specific characteristics, which make it challenging to attract investors. The regulatory framework conditions, such as the EU Green Deal and the EU Action on Financing Sustainable Growth provide tailwind for attracting investors. Nevertheless, although there are different kinds of investors groups that are increasingly searching for low-carbon assets, to direct investors towards DHCN as well as there is a wide range of financial instruments available on financial markets. In this chapter, an investors-financial instruments-matrix was developed, which indicates what kinds of investors (e.g., investment funds) would be inclined to invest in DHCN through which financial instruments (e.g., green bonds). Blended finance-approaches appear in particular promising: By providing guarantees or by taking first-loss-pieces public entities (e.g., governments) can contribute to de-risking of DHCN-projects. This improves the risk-return-relationship for commercial investors on financial markets and makes DHCN-projects more attractive for them. This, in turn, can potentially contribute to mobilizing the funding, which is needed for a larger scale rollout of DHCN throughout Europe.

6 Case Studies from Outside RewardHeat

In this section, nine different projects in the field of district heating and cooling networks (DHC networks) are analysed. The projects are examined for the following aspects: overall scope, specific objectives, expected results and financing of the project.

6.1.1 6.1. Cool DH

COOL DH is an abbreviation of methods using low grade Heat Sources from Cooling and Surplus Heat for heating of Energy Efficient Buildings with new Low Temperature District Heating (LTDH) Solutions. Utilities and municipalities from the cities of Lund (Sweden) and Høje-Taastrup (Denmark), leading DH energy specialists and industrial manufacturers form the project's consortium.

The aim of the COOL DH action is to help cities plan and deploy new, efficient district heating and cooling (DHC) systems, as well as expand and upgrade existing systems to higher standards. This will enable greater use of renewable energy, recovery of surplus heat or cooling. At the same time, the overall efficiency of the systems is improved.

Specific objectives

COOL DH aims to innovate, design and build cooling and heat recovery process systems that enable heat recovery into a local LTDH network, powered primarily by renewable energy. An LTDH network is to be designed and constructed using non-conventional pipe materials. New innovative pipe components will be tested to make the pipes easier to transport and more cost-efficient. suitable heating systems and controls in buildings are developed that combine LTDH with the decentralised integration of locally generated renewable energy. Viable business models and new pricing systems will be developed, ensuring good (low) return temperature and maximum flexibility for contractors in their choice of heating system. Furthermore, a complete system with all necessary components suitable for low DH temperatures (40-65°C) will be demonstrated. This will also include the demonstration of systems for heating Domestic Hot Water (DHW) without the risk of legionella. (COOL DH 2020)

Expected Results

The COOL DH project began at the end of October 2017 and is projected to be completed in September, 2021. A variety of improvements are expected as a result of the project:

the new LTDH supply in Lund (Sweden) is expected to be 10-25% cheaper, according to Euroheat &Power (2019). Although CAPEX is expected to be high, the surplus heat costs nothing and therefore the margin achieved will be passed on to the customers supplied.

The LTDH network in Høje-Taastrup (Denmark) is expected to cover 28.6 hectares.

Brunnshög and Høje-Taastrup's COOL DH project will not only improve the municipality's environmental performance. The research centres of MAX IV and European Spallation Source (ESS) as well as Science Village Scandinavia will make the region a centre of attraction for science,

innovation and education-based businesses. Hoje-Taastrup proposes a new district with highly efficient buildings connected to LTDH.

Furthermore, the local and regional economy is expected to benefit from the location of two top international universities (Klingberg 2013).

Financing of the project

COOL DH is mainly funded by the contribution of financial resources from EU members, which represent about 98% of the budget. The remaining 2% of the budget revenue comes from other revenue sources such as port duties on products outside the EU and fines imposed when companies do not comply with EU rules. The COOLDH project has a total budget of EUR 5 291 186,25. The EU contribution is estimated at EUR 3 958 349.10. (Cordis Europa 2021). The Horizon 2020 does not require co-financing and can be combined with other funds when necessary. Therefore, soft loans as well as private financing from the housing company and public utilities were used by DHC of Brunnshög. In the case of Østerby, a new tariff structure was implemented.

6.2. Flexynets

FLEXYNETS is a European H2020 project coordinated by EURAC and supported by five partners from different European countries. The project started in July 2015 and ended in December 2018.

The aim of the FLEXYNETS project was to develop and implement a new generation of district heating and cooling networks that reduces energy transport losses by operating at "neutral" (15-20°C) temperature levels.

Specific objectives

On the demand side, reversible heat pumps are used for heat exchange with the DHC network to provide the necessary cooling and heating for the buildings. Contemporary heating and cooling can thus be provided by the same grid. In the process, various heating and cooling sources available along the grid will be integrated into the grid in an efficient manner in order to exploit synergies. These include high and low temperature solar thermal, biomass, CHP and waste heat. The project is organised in different work packages. The main topics here include the analysis and simulation of possible substations (including optimised solar solutions), and possible grid configurations, as well as the development of suitable control strategies and smart metering solutions and tests in special laboratories (Flexynets n.d.).

Expected Results

The project carried out an analysis of possible city and settlement typologies, including a literature review and an applied survey on a number of cities in different countries. In order to simulate the concept of FLEXYNETS in different contexts and to understand the applicability of FLEXYNETS in a specific environment, different "reference cities" were developed (Cordis Europa 2017).

Financing of the project

The total budget of the project was around EUR 2 million and was fully funded by the EU (Cordis Europa 2017).

6.3. TEMPO

Temperature Optimisation for Low Temperature District Heating across Europe (TEMPO) is a project supported by the EU's Horizon 2020 funding programme. The project started in October 2017 and ends in September 2021.

The aim of the project is to reduce the temperature level in district heating networks through technological innovations to create low-temperature networks with increased efficiency and integrated residual heat sources, and to develop new, attractive business models.

Specific objectives

The project will develop and demonstrate six innovations related to grids, the digitalisation of these grids and building optimisation. The focus is on fault detection, visualisation tools, intelligent control of DH networks, innovative piping systems, optimisation of building installations and innovative decentralised buffers. The innovations are grouped into 3 solution packages suitable for 3 different application areas: new LT-HD networks in urban areas, new LT-HD networks in rural areas and existing high temperature (HT) networks. Two representative demos will demonstrate the benefits of the solution packages - one in Brescia (Italy), the other in Windsbach (Germany).

Expected Results

Various TEMPO innovations were implemented in the demos. Data on the preliminary work for site preparation, the main technical and economic aspects of the implementation, the reasons for deviations from the original schedule, the quality control of the implementation, and the commissioning of the demo site were recorded in a report. As part of the development of a business model that is attractive to investors, a study has already been prepared that examines and analyses crowdfunding as a financial tool for district heating projects.

Financing of the project

The total budget is around EUR 3.7 million, with the EU contribution amounting to EUR 3.13 million. EU funding is provided by various private, for-profit institutions and research organisations and coordinated by the independent research organisation 'Flemish Institute for Technological Research' (Tempo DHC 2021).

6.4. HeatNet NWE

HeatNet NWE is an EU funded project that promotes the deployment of 4th Generation District Heating and Cooling (4DHC) across North West Europe, helping local authorities and other public sector organisations to implement their own networks. The lead partner organisation is City of Dublin Energy Management Agency Ltd. The project was launched in 2016 and came to an end in 2020.

Specific objectives

The primary objective of HeatNet is to create an integrated transnational NWE approach for supplying commercial and residential buildings with renewable and low-carbon heat, which also includes waste heat. This should significantly reduce CO2 emissions in North West Europe. For this purpose, 6 local district heating and cooling (DHC) networks are being developed and tested in the UK, Ireland, Belgium, France and the Netherlands. A new institutional and organisational framework is being developed for the implementation of the project.

Expected results

The main outputs of the project include a transferable HeatNet model for the implementation of 4DHC schemes in NWE, Six Living Labs that develop, test and demonstrate the HeatNet model to make it robust and Transition roadmaps that plan the introduction of new technical, institutional and organisational arrangements of the six Living Labs.

The expected result of the project is a saving of 15,000t CO2 per year.

Financing of the project

The project has a total budget of EUR 11.57 million, of which about EUR 7 million are provided by the EU (Nweurope.eu 2020).

6.5. SmartReFlex

SmartReFlex is an EU-funded project looking at smart and flexible 100% renewable district heating and cooling systems for European cities. The project ran from March 2014 to February 2017.

SmartReFlex pursues the overall goal of supporting European cities and municipal utilities in the implementation of innovative heating network concepts. The target value for renewable energies is 100%. In particular, medium-sized pioneer cities with populations of 10,000 to 100,000 are to be accompanied step by step in the planning and implementation of renewable heating networks.

Specific objectives

The core elements of the project include the identification of appropriate technical and organisational strategies as well as the optimal utilisation and improvement of the legal, planning, social and economic framework, both at local and regional level. A climate-friendly heat supply of urban areas is to be ensured through an improved integration of renewable heat concepts into energy planning. Both businesses and the local population should be closely involved in this process.

Expected Results

Throughout the project, 12 improved policies were developed at regional and local level to promote RES DH. Six regional working groups with 60 actively involved stakeholders were established and numerous high-level training seminars were held. Furthermore, more than 10

replication cases of the SmartReFlex model were developed beyond the project boundaries. 14 new systems were created that use a high share of renewable energy sources for DHC.

Financing of the project

75% (about EUR 1.06 million) of the total budget was covered by the EU. A further EUR 355,000 was provided by various partners (Solar District Heating n.d.).

6.6. Life4HeatRecovery

Life4HeatRecovery is a project that focuses on low-temperature, urban waste heat into district heating and cooling networks as a clean source of thermal energy. It is coordinated by the Research Institute Accademia Europea di Bolzano and supported by various partners from Italy, the Netherlands and Germany. The duration of the project is from June 2018 to June 2022.

