3.4 – Business models at REWARDHeat demonstrators

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

REWARDHeat

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Table of Contents

Summary

In this report, business models have been developed for the demonstration sites in the REWARDHeat project with the purpose to uncover lessons learned about the shift in business logic when transitioning from conventional DH business models to low temperature schemes. The business models have been developed in an iterative process with the DH companies participating in the project, during the first three years of its elaboration. A particular focus has been placed on the innovative component of the business models, i.e., the green value creation and its value to different stakeholders. Selling heat as a service (instead of as a commodity) has been the starting point in developing the business models. Contractual considerations and ownership forms have been analyzed for each of the demonstration sites. The findings enable the project to respond to the main questions of the deliverable: How does the REWARDHeat business model experiences differ from a conventional DH business model and what can we learn from the transition to low temperature DH solutions?

The aggregated results show that the demo sites focus on technical innovations but seven out of 10 also develop business innovations by increasing the service offer to customers. The business logic of low temperature DH makes it more efficient to develop the business innovation simultaneously with the technical innovation.

The lack of EU legislation on waste heat recovery is causing uncertainties. Investors need to know whether the investment is considered sustainable. The value of green is created at all demo sites and valued by most stakeholders. It is however only exploited in the business model at three demo sites.

Offering more advanced service to customers necessitates a shift towards being more customer oriented. By assuming ownership and maintenance of the substation at the customer site, the boundary condition is shifted to inside the customers' buildings. It creates a value of carefreeness for the customer as the DH company assumes more risk. The DH company gains from increased control of the network, something increasingly important in low temperature solutions. Three demo sites are offering advanced services resulting in a co-dependent relationship with the customer where the collaboration requires integration of processes.

The main change in the business model canvas for low temperature installations, in comparison to conventional DH, is the necessity to manage relationships. Relationship building is required for new partnerships, due to multiple decentralized heat sources, and for the prosumer customer segment, instated from waste heat and renewable energy integration. As decentralized energy sources are introduced to the DH network the distribution network becomes more important and large-scale centralized production plants less important. The business logic of low temperature solutions is more on circulating available resources, utilizing the available flexibility in the distribution network, and implementing more advanced control to manage the system efficiently.

1 Introduction

The "Renewable and Waste Heat Recovery for Competitive District Heating and Cooling Networks" (REWARDHeat) project demonstrates a new generation of low temperature district heating and cooling (DHC) networks, which can recover low temperature heat sources and renewable energy sources available within the urban context. The development of the REWARDHeat solutions is being piloted at ten demonstration sites around Europe where either third generation DH networks are being retrofitted or new networks are being constructed.

In this deliverable, business models are developed together with the demonstration sites focusing on the innovative component and exploring heat as a service. Low temperature DH installations tend to have a technical focus because of the level of innovation and this deliverable is a means to keep business development in the mind of demonstrators throughout the project. The deliverable further evaluates different ownership forms and contractual arrangements. A concluding comparison is then made, contrasting conventional high temperature DH networks with the finding from the REWARDHeat demonstration sites to provide insight on the transition from high temperature to low- and neutral temperature DHC network.

The deliverable is part of work package 3 (WP3) of the REWARDHeat project. The objective of WP3 is to facilitate investments in low temperature DH networks. The first two deliverables in WP3, D3.1 PESTLE Analysis and D.2 Customers' opinion (Fransson and Lygnerud 2021, Fransson, Sandvall et al. 2021) provide input to the rest of the work package. The process resulting in the three deliverables (D3.3, D3.4 and D3.5) is iterative where information flows between bankability-business model and financial instruments. The structure of WP3 is displayed in Figure 1 (developed by Hochschule für Technik Stuttgart).

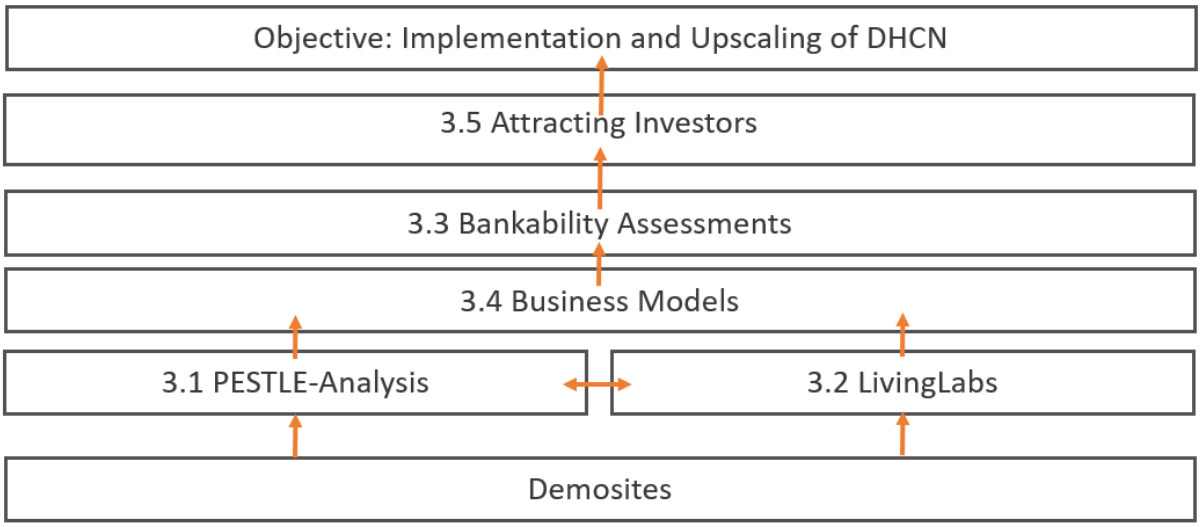


Figure 1: Structure of Work Package 3

In the study of bankability (D3.3), 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 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 and such tools are identified for REWARDHeat solutions. The starting point for bankability in REWARDHeat is the work done for four low temperature demo sites in the sister project ReUseHeat where the proposed credit facility is further examined in REWARDHeat. To understand the best way to finance an

investment, the investors tend to review the return, risk, liquidity, and sustainability of an investment. The ongoing development in the EU on green finance is accounted for both in the study of debt and financing instruments (the bankability deliverable) and in the financial instruments estimated to be efficient for investments like REWARDHeat demo sites (D3.5).

The report is structured in seven chapters. Chapter 1 introduces the REWARDHeat project and positions this deliverable. The chapter then presents the purpose and research question. Chapter 2 explains the method applied during the three years this deliverable has been developed. Chapter 3 is a theoretical section providing information on the topics that are assessed for the business model. Chapter 4 is the main chapter containing the business models for each demonstration site. In Chapter 5 the aggregated results from all business models are presented and the findings are discussed. Chapter 6 completes the deliverable with the generation shift conclusion, the business logic shift from conventional DH to low temperature solutions, and key takeaways.

1.1 Background

Heating and cooling represents approximately 50% of the final energy consumed in the EU (Fleiter, Elsland et al. 2017) and around 79% of the supply is still fossil fuels (EuroStat 2019). The heating and cooling sector is key to reduce greenhouse gas emissions in the EU, to achieve the Paris Agreement and the ambition of the EU to become the first climate-neutral continent by 2050. In urban areas, DH systems can be a cost-effective solution to decarbonize the heating and cooling sector and the level of urbanization in the EU is expected to increase further by 2050 (Connolly, Lund et al. 2014). Multiple studies indicate that DH, and particularly low temperature networks with the ability to incorporate low temperature waste heat and renewable energy, can play an important role in a decarbonized energy system (Lund, Möller et al. 2010, Münster, Morthorst et al. 2012, Rezaie and Rosen 2012, Brand and Svendsen 2013, Connolly, Lund et al. 2014, Schmidt, Kallert et al. 2017).

Business model development has been included in several EU financed projects for heating and cooling solutions from different perspectives. The findings from the Flexynets, ReUseHeat, STORM, CoolDH, Cool Heating, Upgrade DH, SunHorizon and Heat Road Map 4 project are presented here as examples of previous findings. In Flexynets, the focus was on neutral temperature DHC networks where heating and cooling is supplied through the same pipes. The business model focused on the shift from having a central production unit to a multiplayer arena with multiple feed-ins to the network such as local RES (e.g., solar, geothermal) and waste heat (e.g., supermarkets, data centers). Two business model options were identified: 1) thermal producers: waste heat and RES going into the network, 2) prosumers: thermal energy is provided to the network during space cooling operation in buildings. Identified benefits in the business model are that heat recovery can develop at a very low cost or even sold as a cooling service and that it diversifies the utility's business portfolio and customer offer. Identified risks are more elaborate contracts (incl. heating, cooling and services) and a higher risk with multiple producers (Cozzini 2018).

The ReUseHeat project focused on urban excess heat recovery into DH networks and explored efficient contractual forms, ownership structure and changes in the business models. It was identified that all demo sites in the project had a technical focus in the development activities. The value of green was identified as an additional value in urban waste heat recovery investments, but the value is not exploited to customers. The value of green can be important to some customer segments, such as cities, politicians, and companies but generally not to the end-users. Close interaction between the DH company and the excess heat supplier is crucial and new combinations

of technologies are necessary (heat pumps) which increase the risk, mainly due to electricity price (Lygnerud 2019, Wynn 2019).

In STORM an innovative network controller was developed to increase the use of waste heat and RES in DHC networks. One of the demo sites faced challenges in increased competition from alternative heat sources and wanted to increase the value proposition to customers and become more cost competitive. A new pricing model was developed to incentivize customers to have a well-functioning substation and the value provided (cost savings) was to be shared between the DH company and the customer. The other demo site was experiencing high investment costs and wanted to connect more customers to decrease the investment per customer. They moreover needed to increase production capacity at a low cost and reduce demand with existing customers to free up more capacity by encouraging building upgrades. Increased control of the buildings substations, if access is granted, could further increase system efficiency (Smulders 2019).

CoolDH integrated low-grade heat sources into low temperature DH networks to supply heat to energy efficient buildings. The work related to business models focused on developing an easy-to-understand (transparent) price model which also incentivized low return temperature and moving more toward supplying a service. With few customers connected to the network the impact of each customer is greater than in large scale conventional DH network. The business model was developed in two parts. A theoretical section to understand the customer and customer needs, and a numerical part. The price model was divided into a fixed fee based on floor area and a flexible fee divided further into two parts, a minimum energy price and a fee based on the return temperature (Kralmark 2019).

In Cool Heating the focus was on implementation of small and modular heating and cooling networks based on renewable energy in south-eastern Europe. Cool Heating identified different ownership models, both traditional and innovative, suitable for developing DHC network. The business model focused on generic cost and income structure of DHC networks and reviewed some best practice examples of successful DHC projects around Europe (Sunko 2017).

The Upgrade DH project examines the best upgrading and retrofitting measures and tools for DH networks around Europe. The project identifies seven aspects that are characteristic for DH upgrading projects; strategic objective, ownership structure, investment plan, economic aspects, contractual and permitting issues and involved stakeholders. To investors and end-users, the most important aspect is typically financial return, whereas for local governments other aspects within the social and environmental spectra can be more important. A sustainable business model must ensure the planned benefits by different stakeholders are achieved.

In SunHorizon innovative heat pump technologies are coupled with solar appliances to supply a local renewable energy-based system, managed efficiently by control algorithms. The value proposition found in the business models was lower GHG emissions, increased self-supply, primary energy savings and energy efficiency, potentially resulting in cost savings. For some customers the additional value of increased thermal comfort was a result of upgrading the buildings heating system. The value of green was especially important to municipality customers were the government had renewable energy targets. Financial support was found to be especially important for small-to-medium sized residential house owners. The innovation of the technology made new partnerships more important, e.g., people with competence to design and install the equipment, as well as the availability of assistance to manage necessary inspections and issuing permits. Most of the business models for the sites contained some aspect of trying to increase the awareness about energy usage and interact with the customer (e.g. by using visualization tools or dissemination of information) (IVL Swedish Environmental Research Institute 2019).

In Heat Roadmap Europe 4 three categories of barriers were identified for the expansion of DHC network in Europe: 1) Knowledge barriers (e.g., awareness, uncertainties), 2) Economic barriers (e.g., pricing, OPEX, CAPEX, financing, investments, feasibility) and 3) process barriers (e.g., relationships, interactions, organizational changes, political framework). Some of these barriers were addressed by deriving key business strategy recommendations affecting the business model. The first is to transition away from selling a commodity, but rather sell a service. Some examples are energy savings agreements that are mutually beneficial and help overcome financial barriers. The cost of connecting to a DH network could be spread out instead of a lump sum. Instead of selling a heat pump (unit), the supply of heating and cooling, or a set temperature, could be sold (service). The second strategy is to make it easy for the customers by clearly displaying the benefits, which differs depending on customer segment. Including new partnerships increases the partners competitiveness and will be necessary in a more integrated energy system with more complex operational strategies. DH companies must be aware of the competition and increase efficiency and upgrade the pricing model to be better aligned with the cost for the utility and the value of each customer and to incentivize customers to optimize their substations (Trier, Maarten ; Krasatsenka et al. 2018).

In this deliverable, the business logic shift from conventional DH to low temperature solutions is studied. The project contributes with a new perspective on business models for innovative DH networks by focusing on increasing the level of servicification offered by DH companies to customers, by evaluating the green value and by including contractual considerations. The iterative process for developing the business models together with the demo site owners during the first three years of the project has served to create awareness of, and opportunities for, business innovations.

1.2 Purpose & research question

The purpose of the deliverable is to design business models for the demo sites in REWARDHeat to capture the business logic shift needed when transitioning from conventional DH to low temperature solution.

For each demo site the following topics are assessed:

1. Business model innovations
2. Business model canvas
3. Green value creation and exploitation
4. Energy as a service
5. Contractual considerations and suitable ownership models

Combining the topics listed above for all demo sites enable the project to respond to the main research questions of the deliverable:

- How does the REWARDHeat business model experiences differ from a conventional DH business model and what can we learn from the transition to low temperature DH solutions?

2 Method

The process for developing the business models at the demo sites is visualized in Figure 2. The starting point, and the basis for the business models, was results published earlier in the project in the PESTLE analysis on market conditions (D3.1) and the customers perspective on the REWARDHeat solutions (D3.2), described below:

- PESTLE analysis input on market conditions

A PESTLE (Political, Economic, Social, Technical, Legal & Environmental) analysis was performed for Denmark, Croatia, Germany, France, Italy, Sweden and Netherlands in D3.1 *REWARDHeat PESTLE analysis* (Fransson, Sandvall et al. 2021). The PESTLE analysis identified barriers and opportunities for low temperature DHC networks in the respective countries and a summary of the results is presented for each demo site as the macro-economic factors in a country impact the business model.

- Input on customers' perspective

The customer perspective on the REWARDHeat solutions was collected through surveys with customers in connection to the demo site as a part of Task 3.2 *Living labs to understand end user comfort*. More information on the method used for carrying out the survey and results are published in D3.2 *Customers' perspective on REWARDHeat solutions* (Fransson and Lygnerud 2021).

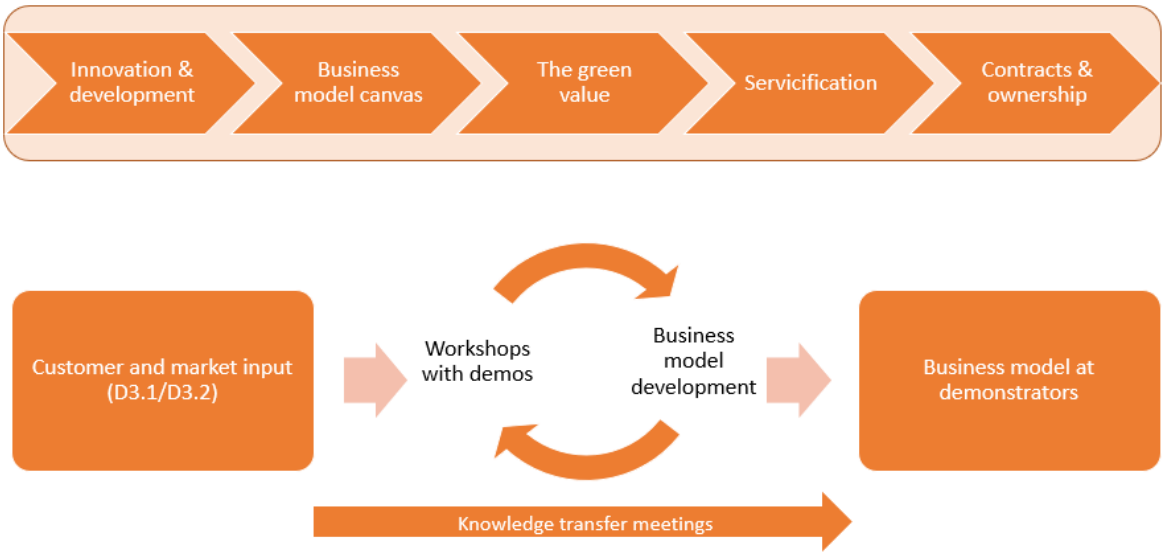


Figure 2: Workflow of D3.4

Developing the business model has been an iterative process with reoccurring bilateral workshops with the demo sites covering the five main topics in focus in the REWARDHeat project: Innovation & development, Business model canvas, The green value, Servicification and Contracts & ownership, described below:

1. Business model innovation and development

In collaboration with each demo site, the innovative component developed in the REWARDHeat project in relation to business models was identified.

2. The business model canvas

The business model canvas framework, described in 3.2, was applied in an iterative process with a particular attention given to the customer value component.

3. The green value

The green value created by having a low temperature installation has been identified by assessing the key benefits of low temperature DH, listed in 3.3. The green value was evaluated from the perspective of different stakeholders: the customers, the DH company, and the city. Finally, it was assessed if the green value is exploited to the customers in the business model through a change in revenue streams.

4. Servicification

The servicification triangle, described in section 3.4, was applied to identify how far the demo sites have come with service offers today, where they want to develop and propose what could be a suitable next step for service. Based on the current and proposed level of service an assessment was made of the advantages and disadvantages for both the customer and the DH company in relation to the service.

5. Efficient contractual arrangements and evaluation of ownership forms

The analysis of effective contractual arrangements and ownership forms was assessed at each demo site using factors presented by Wynn, Wheatcroft and Lygnerud (2021), described in section 3.5. The demo sites were evaluated regarding these factors by reviewing the ownership structure at the site, identifying between which actors' contracts are required and by analyzing what aspects are more important to consider. The analysis also included suggestions on efficient contractual arrangements, when such were deemed applicable, and suggestions on how to approach future ownership at the site or in replication/scaling of the project.

Energy performance contracting, described in 3.5, has been the starting point for assessing how to increase the level of service at the demo sites. Heat as a service is a developing trend in the Nordic countries and the suitability of offering EPC was evaluated for all sites. For an EPC business model to be suitable, both supplier and customer must be suitable and therefore the evaluation was made from both the customer perspective and the DH company perspective to reach a conclusion on whether EPC could be a suitable option to pursue.

The section for each demo site was distributed to the demo site owners in January 2022 and again in June 2022 to provide their feedback and ensure information has been correctly understood. This deliverable, D3.4 on Business models, has been produced in close collaboration with the other deliverables in WP3 on bankability (D3.3) and investment possibilities (D3.5).

To further enhance the development of innovative components in the business models, six-monthly knowledge transfer meetings were held on a voluntary basis with interested demo sites in 2021 and 2022. The meetings have been a platform for the demonstrators to discuss and compare issues and findings, to learn and gain inspire each other. IVL has moderated the meetings and supplemented the discussion with knowledge from other projects on low temperature DH business models. More information on topics discussed in the knowledge transfer meetings is available in section Knowledge transfer meetings8.1.

3 Background

3.1 Development and innovations in the business model from conventional to low temperature district heating

The technology shift when DH transition from conventional high temperature networks to low temperature creates new opportunities to integrate low-grade renewables and waste heat available in the urban context. This shifts the business of the DH company from a large central production unit to multiple distributed heat sources and new partnerships, such as prosumers, in the network. The role of the DH company shifts to more focus on distribution of heat rather than production. Lower distribution temperatures decrease heat losses and is well-suited to supply low-energy buildings with heat, as well as much of the remaining building stock by means of heat pumps. These new technology traits could be exploited in the business model and the shift in technology could be an opportunity for companies to explore new ways of doing, and expanding, the heat business.

Lygnerud (2019) explored how the business model changed by interviewing the project managers of six low temperature implementations around Europe and found the change to be very limited. The conventional DH business logic is based on economies of scale, with key resources in the large central production units and large distribution networks. The strategy in the business model often has a utility-perspective to push heat supply to customers instead of considering the customer perspective and the pull in market demand. The customer in focus for the conventional DH networks are large building owners and the communication is mainly through invoices. The cost and income structure are based on the fixed cost driven by the production and distribution of heat and benefits from a high margin on the heat source.

A feature of low temperature DH networks is the ability to easier integrate waste heat and renewable energy as well as increasing the efficiency in both the system and components. This creates a green value as it reduces the environmental impact from the heat supply. Lygnerud and Averfalk (2021) the business model for six cases of low temperature DH installations and identified that saving energy and reducing environmental impact was important to connected partners. If a greener heat supply is a new value for customers than it could be included as a selling point and as competitive advantage. The value of green is often not exploited to the end customers and this could be the reasons why it is common to use conventional DH business models also for innovative DH networks integrating waste heat and renewables (Lygnerud 2019).

Other aspects that changed in the business model for some of the reviewed cases was the transition of some customers to become prosumers as they supply waste heat to the network. The interaction with prosumers needs to be tailored depending on customer and the waste heat source. For other customers in the network no significant change in interaction was identified. Low temperature DH installations was found to have local engagement because of the distributed heat sources and prosumer contracts that require long-term and stable relationships. Resources in the low temperature DH network are a system that enables lower temperatures, sometimes heat pumps, always a local heat source and staff with competence to manage dialogue and contracts with heat suppliers. Managing the communication with heat suppliers and utilizing recovered heat

efficiently in the system are important activities. The most important partners in the low temperature DH model are prosumers and heat source owners. Costs are driven by investments in heat pumps, retrofitting or building the network as well as time for engaging prosumers and heat source owners. The income structure remained unchanged in all the reviewed cases Lygnerud and Averfalk (2021).

3.2 The business model canvas

The business model canvas (Ostewalder 2010) provides a framework composed of nine blocks and is widely used for understanding business models. It was developed jointly by academic researchers, government officials, professionals from different industries, analysts from different sectors and consultants interested in business modelling. Four of the blocks address the customer, outlining the customer segment, the channels used to reach the customers, customer relationships and the value proposition. Three of the blocks consider activities undertaken to deliver the value, the resources needed for value creation and the imperative partnerships for delivery of the product or service. The last two blocks outline the cost structure undertaken by the business and the income structure of the realized sales. The canvas is illustrated in Table 1 (Ostewalder 2010).

Table 1: The business model canvas

<table>
<tr><td rowspan="2">Key Partners
Who can help you?</td><td>Key Activities
How do you do it?</td><td rowspan="2">Value Proposition
What do you do?
This is where the analysis starts.</td><td>Customer Relationship
How do you interact?</td><td rowspan="2">Customer segment
Who do you help?</td></tr>
<tr><td>Key Resources
What do you need?</td><td>Channels
How do you reach them?</td></tr>
<tr><td colspan="3">Cost structure
What will it cost?</td><td colspan="2">Revenue streams
How will you get paid?</td></tr>
</table>

The traditional business model for conventional district heating is displayed in Table 2 (Lygnerud 2019).

Table 2: Conventional district heating business model

Customer Side		In House (DH Company) Side	
1. Customer value	Heat and hot water	1. Key activities	Production Distribution Maintenance
2. Customer segment	Large building owners	2. Key resources	Production unit Distribution network
3. Customer relationship	Provider to consumer	3. Key partnerships	Fuel providers
4. Customer channel	Invoice, Campaigns	-	-
5. Income structure	Fixed	4. Cost structure	Large fixed costs

The business model canvas has been applied to identify new aspects in the business model between conventional and low-temperature DH installations in previously research (Lygnerud 2019, Lygnerud and Averfalk 2021). The results are visualized in Table 3. Depending on the local set-up, some or all changes are applicable.

Table 3: Previously identified new aspects in the business model for low temperature DH installations.

<table>
<tr><td rowspan="2">Key Partners
Prosumers
Heat source owner(s)</td><td>Key activities
Heat recovery
Manage HPs
Communication with heat suppliers</td><td rowspan="2">Value Proposition
Greener heat supply
Utilization of otherwise wasted resources
Local engagement</td><td>Customer Relationship
Long-term with prosumers</td><td rowspan="2">Customer segment
Prosumers</td></tr>
<tr><td>Key Resources
Network adapted to low temp, HPs
Local heat source
Staff with new competence</td><td>Channels
Tailored for prosumers</td></tr>
<tr><td colspan="3">Cost structure
Investments in HPs, network and prosumer and heat source owner engagement</td><td colspan="2">Revenue streams
Unchanged pricing scheme</td></tr>
</table>

3.3 The green value

The REWARDHeat solutions enables integration of waste heat available in the urban context and low-grade renewables. A DH network with a fuel mix consisting of recovered and renewable energy creates a greener H&C supply to its customers than conventional H&C solution. The value creation

for customers with products or services that has a lower environmental impact than other alternatives is called: *the value of green*.

The ReUseHeat project identified that the value of green (generated from waste heat) can be important to some customer segments, such as cities, politicians and companies but generally not to the end-users (Lygnerud 2019, Wynn 2019). The SunHorizon project came to a similar conclusion that the value of green (here generated by renewable energy) was especially important to municipality customers were the government had renewable energy targets (IVL Swedish Environmental Research Institute 2019).

The willingness to pay (WTP) for greener solutions was assessed through a literature review in *D3.2 Customers' perspective on REWARDHeat solutions* (Fransson and Lygnerud 2021). Demographic factors identified to often correlate with a higher WTP for the green value are a higher education level, a higher income level and younger age groups. The most frequently occurring factor that drives WTP for green is the respondent's environmental attitude, also expressed as behavior, concern and awareness. In *D3.2 Customers' perspective on REWARDHeat solutions* a survey was conducted with professional customers and end-users connected to, or foreseen to be connected to, the REWARDHeat demo sites. 56% of respondents show a WTP more for a greener H&C supply. 38% are willing to pay a few percentages more (1-5% more) and 18% would pay more than 6% more. 44% of respondents are unwilling to pay additionally for a greener H&C supply and want the price to be the same as today or even lower (Fransson and Lygnerud 2021). As can be seen in Figure 3 there is no distinct difference in the WTP between professional customers and end-users.

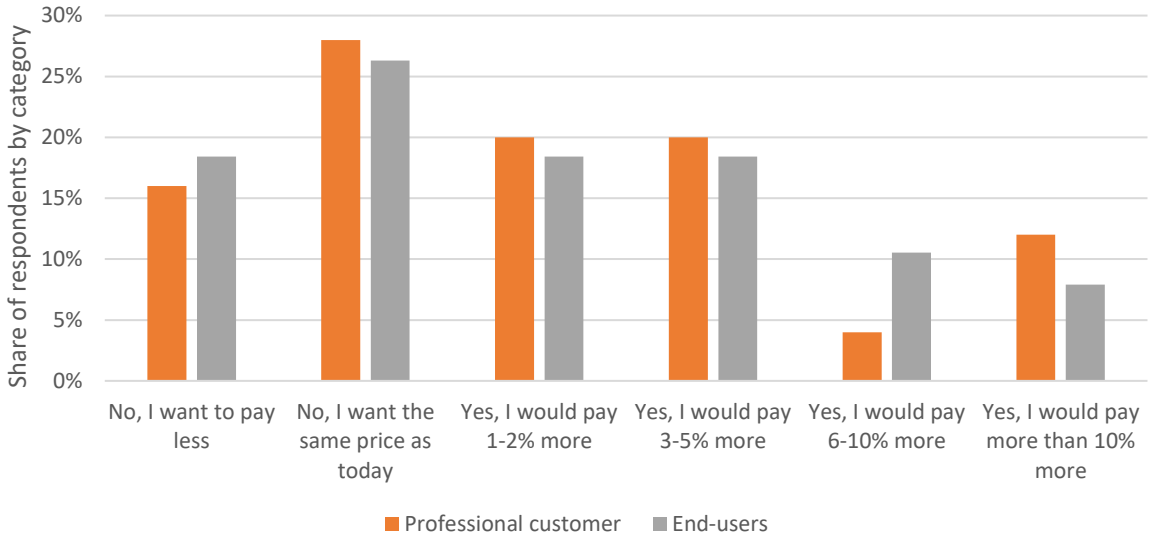


Figure 3: The willingness to pay for a greener heat supply among customers in connection to the REWARDHeat demo sites

In Sweden, some DH companies offer a "greener heat" as an add-on to the DH supply. 10 of the larger DH companies were reviewed and six of them offered a green heat add-on to professional customers and two also offered it to private customers. Two different offers (or a combination) are distinguished. The first being DH (or cooling) produced only from renewable energy. A main driver for the offer seems to be buildings required to comply with green building certificates. The second offer is for the DH company to compensate for the emissions due to the heat supplied. The DH companies offer to compensate for different scope of emission. Some offer to compensate only for the fossil fuel part of combustion and some also include all the upstream emissions, for

example cause by transportation. Where pricing was publicly available the add-ons for business customers for different percentages of renewable energy allocated to the customer mix were offered at 1-25 SEK/MWh and the add-ons for climate compensated heat in the range of 4.5-15 SEK/MWh. The price range for private customers for a greener add-on was 3.1-4.5 SEK/MWh. Göteborg energi (2021) delivers 5% of the total heat delivery as "Bra Miljöval" meaning renewable energy with high standard for biodiversity and other environmental aspects (Bra Miljöval 2021).

3.3.1 Low temperature district heating can provide a more efficient heat supply

Low temperature DH can improve the efficiency of networks depending on the local set-up. In Geyer, Werner et al. (2021) a review of economic benefits that are created by a lower distribution temperature in DH networks was performed. Eight of the assessed factors are at the same time providing green value by improving the efficiency of the network. The eight factors are described briefly below including how they create a green value in a network.

1. More geothermal heat extracted

Lower return temperatures in the DH network makes for a better thermal output from a geothermal heat source. A geothermal source with temperatures above the supply temperatures of the DH network is the best alternative as it can then be utilized directly. More renewable energy can be produced in the system.

2. Less electricity used in heat pumps

Large scale heat pumps are used in DH networks to utilize sewage water, ambient water (seas, lakes, and rivers) and industrial waste heat as heat sources. The COP of a heat pump is dependent on the temperature levels on the source (cold side) and sink (hot side). With a lower sink temperature, the temperature difference between the sink and the source reduces and the heat pump can generate more heat from the same amount of electricity. Less primary energy is needed when heat pumps are operating more efficiently.

3. More waste heat extracted

The amount of waste heat that can be integrated into a DH network without the need for heat pumps increase with lower distribution temperatures. This requires that the available waste heat is above or similar to the supply temperature of the system. More waste heat in the DH network reduces the primary energy need.

4. More heat obtained from solar collectors

The operating temperature of solar collectors are an important factor for efficiency as it affects the heat losses and therefore is amount of useable heat. Operating at lower temperatures increases the amount of energy produced and more renewable energy can be produced in the system.

5. More heat recovered from flue gas condensation

The efficiency of flue gas condensation is mainly driven by three factors: the return temperatures of the DH network, the water content of the fuel and the excess air during combustion. The return temperature of the DH network must be sufficiently low to cool the flue gas below the dew point and lowering the distribution temperatures therefore enables more heat to be extracted from flue gas condensation. More heat extracted from flue gas condensation reduces the primary energy need.

6. More electricity generated in combined heat and power plants

Lower supply temperatures in a DH network enables higher power-to-heat ratios as the steam power process becomes more efficient. More electricity produced per unit heat reduces the need for primary energy supply in the system.

7. Higher heat storage capacity

Storage capacity depends on the spread of temperature between supply and return temperature. A lower return temperature creates a larger temperature spread and an increased storage capacity. Lower operating temperatures also decreases thermal losses from the storage. A more efficient storage with lower losses decreases the primary energy need of the system.

8. Lower heat distribution loss

A reduction of average temperature in the network reduces heat losses from pipes to the surrounding environment. With lower heat losses in the system less primary energy s needed to deliver the same amount of energy.

3.4 Servicification

Servicification in the energy sector is a shift in focus from delivering products to offering services. It requires a shift in the business logic from a cost-optimizing perspective to a customer-driven focus and to deliver a high level of service it is necessary to develop solutions together with the customer.