Specific objectives

The main objectives of Life4HeatRecovery include demonstrating various opportunities and the effectiveness of waste heat recovery from multiple urban sources, demonstrating trading systems and management strategies, and developing innovative financing schemes.

Expected results

Financial and technical solutions are tested in four networks in Germany, Italy and the Netherlands and the environmental and socio-economic performance capabilities are assessed. Furthermore, four different modular, standardised and prefabricated skids are developed and demonstrated. These are intended to integrate waste heat sources into district heating networks. A financing and risk management plan for utilities and investors is being developed. This is based on synergies in the use of public and private funding (Life4heatrecovery 2021).

Financing of the Project

The project is supported by the EU financial instrument "LIFE" with an amount of about EUR 3.36 million. The total budget of the project is about EUR 5.82 million (EC-LIFE4HeatRecovery n.d.).

6.7. DETEPA

District Heating Municipal Company of Amyntaio (DETEPA), Greece – Building of a new biomass plant to cover thermal needs' is an ongoing project in the region of Western Macedonia, which started in October 2018 and should end in February 2020.

Specific objectives

The main objective of the investment programme for Amyntaio's DH system is the installation of a new biomass combustion plant. This will serve both Amyndeon's existing district heating system and its future extensions. The thermal energy plant under construction will burn biomass and a small amount of lignite to meet the heating needs of the existing district heating network in the villages of Amyntaion, Filotas and Levaia. The plant has a total capacity of 30 MW (2x15MW).

Expected results

The existing district heating network uses waste heat from the Amyntaio lignite-fired power plant (PPC), which is expected to close by 2021. The buildings in the villages concerned will not pollute the environment through the use of separate heating devices (oil boilers, wood stoves, fireplaces, etc.) as a result of the plant. The network is also to be extended to nearby villages. Furthermore, the project creates jobs in the organisation of the biomass supply chain in the region.

Financing of the Project

The project costs are expected to reach EUR 14.57 million including VAT and will be to 55% financed by European Cohesion Policy funds through the "National Strategic Reference Framework 2014-2020". With a capital grant of EUR 1.5 million, the Special Development Programme of the Region of Western Macedonia is also contributing to the financing of the project.

As the project uses more than 50% renewable energy sources, it complies with the provisions of Directive 2012/27 / EU on energy efficiency (L.4422 / 2015) as an efficient district heating system (Euroheat & Power 2019).

6.8. Networks for Networks

The project "Networks of Networks" is a proposal of the European Commission for which a detailed strategy has been elaborated. The project aims to demonstrate the benefits of using smart heat networks to provide heat energy in three ports. The heat demand is currently covered either by individual or central boilers. In all three ports, about the same amount of fossil heat generation would be replaced.

Specific objectives

Through the development of thermal energy networks, an integration of renewable energy sources will take place in the three port areas in Andalucía, Seville, Málaga and Motríl Granada. The project also aims to demonstrate the benefits of meeting heating and cooling needs through a combination of different renewable energy technologies. Lastly, it will be shown that public and private energy needs can be met through various combinations of renewable energies and that this can be made possible through a cooperation of public-private partnerships on the ground.

Expected Results

This project will demonstrate thermal energy smart grids and the benefits of renewable technologies for heating and cooling, thus contributing to citizens' awareness and confidence in such systems. The direct impact on energy savings and CO2 emissions could be significant if the new technology is deployed on a large scale.

Financing of the Project

About 20-30% of the total budget needed will be provided in form of grants from the EU. The rest of the budget could be covered by EU loans. It is still unclear whether there will be co-funding from the ports or companies that will be part of the energy networks. However, European cooperation

is possible for the project as one of the objectives is to demonstrate the benefits of thermal energy networks in ports (Van der Veen et al. 2019).

The following table shows how much budget is expected to be needed per port and per technology (see Figure 72):

Málaga Port		Sevilla Port		Motríl Granada Port	
Marine G.H.P	EUR 2.0M	Gasification	EUR 7.3M	Marine G.H.P.	EUR 0.4M
Solar & Abs.	EUR 2.3M	Absorption	EUR 6.9M	Gasification	EUR 2.5M
Network distr.	EUR 4.0M	Biomass CHP (Networks civil works included)	EUR 29.5M	Solar & Abs.	EUR 0.5M
Tech room	EUR 3.7M			Network distr.	EUR 2.5M
PV	EUR 1.0M				
Total	**EUR 13.0M**	**Total**	**EUR 43.7M**	**Total**	**EUR 5.9M**

Figure 72: Expected costs per port (Van der Veen et al. 2019)

6.9. Heat Pipe exchanger project - Romania

The aim of this project is to develop an energy-efficient heat pipe/heat pipe heat exchanger that can recover a significant amount of heat from the residual energy of service water from buildings. The basis for this is first of all basic research of the equipment and materials used, the construction of a case study and in-situ analysis of the system. This is followed by the implementation, as well as the evaluation of the results.

Specific Objectives

The project duration is 36 months. The first step of the project is the implementation of the idea (principle and technology) and the realisation of the prototype, as well as the testing in the laboratories of the Technical University "Gheorghe Asachi" in Iasi. The aim is to determine reliability parameters and maximise efficiency. In parallel, the consortium, together with the representatives of the Metropolitan Church of Moldova and Bukovina, will construct a building with a social function (accommodation for different categories of the poor population, etc.), in which the design for the prototype installation will be realised and put into operation.

Expected Results

The use of described innovation is also possible in the residential sector. It would be very efficient in a hotel, for example, where the thermal energy wasted in the domestic water can be considerable. Furthermore, it can also be used in the industrial sector, where thermal energy can be recovered from the cooling liquids.

Financing of the project

The total cost of the project is estimated at EUR 100.000. This includes approximately EUR 25,000 for laboratory research, EUR 50,000 for the construction of the equipment and the in-situ analysis of the system, and EUR 25,000 for the implementation phase and the preparation of the results, conclusions and implementation instructions. As the project is comparatively quite small, it is recommended to use local, regional or national funding. It is recommended to seek funding through the European Structural & Investment Funds (ESIF) in the form of a grant (Van der Veen et al. 2019).

6.10. Brief Synopsis of further Case Studies

The following table provides an interview of additional DHCN-projects in different countries, discussing the respective overall scopes, expected results and financing sources:

6.11. Conclusions from Case Study Analysis

The best practice examples of DHC projects presented in this chapter provide evidence that DHC networks can be funded and successfully implemented through collaboration between public and private institutions. It has been shown that there are a variety of ways to combine private funding with funding instruments from local, national or other multilateral institutions. Due to the early stage most of the projects are still in, in most cases publicly funded by the EU (e.g., Horizon 2020, European Structural & Investment Fund (ESIF)). This underpins the high importance of attracting investors via financial markets in order to provide a long-term funding for upscaling DHCN. The EU Green Deal and the EU Action Plan for Sustainable Growth are intended to help steer financial flows towards sustainable investments and thus also facilitate the financing of DHCN projects. The analysed projects will be further observed over the course of the remaining project time, in order to gain further valuable insights for REWARDHeat.

Key Takeaway of Chapter 6:

The review of several case studies served the purpose to illustrate how longer existing DHCN are financed. The analysis showed that most of them depend on public and/or subsidized funding local, national or other multilateral institutions. The large majority has not yet been funded by commercial investors via financial markets. This underpins the necessity to implement innovative financing approaches, such as blended finance, in order to mobilize private capital from financial markets.

7 Networking with Investors

Networking with investors is crucial in order to gain practical experience and feedback on the results achieved. Therefore, various activities were undertaken to network with investors. Two investors workshops were conducted. The first in June 2021, hosted as an online event. The second in June 2022 was held as a live event at the 5th General Assembly Meeting as a REWARDHeat conference in Helsingborg, Sweden. Furthermore, between the workshops the interviews were conducted with various investors and financial experts to get feedback from the field.

7.1. Interviews and Interview Results

The aim of the interviews was to discuss the risks and financing schemes of investments in DHCN with institutional investors.

In preparation for the interviews, a questionnaire was developed covering the most important points on open questions in work package 3.5 (the questionnaire used in the interviews is in the Annex). In addition, contacts of potential interview partners were gathered. HFT sent interview invitations to 30 potential interview partners of different organizations and backgrounds, like commercial banks, investment funds, pension funds, development banks, consulting companies, rating agencies and non-commercial organizations. Five contacts of different organizations committed for an interview. The five interview partners have different backgrounds and can be assigned to the following organizations: (see Table 15):

Table 15: Perspective of different investors on clean energy projects (own representation)

	Background	Distinct Organization
1	Municipal investor	
2	Investor with an explicit green profile	
3	A conventional bank	
4	Pension fund	
5	The European Investment Bank	

(i) a Development Bank (ii) a research and consulting company specialised on sustainable finance (iii) United Nations Environment Programme Finance Initiative (UNEP FI) (iv) advisory to institutional investors specialized on infrastructure investments (v) a local German development bank.

The interviews were conducted in May and begin of June 2022 via video meeting. The target time was 30 minutes, but could be extended if the interview partner had time and were willing to answer more questions.

To account for GDPR, all interview partners were informed about the project and the purpose of the interviews, already in the previous email communication and at the beginning of the interview. The interviewees were asked in particular whether their name and organisation could be published in the project results or whether they wished to remain anonymous. The answers were documented and saved on the HFT internal Cloud Drive of the project.

Due to the different backgrounds of the interview partners the questionnaire was developed as a pool of questions to different topics. Questions were asked to every of the topics, but depending

on the feedback with different focus and more or less questions in a topic. The topics were infrastructure investments in general, investments in district heating and cooling networks, investors objective and needs in the case of sustainable infrastructure investments, Key performance indicators (KPIs), sustainable (infrastructure) finance and EU (sustainable finance) policy/regulation.