Delivering a service to customers requires a closer relationship where the customers continuous feedback improves the quality of the service. Digital solutions are often a very important aspect of delivering a service. Data analysis can be used for maintaining control, collect feedback efficiently and improve the offered service. Benefits of servicification for the company is increased control of the network, more knowledge about the customers and can result in increased loyalty and increased competitiveness. Servicification can help companies deliver more value to customers, can create new income streams and possibly identifying new customer segment. Servicification is an increased risk for the company compared to only delivering a product and delivering services requires more personnel and a different structure in the organization (Hansson 2019).

The servicification triangle was presented in Coreynen (2017) and is displayed in Figure 4. The triangle is divided into six sections where the horizontal dimension distinguishes the focus of the service between product-driven and customer-driven processes and the vertical dimension divides the value proposition into three categories. Level 1 is for customers “who want to do it themselves“. It provides the customer with a certain input, but the responsibility is on the customer. Level 2 is aimed at customers “who want us to do it with them” and provides a performance agreement. Level 3 is supplying the customers with a guaranteed result, “who want us to do it for them”. The triangle can by companies to analyze where they are in the triangle today, where they want to be in the triangle and explore pathways and remove barriers to ascend higher up in the triangle.

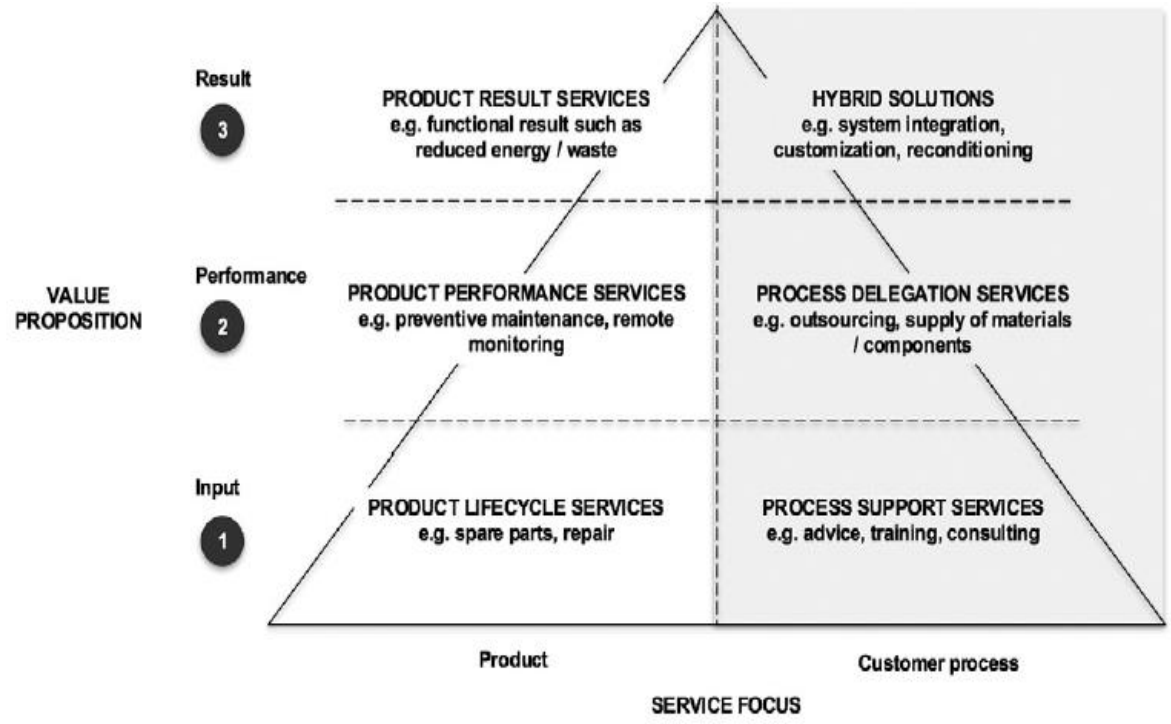


Figure 4: The servicification triangle

In Hansson (2019) barriers towards advancing in the servicification triangle were identified. Reaching the base of the triangle can meet opposition in the business culture of the organization if focus is only on reducing cost. Progressing to the middle of the pyramid can instead meet resistance among customers, especially when there is low trust in the company offering the service. Increased servicification requires additional trust-building. To reach the top level of the triangle, the main barrier is a lack of experience and competence in the organization for developing a structured process for providing services.

Increasing the level of service offered to customers necessitates a deeper understanding of the customer demand and therefore a closer relationship. For utilities a closer relationship with customers is a value as it can lead to increased transparency, trust, and long-term engagement. Service offers increase competitiveness against other heating alternatives and is more difficult to replicate for competitors compared to selling a product (Ottosson 2020).

3.4.1 Services offered by district heating companies

Traditionally DH companies sell a product to a customer, the substation and connection to the DH network, and the cost is allocated to the customer as investment cost. Then the customer is supplied with a consumable (energy) often charged as a price per MWh (commodity). The price is sometimes differentiated depending on season. This traditional business model is product-oriented as opposed to service-oriented. The heating market is a changing market, global warming and increased energy efficiency in buildings are reducing the heating demand. Individual HPs are a strong and growing competitor. The changes in the market drives DH companies towards customers- and service-oriented business models to be better adjusted to meet the developing demand from customers.

The shift towards the heat supply also including some element of service is a developing trend in the Nordic countries. Examples of energy services provided by Swedish DH companies and their

position in the servicification triangle was developed by Ottosson (2020) and is displayed in Figure 5. The base of the triangle consists of simpler services offered to customers. Examples on the product-side are installation and repairs and, on the customer-side, energy audits and consultation services. On the second level of the triangle are services relating to the performance. For the product this includes maintenance, monitoring, and optimization and on the customer-side the packaging of measurements to support the customers processes. The top of the triangle is the all-inclusive and carefree functional contracts (comfort agreements) where the customer pays for an indoor temperature and the supplier manages the system.

Another example of services at the top of the triangle resulting in co-creation of value is brought forward in Lygnerud, Ottosson et al. (2021). It is suggested that the DH companies shift the boundary condition to take over operation of HPs available at the customer site and includes them in optimizing the overall production resulting in cost savings. Value created for the customer is lower heating cost without spending additional time while the DH company retains a customer and can better optimize the production to lower costs.

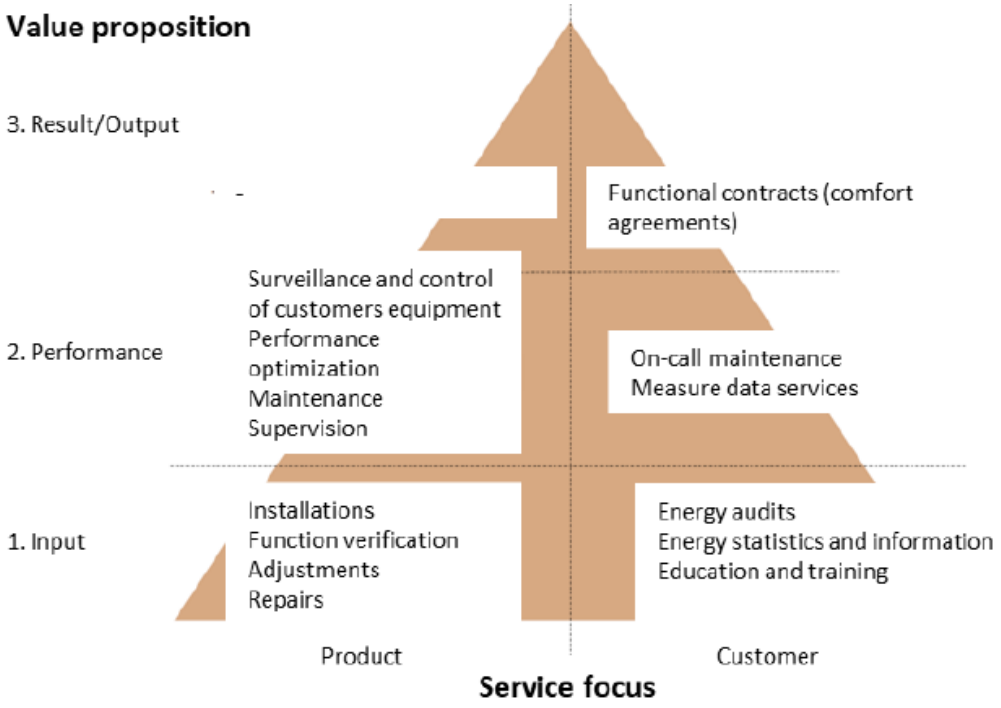
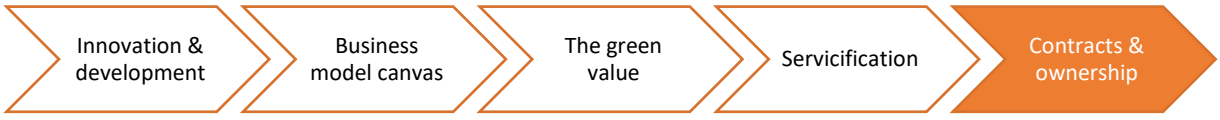


Figure 5: Energy services offered by Swedish DH companies.

More examples of service packages offered by DH companies to private and professional customers have been identified in this deliverable to provide more input to the demo sites as they are developing their service offer. The results are available in Annex 8.2.

3.5 Contractual efficiency and ownership models



In Wynn, Wheatcroft and Lygnerud (2021), efficient contracts are considered to promote the viability of the project and place the risk (and reward) at the partners who are most apt to manage

it well. Hence an ownership structure where a company owns more components and resources is associated with having more control over the installation, thus taking on more of the risk but also more of the control.

The seven factors described by Wynn, Wheatcroft and Lygnerud (2021) that require consideration in the design of efficient contracts are presented below.

1. Low maturity of the installations

The low maturity does not concern the supply and manufacturing of the components in a low-temperature installation, but rather the operators' and installers' limited knowledge about the installation. Moreover, the low maturity is visible in the limited number of realized installations and this impacts the risk associated with the investments, which must be managed by the contracts.

2. No legal framework in place and incentives for renewable energy sources and CHP

This factor concerns the lack of legal framework for waste heat recovery, which means that there are no standards for the contracts between waste heat suppliers and other partners. There is also a lack of targets in Europe for the increased exploitation of waste heat resources.

3. The value of waste heat is subjective

The demand for heat depends on the customer and could vary with weather conditions or with seasons. Thus, the value of heat must be agreed upon and clearly stated in the contract.

4. The payback period

The payback period for waste heat recovery investments can be long but it depends on the temperature and the volume of the heat source. It is important to properly estimate the payback for the establishment of an efficient contract.

5. Asymmetric information

Different views are held by the supplier and the receiver of the heat, regarding the nature of the heat source, where the supplier may often view it as having higher quality than how the quality is perceived by the receiving part. Therefore, all collaborating parts must strive for mutual understanding of the heat source.

6. Shared incentives

Shared incentives are necessary to achieve well-functioning collaboration. Contracts could facilitate and create shared incentives by including clauses on maintenance, pricing, monitoring (among others).

7. Termination of the waste heat source

The risk of industrial actors terminating their operations is present in waste heat recovery installations. In urban waste heat recovery, the heat source is often small and one source disappearing therefore constitutes a smaller risk to a utility company compared to waste heat recovery from larger industries. The contracts need to consider this risk by including clauses on proceedings in the event of termination.

3.5.1 Energy performance contracts

Energy Performance Contracting (EPC) is "a contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure, verified and monitored during the whole term of the contract, where investments (work, supply, or service) in that measure are paid

for in relation to a contractually agreed level of energy efficiency improvement or other agreed energy performance criterion, such as financial savings" (Directive 2012/27/EU).

The EPC business model is based on performance where the supplier of the energy efficient measure, the energy service company (ESCO) is renumerated based on generated savings compared to an established baseline (IEA 2018). The two most common types of EPC are the shared savings contract and the guaranteed savings model. The main difference is what part assumes the financial risk and provides access to investment capital. Guaranteed savings contract is the most common in Europe (IEA 2018). The EPC is a turnkey solution where the ESCO is involved from project start, through installation, maintenance, and monitoring, until contract completion. The EPC is most found in large projects for the public sector (IEA 2018). Many governments in the EU are encouraging EPC solution to promote energy efficient buildings but the contracting type is still immature in many countries (IVL Swedish Environmental Research Institute 2019). Apart from investment cost the EPC has additional cost in the monitoring and verification process. Data measurements are key to an EPC. It is required to establish a baseline and then to verify performance throughout project duration. EPCs are often complex contracts and could drive administrative costs for the client. Payback period are often between 5-12 years and contractual lengths typically 10-15 years (Moles-Grueso, Bertoldi et al. 2021).

Benefits of an EPC for the customer is to replace or upgrade inefficient equipment/systems to save energy/money and to improve comfort. It is suitable for customers with a need to reinvest, when the baseline is inefficient, when energy is not core business and when investment costs are considered too high. For a customer to undertake such large projects independently it would require a lot of resources both in staff, time, and capital. The EPC is a single contract covering the whole project and enables the building owner to utilize the competence and experience of the ESCO. For public building owners acting going through public procurement having a single contract could reduce complexity. For the ESCO the benefits of an EPC are that is creates a reliable source of income for the duration of the project if implemented properly. Hägg and Lagerfelt (2012) listed advantages and disadvantages for municipalities in engaging in an EPC. Advantages include a single procurement process, savings guaranteed, the investment is financed by the generated savings and monitoring ensuring long-term reduction in energy. Disadvantages include complexity, comprehensive documentation needed and less control. The Australasian Energy Performance Contracting Association (2000) developed a checklist for building owners to assess whether their facilities are suitable for an EPC contract. Large buildings with a high annual energy bill, preferably older than 20 years and with at least 4 years passed since last major upgrade are assessed to be the best candidates for EPC. Less suitable would be a building owner with a multitude of smaller buildings with low energy prices, newly built buildings or recently undergone major upgrade.

4 Business models at the REWARDHeat demo sites

4.1 Denmark- Albertslund

The demo site in Albertslund is summarized in Table 4. Following a short introduction to the demo site are the five topics in focus in the REWARDHeat project: Innovation & development, Business model canvas, The green value, Servicification and Contracts & ownership.

Table 4: Albertslund - Summary of the demo site

Albertslund	Innovation & development	Business model canvas
Municipality-owned third generation DH network in Denmark transitioning to lower supply temperature through sectioning. Conventional DH is main heat source with locally available waste heat being integrated in REWARDHeat.	Technical: Retrofitting a section of the network to lower supply temperature. Integration of waste heat. Customer: Increasingly taking over the ownership and maintenance of substations at customer's site.	The innovations impact most aspects of the canvas. DH is non-profit in Denmark and lower operational cost is seen by customers as reduced energy bill. Waste heat suppliers (prosumers) necessitate a closer relationship and tailor-made dialogue.
The green value	**Servicification**	**Contracts & ownership**
The green value is noticeable to the customer as it lowers the energy bill. The value of green is important to the DH company and its city owners. To end-customers green heat is mainly a cleanliness factor.	No new services are being offered to customers but increasingly the ownership and maintenance of the substations is transitioned from the customer to the DH company.	The waste heat integration adds complexity with multiple contracts necessary. EPC is not recommended for Albertslund to pursue, mainly due to the customers segment being private buildings owners.

4.1.1 Denmark: Input from PESTLE analysis and customers' perspective

Conclusions from the PESTLE analysis (Fransson, Sandvall et al. 2021) that is relevant for business model development:

- Establish a clear value proposition against alternative heat supply options

- Develop a fair pricing structure for the division of system cost among customers
- The value of increased efficiency (reduce cost of system) is transferred to customers as DH is non-profit

Conclusions from the customers' perspective (Fransson and Lygnerud 2021) that is relevant for business model development:

- Customers in Albertslund demonstration are willing to pay more for a greener heat supply (more so than other demo sites), at least by a few percentages
- Customers want an incentive-based pricing scheme
- Most customers are hesitant towards increased service

4.1.2 Business model innovation and development

The demo site leader in REWARDHeat is Albertslund Kommune (Albertslund). Albertslund is located 15 kilometers west of Copenhagen in Denmark. The DH network is owned by the city and has been in place since 1964 and it covers 90% of heat demand in the city. Albertslund is connected to the DH network of the greater Copenhagen region and buys the heat from the DH transmission company (VEKS). 60% of the housing stock is non-profit social housing. In 2018, the annual heat volume was 220 GWh. Heat losses in the system is 18-20%. Currently, 5 areas in the system are supplied with low temperature DH through shunts being installed streetwise. The areas consist of both refurbished and new buildings.