Findings

In the following section the main findings of the interviews are described.
A significant finding of the interviews was that even infrastructure experts know little about district heating. This goes hand in hand with the statements that district heating is barley known by institutional investors. On the one hand it is not known by the most investors, on the other hand the invested volumes seem to be too low to be interesting for a bright market.

District heating has some barriers to become an established asset class. One is that infrastructure in general is complex and it takes time to understand projects. For district heating that could take even more time, due to the lack of knowledge so far. This knowledge barrier could be overcome by using standards. Standards existing for infrastructure investments in general, but they have to fit for district heating and cooling networks. The use of standards depends on good data quality. This is the case for fulfilling regulation like the EU Taxonomy. Data quality and availability is the most important issue. Another barrier is that a single project is not big enough for institutional investors to be of interest. An investment volume of at least 100 million euros up to 500 million euros is needed. One solution could be to bundle projects for an investment in one network operator to reach the critical mass.

Policy and regulation do play an important role. It turned out that regulation can be act in two ways. A lack of regulation can hold the sector back, but new regulation can also be the main driver. In Europe the most important regulation in the moment is the EU Taxonomy. Worldwide the most important policies are the UN Sustainable Development Goals and the Paris Agreement. Investment activities has to contribute to them and have to be in alignment with the 1.5-degree pathway to be green for the interview partners. It was also mentioned that the EU Taxonomy is too strict for poor developed countries. In addition, it was mentioned that sustainable (finance) policy had to develop further. The focus on climate is not sufficient, areas like biodiversity, social and nature has to become more important. More standards and regulation in general for district heating would help the sector. If district heating investments could be in alignment with the EU Green Bond Standard, this would help to find financing for district heating too. New generations of District heating networks would benefit from a CO2-price, but it was also mentioned large networks over 20 MW capacity have to be in the EU emission trading scheme (EU ETS), while e.g. individual gas boilers in households are not in the EU ETS, which is a competitive disadvantage for DH.

Besides the barriers for district heating, there are also chances: With green technology inside, district heating could come onto the radar of green investors. The times are in favour of district heating as green investment, due to the fact that “everything has to become green” as an interview partner said. A district heating investment could have a diversification effect on the portfolio of an investor, as it is not linked to the normal stock market cycle. (Sustainability) Certifications could help to convince investors or speed up the assessment process. Another benefit of district heating-investments could be inflation linked revenues, if the consumer contracts are designed in this way.

However, the interview partner pointed out that this could also be a milkmaid's calculation if one's own costs also rise due to inflation.

One financing possibility to attract private investors is to use blended finance. This means that a public investor takes the initial investment and take the biggest risks and private investors follow at later stage with lower risk. Otherwise private investors may be deterred if they cannot assess the risk or consider it too high. Another solution could be the combination of equity and debt financing. For example, equity could be placed by private equity investors and then the investment is leveraged by debt financing over the financial markets. The larger the group of potential investors, the better is the selection and the interest rate for the district heating networks.

One crucial question is what investors need for their decision making. Traditionally the relationship of risk, return and liquidity is the basis of the decision making. Nowadays, sustainability plays a role too. However, the most important information for investors is the economic efficiency, besides this sustainability is more and more important too. One interview partner said that his customers search desperately for real green investments in the moment. As practical examples show again and again Greenwashing is a treat to companies and investors equally (WirtschaftsWoche 2022). The sustainability decision making of investors is often focussed on CO2 emissions or carbon footprints. More ambitious investors are looking on the special impact an investment has. Not only the positive but also the negative effects associated with funding activities should be considered. Common ways to do so are disinvestment, commitment, or exclusions of companies or whole industries. Regarding the risk assessment investors look on what alternatives and competition is there. Does the sector have a monopoly character or can customers switch quickly? How likely is the risk of getting a stranded asset over the long time period the hold it? Finally, different investors have to be approached differently. They have different needs and expectations and therefore it is needed to be able to address this.

Key Performance Indicators (KPIs) support the decision-making process. There have to be economically and sustainability KPIs as well. In case of the sustainable KPIs CO2 emissions are important but more interesting is CO2 intensity in comparison to the benchmark or the status quo (e.g. an individual heating solution). The question is how much could be saved with the district heating solution? Also relevant for district heating as an own asset class are the financed emissions. Therefore, it must be possible to determine them. Additionally, the question of resource efficiency could be of interest: How many resources are used for the district heating network compared to another solution (e.g. a common individual solution? Furthermore, social KPIs could be become more important in case of district heating investment, e.g. affordability or independency.

7.2. Workshops and Conferences with Investors

1st Investors Workshop June 2021 (With Bloomberg) (Online)

The first investors workshop took place on 24th June 2021 as an online event due to the Covid-19 Pandemic. It was moderated by Emma Coker from Bloomberg. The three speakers Tobias Popovic from HFT, Gabriele Pesce from EHP and Olivier Delpon de Vaux from Asper Investment Management had a short presentation each and after that a moderated question and answer session was done, which included questions from the audience. About 30 to 40 participants joined the workshop. The focus of the workshop was how to attract institutional investors to district heating and which role does the EU Taxonomy and sustainable finance in general plays for investments in district heating networks.

Findings from the first investors workshop:

Challenges for investors with the district heating market in Europe are that the market is fragmented due to different manifestation of district heating in the different countries. The district heating infrastructure is aging and need investment to decarbonize it. Investments in district heating are taking place and have been increasing in number and volume for years, but almost exclusively in the brownfield sector. Asper has seen institutional investors valuations more than doubled to more than 20 times of the enterprise value divided by EBITDA (EV/EBITDA). In addition, according to Asper, all district heating assets sold were operational, cash generative high temperature networks. Once networks are operational, they present some very attractive infrastructure asset characteristics. They have a big CAPEX, but they offer an essential service to their customers, in a cost-effective manner. Additionally, they deliver long-term stable cash flows, which are often inflation linked, which makes them attractive to long term investors. The conclusion from this is, that there is a market for brownfield and operational district heating networks and they already attract capital from institutional investors. But as the deals are almost exclusively brownfield investments, greenfield investments are much more challenging in attracting investors. Key Challenges for greenfield projects are for instance that they are more difficult to build and operate, because they are more complex. Many stakeholders have to be involved, which takes a lot of time and effort. Regulatory uncertainties, due a lag of regulation or a regulation in development creates uncertainties for the investment. The high upfront costs (CAPEX) in addition to the demand uncertainty are high risks for the investor. To make these risks calculable, there must be visibility for the investor regarding possible anchor loads or customers. Does the anchor loads already provide positive returns so that the investment becomes feasible for investors? If not, a high risk would remain to the investor, which they often would not be willing to take. Various technologies can be used from an investor's point of view as long as they are proven. An investor will not take a technology risk. Possible options are waste heat, heat pumps in combination with data centres, waste heat from waste incineration plants, biomass and geothermal energy. Waste heat sources are usually the cheapest, but the credit worthiness of the supplier and the stability of the heat source has to be checked. Waste heat from waste incineration plants are cheap and stable as well, but debateable in case of their sustainability. The same could happen to biomass. Conclusions for greenfield projects are that they are more difficult to finance than brownfield networks because they are more complex and have higher uncertainties and risks to the investor, due to fact that they have to proof to be profitable. Investors want to be involved as early as possible and need to have visibility about the potential returns to calculate their risk. Greenfield investors need more experience with district heating investments and an experienced investor could accept a higher level of risk.

Other points were also discussed, how district heating could become more attractive to investors. For instance, district heating relies a lot on public subsidies. It makes sense to rise potential and relieve the public sector by combining the benefits from public investment and private investment. Public initial investment as an incentive to private investors to join, so they can fill the gaps and make use of a marked based behaviour. Instruments like public private partnerships (PPP) and blended finance could be used for this. Another point for attractiveness is communication. People do not see much of district heating infrastructure, unlike the use of electric cars, for example. Therefore, positive communication is important to convince customers and investors. The positive effects must be presented, such as the effect on the climate or that heat and cool sources like supermarkets from the neighbourhood can be used to heat up people’s homes. Finally, it was also discussed who are the right investors for district heating. Due to the long-term time horizon this is not an asset class for investors who are aiming for a short payback time. Typical investors are

pension funds and insurance companies. To find the right investors there should be a pool of investors over the project lifetime. For instance, some investors could finance greenfield projects, if they are willing to take a higher risk and aim for potential higher returns. Others could invest in existing networks, to renew them and sell them when they reached a level of profitability. Lastly, low risk investors could buy such networks with stable but lower returns, without the need to invest into the network themselves.

Another focus of the workshop was the EU Taxonomy and regulation in general. At the time of the workshop the EU Taxonomy was still under development and none framework of the six objectives had been published. District heating networks fall under the Taxonomy, regardless of their size. The participants agreed that the taxonomy will probably give a push to district heating investments. However, hurdles were also identified. The taxonomy must be designed in such a way that it is easy to use and the data must be available. Data availability and quality is a major problem in sustainability and climate reporting and is likely to be the same for the taxonomy. The fragmentation of general district heating regulatory in Europe is a barrier for investments, but from the investors view this can be overcome by having experienced people in the different markets.

Key findings from the first investors workshop:

- There is a market for district heating, but mostly for brownfield (challenges for Greenfield)
- Investors want to be involved at an early stage
- Relationship building as an important aspect – more collaborative
- Investor pool through project lifetime
- EU Taxonomy and regulation could give a push, if well designed

7.1.1 2nd Investors Workshop at the Decarbonize Heat Conference June 2022 (Helsingborg)

The second investors workshop took place on June 16th 2022 in Helsingborg at the Decarbonize Heat Conference at the 5. General Assembly Meeting of the REWARDHeat project. About 70 participants joined the session, from the project and externals. The workshop was introduced with a keynote speech by Anders Ericsson who is CEO at Värmevärden/Adven. After that, learnings from the REWARDHeat project were presented from Prof. Dr. Tobias Popovic from HFT. Then the main parts followed, the panel discussion with three financial experts and the pitch sessions, where two representatives from the REWARDHeat demos sites Helsingborg and Mölndal, and Szczecin performed a pitch, which was assessed by the financial experts.

Findings from the second investors workshop:

The workshop showed among other things how important a well-designed regulation for district heating and the energy sector is to reach successfully reach climate goals and move private capital into district heating. Anders Ericsson showed in his keynote speech the history of district heating in Sweden and the learnings from that. The decarbonization of the sector to fossil free started mainly when 1992 the carbon tax in Sweden was introduced. De-regulation a few years later made private investments possible, but also created market disturbances when first Divestments due to price increases took place. This showed the need for a district heating law and market transparency. The learnings from the Swedish example are that district heating contributes to the

needed decarbonization of the heating and cooling sector. It also showed that district heating can provide predictable cash flows which matching the need from institutional investors. On the customer side district heating require either regulation or high trust/transparency to build customer confidence, due to the fact that the networks have a monopoly character. Lastly, to develop district heating greenfield projects is a long-term effort and involves many different players, for these reasons green field project needs yet to be proven to fit for institutional investors. The experts in the panel discussion confirmed this point and this was already a key finding from the first investors workshop. Although investors like Asper want to be involved at an early stage, they are only interested when they have reliable facts and a calculable risk for the investment. For this reason, investors in greenfield projects are currently mainly project developers. This underlines the importance of blended finance, i.e. the assumption of part of the risk by the public sector to make the investment interesting for private investors. Blended finance was also mentioned by the financial experts as a solution to unlock more private capital.

In general, the workshop confirmed a lot of findings which were learned in the interviews before. For instance, the critical investment volume for institutional investors of at least minimum 100 Mio Euro to be a worthwhile investment, was also mentioned on the panel discussion. The need for regulation in the sector was also identified as very important. Investors want clear framework conditions for their investments in order to minimise uncertainties. Another point which is important for investors is relationship building with the municipalities. The relationship needs to be built up early if municipalities want to work with private investors. Also, knowhow is important on both sides. As already learned from the interviews, investors need to build know how in district heating, but also on the municipality side enough technical and economical knowhow is needed, which requires sufficient manpower. The decarbonisation and diversification effect for the investor's portfolio was mentioned positively. Like it was mentioned in the interviews already, investors search for real green assets and also investments which are not linked to the normal stock market cycle to flatten the volatility of their portfolios. However, since sustainability is important for investors, sufficient economical numbers of an investment are absolutely mandatory. It also became clear once again that a pool of investors over the project life cycle makes sense in order to satisfy the needs of different investors. The workshop participants Asper Investment Management and Polhem Infra confirmed this as examples. Asper would like to get involved earlier in the life cycle, but needs the prospect of predictable cash flows. Their clients are mainly pension funds and insurance companies. Polhem Infra would rather enter late in the life cycle, when the risk is still lower. Their clients are the AP pension funds of Sweden, which have different objectives and requirements. Additionally, other types of investors, with different needs could be placed at different times of the lifecycle. The different types of investors and their requirements, however, also require a differentiated approach and different investment instruments.

The last part of the workshop was a pitch session with two presentations. The REWARDHeat demo sites DS 4 and DS 6 were presented and evaluated by the financial experts. At the end the experts and the audience could vote, if they would invest in the projects. The pitches included a brief explanation of the actual project status, as well as the planned actions. Additionally, some facts about the networks, selected economic key figures and data about CO2 emissions were provided. Feedback from these sessions confirmed that investors are interested in proven and not in innovative technologies that are not yet ready for the market. Furthermore, it became clear that such a pitch needs to be short and precise with the most important facts for investors, which can be backed up with additional information if necessary. Communication is extremely important to

convince investors. Finally, the feedback from these sessions will be used to develop tools and methods that will enable demo sites to prepare and present the required information to investors. This will be part of the further project work.

Key findings:

- Regulation is needed and can be a key driver for district heating
- Critical investment volume of minimum 100 million Euro
- Blended Finance as a solution to reduce risk and attract private investors
- Different approaches and instruments for different investors needed

Case study: Albertslund ➔ Helsingborg

Albertslund Case – lowering the temperature in an existing DH network to 60 degrees at the end user. The use of shunts to devide the overall DH network in smaller islands (35 all in all).

Step 1: Infrastructure:

- Shunts to lower temperature of district heating in an existing network
- With the shunts we create smaller islands with the overall DH grid in order to be able to lower the temperature step by step
- If we don't divide the existing net, we need to have high temperatures close to the DH work in order to be able to provide the last customer with a sufficient temperature at 60 degrees
- With the lower temperature we increase the overall efficiency, by reducing the heat loss from the pipes – and we improve the possibilities of sector coupling by providing storage for excess electricity as hot water – and by increasing the efficiency of exploiting local energy resources (surplus heat, solar, geothermal, etc.) through heat pumps (higher COP)

Step 2: Business model:

- Selling heat – yearly turnover of about 19 Mio. €
- DH distribution is non-profit by law
- No making money, however little risk of losing money, too

Step 3: Investment story/case:

- Lower temperature leads to higher efficiency in the DH grid
- Lower heat loss
- Better integration with electric heat production (waste heat, heat pumps, heat storage, etc.)
- Lower carbon intensity
- Taxonomy article 10, chapter 1, paragraph a, b (and g?)

Step 4:

- Investor groups
- KommuneKredit
- Can we secure enough funds from them? Yes

- Normally 30 years bond loans
- Can we find cheaper loans? Maybe
- Loan issuers wanting to lower the carbon intensity of their portfolio?
- Normally loans from KommuneKredit are cheap
- The municipal debt ceiling applies, no matter who we loan from
- Dept ceiling by law
- Voluntary dept ceiling

⇨ We need more knowledge on this point - Ask the municipality!

Risks:

- A constant risk is the competition with alternatives to DH like heat pumps
- We need a constant focus on costs
- Albertslund DH is a little organization - little man power - many projects ideas
- The municipality of Albertslund guarantees the loans for DH

Results:

The case study of Albertslund shows that necessary investments are funded by KommuneKredit. These loans are cheap and have a duration of normally 30 years. The risk is manageable as the capital market is approached via KommuneKredit. These structures make it difficult to develop the demo site of Albertslund within the RewardHeat-Project.

- Investor's money would be needed in case there are no more subsidies or other public money sources
- There are a lot of risks connected to these projects, which have to evaluated more accurately in the SBSC
- All demo sites try to fulfil the CO2-targets

7.1.2 Investment Case Workshop for Demo-sites in May 2023 (Topusko)

The third investors workshop took place on May 11th 2023 in Topusko at the 6. General Assembly Meeting of the REWARDHeat project. The focus of this workshop was to attract investors to District Heating and Cooling Networks (DHCN). The path should lead from technology to long-term funded DHCN Infrastructure. The workshop was introduced with a keynote speech by Jan Eric Thorsen who is Director, Global Application Expert, *Danfoss* A/S. About 15 participants were presenting their various results – among them Eurac, IVL, HFT, HAWK, UNIZAG FSB, Euroheat & Power. Topusko La Seyne Sur Mere and Milan – Balilla made a "pitch" and thereby gave valuable insights into their organizational and financial structure as well as their future investment needs.

The last part of the workshop was a pitch session with three presentations. The REWARDHeat demo sites Gardanne / Lay Seyne-sur-Mere, Balilla und Topusko gave answers to the points above. It was obvious that the financing structures are complex and that there are a lot of risks to consider. Moreover, each demo site is on a different stage in its development. Some of the demo sites revealed figures and facts and gave insights in their organizational and financing structures. Whereas Gardanne and La Seyne-sur-Mere are very well developed, Topusko is not yet so far developed but has great potential in extending the network once the barriers can be overcome. Another advantage of Topusko is that their energy sources (geothermal energy) are CO_2-neutral

and that the system is enormously powerful. Unfortunately, Topusko is too underdeveloped and risky for being a series investment case. The demo site Albertslund gave an insight in its organizational structure which is deeply intertwined with KommuneKredit and the municipality. The demo site Szczecin in Poland has to replace its fossil-based energy sources by green energy sources in order to improve its CO2-emission factor. This requires high investment sums.

Offer: Voluntary Coaching Session

The investment case is supported by a voluntary coaching session giving the demo sites a "roadmap" of the information interesting to investors and the way this information has to be processed. The goal of the coaching session (Fig. 28) is to prepare them for making a pitch in front of investors as soon as they decide to refresh their equity base with fresh money (see Figure 73):

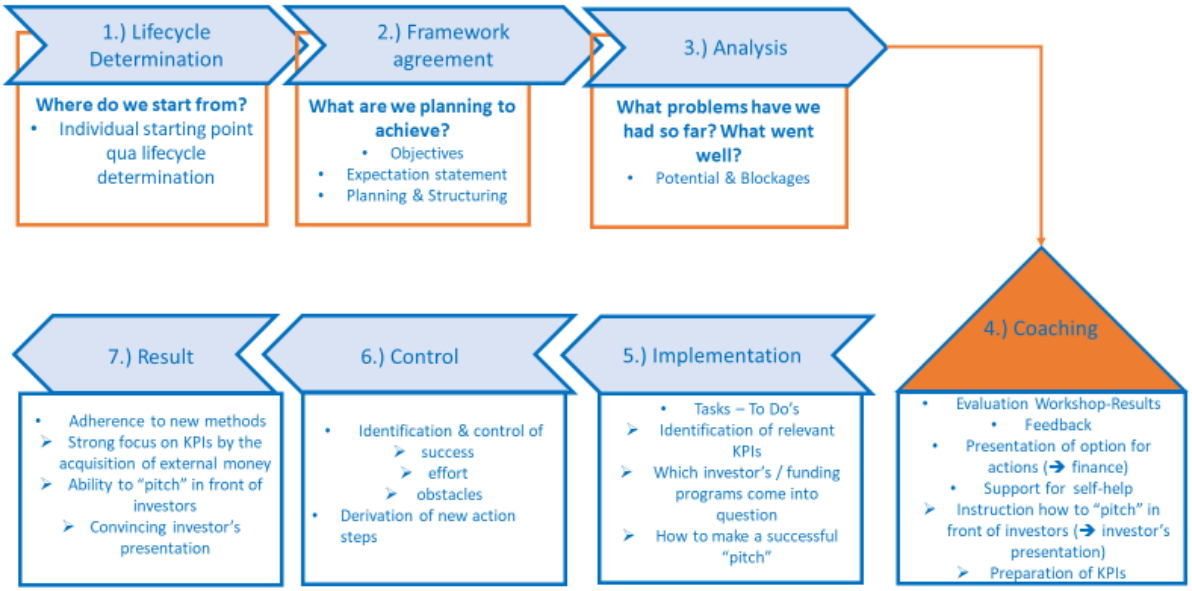

Figure 73: Coaching-session (Own representation based on (Kamelgarn and Blanc 2017))