The intent is to transition from a third-generation, centralized high temperature heat supply of 85 °C to a supply temperature of 60 °C (provided from both central and local heat sources). The goal is to reduce the heat losses and to make more efficient use of excess heat and locally available renewables. Specifically, in REWARDHeat the plan is to expand and increase the waste heat supplied from the data center and to connect a supermarket. According to legislation in Denmark an administrative process (a project proposal) is necessary to integrate waste heat into the DH network if it is above a certain size. Due to this reason the initial plan was for the waste heat to be collected from the supermarket and to be directly inserted into a municipality building without entering the DH network as the project proposal process can then be avoided. Further investigation identified that the proposed waste heat project is small enough to avoid the administrative process.

Prior to REWARDHeat Albertslund started taking over the ownership and maintenance of substations at customer's site and at the start of the project approximately 10% of customers rented their substation. During the project, and post-project, Albertslund are increasingly taking over ownership of more substations to create more opportunity to optimize the network.

Within the first year of lowering the temperatures in the neighborhood about 5% of customers contacted Albertslund with complaint that could all be resolved by adjusting in the customers substation. After those first adjustments no customers have reached out with complaints on temperature levels. This entails that building refurbishment are not necessarily required prior to

lowering the temperature in a DH network, which has been identified in Lygnerud and Averfalk (2021).

A key issue for Albertslund is to incentivize customers to make improvements resulting in a lower return temperature. There is a motivational tariff in place today, but few customers act on it. It was therefore decided that IVL together with Albertslund would develop a climate-based motivational tariff as another way of incentivizing customers: by also providing an environmental incentive, in combination with an economical. Poor cooling decreases the efficiency of the network and the decrease in efficiency can be associated with an amount of CO_2. The CO_2 amount along with an associated cost of CO_2 was proposed as a measure to incentivize customers. The results show that even when using a high CO_2 cost, based on scientific literature on the subject, the yearly climate-based motivational cost for a building with poor cooling would only be around €100. It is estimated that a poor performing building causes seven times more CO_2-emissions due to poor delta T compared to a building with a good delta T (using measurement data from the Albertslund demo site). The additional CO_2 because of poor cooling in a single building is not enough to create economic incentive for customers, even with a very high cost of CO_2 from the literature. More information about the climate-based motivational tariff is presented in Section 8.3.

4.1.3 Business model canvas

- Value proposition

Heat and hot water are the values provided to 90% of the customers. The remaining 10% of customers receive an additional energy service as Albertslund owns and manages the substations inside the customers building.

- Customer segment, relationship, and channels

The customer segment (in the demo area) is semi-detached houses owned by private customers. The transition to a low temperature grid, and increasingly taking over ownership of customers substation, requires additional customer dialogue. The relationship with prosumers is close.

- Key resources, activities, and partners

The DH network of Albertslund, the shunt lowering temperature in the demonstrated building block and the heating station of the customer (located in their basements) are the most important fixed assets. Also, staff that can manage the customer and prosumer dialogue are important and for the 10% of customers obtaining service, staff that can provide the service are important.

Important activities are to lower the temperature levels and to monitor the temperatures. To do so monitoring equipment is important. In REWARDHeat, it is provided by Artelys. All customers have smart meters today.

In Albertslund waste heat is collected from a data center and a contract is under development to connect a local supermarket. The waste heat supplier, also prosumers, are important partners to the DH company.

- Cost structure and revenue streams

The cost structure remains the same as for the conventional high temperature business case. For that business the price model is being updated to better reflect the price charged from the heat supplier (VEKS). For the demo site it is important to identify how monitored data in the low temperature area can be used to build an efficient motivational tariff (an examples of a climate-based motivational tariff that can be implemented post-project is presented above). If Albertslund Utility can reduce its return temperature to VEKS the price of heat will decrease as VEKS is applying motivational tariffs too. The lower price of heat is reflected at the individual customers' heat price.

Albertslund would like to go for monthly bills based on actual measurements. In this way the end users will learn that DH is more expensive in the wintertime – motivating more for energy refurbishments. At the same time, the end users will learn that DH is available at a low cost in summertime, why there is no need for installing individual heat collectors and/or using electricity for domestic hot water.

The heat bill in Albertslund is a mix of energy consumed in MWh, flow in m^3, area heated in m^2 and meter fee. For the customers renting a substation, there is an additional fixed monthly service charge and a variable service fee for the substation.

- Business model canvas

Table 5: Albertslund - Business model canvas.

<table>
<tr><td rowspan="2">Key Partners

Equipment providers

VEKS

Waste heat supplier/ prosumers</td><td>Key activities

Monitor and operate network

Service equipment at customer site

Lowering the supply temperature

Connect more waste heat</td><td rowspan="2">Value Proposition

Heating, hot water Comfortable indoor climate Security of supply

Carefreeness (rent substation)

Value of green (urban heat source, lower losses)</td><td>Customer Relationship

Closer than arm's length (service at customer's site)

Close with prosumers</td><td rowspan="2">Customer segment

Detached homeowners

Waste heat supplier/ prosumers</td></tr>
<tr><td>Key Resources

Network, substations, shunt

Monitoring eq.

Staff (for service and prosumer dialogue)</td><td>Channels

Customer dialogue

Prosumer tailor-made dialogue</td></tr>
<tr><td colspan="3">Cost structure

Driven by fixed costs

Optimized substations provide a higher delta T and thus reduces cost

Decreases operational cost due to lower heat losses</td><td colspan="2">Revenue streams

Fixed tariff in combination with variable tariff depending on consumption and flow.</td></tr>
</table>

Waste heat lowers cost of heat	If costs are lower, customer see a reduced cost of heat (DH is non-profit in Denmark)

4.1.4 The green value

The value of green is produced by lower distribution temperature enabling easier integration of urban waste heat from the supermarket and the data center. The lower network temperatures reduce heat losses in the network. As a result, primary energy demand and CO_2-emissions are reduced. Further, the work done to reduce return temperatures enables more heat to be recovered from the flue gas condensation and more electricity to be generated in the CHP in the greater Copenhagen DH network.

A greener heat supply is a value to the energy company by creating a greener profile. The lower supply temperature and the green value is further of importance to the city (owners).

To the customers (private building owners) green energy is considered a cleanliness factor. The value of green can be important to private building owners depending on perception of climate change among customers. As customers are willing to pay more if the supply really is greener there is a value in creating an awareness of the green value to customers and being transparent.

Gas is still a large part of the heat supply in Denmark, and it must be replaced by a greener energy to meet national targets. The DH supply in general in Denmark still has coal (13%) and gas (22%). The DH supply in Albertslund containing locally recovered energy provides a greener value than other DH in Denmark.

The value of green is not exploited to customers at this point. In REWARDHeat Albertslund are foreseen to implement a climate-based motivational tariff to create awareness of energy and environmental savings possible through an optimized heating system in the building.

4.1.5 Services offered to customers

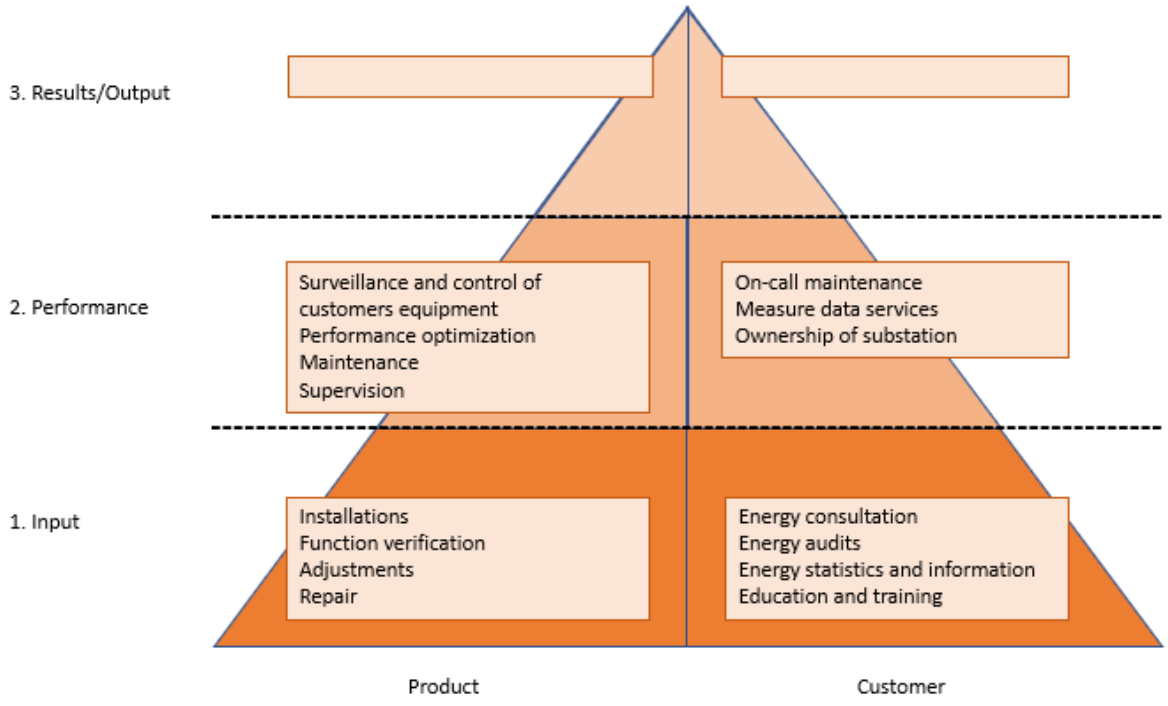


Figure 6: Albertslund - The servicification triangle.

Figure 6 visualize the servicification triangle for the demo site. Italics represents what is new in services offered to customers in REWARDHeat and bold represent possibilities beyond REWARDHeat.

To avoid malfunctioning substations and enable better control to optimize the DH network, Albertslund has an ambition to take over ownership of the DH substation from customers and thus shifting the boundary condition of the business into the customers building. For some customers this is already the case today and the customer then pays a monthly fee for renting the substation.

After Albertslund has taken over ownership of the substation the remaining actions to improve return temperatures are still on the customer. A possibility for Albertslund could be to move the boundary conditions further inside the customers building and take over the radiator system inside the customer building. The value for Albertslund would be a more optimized system and for the customer a carefreeness of the total technical heating system. This would require a further integration of the DH companies and the customers processes.

Other possibilities to improve the customers system could be to provide more information, such as for Albertslund to target selected customers where it is known that the heating system has poor cooling, or other malfunctions, and perform an analysis of the radiators to identify malfunctions. The radiators could, for example, be marker with a sticker of a green, yellow, or red smiley to create awareness among customers. Another option could be to provide more incentives to improve the heating system, for example through a climate-based motivational tariff as the one developed earlier in this chapter.

Table 6: Albertslund - Advantages and disadvantages with new and proposed services

Advantages with proposed services at demo site	Disadvantages
Taking over ownership of substation enables higher control to optimize the system, resulting in cost savings for the DH company. As DH is non-profit in Denmark cost savings are transferred to the customers. Renting equipment is carefree for the customer with reduced responsibility.	Increased complexity when shifting the boundary condition as there is a need to integrate with the customer process. Service needs to be delivered in dialogue with customer and fit in with customers everyday life.
Increased service in general creates a closer relationship with more interaction and higher loyalty.	Increased cost as increased service requires more resources (e.g., personnel, fault detection equipment). Necessary to perform enough service to reduce the risk of failure.
Progressing further into the customers building and taking over responsibility for the entire heating system (including radiators) would provide further opportunities to optimize the system.	Assuming more responsibility, also inside the customer building, increases the risk in the business model. The importance of digital monitoring and fault detection increases (e.g., leak detection).

4.1.6 Ownership & Contractual efficiency

The contracts required for a functioning cooperation at the demo site is between the municipality of Albertslund and the DH customers; and between the waste heat suppliers (both data center and supermarket) and the municipality; and between Albertslund and VEKS (for heat supply). The factors affecting these contracts are considered below and are described in more detail in section 3.5.

1. Low maturity of the technical solution

The technological solution at the demo site is not new. Instead, an already existing network is adapted for low temperature heat distribution, through sectioning. This factor does therefore not apply to the Albertslund case.

2. No legal framework for low temperature district heating

The Danish legal framework for waste heat was changed in 2021 to promote its exploitation. Waste heat sources below a certain size (0.25 MW) are not subject to price regulation, while the price of other waste heat sources can be freely negotiated below a price regulation cap.

According to legislation in Denmark an administrative process (a project proposal) is necessary to integrate waste heat into the DH network if it is above a certain size. For the waste heat integration from the supermarket a project proposal is not required. Legislation on waste heat integration in Denmark needs to be considered when initiating a collaboration and drafting the contract.

3. The value of waste heat is subjective

Waste heat from two suppliers (datacenter and supermarket) is or will be integrated into the Albertslund heat distribution network. The energy company must be transparent with conditions for its demand of waste heat (and whether there is for example any seasonal variations) and this must be captured by the contract. It is especially important to be transparent with how the energy company values the waste heat in this case since neither the supermarket nor the data center have energy as their core business.

4. The payback period

The payback period has not been the main priority for this installation. Instead, the city target of a lowered network temperature by 2026 has directed the decision to shunt parts of the network and successively lower the temperature. If replicated elsewhere in a mature network, the payback is comparatively shorter compared to cases where a new network is built, and new heat recovery sites are to be integrated.

5. Asymmetric information

The municipality of Albertslund owns the network and purchases the energy from VEKS, the distribution company. There is also a data center (and soon a supermarket) that supplies low temperature heat to the network. The municipality of Albertslund therefore needs to collaborate with their partners to supply the energy and focus on clear communication with the companies who are less experienced in waste heat extraction. However, since Albertslund is already collaborating with these heat suppliers it is assumed that they can access the information they need for the system to be well-functioning, and this factor is already managed in the current layout.

By increasingly taking on the ownership of the customers' substations, the information is shared even more easily along the heat supply chain.

6. Shared incentives

The shared incentives between the municipality of Albertslund and their customers are manifested in the contract through a motivational tariff encouraging low return temperatures. Albertslund reward customers using their heat efficiently (a high delta T), while punishing those who do not. As customers contribute to lower return temperature the efficiency in the network increases. VEKS has a similar motivational tariff toward Albertslund to incentives low return temperatures in the whole network.

Well-functioning collaboration between the waste heat suppliers and the municipality of Albertslund could be further incentivized for example by rewarding the waste heat owners when they allow Albertslund to optimize their heat exchange equipment.

7. Termination of heat recovery

There is no risk of termination in this case. The heat source is mainly the DH mix of the Greater Copenhagen region and thus no single source of heat or waste heat is crucial for the functioning of the heat supply. The factor does therefore not apply to this case.

- Ownership

One of the lessons from the ReUseHeat project is that the heat supply and consumption is less complex when fewer actors are involved.

The municipality of Albertslund aims to own the customer substations to achieve an optimization of the DH system. The customers are then offered the service of renting the substation along with their heat supply, while the DH company increases their control of the system. In doing this, Albertslund take on more risk.

The recommendation for the municipality of Albertslund is to continue to offer the rental service to their customers to be in control of as much of the heat supply chain as possible, aiming to increase the share of rental customers in the future.

- Energy performance contract

Energy performance contracting has been the starting point for assessing how to increase the level of service at the demo sites. Heat as a service is a developing trend in the Nordic countries and the suitability of offering EPC was evaluated for all sites.

In Denmark the energy performance contracting (EPC) market is mature but static (Moles-Grueso, Bertoldi et al. 2021).

Private building owners are a less suitable customer segment for EPC. EPC are a complex contractual arrangement and to only include a single house in such an arrangement would make it difficult to obtain profitability. Possibly the customer segment does not have the capital for making the necessary upfront investments. Contractual length of 10-15 years is not desirable by private customer who want short contracts to allow for flexibility. Many customers want the freedom to move and thus ending contracts prematurely.

Developing into an ESCO would be a large step for Albertslund and doing so would face organizational barriers. Albertslund does not have the competence or experience to deliver EPC to customers nor do they have the ambition or will to develop into an ESCO.

EPC is not recommended for Albertslund to pursue at this point.

4.2 France- La Seyne-sur-Mer

The demo site in La Seyne-sur-Mer is summarized in Table 7. Following a short introduction to the demo site are the five topics in focus in the REWARDHeat project: Innovation & development, Business model canvas, The green value, Servicification and Contracts & ownership.