Findings from the third investors workshop:

The goal of the third investor workshop was to raise funding for the demo-sites. Before the workshop took place, a questionnaire had been sent out in order to learn about the innovation plans of the demo-sites (e.g. renovation, extension, technological development etc.) and how these plans could be financed. However, the foremost goal of this workshop was to show to the demo sites how an investment case has to be built up. In order to build up the investment case, the following key questions should be used:

- What is the amount of your investment volume?
- What kind of risk are connected to the project?
- What is the amount of the cash flow / how high is your yield potential?
- How extensive is your contribution to CO2-reduction? Workshop Results – Lay Seyne-sur-Mere

- CO2-neutral because of geothermal energy

7.1.3 Demo-site Knowledge Sharing Workshop (November 2023), Milan

The fourth investors workshop took place from November the 8th till November 11th 2023 in Milan at the 7. General Assembly Meeting of the REWARDHeat project. The goal of this workshop was to share the knowledge that had been attained throughout the project. The main focus of this Knowledge Sharing Workshop was to acknowledge the climate change as a "Grand Challenge". It should be emphasized once again that a Great Transformation" of society and economy towards sustainability was imminent. The decarbonization – especially of the building sector – is only one key issue since 35% of the EU's carbon emissions can be attributed to this sector. District Heating (DH) and Cooling Networks (DHCN) could provide a part of this solution. Nevertheless, high public debt levels will governments keep from providing the required funding. The goal of this workshop is to find out whether this funding gap could be filled by financial markets. The demo sites support the workshop goal by outlining their financial structure:

General key findings of the workshops:

The results of the four workshops show that DHCN represents a crucial element for achieving the EUs climate goals. It has also become obvious that an EU-wide role-out and upscaling of DHCN requires massive investments, esp. in countries such as France and Germany. In both countries the municipalities are obliged to develop and implement masterplans for DHCN. This process can be influenced positively by the EU that has taken measures such as the EU Action Plan on Financing Sustainable Growth / Green Deal / and the Taxonomy also provides tailwind attracting investors to DHCN. Connected to these efforts are big opportunities for DHCN-owners, -operators and -developers to acquire long-term funding. New financial concepts, such as Public Private Partnerships (PPP) and Blended Finance-concepts as promising approaches for mobilising funding for DHCN from financial markets. There is also the possibility to learn from other countries. For example, it is an interesting question whether the Danish KommuneKredit-system can also be applied in other EU-countries. What is urgently needed is a standardized, digitalized gathering of data in line with EPBD, EED, EU Action Plan / Taxonomy is urgently needed by all involved. In the coming months two events together with the German Investment Funds Associations (BVI, > 100 members, representing EUR 4 trillion assets under management (!))

The following tables show a comparison of different demo-sites:

Comparison of the Demo-Sites:

The following figures contains comparison of the demo-sites with regard to technological innovation, investment requirements, funding structure, investors and taxonomy conformity (see Figure 74, Figure 75, Figure 76):

	Technological Innovation (Planned)	Investment Requirements	Funded by ...?	Investors	Taxonomy Conformity
Albertslund (Forsygning)	• By 2026 low-temperature district heating will lower the outgoing temperature to 60 Celsius. • Putting mixing valves underground by submerged shunt stations – testing a new technology (Grundfos iGrid)		In general: • Green Bonds • Green Loans • Mortgage Funds Shunt at Porsager: • European Union's Horizon 2020	• Investment via KommuneKredit (KommuneKredit is partially known by the municipality) • Others (via Green Bonds, Green Loans and Mortgage Funds)	• Questionnaire

Quelle: https://www.grundfos.com/about-us/cases/danish-utility-enjoys-ease-of-grundfos-igrid-to-control-low-temperature-district-heating

Figure 74: Comparison of the demo-site (Table 1), Own representation

	Technological Innovation (Planned)	Investment Requirements	Funded by ...?	Investors	Taxonomy Conformity
Helsingborg / Mölndal (Tornet AB)	• No innovation planned, but the network would need more customers	• All funding is kept within the group	• Municipality via Tornet AB	• Municpality via Tornet AB	-
Poland (SEC)	• Decarbonization of the network (= reduction/ replacement of fossil energy sources)	• Yes, but 100%-daughter of E.ON (66,4%)	• Green Bonds	• E.ON. • Others (via Green Bonds)	• Questionnaire
Milan (A2A)	• Extension of district heating and cooling systems	• All funding is kept within the group	• Green Bonds • Other green investments	• All kinds of investors	• Project in alignment with EU-Taxonomy (70% and still rising)

Figure 75: Comparison of the demo-sites (Table 2), Own representation

	Technological Innovation (Planned)	Investment Requirements	Funded by ...?	Investors	Taxonomy Conformity
Topusko	• Renovation and extension of the existing network • Drilling more wells for more geothermal energy	• Yes, but prices are too low	• State/EU		
Toulon (EDF)	• Renovation and extension of the heating and cooling network	• All funding is kept within the group	• Public DH Fund (Funding of 20% to 30%) • 50% - 70% third party funding needed • Green Bonds	• Public • Third party	• CO2 emissions in accordance with EU-Taxonomy
La Seyne-sur-Mer (Dalkia)					

Figure 76: Comparison of the demo-sites (Table 3), Own representation

7.1.4 3rd Investor-Workshop (Online) January 19th, 2024 in cooperation with BVI and VKU

On the 19th January 2024 the BVI (Competence Center for the German Funds Industry, BVI for short)) organized an online-workshop with the VKU (Verband Kommunaler Unternehmen) and HFT. The goal of this workshop was to approach the question how investors can be encouraged to make investments into District Heating-networks and what efforts have to be made by the political decision-making process.

The BVI is an association of investment companies founded in 1970. Its more than 115 members manage more than EUR 4 trillion in mutual funds, special funds and asset management mandates. The task of the BVI is to represent the interests of the German fund industry at national and international level. The BVI also holds close contacts to politicians and regulators on all issues relating to the German Investment Code. (BVI 2024)

The goal of the VKU (Association of Municipal Enterprises) is to make sure that municipal companies can guarantee the important tasks of public services at a high level of quality. The VKU represent the interests of its member companies close to politics, business and administration at state level. The organization's goal is to create the best possible framework conditions for an economical, safe and sustainable municipal energy and water supply as well as waste and wastewater disposal. In addition, the member companies are supported in the areas of public transport, swimming pools and parking garages as well as broadband supply and telecommunications. The close strategic partnership with the municipal umbrella organizations has proven to be advantageous. The VKU informs its members about legislative projects and

measures at state level. In addition, we organize the exchange of opinions and experiences between companies in very different working groups and at events. (VKU 2024)

The persons presenting were:

- Roberto Fedrizzi (EURAC Research) gave an update of the technical status and the potential of low-temperature networks
- Kristina Lygnerud (Swedish Environment Research Institute (IVL)) talked about the historical background and the development of district heating in Scandinavia
- Nils Weil (VKU) talked about the organization of district heating in Germany
- Tobias Popovic (HFT) talked about the scientific progresses within the RewardHeat community

Key findings of the BVI-workshop:

The workshop revealed that the implementation of efficient low-temperature networks and also cooling-networks is technically complex and therefore it requires high investment sums over a long period of time. Transporting heat over long distances is challenging for low-temperature networks and this is why municipalities should make use of local heating-networks. Moreover, greenfield investments should be based on a strong data base, but this makes it necessary to identify the energy demand of the buildings and getting valid data is difficult in decentralized systems such as Germany. Other systems of funding large-scale infrastructure projects, such as KommuneKredit in Denmark, may serve as a blueprint. This will make it hard to find suitable investors. New financial models such as infrastructure funds or Green Bonds may help to close this gap.

7.1.5 4th Investor-Workshop from 14th to 17th May 2023 in Brussels

From 14th to 17th May 2024 an international investor workshop in Brussels took place. The title of this hybrid conference (presence/online) was "Accelerating the European district heating rollout - Unlocking the potential of financial markets". The workshop was planned and carried out as a hybrid format. The presentations were followed by an interactive policy recommendations roundtable where all participants were invited to contribute their perspective and input.

Summary of the key findings of the speakers:

Madis Laaniste from the European Commission provided an update on regulation, supportive policy and financial frameworks relevant to district heating and cooling networks (DHCN). This also included a Discussion of the EU-Directive (EU) 2023/1791, Article 26, which contains a provision regarding the heating and cooling supply as well as an explanation of the progressive evolution of an efficient district heating and cooling definition in view of the sector decarbonization in 2050. Laaniste also talked about the conversion plans for DHC laid down in Article 30 (EED) and the discussion of the EU Taxonomy Regulation containing the climate delegated act on district heating.