Table 7: La Seyne-sur-Mer - Summary of the demo site

La Seyne-sur-Mer	Innovation & development	Business model canvas
Existing low temperature heating and cooling network in France owned by the city and operated by DALKIA under a "Public Delegation of Service" contract. The heat supply is seawater.	Technical: Develop an online platform for control and performance optimization. Customer: Energy performance contract.	The EPC necessitates changes in the customer relationship as well as in competence and activities at the DH company. The EPC creates new values to the customer.

The green value	Servicification	Contracts & ownership
The green value is important to the DH company and the city as well as to the professional customers. The green value is noticeable to the customer where an EPC has been established.	The EPC is a new service being offered to customers. EPC is an example of advanced services at the top of the servicification triangle.	An EPC has been signed with one customer and is a more complex and comprehensive contract than with other end-customers.

4.2.1 France: Input from PESTLE analysis and customers' perspective

Conclusions from the PESTLE analysis (Fransson, Sandvall et al. 2021) that is relevant for business model development:

- Difficult for DH to compete with other heat supply option in price and it is therefore very important to have a clear value proposition to customers based on other values
- Different values are important to different customer segments, and this should be exploited in the business model
- The fact that the DHC network is "classified" as by French regulation, is an opportunity to expand the customer base, due to the obligation for new buildings or to be renovated, to evaluate the connection to the DHC network however, the utility operator must provide competitive pricing against other solutions.

Conclusions from the customers' perspective (Fransson and Lygnerud 2021) that is relevant for business model development:

- Most end-users state that they are willing to pay a few percentages more for a greener heat supply
- Customers are not so mature to increased service and it is perceived as more expensive.
- Taking over maintenance of H&C equipment could be a wanted first step.

4.2.2 Business model innovation and development

In La-Seyne-sur-Mer an already existing neutral temperature DHC network owned by the city and operated by DALKIA has been extended during the project. As of spring 2022, approximately 10 customers are connected to the system including public, tertiary, and residential buildings. The system is supplied by seawater as energy source. The only constraint with the source is in relation to the environmental law that does not allow water temperatures higher than 30 °C to be disposed into the sea. The innovation in La-Seyne-sur-Mer is the implementation of smart automated energy monitoring and control together with DALKIA including performance optimization through intelligent control through an online platform called DEMIX. Regarding the Casino, an innovative EPC has been signed during the REWARDHeat project.

4.2.3 Business model canvas

- Value proposition

In La Seyne-sur-Mer all customers receive space heating and some also cooling from the network ensuring a comfortable indoor climate. The ownership of the substation is assumed by DALKIA enabling carefreeness for the customer and increases security of supply. The platform for intelligent control being developed in REWARDHeat provides performance optimization in the network and for the customers. The green value of having a renewable energy source can be used by the customer for its corporate social responsibility (CSR) strategy.

The DH company is providing additional services to one of the customers in the network other than supply of thermal energy as a commodity. One of the commercial customers connected to the demo site has a new type of EPC, where a fixed retribution has been introduced to reward the customer for the energy injected in the network. The injected energy is used to balance the temperature, thus making less use of the sea water source.

The DH company is interested to further extend the offering to the customer by providing more service behind the substation, such as automated energy monitoring and performance optimization through intelligent control. The service offering is a tailor-made solution for each customer and goes beyond the delegation of service contract for the thermal energy provision.

The customer value of having the DH company also supplying other building services is single point of contact for O&M issues and monetary savings through energy savings. Key value proposition in this case is to avoid increasing the energy related budget of the customer under the new increased tariffs under the new “public delegation of service” contract. The customer obtains a comparable energy budget but receives an increased level of service.

- Customer segment, relationship, and channels

As the DH company need to make investments to provide the energy efficiency services required by the customer, the contract duration has to be tailored. The operator needs to ensure a certain return on the investment and the customers need to receive a reasonable energy efficiency. Such mid-term contracts (7 years) are possible due to the long life of the installed building equipment. Providing a comprehensive service offering, tailor-made solutions, and related EPC contracts, ensures loyal customers, reducing interfaces and better O&M performances for both parties. It further necessitates a closer relationship and a better understanding of customer demand. Tertiary buildings are the customer segment being explored for La Seyne-sur-Mer for the EPC. The EPC in place at the demo site includes a special feature where the customer receives a retribution for the energy exchanges/injected into the network, making it a prosumer.

- Key resources, activities, and partners

DALKIA owns, manages, operates, and maintains the equipment at the customer site which enables control of achieving required performance which must be monitored. In EPC defining the tailor-made contracts is a key activity. The boundary conditions in the system changes as the DH company takes over more building services making system analysis more important. A dashboard is provided to all customers providing an interface where energy performance can be viewed.

Keeping close commercial relation with the customer is a key activity, together with the O&M staff on site, ensuring the daily operation of the system.

- Cost structure and revenue streams

Providing a comprehensive service offering is a risk by the energy provider and numbers in the business model needs to be thoroughly checked to ensure the objectives can be met with the technical means put in place. The main value in the case of the Casino is in customer retention and secondly, the increased servicification enables the DH company to increase revenues from such customer. With the casino the following scheme has been agreed on: the operator has identified several Energy Performance Actions (EPA) to achieve the set efficiency objective (about 5 actions for e.g., lighting, HVAC regulation and metering scheme); the works are at charge of the operator and the payback for those is achieved by retaining the energy efficiency benefits for 3 years (about 10 000 EUR/year). Moreover, the overall approach is to propose this as a service, so a "fixed service fee" is charged to the operator for the duration of the contract (about 10% of the benefits).

- Business model canvas

Table 8: La-Seyne-sur-Mer - Business model canvas.

<table>
<tr>
<td rowspan="2">Key Partners

Engineering companies

Equipment and technology providers

City (both owner and key partner)

Waste heat supplier/ Prosumers (through the EPC)</td>
<td>Key activities

Monitor and operate system

Monitor and assess customer consumption

Install and service equipment at customer site

Manage energy budget at customer

Establish and perform EPC contract</td>
<td rowspan="2">Value Proposition

Heating, cooling Comfortable indoor climate
Security of supply

Value of green (seawater as heat source – increases with optimization)

Tailor-made solutions: Energy savings -Monetary savings (EPC contract with casino)
Single point of contact</td>
<td>Customer Relationship

Closer than arm's length (service at customer's site)

Close and frequent contact with EPC customers and their O&M staff</td>
<td rowspan="2">Customer segment

Private or public tertiary buildings

Prosumers (through the EPC)</td>
</tr>
<tr>
<td>Key Resources

Network, substations, dashboard

Monitoring eq.

Staff (sell and perform EPC)

Performance optimization platform</td>
<td>Channels

Invoice

Dashboard

Tailor-made, personal dialogue with casino</td>
</tr>
</table>

Cost structure	Revenue streams
Thermal energy provision from the DHC network is regulated via usual fixed and variable fees scheme as defined under the "public delegation of service contract". Lower operational costs for the DHC network operation through the performance optimization platform (DEMIX) EPC: additional reduction of fixed costs for Casino customer due to the injected energy used to balance the DHC networks temperature.	Fixed tariff (connection costs) in combination with variable tariff (consumption). With the casino: Shared savings EPC. "Fixed service fee" is charged to the operator for the duration of the contract.

4.2.4 The green value

In REWARDHeat new customers have been connected and because of the low temperature in the network less electricity is used in heat pumps as they operate at a higher COP. The lower temperature in the network has lower distribution losses if it were a conventional network. With the developed forecast and optimization platform (DEMIX) a better operational performance in the network is expected, reducing auxiliaries' electricity consumption (pumps), and improving the overall COP of the HP.

For the city, La Seyne-sur-Mer, the green value is the reason for having invested in a low temperature network asset. The city's' goal is to achieve its low-carbon development plan and the network is a key infrastructure to obtain the goal. An important part of this is the awareness creation of the green value to customers and the public by means of a dashboard developed in sister project (ReUseHeat).

Customer segment is professional business owners (i.e., the casino) for whom it is an important marketing aspect to have green energy. Today there are mostly existing buildings connected to the network but for new constructions, or extensive refurbishment of existing buildings, a green DH network is very valuable to meet thermal regulation values and comply with their own CSR plans

Alternative heat production in France is mainly natural gas, oil, and electric resistance heating. The general DH supply in France has a high share of natural gas meaning that the DH supply in La Seyne-sur-Mer is a greener heat alternative and often relacing gas as space heating.

The green value is exploited to the casino where an EPC has been established and green heat is a part of the contract.

4.2.5 Services offered to customers

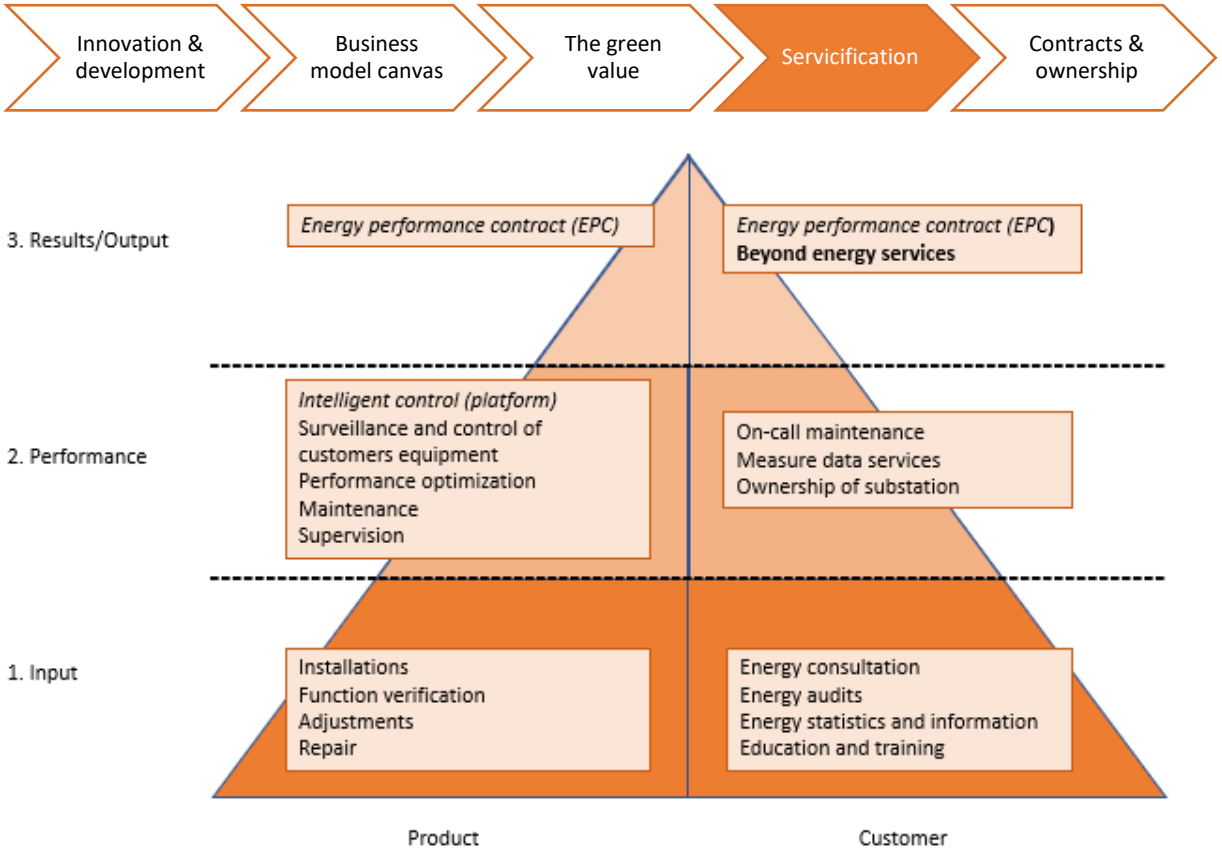


Figure 7: La Seyne-sur-Mer - The servicification triangle.

Figure 7 visualize the servicification triangle for the demo site. Italics represents what is new in services offered to customers in REWARDHeat and bold represent possibilities beyond REWARDHeat.

Normally the responsibility of the DHC network operator (DALKIA) ends at the customer substation at the heat exchanger level (owned and maintained by DALKIA) and they do not involve in the secondary (customer) side. In La Seyne-sur-Mer, as a decentralized architecture has been chosen, the space heat and cooling provision also includes the O&M of the HPs (as well as other associated equipment as gas boilers or solar thermal panels). DALKIA is furthermore expanding the service offer to professional customers by offering an EPC to reach energy savings at customer facility (i.e., the casino, but other customers are targeted). The EPC with the casino includes energy efficiency improvements measures in the ventilation system, lighting, and extended monitoring. This integrates DALKIA further into the customer processes and builds a closer customer relationship. Basically, DALKIA is responsible for the overall energy budget of the customer for the duration of the EPC contract. It is outside the scope of DALKIA to offer EPC to private customers (housing). With the EPC offer available to customers, DALKIA has a comprehensive service offering available and covers all levels of the servicification triangle. In the EPC with the casino the contract also integrates the casino as a prosumer. The customer receives retribution for energy exchanged between the DHC network and its own installation. The energy is used to balance the temperature of the DHC network (increasing overall performance).

Beyond the REWARDHeat project, DALKIA has an ambition to increase the scope of services offered to the customer and assume more of the customers spending on external services by moving beyond energy services, for example by also assuming the role of the caretaker of buildings. The value to customers is a single point of contact and carefreeness and for DALKIA larger revenues per customers and closer customer connection. To expand the offer beyond pure energy provision and related installations' O&M, requires organizational changes and development of new processes within the company, enabling to take on more responsibility in new areas.

Table 9: La Seyne-sur-Mer - Advantages and disadvantages with new and proposed services

Advantages with proposed services at demo site	Disadvantages
The EPC create a value for customers in single point of contact and guarantees energy savings, and therefore cost savings. For the DH company the scope of each business can be expanded (increased revenue).	More risk in guaranteeing energy savings in the EPC and provide services beyond the substation and be responsible for the customers processes. Necessary to have proper knowledge and monitoring systems. Dependence of the customer of a third party for managing its energy related budget.
Energy performance contract is an additional contract beyond DHC provision, enabling a close relationship with customers and loyalty.	Performing additional services drives the cost of staff to perform the service and manage the customer dialogue.
Ambition to expanding beyond energy services in the future and assume the caretaker role. Increasing the scope of services leads to more revenue per customer. For the customer it is more carefree and enables a single point of contact.	Increased complexity and risk in the business model if expanding beyond energy, necessitates new processes in the organization.

4.2.6 Ownership & Contractual considerations

The contracts required at the demo site are those between the DHC network owner (local authority) and the DHC network operator (DALKIA) via a *delegation of service* contract, and a contract between DALKIA and their customers.

The factors affecting the demo site contracts are considered below.

1. Low maturity of the technical solution

Although there are not many low temperature DH networks in the world, DALKIA has implemented this concept in other places apart from La Seyne-sur-Mer and has thus more knowledge about building and operating such systems than its French competitors. Nevertheless, having to expand an existing DHC network, it has to manage the system within the constraints imposed by the

already implemented solutions (i.e., system sizing and chosen technologies) and ensure these are reflected in the objectives they have adopted via the PDS contract with the city.

In the case of the EPC formed with the casino, the factor of low maturity applies and needs consideration in the contract negotiation. However, the EPC entails a close and stable relationship between DALKIA and the customer, and this relationship could alleviate the risk associated with low maturity.

2. No legal framework for low temperature district heating

There is no specific legal framework on low temperature DH in France, and they are thus regulated as other conventional DHC networks, in terms of related regulation, permitting, contracts and financing. This does not obstruct or interfere with the operator activities and the extension and operation of the DHC network.

The operator must however consider environmental law concerning maximum admissible temperature of the exhaust water from the system.

3. The value of waste heat is subjective

There is no general consent on heat source pricing for sea water or other renewable or waste heat sources. The cost is a negotiation between the heat source owner and the DHC network operator and usually based on a negotiation of the share of the CAPEX needed to realize the asset and to access the energy source. In this case of La Seyne-sur-Mer, no specific owner is identified for the energy source (sea water) and all cost are thus sustained by the delegated party under the Public Delegation of Service contract and part of the overall business model.