Tobias Popovic from the Hochschule für Technik (HFT), Stuttgart stressed the importance of innovative financing schemes, such as e.g. Blended Finance, ELTIFs, etc., and also emphasized that energy cooperatives could play an increasing role in the heat transition. Furthermore, he spoke out in favor of a more holistic approach based on an openness to technology, individual buildings and neighborhoods/districts, energy efficiency and renewable energy supply, etc. In his view, it is essential to see the neighborhood/district as an innovation ecosystem and also an investment

object. Distinct areas should be prioritized and as a second step measures should be defined at an individual building level (e.g. energy efficiency, heat supply). From the regulatory side, different frameworks should be included and there should also be a harmonization of the EU Taxonomy with other regulatory requirements such as EPBD, CEAP, EED, etc. He also made clear that especially Germany would need a more flexible regulatory-(tax)-framework for investment funds. A standardized, taxonomy-compliant DHCN-data and as well as digital tools, esp. for collecting and evaluating KIPs, would also be helpful. In order to ensure funding, the municipalities and "Stadtwerke" should consider financial markets and financial institutions as powerful partners for mastering the heat transition. He also stressed the need for an impact-orientated financing, insurance and subsidized financing. Investors should be attracted by utilizing innovative finance instruments, e.g. Blended Finance, Sustainable Finance. An innovative approach could be the setting up of nation-wide financing agency/platforms for municipalities as it is the case in Denmark or France.

Helene Vinten from KommuneKredit provided an insight on the advantage of a nationwide funding platform making it possible to raise capital on global financial markets for financing infrastructure projects such as DHCN on the municipal level. Her emphasis was on showing that this platform could potentially serve as a role model for other European countries. In Denmark all municipalities and regions are members of KommuneKredit, which means that they have a joint liability for their obligations combined with a very secure business model. All of this is provided by KommuneKredit, which has the highest possible credit rating in line with that assigned to the Kingdom of Denmark. KommuneKredit's lending covers many different local projects in Danish society, such as green investments as well as an expansion and improvement of the infrastructure. A construction credit is granted to start the project and final financing is ensured by a 30-year amortizing loan with fixed or floating interest rates. There is a Danish legislation on collective heating so that district heating is a public task. This becomes obvious in the fact that 100% of the capital investment for DH is provided by the Danish legislation. Another fact is that local heat planning remains within the municipality, which means that the municipality has to approve all new collective heating projects. The DH company has a de facto monopoly and this means that there is no direct competition.

Sebastian Glock from VC Trade discussed in what way investment and trading platforms could support accelerating the flow of funds into DHC. In this context he outlined the importance of covering the entire value chain in one venue via platforms. He also illustrated the various advantages of the so called "platformization" in processing financial transactions, in complying to regulatory requirements and the changes that this "digital revolution" would mean to the investor universe. Furthermore, he outlined how the increasing shift of market transactions to platforms leads to a combination of marketplace and infrastructure. When being compared to conventional market transactions, this new digital technology has the following advantages: maximum efficiency, settlements in minutes, a high connectivity, compliance proof, collaboration and negotiation, transfer/ assignment as well as price efficiency.

Peter Dahl from Pohlem Infra provided the perspective of a Swedish pension fund as a long-term investor, which is focusing on equity investments into DHC. In concrete terms, this means that municipality owned companies should be enabled to compensate their financing gaps through the capital market. Financing via the capital market has several advantages for municipality owed companies, such as a much broader investment base, an improved liquidity and a variety of instruments leading to diversified funding sources, which may lead to potentially lower cost of equity. Pohlem Infra has set itself the task of bridging the gap between capital market funding and public funding.

Tim Ockenga from the German Insurance Association, GDV discussed the importance of insurance companies (as long-term investors) for financing sustainable infrastructures (such as DHC). In addition, he shared insights of policy recommendations he had co-authored for the Sustainable Finance Advisory Board to the German government. He also outlined the advantages of these kinds of investments, which can be summarized on the basis of the following key points: Security, duration, regulatory requirements and flexibility.

Kristina Lygnerud from IVL (Swedish Environmental Research Institute) and Lund University gave an update on the EU Taxonomy and SFDR and presented a digital tool for investors to analyse whether a potential DHC-investment is Taxonomy-compliant. She argues that the current energy systems have to be enabled in order to become future proof energy systems and to fulfill the requirements of the EU Taxonomy in terms of technology and fuel mix as well as environmental impact.

Chris Garside from Resourceful Futures discussed policy recommendations for accelerating sustainable investments. He also gave an insight on latest developments in the regulatory landscape in the UK. He emphasized that the preconditions for stable investments are a clear market framework, a clear role of the government, a joint-up thinking through policy levels, stability and a good knowledge base.

Key findings of the workshop:

- In the context of a Great Transformation DHC are a crucial element for decarbonizing both the utilities and the building sector. But this will require several 100s bn EUR of investments.
- The money is there. It "just" needs to be directed into DHC.
- Less amounts of public money must trigger big private capital: Against the background of high public debt and also high investment costs Blended Finance could be a promising approach for mobilizing private capital on financial markets.
- For this reason, the regulatory and frameworks need to be improved for Blended Finance and other innovative financing instruments (e.g., ELTIFs)
- Regulation is too complex for the stakeholders involved: Complexity needs to be reduced and frameworks streamlined. Also: The different regulatory frameworks (EED, RED, EPBD, Action Plan/ Taxonomy/ CSRD/ SFDR) need to be better coordinated and made more compatible to one another.
- Transparency has to be increased, in order to reduce uncertainty
- Consistency must be established in order to regain trust
- Ambitious EU-wide CO_2-pricing schemes for all sectors are needed

Interim Results on the Taxonomy-part of the Workshop:

The evaluation of the interactive part on the Taxonomy has shown that the funding of DHC is regarded as a problem because of the high investment costs that cannot be covered by the municipalities alone. Passing these costs on to end consumers would lead to major social distortions because of the increase in price. Another major concern can be seen in the EU Taxonomy, which is regarded as non-transparent and also inconsistent. The lack of transparency is due to its high complexity. Inconsistency is a result of the Taxonomy's constant expansion and the changes made to its regulations. Both is unsettling to is applicants. The lack of knowledge on

goals of the Taxonomy leads to doubts regarding the significance of the EU Taxonomy. A direct consequence is uncertainty and loss of confidence – also among potential investors and this makes funding more difficult. Another concern can be found on the side of competition, e.g. to other energy sources (e.g. gas), because of lower costs and price advantages. Concerns about the technical adaptability results from the need to decarbonize older DHC networks.

Regaining trust in the EU-Taxonomy makes it necessary to arrive at a downsizing of the regulations so that its application within companies is to be facilitated. This is essential for the planning and construction process of new DHC-networks. Investors, who invest their capital in long-term assets, place importance on planning security and a predictable course of all the project's lifecycle phases. Frequent changes in regulation or additions are unsettling for everyone involved – for those companies leading the construction process and also for potential investors. Further concerns were expressed with regard to competitiveness referring to the EU Taxonomy's scope of application. Those countries which are subject to the EU Taxonomy fear competitive disadvantages compared to those not within the scope of the EU Taxonomy. Other concerns were expressed with regard to the technology of older heating systems and their tolerance with regard to their refitting. This interactive part of the workshop has also shown that there is a lack of knowledge concerning the EU-Taxonomy. As a result, it can be said that it would be advisable to work on the EU-Taxonomy's transparency, its application (downsizing) and to highlight its significance.

Comparison of the demo sites financial structure:

The following figures show a comparison of the financial structure of the countries in which the demo sites are located: (see Figure 77, Figure 78, Figure 79, Figure 80):

Country / Organisation	How does the financial struture look like?	Which (sustainable) financial instruments are used?
e·on	• Financing via the capital market	• **Green Bonds** • Issuance of green bonds in the amount of €1.5 billion for the financing of "green" projects in 2024

Figure 77: Comparison of the demo-sites financial structure, table 1, own representation

Country / Organisation	How does the financial struture look like?	Which (sustainable) financial instruments are used?
	• At A2A, all DH investments are on one balance sheet • Financing is also provided by the European Investment Bank (EIB) subsidies (only to a small extent) • Wide range of investors (e.g. pension funds etc.) • Investments must reach certain target values in order to be continued	• **Green Bonds** (Green Bonds start with €500 Mil.) • Other „green" Investments

Figure 78: Comparison of the demo-sites financial structure, table 2, own representation

Country / Organisation	How does the financial struture look like?	Which (sustainable) financial instruments are used?
	• There is a public DH fund for renewable energies (incl. DHCN), which provides 20-30% of the financing. • With the Chaleur @ADEME fund, financing is based on CO2-reduction • If a project is worth more than €20 million, a third party investor is sought	• Green Bonds are used by EDF for the refinancing of investments

Figure 79: Comparison of the demo-sites financial structure, table 3, own representation

Country / Organisation	How does the financial struture look like?	Which (sustainable) financial instruments are used?
KOMMUNEKREDIT	• Access to the capital market through EMTN program 1993 • Maximum outstanding amount: € 30 billion • Dealers in the programBNP PARIBAS Deutsche BankMorgan Stanley etc. • Program is listed on the stock exchange in Luxembourg • Main paying agent: Citibank ➔ KommuneKredit serves as a financial platform that refinances itself with green bonds and other financial instruments	• Green Bonds • Green Loans • Mortgage Funds • Loans are granted for 30 to 40 years at fixed interest rates

Figure 80: Comparison of the demo-sites financial structure, table 4, own representation

Key Takeaway of Chapter 7:

Networking with investors is essential to help a new technology achieve a breakthrough by mobilizing the funding needed via financial markets. Through the different workshops carried out throughout the project, innovative financing concepts (e.g., ESG-linked instruments, blended finance) developed in this work package were presented to investors and discussed, as well as feedback collected. These iterative feedback-loops contributed to further developing and refining the concepts. Also, the financing and ownership structures of the demosites where analyzed in order to find out more about their particular funding needs and how these could potentially be met. Also, it was analyzed and discussed, which investors follow which investment strategies and what criteria and KPIs are important to them in their investment decision-making process. In addition, the HFT-team offered a coaching process for demosites supporting them in developing business models and investment cases in order to be able to attract investors. The evaluation of the results of the interactive part of the Brussels-workshop has shown that some participants see challenges in the regulatory environment affecting the funding of new DHCN, the lack in transparency (complexity), inconsistency (changes) and significance of the EU-Taxonomy, which could not make the funding of such projects more, but also their implementation.