4. The payback period

The concept of low temperature DH is still considered to entail a long payback. However, DALKIA is able to integrate prior learnings from similar low temperature DHC networks and when the installation is replicated elsewhere, the foreseen payback would be shorter. Seawater-based low temperature DHC networks shows potential in the Mediterranean region, where there are numerous urban, dense, coastal areas. The replicability is therefore high and even more so once local authorities gain more knowledge of this type of solution and it is integrated into energy strategies and related tendering.

5. Asymmetric information

There is no asymmetric aspect at the heat source, thanks to it being a resource that no part owns. The information is symmetric at the customer sites as customers are given access to information about their installation and consequent metering on the dashboard that has been implemented as part of the project. Concerning the EPC, through which DALKIA has assumed ownership of the customer energy installations and carries all the risk of the overall energy budget, information is asymmetric, as the customer has delegated the responsibility of the exploitation of the system to the operator, losing the direct control of the system exploitation and related budget.

6. Shared incentives

There are no shared incentives concerning the heat source. DALKIA is the only part involved in the energy recovery from the ocean. The EPC with the customer has created a shared incentive for efficient energy use and a retribution for the energy the customer injects in the DHC network used to balance its temperature.

7. Termination of heat recovery

The risk of termination of heat recovery from ocean water is very low (even not applicable). The only risk that could discontinue the operations is if the environmental regulations are trespassed concerning admissible maximal water rejection temperatures and the consequent possible fines or other type of sanctions applicable by the regulating authority.

There is also the risk of customers disconnecting from the heat network, which would leave DALKIA with disused heat exchange components at the customer site. This risk needs to be managed in the EPC contracts by setting a suitable length of the contract.

- Ownership

The ownership structure at the demo site is simple. The city owns the DHC network and delegates its operation and extension to the operator, DALKIA. The contract perimeter is heating and cooling provision for customers (no domestic hot water and ownership of the substation equipment (exchangers and HPs) is thus part of the contract.

In the case of the EPC, the operated equipment is owned by the customer. Additional equipment needed for the identified energy efficiency measures, is invested by DALKIA, and once repaid, transposed to the customer. DALKIA thus takes all the risk of the system and costs are shared according to the contract.

For future replication or scaling up of the project, it is recommended for DALKIA to strive for a similar ownership structure as in this case. In case of scaling, the same Public Delegation of Service contract will apply, and the ownership structure will therefore likely be similar, though a new DHC network might be required to operate in parallel to increase capacity. If the project is replicated at another location, the ownership scheme might require adjustments to fit local conditions and requirements.

- Energy performance contract

The energy performance contracting (EPC) market in France is at preliminary stage and currently static due to legal issues (Moles-Grueso, Bertoldi et al. 2021).

The customers of La Seyne-sur-Mer are professional building owners of housing, tertiary, or public buildings, not having energy as core business. For the Casino an energy baseline has been established and it has been identified a potential for energy savings in the building. The casino has concession to perform the business and a contract length is tailored to the set objectives and its overall economic balance (7 years).

EPC is still a rather new contractual arrangement in the DHC network sector but the ambition of DALKIA is to grow the business in this direction. It is however, not in the strategy of DALKIA to offer EPC to private housing estates, as regulation does yet not enable to engage in energy efficiency objectives with tenants. This is not the case in public housing estates with centralized energy production units.

In La Seyne-sur-Mer it has been decided to enter an EPC with casino and from both a customer and energy company perspective this it a suitable option. The investment cost will be shared between DALKIA and the Casino in accordance with the EPC. EPC in this case it was a good mean to offset future increased energy cost for the casino and to keep it as a customer.

4.3 France – Gardanne

The demo site in Gardanne is summarized in Table 10. Following a short introduction to the demo site are the five topics in focus in the REWARDHeat project: Innovation & development, Business model canvas, The green value, Servicification and Contracts & ownership.

Table 10: Gardanne - Summary of the demo site

Gardanne	Innovation & development	Business model canvas
A greenfield low temperature DHC network in France owned by the city and operated by DALKIA under a "Public Delegation of Service" contract. The heat supply is mainly from a mineshaft but also from solar panels owned by Energie Solidaire.	Technical: Local PV production increases the share of renewables. Increased flexibility using the mineshaft as a storage, integration of solar production and BESS in optimization. Customer: DALKIA is examining the possibility to enable solar peer-to-peer energy trading.	The innovations impact most aspects of the canvas. The integration of customers solar energy affects the customer relationship, the skill set of and activities of the staff.
The green value	**Servicification**	**Contracts & ownership**
Increased flexibility and renewable energy create a green value. A green heat supply is valuable to the city and the DH company, and it is the reason DALKIA was awarded the tender. Customers pay a premium price for the green heat.	Solar peer-to-peer energy trading is a new service foreseen to be offered at the site.	Contracts are required with the customers owning the solar panels, end-customers, and the municipality. EPC with the municipality and other customers could be pursued beyond the project.

4.3.1 Business model innovation and development

A second site was included during project progression. It is a greenfield site located in Gardanne where the city decided to create a joint venture to design and operate the DH network called Energie Solidaire. The DH company (DALKIA) was assigned by the city to collaborate in the joint venture and is in charge to provide an energy, environmental, and social solution for an 80 000 m^2 area of mixed buildings (hotel, offices, and cultural site). At Gardanne there is an old coal-mine that closed in 2003 reaching down to 1100 meters in depth. The mineshaft can operate as a seasonal energy storage and has a capacity to store 65 000 m^3 water. The mineshaft also works as a geothermal energy source (500 kW). The publicly owned building in Gardanne, that is foreseen to develop into a science centre, has a large PV installation (240 kW) and battery energy storage system (BESS) in operation. The site is foreseen to become an economic hub with strict requirements on environmental, energy and social settings. The buildings in the area will be supplied with heating and cooling by a neutral temperature network. The network will be 1.3 km long and supply 2200 MWh heat and 1400 MWh cooling and integrate decentralized renewable electricity production located at the customer site as well as an energy storage (thermal and electrical). There will be 6 substations for the hotel, offices, and the science center.

The technical innovation in Gardanne is using the mineshaft as a storage (not only as a heat source) as well as control and optimize the entire system with integration of solar energy and BESS to increase the share of renewables in the network. The forecasting of solar PV production is developed and integrated into the network management. Towards the customer the innovation foreseen to happen (currently being studied) is making it possible for solar peer-to-peer energy trading. It is also foreseen to increase the share of solar energy in the system by purchasing energy from customers on site that have solar panels, thus creating a shift in the customer relationship.

4.3.2 Business model canvas

- Value proposition

Customers are supplied with both heating and cooling from the network which creates a comfortable indoor climate and increases the security of supply. Same as in La Seyne-sur-Mer, DALKIA performs the maintenance of the customers substations creating carefreeness for the customer. The green value arising from using the mineshaft as an energy source (and energy storage) as well as the integration of solar PV system with battery energy storage systems ensures a high share of renewables.

For the city, important aspects are optimization of the network, making use of the mine shaft and to have a collective energy system enabled through the joint venture with DALKIA called Energie Solidaire. The city also owns the building which will become the future science centre where they want to create awareness about benefits connected to low temperature solutions.

The energy network has the possibility for customers to perform solar peer-to-peer electricity trading. A value to the customers that can be both economic and environmental. Solar peer-to-peer is a service studied right now that the energy company wants to provide.

- Customer segment, relationship, and channels

The main customer segment is professional owners of office buildings, hotel, and the owner (the city) itself. The relationship with the customers will be close and built on long term arrangements. It is foreseen that more solar energy will be integrated into the system over time, coming for customer buildings. The relationship with the customer would then include more dialogue and a closer relationship. The thermal exchangers at the customer site makes all customers prosumers.

- Key resources, activities, and partners

PV panels are an important resource ensuring stable energy price for operating the facility. At the Gardanne site prefabricated, space-saving, substations (Danfoss) and Thermaflex pipes will be tested and evaluated. A SCADA system is used to monitor the network, and it will ensure integration of solar production forecasts (provided by Solar GIS) for optimization of the system. The mineshaft is an important asset, and the challenge is to understand how it can be optimally charged and discharged. Equipment and technology providers are key partners in constructing the network. The city is also a key partner, a customer, a supplier of solar energy, as well as majority owner of Energie Solidaire. Going forward it is possible that solar energy located at the customer site is integrated into the system and then the customers would also become prosumers and partners in the business model.

The PV panels, substations and mineshaft optimization are financed by the REWARDHeat project. The costs to maintain and operate will be carried by the owners of the site (Energie Solidaire) where the city is the largest owner.

- Cost structure and revenue streams

The cost structure is mainly driven by fixed cost and operational costs. As customers PV assets are foreseen to be connected a necessity to establish prosumer contracts with building owners. All the gains from using the mineshaft as an efficient storage and flexibility provider will be in the benefit of the owners of the system (Energie Solidaire: the city and energy company). Solar peer-to-peer is currently being studied and one topic is whether to offer this service for free, or not, to the customers. Currently all solar panels in the system are owned by Energie Solidaire.

Customers are paying a premium price to receive the green heat, which is a little bit higher than for other DHC network.

- Business model canvas

Table 11: Gardanne - Business model canvas.

Key Partners	Key Activities	Value Proposition	Customer Relationship	Customer segment
Equipment providers City (both owner and key partner) Prosumers (solar energy partners)	Monitor and operate network Service equipment at customer site Manage prosumer relationship and contract Optimize mineshaft usage	Heating, cooling Comfortable indoor climate Security of supply Carefreeness (rent substation, Awareness building and collective energy system (the city) Value of green (Solar PV integration and	Long term (loyal) For some the relationship is based on prosumers (solar energy integration)	Commercial (office buildings, hotels) Publicly owned buildings Prosumers through the

Solar PV forecasting company	Key Resources Network, substations, Mineshaft, BESS Control system Staff (install and operate system and perform services) City's' and customer's PV asset	mineshaft creating flexible production) Foreseen: Solar peer-to-peer EPC creating more carefree for customers	Channels Direct and personal dialogue for tailor-made solutions (increasingly with solar integration) Webtool	solar energy integration
Cost structure Driven by fixed and operational costs Lower operational costs through optimized use of heat sources and energy storage			Revenue streams Fixed tariff in combination with variable tariff depending on consumption. Premium price for green heat	

4.3.3 The green value

Developing a low temperature network enables low heat distribution losses, more geothermal heat can be extracted from the mineshaft, less electricity used in heat pumps and higher heat storage capacities in the mineshaft.

The thermal energy storage can be used to optimize energy production and provide flexibility in the system (seasonal) which can reduce primary energy. The battery energy storage systems are also supplying flexibility and optimizing the system (intra-day).

A greener heat supply by means of renewables (geothermal and solar) is a value to the municipality owned buildings as the government has targets on increasing the share of renewable. The green value was a key aspect in the tendering process. A special value of the green heat, and of having a low temperature installation, to the city is awareness creation the house of energy (part of the science centre). The developing area is targeting environmentally aware customers by marketing and applying stringent energy, environmental and social requirements. Most buildings in the area are new constructions which have very strict requirements on limiting their energy consumption. The green heat supply is valuable to meet the thermal regulation values for new buildings.

Alternative heat production in France is mainly natural gas, oil, and electric heating. The general DH supply in France has a high share of natural gas, followed by biomass and waste heat, meaning that the DH supply in Gardanne is a greener heat supply. The green value was a key aspect to success in the tendering process, and customer are paying a premium price for the greener heat which is slightly higher than for other DHC networks.

4.3.4 Services offered to customers

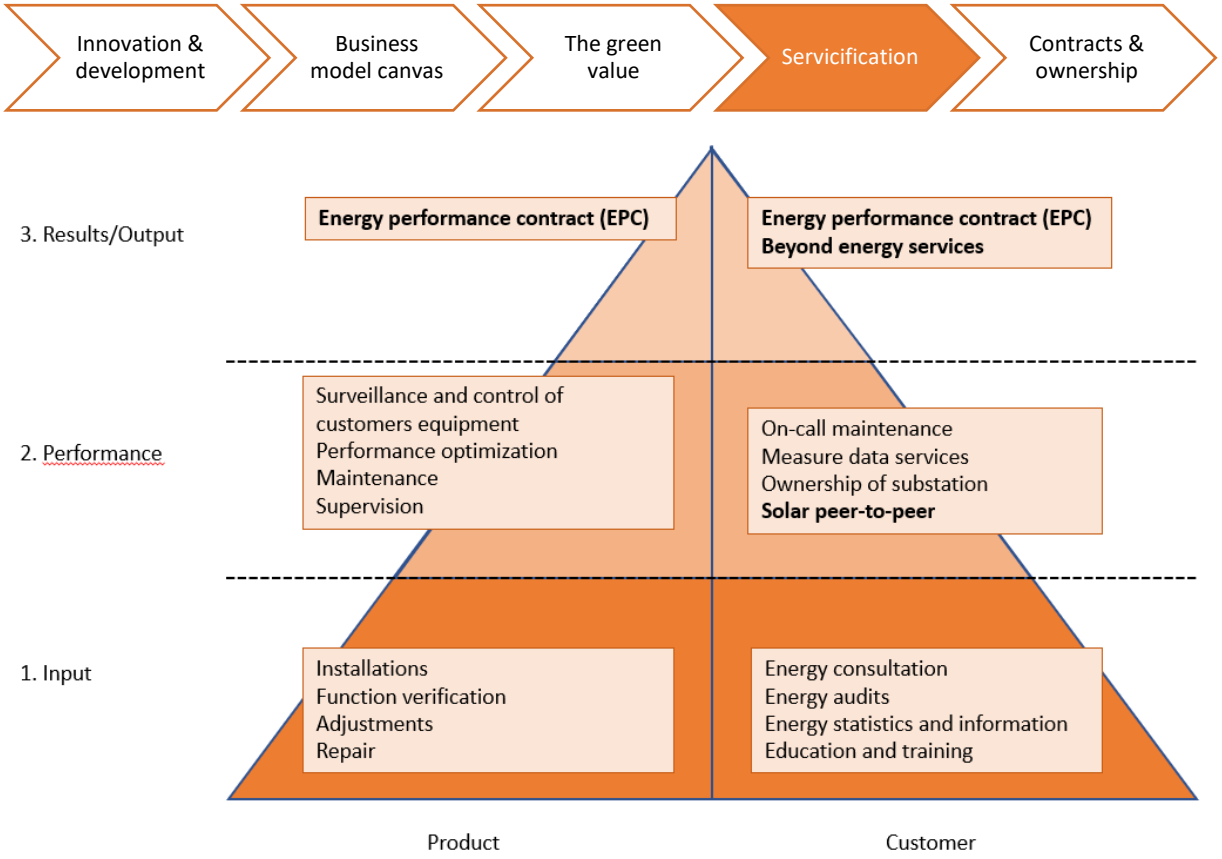


Figure 8: Gardanne - The servicification triangle.

Figure 8 visualize the servicification triangle for the demo site. Italics represents what is new in services offered to customers in REWARDHeat and bold represent possibilities beyond REWARDHeat.

DALKIA performs maintenance of the substations which is a level of service in the middle of the triangle. The new service foreseen to be implemented at the Gardanne site is the collective self-consumption service made possible by the DH company (solar peer-to-peer). It would enable electricity to be transferred between buildings as the area in Gardanne meets the legal requirements. For example, the buildings must be in a 2 km radius, maximum 2 MW solar capacity, part of the same branch in the electrical network, have smart metering and the distribution taxes must still be paid. Today the electricity produced from solar in the system is provided by the city and used to produce energy for the DH network.

DALKIA has an ambition to grow the business in a service-oriented direction and plans to offer EPC as suitable customers connect to the network. Same as in La Seyne-sur-Mer, there is a possibility to extend services beyond energy.

Table 12:Gardanne - Advantages and disadvantages with new and proposed services

Advantages with proposed services at demo site	Disadvantages
Enabling solar energy peer-to-peer business is an opportunity for customers and develops the energy community. It further strengthens the relationship with the DH company.	Solar peer-to-peer adds complexity and administrative work for the energy company.
Long-term contracts with prosumers build a closer relationship with customers and loyalty. Integrating solar energy increases the possibility to further optimize the system.	Integration of solar PV and BESS owned by a customer adds complexity to the system.
Ambition to expanding beyond energy services in the future and assume the caretaker role. Increasing the scope of services leads to more revenue per customer. For the customer it is more carefree and enables a single point of contact.	Increased complexity and risk in the business model if expanding beyond energy, necessitates new processes in the organization.

4.3.5 Ownership & Contractual considerations

At the Gardanne demo site, the joint venture Energie Solidaire, between the city and DALKIA, is guarded by a contract, further contract needed are a contract between the municipality and DALKIA regulating the heat recovery and storage in the mine shaft is needed, along with the contracts between DALKIA and their customers, especially with customers foreseen to supply solar energy. The factors affecting these contracts are considered below.

1. Low maturity of the technical solution

The contracting at the demo site is affected by the innovative concept of using the old mines both as a storage and as a heat source, while simultaneously integrating solar energy in the system. Just like the case of Heerlen (discussed in 4.8.6), this demo site with its use of a mineshaft as both energy storage and heat source, has the same layout as only a few other examples found in the United Kingdom and Spain making the factor of low maturity highly applicable. Dialogue between DALKIA and the city is required. However, an assumption could be made that DALKIA and the city both are engaged to form a strong relationship through their joint venture and would therefore have good knowledge of the role of each organization.

2. No legal framework for low temperature district heating

This factor has the same impact on the Gardanne demo site as for La Seyne-sur-Mer – the absence of a legal framework and the resulting lack of guidance necessitates close and careful dialogue

between Energie Solidaire and their customers. This need is further emphasized due to the ownership structure at the demo site, where all customers are prosumers thanks to the heat exchangers located at each customer.

3. The value of waste heat is subjective

At this demo site the value of flexibility is more important than the value of the heat source. Thus far, the heat has been acquired for free (although this might need re-evaluation in the case of a future scaling of the site). The seasonal storage has a value in the Gardanne energy system, and this value needs to be established and agreed on by both parts.

4. The payback period

The payback period is long but was shortened thanks to the REWARDHeat project funding. It is however likely that learnings from the demo site could be integrated in a replication of the project, which would then allow for a shorter payback. The local government ownership is beneficial for the demo site, where the city has a larger so-called *patience capital* than DALKIA and can therefore select a lower discount rate for their investments. A similar constellation could be beneficial in future replications as well.

5. Asymmetric information

The heat source and storage in the old mines are owned by the city and this part of the chain appears to be the most asymmetric by nature. Thus, DALKIA must be mindful to acquire the information of the technical aspects and ensure access that allow them to secure the operations of the system. To optimize the system, the network operator needs to learn as much as possible about the heat source and include its dynamics in their control system.

DALKIA has also gained access to their customers' substations and could thus integrate customer information in their control system.

6. Shared incentives

The joint venture between DALKIA and the city intrinsically unifies some of their incentives. The city has a clearer incentive for the heat source to be efficiently exploited but this incentive could be integrated by DALKIA as well by including a long-term target of energy efficiency. No such explicit example has been documented at the demo site.

7. Termination of heat recovery

The geothermal energy source is continuous, and the risk of its termination is low. Even if the collaboration between DALKIA and the city should end, the heat sources and systems remain. However, the risk of termination is considered low also in terms of the two parts' collaboration, thanks to both actors owning parts of the installed system.

- Ownership

The ownership constellation in Energie Solidaire includes the city which reduces the overall risk of the investment. It appears relevant to keep the city as a majority owner to ensure that there is an organization that will continue operation post project.

A recommendation for any replication or scaling of the project is to investigate whether it would be possible for DALKIA to at least co-own the heat recovery units at the heat source, since this allows for easier access for DALKIA to carry out maintenance and optimization of the system.

- Energy performance contract

The customers in the network are the soon-to-be science centre (publicity owned building) and tertiary buildings (hotels, offices) owned by professional building owners. The hotels and offices are new buildings in the area which means that the energy consumption and related systems should be already at a good level. The science centre is an older building and could be a potential for EPC and municipalities are often considered the target group for EPC. The buildings connected to the network today are considered too small for establishing an EPC but as more buildings connect it is the ambition of DALKIA to have EPC also in Gardanne.

As the city owns 76% of the network and DALKIA the remaining 24%, there is already an established relationship in the public-private partnership for ownership of the network. The already established trust-building with the customer could be an enabler to approach the city with an EPC offer.

4.4 Italy- Milan – Balilla

The demo site in Balilla is summarized in Table 13. Following a short introduction to the demo site are the five topics in focus in the REWARDHeat project: Innovation & development, Business model canvas, The green value, Servicification and Contracts & ownership.

Table 13: Balilla - Summary of the demo site.

Balilla	Innovation & development	Business model canvas
A new low temperature network in Italy, Milan, owned by ACS Calore e Servizi. The heat supply is groundwater wells in combination with a HP at each customer.	Technical: New network integrating groundwater wells. Customer: Take over the ownership and maintenance of HPs at customer's site.	The increased service drives changes in the customer relationship as well as competence and activities of the DH company. Replacing fossil boilers creates new values.
The green value	**Servicification**	**Contracts & ownership**
The green value is valuable to the DH company and to the city (part-owner). It is not highly valued by customers.	Taking over the ownership of the HP at the customers' site is news.	New contracts are needed with the customers around the HP. EPC with the municipality is a possibility beyond the project.

4.4.1 Italy: Input from PESTLE analysis and customers' perspective

Conclusions from the PESTLE analysis (Fransson, Sandvall et al. 2021) that is relevant for business model development:

- DH is competing with individual solutions for heating receiving state-based financial support
- People and partnerships are important to realize DH in Italy
- Establish a clear value proposition to all stakeholders, especially to the city and customers
- Low temperature DH should provide both heating & cooling to increase value and competitiveness against HPs

Conclusions from the customers' perspective (Fransson and Lygnerud 2021) that is relevant for business model development:

- Most customers are not willing to pay more for greener heat
- Customers want an incentive-based pricing scheme
- Customers are unwilling to increase service offer in connection to DH supply as it is perceived to results in higher cost.
- More information could make customers more interested in services and taking over maintenance could be a wanted first step.

4.4.2 Business model innovation and development

The demo site leader for the Italian demo sites is ACS Calore e Servizi (ACS). The sites are both located in Milan and are identified after the street names "Balilla" and "Gadio".

In the Balilla site a new neutral temperature network will be built, and heat will be supplied from groundwater wells. The water will be transported directly to customers at around 15 °C where the temperature is raised to about 65 °C using a HP at each customer substation. The connecting customers will be a residential building (a multi–family house), a municipal centre and a kindergarten, supplied with heating and cooling (only in the municipal centre).

In REWARDHeat, ACS is constructing a new neutral temperature network in Balilla and integrating groundwater heat. In the project ACS is developing the business model by providing an increased level of service to customer by having ownership of the HPs and provide the maintenance. This results in a shift in boundary condition to inside the customers building. By taking over the ownership, operation, and maintenance of the HP it reduces the investment for the building owner and minimizes the effort spent on heating provision for the caretaker of the building. For ACS a benefit of taking over the maintenance is the increased control over the customer site and the possibility to optimize performance in the network. A challenge in scaling the increased service offer is the necessity to develop a structure to manage the maintenance. More information on various service packages offered by Swedish DH companies to private and professional customer is available in Section 8.1 as inspiration. A second challenge for ACS is that the municipality is

unwilling to agree to maintenance contracts as there is already an engineering company employed to manage the maintenance of technical equipment.

The replicability potential is high and developing a good structure and business model is essential. In Milan there are approximately 95 groundwater wells located.

4.4.3 Business model canvas

- Value proposition

The municipal centre receives a comfortable indoor climate by the DHC system supplying H&C. The customer will not notice any change in comfort compared to the system today. Heat supply and maintenance of the substations are offered to give customers an optimized and carefree installation. For the residential building, DHW will still be supplied by apartment switches owned by the end customer of the flat. New values arising by having the customers fossil fuel boiler replaced by a DH system is the value of green, improved safety (the risk of explosion removed), increased reliability of heating supply and compliance with the Milan municipality regulation to replace fossil-based fuel units (targeted at removing all gasoline heating systems) by 2023.

In the Balilla site, the DH company takes ownership of the HPs which results in customer saving money on the investment capital. The DH company is performing additional services to the customer by removing the old boiler and managing the maintenance of the new equipment. Moving the ownership and maintenance of equipment from the customer to the DH company is an increased level of servicification and a shift in boundary condition to be inside the customers building. This creates a value in carefreeness for the customer.

- Customer segment, relationship, and channels

In the private building where the customer interaction is with the caretaker of the building (*Italian: amministratore*). The caretaker manages the building on behalf of the apartment owners. The customer is no longer considered a heat sink in the system but an integrated part of circulating energy in the system. The concept of neutral temperature networks has not been standardized by ACS, so a closer relationship is required with ongoing dialogue.

Regarding the municipal buildings (i.e., the municipal centre and the kindergarten), the utility company needs to interact directly with the Department of the Municipality of Milan in charge of municipal buildings management. Therefore, this relationship uses more institutional channels but still requires the closer dialogue and tailoring in the offer to the customer.

- Key resources, activities, and partners

New resources are required to deliver the DHC to the customer: heat pumps, distribution system, monitoring system. Maintenance service of the substations in the municipal buildings is offered to the customer with the intent to optimize the performance of the network. The key activities will involve managing, operating, and monitoring the new resources as well as managing the customer dialogue. It is estimated that personnel within the company have the skillset to manage the additional customer dialogue as well as to sell the service.

- Cost structure and revenue streams

The new resources (one-time investment cost of HPs, distribution network, and monitoring system) and new activities (operational cost for maintenance of system and equipment as well as electricity cost for the HPs and other pumps) are associated with a cost. At the customer site where there is a fossil-fueled boiler there is a one-time cost for removing it.

The income structure is foreseen to remain the same as in the remaining DH networks in Milan today, during the REWARDHeat project life. When more data becomes available on network performance a tailor-made business case can be proposed to customers. It is considered important, initially, to be able to show the customer a comparison of performance and cost by applying the conventional tariff structure to the new site. It should be noted that since the maintenance service is included in the offer, it will be more expensive than previously when only heat supply was included (previously maintenance was made by an engineering company). It will be a fixed tariff in combination with variable tariff depending on the volumes of water consumed (commodity).

- Business model canvas

Table 14: Balilla - Business model canvas.

<table>
<tr><td rowspan="2">Key Partners

Equipment providers

City (both owner and key partner)

Province of Milan authority

Groundwater management utility</td><td>Key activities

Monitor and operate network

Service equipment at customer site</td><td rowspan="2">Value Proposition

Heating, cooling, hot water
Comfortable indoor climate
Security of supply

Improved safety (removing fossil boiler)

Compliance with Milan law

Carefreeness (rent equipment)

Value of green (groundwater wells, lower losses)</td><td>Customer Relationship

Closer than arm’s length (service at customer’s site)</td><td rowspan="2">Customer segment

Private building/ caretaker of building

Municipal buildings department/ municipality</td></tr>
<tr><td>Key Resources

Network, substations, monitoring eq.

Groundwater wells (owned by city)

Heat pumps

Staff (manage customer dialogue perform service)</td><td>Channels

Increased dialogue</td></tr>
<tr><td colspan="3">Cost structure

Driven by fixed costs

More staff to perform service drives additional cost

Lower operational costs due to lower distribution losses</td><td colspan="2">Revenue streams

Fixed tariff (higher because service is included) in combination with variable tariff depending on consumption.</td></tr>
</table>

4.4.4 The green value

Having a low temperature DH network enables that more geothermal energy can be extracted from the groundwater well, less electricity is required in the heat pump, the heat distribution losses in the system will be less.

To the DH company having a green heat supply in the network is a valuable aspect for marketing. The DH supply replaces fossil fuels in the customers heating supply (gasoline and natural gas). The value of green is especially important to the municipality customers as the municipalities should lead by example in the energy transition. It is, however, not noticeably easier to change the heating system to a greener supply with a municipality customer in this case. The customer survey identified that customers are not willing to pay for receiving a greener heat supply.

51% of H&C in Italy is produced by natural gas and in the DH network supply gas is the main fuel used in production. The network in Balilla offers a greener solution than the average supply. The value of green does not appear in the business model as conventional DH business model will be applied at the demo.

4.4.5 Services offered to customers

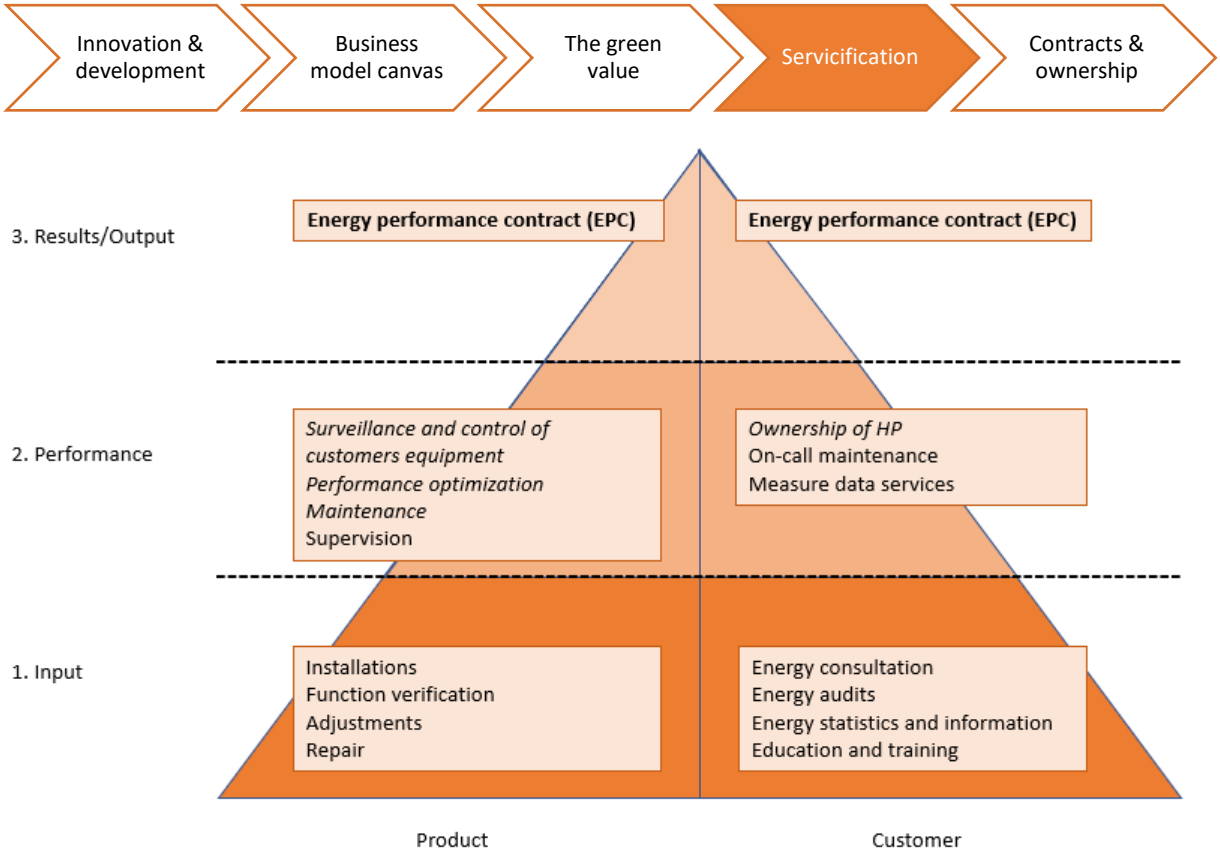


Figure 9: Balilla - The servicification triangle.

Figure 9 visualize the servicification triangle for the demo site. Italics represents what is new in services offered to customers in REWARDHeat and bold represent possibilities beyond REWARDHeat.

At the Balilla site the newness in services offered to customers is the maintenance of customers substation (step 2: services related to product performance) and the ownership of HPs at customers location (step 2: related to customer process). The change in services necessitates that ACS starts integrating with the customers processes and the ownership of the HP at customers location creates a shift in boundary condition.

For the Balilla site to reach higher in the servicification triangle, EPC contract with the municipality customers could be considered when the current contract between another supplier and the municipality expires.

Table 15: Balilla - Advantages and disadvantages with new services

Advantages with proposed services at demo site	Disadvantages
Ownership of the HP at the customers' site by the DH company creates a value to both the customer and the DH company. To the customer it is carefree. To the DH company it enables increased control of the system.	Assuming ownership and maintenance increases the risk and the amount of resource (e.g., staff, fault detection equipment) required. Necessary to perform enough service to reduce the risk of failure.

Improved safety and reliability of heat supply as DH company performs regular services to equipment.	A need to optimize the system for all customer (not only to the ones connected to the REWARDHeat demo) to ensure a fair and just heat delivery. Could cause more work to increase the performance everywhere in the system.