8 Conclusions

Financing DHCN is a crucial issue for the success of DHCN in Europe. Upscaling DHCN in Europe will need enormous investments, which cannot – due to the already high debt levels –exclusively be financed by the public sector. Furthermore, private investments will be needed in particular. Therefore, this work packages elaborates – among others - DHCN is or can become an attractive investment for financial market participants. Due to changes in the regulatory environment, DHCN as an asset class should increasingly benefit from regulatory measures, such as the EU Action Plan on Financing Sustainable Growth and – as part of the Action Plan – the EU Taxonomy as well the EU Green Deal. However, there are still hurdles to be overcome in practice:

Firstly, there is a lack of awareness of the issue of private financing on the part of operators. Often, initial investment is supported or fully financed by subsidies and public funding, and the urgent problems are of technical nature. Little thought seems to be given to how DHCN can be financed without public support in case public funding would not be available anymore in the future. The level of public debt in some countries and especially in municipalities is likely to reduce the ability to spend, especially with the current rising interest burden. Capital markets are not yet sufficiently used for DHCN. Therefore, the potential of financial markets for financing DHCN has not been extensively utilized, yet.

Secondly, more project developers are needed who cover the entire spectrum and all stages of the infrastructure lifecycle. This means planning, building and operating the network, as well as having the necessary financial know-how to finance the network or to obtain financing via the capital markets.

Thirdly, investors should already be involved at an early lifecycle stage. The findings of the interviews and workshops showed that investors want to be involved at an early stage. Especially when it comes to greenfield projects, investors want to know what they are buying, want to proactively manage relevant risks and can contribute their know-how to the development process. Of course, there are also investors like pension funds who want to take less risk and buy later in the life cycle, when a network is already up and running and generating stable returns. However, it is important for upscaling to attract investors for new networks or the refurbishment and decarbonization of old networks. In this context, blended finance instruments, where e.g., a public institution takes – especially in earl life cycle stages – a majority of the project's risk, seem to bear quite some potential to attract institutional investors to DHCN-projects. In this respect, the EU Green Deal might improve the availability of blended finance instruments.

Fourthly, Data! Data is needed to be able to finance DHCN. Investors need to know what they are buying. The "Magic Square" of investment decision making with its four dimensions (return, risk, liquidity, sustainability) can provide orientation to investors. In order to be able to calculate specific key performance indicators (KPIs) the corresponding raw data needs to be provided by the different demo sites. In addition, the need for data has increased due to the EU Taxonomy. As DHCN fall under the Taxonomy, DHCN owners or operators need to be able to provide data on their sustainability as soon as financing via financial markets is needed or targeted. This already applies to a simple bank loan. As a consequence, DHCN operators have to deal with the Taxonomy. Based on the findings from the interviews with the demo sites partners, in the majority of the cases, the Taxonomy does not seem to be known in detail, yet. Especially the smaller operator or the employees with a technical background had no knowledge or little knowledge about the

Taxonomy. However, the interviews and workshops with investors showed that data is urgently needed. In the project, it was difficult to get data from the demo sites to calculate financing cases. Data will therefore remain a major task for the future.

A particular focus was on the topic of blended finance to finance large-scale infrastructure projects such as DHCN and to promote the utilization of green energy technologies. Throughout the project it could be shown that DHCN has emerged as promising technology for realizing a successful heat transition. However, high levels of public debt and national, state and local levels, which are not able to raise these high investments, lead to a slowing down of this development. For a long time, blended finance was only focused on infrastructure projects in developing countries. Now, blended finance has become a model to create new incentives for the urgent topic of the heat transition and thereby enable Europe to achieve its climate targets. The goal is to combine private, philanthropic and public funding to achieve positive changes within the system.

For instance, blended finance-approaches are based on the basic idea that the redevelopment of the community is not a homogeneous activity generating certain returns under a risk that is fixed. Instead, many levels must be integrated – of which each generates its own returns. This makes it necessary to divide the necessary work in a financial and non-financial section associated with each level. The creation of these framework can serve as preconditions for large-area application in the field of blended finance – especially for the financing of DHCN.

To conclude, DHCN seem to have great potential as a sustainable asset class in their own right and can be an attractive investment. In practice, however, there are still some hurdles that still need to be overcome. The work in this work package will also do some "translation work" between technicians and investors. This is also urgently needed and must be continued.

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10 Annex I

Questionnaire

Introduction:

- Small talk
- Introduction of myself and the REWARDHeat project
- Obtaining consent for recording - absolutely necessary! (be sure to ask beforehand)

Entry questions:

- Introduction of interview partner (Name and position, organization, country, expertise)
- What type of financing schemes are you usually interested in?
- What type of financing instruments are attractive to you and why?

Investments in infrastructure projects:

- Have you invested in infrastructure projects previously?
    - If yes:
    - What was the key driver for you?
    - Did you get what you have been anticipating out of your investment?
    - What was good/ bad about it?
    - If no:
    - Have you ever had the opportunity to do so?
    - What are the reasons for not investing in such projects yet?
- What opportunities do you associate with infrastructure projects?
- Which risks / uncertainties do you associate with infrastructure projects?
- What information is most relevant to you before taking a decision whether or not to invest in infrastructure projects?

DHCN projects

- How familiar are you with the topic of DHCN networks and related Business Models?
- Which role does the technology involved play for you if you were to invest in a DHCN project?
- If already invested in DHCN: How did you invest, which finance instruments did you used? If not: Which instruments would you consider appropriate?
- Do you think district heating have to develop new business models to be competitive in the future (lower demand volumes, heat as a service, …)?

Investors' objectives and needs with respect to sustainable infrastructure investments

- What are concreate objectives and needs in respect to sustainable infrastructure you have as an investor? (criteria)

KPIs

- Outgoing from the „Magic Square", which KPIs are important for you in the areas ("corners") of return, risk, liquidity and sustainability? ("Magic Square" -> go through "corners", ask along the corners which KPIs are important)
- Name three key KPIs that are relevant to you when making investment decisions
- Do you consider qualitative KPIs as well?
    - if yes, how do you measure them?
    - If no, how do you overcome related uncertainties/anticipate related opportunities?
- What relevance do certifications have? Are there any certification programs you know and rely on?

Sustainability/Sustainable (Infrastructure)Finance

- How do you define sustainability and sustainable finance?
- Have you been measuring sustainability so far (of your investments or your company)? If yes how? If no why?
- In your opinion, what is the role of the financial sector in fostering sustainability?
- How can Sustainable (Infrastructure)Finance contribute to a sustainable development and to met climate goals?
- Sustainability is often all about Climate and CO2-emissions. Do other factors of sustainability really matters?
- What impact could CO2-pricing have on DHCN?

EU (sustainable finance) regulation: EU Action Plan on Financing Sust. Growth (esp. EU Taxonomy), EU Green Deal, NextGenEU, EU Fit for 55

- How familiar are you with the Taxonomy?
- How does the Taxonomy (will) influence your investment decisions?
- Which role does the taxonomy play for you in practice?
- What are the greatest challenges in the implementation of the EU Taxonomy?
- Have you already done any form of Reporting of EU taxonomy Conformity according to the Disclosure Regulation, if yes what were the difficulties?

Concluding questions:

- Would you be interested in further information on the Reward Project?
- May we contact you in future for further questions (surveys or workshops)
- Is there anything you would like to ask? Is there anything we did not considered yet?
- Are we allowed to mention your name and organization within our project results or would you rather stay anonymous?

Questionnaire: demo sites

A first Questionnaire has been sent out in April 2023. The query only referred to financial data. The recipients were the demo-sites from Helsingborg/Mölndal, Alberstlund, Ballila, Topusko, Toulon and La Seyne-sur-Mere.

No.	Opening question	
1	Describe shortly the business construction of your demo site. • Is it publicly or privately owned? • What is the nature of this construction (Joint Venture, SPV, non-profit, etc.)? • How many shareholders are involved and who are they?	

No.	Setting / Technical and Environmental Questions	Unit	Value
1	Number of houses	Description only	
2	Type of houses (e.g. single-family houses / apartment block / communal buildings)	Description only	
3	Principle energy sources	Description only	
3	Year of construction	Date	
4	New development / renovation	Date	
5	Total heated area	m^2	
6	Supply temperature	Celsius	
7	Return temperature	Celsius	
8	Distribution losses	%	
9	CO2 – emission factor (cooling)	kg/MWh	
10	CO2 – emission factor (heating)	kg/MWh	

11	CO2 – emission factor (total)	Kg/MWh	

No.	Economic Questions	Period	Value
1	Initial Investment Sum		€
2	CAPEX (Capital Expenditures)	p.a.	€
3	OPEX (Operational Expenditures)	p.a.	€
4	MEX (Maintenance Expenditures)	p.a.	€
5	Return of Investment (ROI)	p.a.	€
6	Internal Rate of Return (IRR)	p.a.	€

Brief synopsis of further case studies

Project	*Overall Scope*	*Expected Results*	*Financing & Source*
Aarhus (Lystrup) DK	*The local site network supplies 40 terraced low-energy houses and one communal building with domestic hot water and space heating* *(Celsius Wiki 2020)*	• *In 2010, the results have made clear that it is possible to supply customers with a supply temperature of approximately 50 °C and satisfy both the storage heater requirements and to guarantee safe preparation of DHW.* • *By 2022, the geothermal district heating plant will heat thousands of homes by getting heat from the earth's core in Denmark's second largest city.* • *The upcoming plant is expected to provide 20 % of the district heating demand in Aarhus municipality, which has 330,000 citizens and 180,000 households. 95 percent of these are connected to the district heating system.* • *The planned capacity of the geothermal heating plant is 110MW, and the annual CO_2 emissions are expected to be reduced by up to 165,000t.* • *Subject to a successful appraisal process, the geothermal plant will be completed in 2029 with an expected operation of at least 30 years. Once operational, water will be extracted two to three km below the surface at a temperature of 60-90 degrees Celsius. At the surface, the water's heat is captured and transferred to the district heating*	*Revenue:* *812,047* *EBITDA:* *155,974* *Net profit:* *89,098* *Total Investment:* *107,449* *Equity:* *329,27* *(Verdo 2022)*

		network. (State of Green, 2022) • *44% toward Denmark's overall goal of cutting CO2-emissions by 70% by 2030. (Verdo 2022)*	
Slough, United Kingdom (UK)	*A small, experimental low temperature district heating system has been in operation since 2010 in Slough, west of London. It consists of an energy center that supplies heat to nearby dwellings (in total 10 dwellings with 25 residents) and an information center. (Celsius Wiki 2020)*	• *In moving away from gas heating systems, Slough Borrow Council considers the uptake of non-fossil fuel sources for heating within homes and commercial properties, including heat pumps, district heating and combined heat and power networks (CHP). The impact of the fuel mix will be heavily influenced by the increased availability of renewable energy.* • *The system is intended to demonstrate different renewable technologies in combination with low-energy houses. One of them is DC.* • *To keep Slough aligned with the Paris Agreement, emissions must be reduced by 12.7% per year. (SLOUGH BOROUGH COUNCIL 2021)*	*No data available*
Høje Taastrup (Sønderby), (DK)	*In Høje Taastrup, Denmark, the old district heating system has been replaced in an area with about 75 detached houses in an area called Sønderby.* *The existing system was only*	• *Cheaper and almost fossil fuel free district heating production.* • *Improved aquatic environments and dry basements.* • *With four positive outcomes, Høje Taastrup Fjernvarme has declared the system a win-win-win-win.*	*Total Investment:* *903.508* *Total Savings:* *43.706* *(Cp. Upgrade DH, 2021, p. 11-12)*

	about 15 years old but had distribution losses at levels of 38-44 % (Olsen, 2014). The new system was connected via a shunt connection to the main network, which has a supply temperature of about 80 °C and a return temperature of about 50 C. (Celsius Wiki 2020)	• *When the pumps were first put in operation in January 2019, the very high-water table immediately sank by 40 centimeters. The facility is therefore not only considered a success in terms of climate change adaptation. It also means no more wet basements in the area.* • *Furthermore, heat production is cheap, because it only requires the electricity needed to power the heat pump. And the electricity for this comes from a biogas plant and is therefore sustainable. (ClimateChangeAdaptation 2022)*	
Stavanger (Østre Hageby), Norway	*In Norway, a new passive house project with 66 dwellings, consisting of both apartment blocks and terraced houses, was built between 2012 and 2014. The houses will be provided with space heating and domestic hot water heating from a ground-source heat pump system, distributed by a small-scale district heating network.* *66 residential units* *• 6 800 m²*	*The new central energy plant will reduce CO_2 emissions from 571 tonnes to 65 tonnes. (Cp. Triangulum)* *First 4th gen. in Norway* • *Is operating reliably for 2.5 years* • *40 % lower energy consumption pr. M* • *Greener choice than all-electric solutions* • *Downside is lack of more exact measurements* *(Tor Line, Frode Frafjord, Roar Nysted 2019)*	*No data available*

	• Low-temperature heating system • Lower installation costs due to smaller pipe systems • Learnt from the Lystrup project in Aarhus, Denmark (Tor Line, Frode Frafjord, Roar Nysted 2019)		
Ludwigsburg, Germany	In Ludwigsburg, Germany, an area with low-energy (passive) houses will be supplied withdistrict heating using a concept called "LowEx". The system is a subgrid of a main grid, where the return temperature of the main grid is used as the supply temperature in the subgrid, at about 40 °C (return temperature 20 °C). (Celsius Wiki 2020)	• According to the local company the yearly reduction of 3700 CO_2-emissions will help to save 1.6 Mio liter petroleum or a forest area of app. 470 football fields. • Solar panels are collecting 522 MW per year. This provides 300 average households with heat to power. Furthermore, this leads to a reduction of CO_2-emission of 3700 t p.a. The system also relieves with its amount of warmth the wood heating plant, which therefore needs less pellets.(sdg21 2020)	Total investment: 15 Mio. (with 10 Mio. subsidies of the Federal Government) (stadt+werk 2019)
Hamburg, Germany	In September 2019 the residents of Hamburg decided in a referendum (2013) to repurchase the district heating system from the	• By 2030. This means that the coal-fired power station Wedel will be abandoned after the heating period 2024/25. Another one will follow until 2030. • It is planned to use district heating instead of coal-	No data available

	Swedish energy company Vattenfall. *Now, the company is called Wärme Hamburg GmbH und belongs to 100% to the city. It delivers heat to 490.000 residential units.* *(hamburg.de)*	*fired power plants. (hamburg.de)* • *The goal of the city is to reduce the amount of heat from coal from 64 % to 0%.* • *(European Bank for Reconstruction and Development 2020)*	
Kyiv (Ukraine)	*The Project aims to provide sustainable and efficient operation of the existing combined heat and power plants and boiler houses in the city of Kyiv.(European Bank for Reconstruction and Development 2020)*	• *The Project's primary goal is to achieve significant environmental improvements and promote the green transition quality within the relevant cities.* • *The GrCF2 [Green City Framework 2] also aims to build necessary capacity and facilitate better coordination among various stakeholders within the relevant cities in order to improve the governance, operational efficiency and financial sustainability of the targeted investments and initiatives.* • *The Project is part of an ongoing rehabilitation and modernisation of the district heating infrastructure in Kyiv and will result in environmental and social benefits associated with the overall improvement in the quality of heating and hot water services, improved energy*	*Total Investment:* *140 Mio. (* *(European Bank for Reconstruction and Development 2020)*

		efficiency, reduction in fuel consumption and heat and water losses, and lower air emissions. As a result, net reduction of Green House Gas ('GHG') emissions will be around 196 k t/yr of CO_2 equivalent. (European Bank for Reconstruction and Development 2020)	
Espoo (Finland)	*The Finnish geothermal heat company QHeat has announced the completion of drilling of the first thermal well of the Finnoo project in Espoo, Finland. Drilled to a depth of 1500 meters, the well will supply geothermal heat to six apartment buildings as part of Finland's first geothermal district heating network. (Carrington 2022)*	• *When the geothermal wells are completed in Finnoo, the amount of purchased energy in the six apartment buildings in Djupsundsbäcken will be reduced by a quarter, and the climate emissions from heating will be reduced by 90% compared to district heating, calculated according to the specific emissions of Finnish electricity production. (Carrington 2022)*	*Total investment:* *3.3 Mio. loan by Finland's Climate Fund* *(Richter 2022a)*
Västerås, Sweden (S)	*A new area of 130 dwellings is situated in Västerås, Sweden. All houses will have district heating, and their energy demand is low because of energy efficient building techniques.* ⇨ *Västerås combines heat and*	• *The investments costs per metre of pipes are estimated to be about 10 % lower than for conventional systems.* • *According to Mälarenergi, three conditions need to be met for district heating supply to low-energy houses:* • *Lower distribution losses* • *Lower investments*	*Investment:* *82,6 Mio. Loan facility (for a new combined heat and power (CHP) plant)* *Total Investment:* *165 Mio.* *(NIB - Nordic Investment Bank 2019)*

	power. (Celsius Wiki 2020)	• *Increasing the use of heat by replacing electricity with heat. (Cp. Celsius)* • *The new unit, which will be fuelled by wood and biomass, will replace the use of coal and oil. This will complete the transition to biofuels for heat and power generation in Västerås, as fossil fuels will no longer be used in the operations. (NIB - Nordic Investment Bank 2019) (Cp. NIB- Nordic Investment Bank, 2019)* • *By producing electricity and heat simultaneously, a very high level of efficiency is achieved. A massive 90% of the fuel's energy content can be utilised in the process.* • *By way of comparison, a steam power plant that solely produces electrical energy only utilises around 40 % of the fuel's energy content.(MalärEnergi AB)*	
Marstal, Denmark	*The Marstal District Heating (DH) Plant has been completed in December 2011 in Marstal, Denmark. Since then, it provides heating to around 1550 buildings (most of it are single family homes). Its goal was to demonstrate that 100% renewable energy would be*	• *As the DH system is very flexible, it allows to convert not only surplus electricity into storable thermal energy (power-to-heat) but also makes it possible to store hot water back into electricity (heat-to-power). The system is changeable so optimal year-round performance is possible.* • *Throughout the summer, solar collectors provide most heat and storage. They are supported by the heat pump and the wood chip during most of the*	*Investment:* *The inhabitants of Marstal financed the original district heating network in the 1960s. Subsequently, the company financed the transition to solar by tapping into available subsidies and funding programmes.* *In the end, the total investment costs for the plant amounted*

	sufficient for district heating. The facility combines solar thermal energy collectors (33 365 m2) with biomass (wood chip) boilers, a 4 MW heat and power (CHP) unit, a 1.5 MW compression heat pump and 87 100 cubic metres (m3) of local heat storage. (Weber et al. 2016)	*remaining year when there is less sun. On very cold and dark winter days the system relies on back-up waste/bio oil boilers. (Weber et al. 2016)*	*to EUR 15.1 million, 35 per cent of which was covered by subsidies from an EU fund and the remainder of which was raised through Kommune Credit, a Danish funding programme that allows borrowing money at favourable rates.(Kovačević 2022)*