4.4.6 Ownership & Contractual considerations

At the Balilla demo site, the system boundary is shifted into ACS's customers' buildings, where customers do not own but rent their substations. Therefore, ACS must collaborate and agree on contractual forms both with the municipality (who owns the geothermal wells) and their end customers.

The factors affecting the contracts are considered below.

1. Low maturity of the technical solution

The contracts at the Balilla site are affected by the low maturity of the technological solution, where an entirely new low temperature network is built and the subsequent knowledge gap in terms of installation and operation of such a grid. This innovative structure calls for extensive dialogue between the collaborating parts.

2. No legal framework for low temperature district heating

Both demo sites are affected by the absence of legislation on low temperature DH. In lack thereof, the collaborating parts must instead specify their own terms and conditions that adequately reflect the value for all involved parts and distribute the potential risks associated with the investment in a fair manner. Negotiations, dialogue, and a good relationship is important to maintain a functioning collaboration.

Although there is no legal framework adopted, there is a municipal goal of phasing out all gasoline heating system by 2023 and this local framework creates a window of opportunity where DH could claim the resulting market shares and allow customers to meet the sustainability target.

3. The value of waste heat is subjective

The value of the waste heat has not been discussed explicitly at the demo site, though the use of groundwater is seen in a positive light. The value of the waste heat is not addressed in the contracts with their end customers either, who instead will pay the same price as the traditional DH. The perceived value of the waste heat might require future discussions when the solutions is scaled but poses no pressing threat, since the municipality both owns the heat source and holds a share in the ACS group.

4. The payback period

This aspect affects both Italian demo sites, though it is likely that the payback period will be shorter if the investment is replicated elsewhere, along with better knowledge on these installations. As a public-private partnership, ACS generally has a larger patience capital compared to a fully private

organization and is thus better prepared for such an investment. The payback is secured by ACS assuming the ownership of the customers' substation, which could eliminate installation and operating errors and allows system optimization and an efficient use of the heat source and in turn, the return on investment.

5. Asymmetric information

Information can be freely shared at the heat source at this demonstration site thanks to municipal share in the ACS group which connects the two organizations. On the customer end of the network, ACS has more insight in the case of non-municipal customers through the ownership of the substation, while the municipal customers thus far have employed another maintenance company for a duration of time set in a contract.

6. Shared incentives

The objective to extract as much energy from the heat source is shared between the municipality, who owns the heat source, and ACS. The more energy that could be extracted, the more customers could be connected to the network, and this is positive both from the perspective of municipality and energy company. There is also the municipal target of phasing out gasoline boilers, which creates a motivation for the municipality to expand the geothermal solution as much as possible. The municipality could further incentivize ACS to use energy in the most efficient way by setting a target on the efficiency in their contract. There are no intrinsically shared incentives between ACS and their customers, but they could also be created in the contract. For example, customers could be rewarded by being charged less for efficient use of energy through a motivational tariff

7. Termination of heat recovery

There is no tangible risk of the termination of the groundwater well as a heat source, especially not since the municipality owns ACS in part and naturally adopts a long-term perspective on the investment and the related development of the city.

- Ownership

The recommendation is for ACS to strive to access and operate as many of the components as possible. This ambition has been adopted and fulfilled in the case of non-municipal customers in Balilla, where customers rent instead of owning their substation. This allows ACS access to the equipment and enables maintenance and monitoring of their performance. It is however not a possible model for the municipal customers in Balilla, for the previously mentioned reason that they have contracted another company for maintaining their substations and heat pumps.

The recommendation for the future operation at the demo site is for ACS to try and at least contract service and maintenance of substations and heat pumps at all customer sites and at best to offer the rental model for their municipal customers so that further optimization could be achieved.

- Energy performance contract

The energy performance contracting (EPC) market in Italy is both sizable and developing (Moles-Grueso, Bertoldi et al. 2021).

Two of the customers at the Balilla site are publicly owned, the municipality center and kindergarten, and could be suitable candidates. The buildings are older, and an energy analysis could determine if the baseline is suitable for an EPC. The customer does not have energy as core business and in the business model values related to carefreeness of heating equipment appears meaning that if energy efficiency measures can be implemented in the buildings an ESCO could

provide value to the customer with knowledge of energy improvements. The private building has multiple ownerships which could make an EPC contract an overly complex solution and the individual owners wants flexibility of residence and not be tied to long contracts.

In the strategy of ACS, it is included to offer extended services beyond the delivery of heat to municipalities in cities where ACS has a DH network. In Milan this is not an option today as the municipality already has a contract with another supplier of these services. However, when the contract is due to be renewed it is likely that ACS will offer their services. ACS is partly owned by the municipality and therefore shares some of the ownership, culture, and relationships as the proposed customers of an EPC. Offering energy efficiency services to private customers is outside the scope of ACSs business. EPC could be a suitable option for the municipality-owned buildings at the Balilla site and something ACS could pursue when the current contract by another supplier with the municipality expires. A first step would then be to establish common goals with the customer, to establish a baseline and integrate with the customers processes.

4.5 Italy- Milan – Gadio

The demo site in Gadio is summarized in Table 16. Following a short introduction to the demo site are the five topics in focus in the REWARDHeat project: Innovation & development, Business model canvas, The green value, Servicification and Contracts & ownership.

Table 16: Gadio - Summary of the demo site.

Gadio	Innovation & development	Business model canvas
A new low temperature network in Italy, Milan, owned by ACS Calore e Servizi. Heat supply is excess heat from an electrical transformer.	Technical: Integrating of urban excess heat source (transformer). Customer: Take over the ownership and maintenance of substation at customer's site.	The increased service impacts the canvas in multiple ways. The waste heat integration creates a need for prosumer dialogue characterized by a close and tailored relationship.
The green value	**Servicification**	**Contracts & ownership**
The green value is valuable to the DH company and to the city (part-owner). It is not highly valued by customers.	Taking over the ownership of the substation at the customers' site is news.	New contracts are needed with the customers for the service as well as with the waste heat supplier. EPC with the municipality is a possibility beyond the project.

4.5.1 Business model innovation and development

The Gadio site will be a new low temperature DH network which is integrating available urban waste heat from a transformer. The transformer has approximately 400kW heat availability at a temperature of 30-40 °C. The temperature will be raised to 60-70 °C by a heat pump before being distributed in the grid. The waste heat will be used by the municipal aquarium and by the company that owns the transformers, Unareti (also part of the ACS Group making this party a prosumer). Heating is only supplied to the aquarium during the winter season. New customers are connected to the demo site and the provider of the waste heat will also be connected to the heat supply and thus become a prosumer in the network. Like at the Balilla site, ACS will develop the business model by taking over ownership of the substations inside the customer buildings.

The replicability potential is high also for the Gadio site and developing a good structure and business model is essential. The set-up with transformers owned by Unareti can be replicated both in Milan as well as in other cities and because the collaboration is internally in the ACS group there is no need to involve the municipality which makes the process easier.

4.5.2 Business model canvas

- Value proposition

The municipal aquarium reduces its dependence of natural gas as the DH network supplies heat during the winter season. This creates a green value and an increased reliability of supply. The indoor comfort remains the same in the aquarium. To the electricity company there was no heat supply for space heating prior to this installation and thus the indoor climate will be improved. As the DH company assumes owning and managing the heating equipment from the customer the value of carefreeness is created.

- Customer segment, relationships, and channel

As the aquarium is a municipality-owned building the relationship will be similar to the case for the demo in Balilla and the DH company needs to interact directly with the Department of the Municipality of Milan in charge of municipal buildings management.

As Unareti and the DH company both are part of the ACS group the relationship can be less formal as it is managed internally. Unareti becomes a prosumer in the system as they are both suppliers and consumers of heat. The prosumer relationship is not standardized today and requires tailoring and a close dialogue.

- Key resources, activities, and partners

New resources in the system are the heat pump required to bring the transformer excess heat up to distribution network temperatures as well as increased monitoring of the heat supply. The key

activities involve managing, operating, and monitoring the new resources as well as managing the prosumer dialogue

- Cost structure and revenue streams

Same as for the Balilla site.

- Business model canvas

Table 7: Gadio - Business model canvas.

<table>
<tr>
<td rowspan="2">Key Partners

Equipment providers

Municipality of Milan

Electricity company/ Unareti (prosumer)</td>
<td>Key Activities

Monitor and operate network

Service equipment at customer site

Prosumer dialogue</td>
<td rowspan="2">Value Proposition

Heating, cooling, hot water
Comfortable indoor climate (improved for Unareti)
Security of supply

Carefreeness (rent equipment)

Value of green (urban waste heat source, lower distribution losses)</td>
<td>Customer Relationship

Closer than arm’s length (service at customer’s site)</td>
<td rowspan="2">Customer segment

Municipal buildings department/ municipality

Electricity company/ Unareti (prosumer)</td>
</tr>
<tr>
<td>Key Resources

Network, substations, monitoring eq.

Transformer (owned by Unareti)

Centralized heat pump

Staff (manage customer dialogue perform service)</td>
<td>Channels

Increased dialogue</td>
</tr>
<tr>
<td colspan="3">Cost structure

Driven by fixed costs

More staff to perform service drives additional cost

Lower operational costs due to lower distribution losses</td>
<td colspan="2">Revenue streams

Fixed tariff (higher because service is included) in combination with variable tariff depending on consumption.</td>
</tr>
</table>

4.5.3 The green value

The low network temperatures enable more heat to be extracted from the urban waste heat source – the transformer – and less electricity is needed in the HP to bring the waste heat up to network temperatures. Because it is a low temperature network the distribution losses are lower and because the transformer (heat supply) is located close to the customer location the heat distribution losses are reduced.

To the DH company the use of excess heat from the transformer (owned by Unareti part of ACS group) which was previously wasted, as heat supply in the network creates a green value that can be utilized in marketing.

The DH supply replaces fossil fuels in the aquariums heating supply. As the customer is owned by the municipality the value of green can be especially important. The customer survey however, identified that customers are not willing to pay for receiving a greener heat supply.

51% of H&C in Italy is produced by natural gas and in DH networks, gas is the main fuel used in production. The network in Gadio, supplied by urban waste heat, offers a greener solution than the average supply.

The value of green does not appear in the business model as conventional DH business model will be applied at the demo.

4.5.4 Services offered to customers

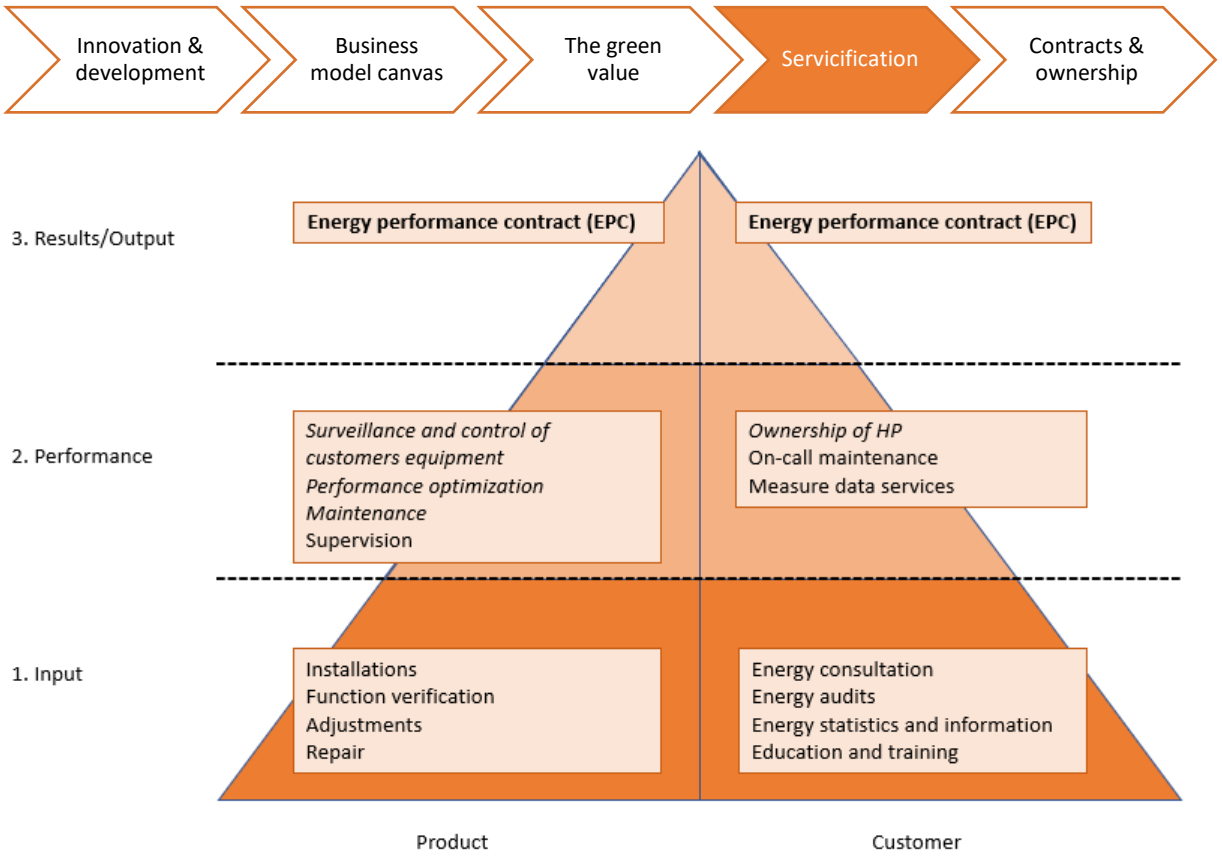


Figure 10: Gadio - The servicification triangle.

Figure 10 visualize the servicification triangle for the demo site. Italics represents what is new in services offered to customers in REWARDHeat and bold represent possibilities beyond REWARDHeat.

For the Gadio site, ACS has the same planned new services as for the Balilla site: maintenance of customers substation and ownership of HP, here a centralized HP by the transformer. An EPC is probably too complex to offer only to the aquarium because of small and seasonal heat volumes but the building could be included if ACS takes over the energy management contract for all municipality buildings.

Advantages and disadvantages with new services is same as for Balilla.

4.5.5 Ownership & Contractual considerations

At the Gadio site, contracts need to be in place between ACS and Unareti and between ACS and the customers. The factors affecting these contracts are considered below.

1. Low maturity of the technical solution

The low technological maturity of the waste recovery installation in Gadio is managed by connecting the solution to the existing DH network. Thus, the incumbent system functions as backup if there is an outage in the heat recovered from the transformer. However, close dialogue between ACS and Unareti is still required. The prosumer relationship between ACS and Unareti further requires dialogue and collaboration.

2. No legal framework for low temperature district heating

Gadio, just like Balilla, is affected by the lack of legislation on low temperature DH and ACS is required to have a close dialogue with the supplier of the waste heat, Unareti, to set the terms and conditions. This factor has less impact on the heat supply in the case Gadio, as both companies are in the ACS group.

3. The value of waste heat is subjective

As ACS and Unareti belong to the same company it is assumed that they intrinsically have aligning views on the value of the heat from the transformer station. By having the contract reflecting of the value of waste heat for both, a win-win situation should be enabled. For the municipal aquarium on the other end, there is a clear value of the waste heat where it replaces the use of natural gas while the indoor comfort remains unchanged, though the seasonal demand for heating must be agreed on in the contract terms.

4. The payback period

The foreseen payback period at the start of the project was to correspond to the project duration. For future projects, ACS would apply standard payback period enabled through the experience gained from these demo sites The project concept has high replicability potential, and the payback period would likely be shorter in the future.

5. Asymmetric information

This factor does not affect the demo site, as ACS and Unareti are organizationally connected. Information on the heat source is then readily available, which allows ACS to integrate it in a holistic manner in its control system.

As ACS at this point in time are unable to sign a maintenance contract with the municipality, they do not have full access to the municipality owned buildings substations and this limits ACS's ability to control the network.

6. Shared incentives

There is a natural shared incentive between ACS and Unareti to exploit as much of the available heat in the heat source as possible. The contract must reflect this so that there is economic benefit for both companies to draw from the investment.

7. Termination of heat source

Unareti is part of the ACS group, and a well-functioning collaboration is therefore assumed. This would imply that any desired changes in operation or termination of the collaboration should be discussed well in advance, though it is still an important factor to incorporate in the contract. The transformer station will likely not seize to exist.

- Ownership

The main customer, the municipal aquarium, are not able to form a service agreement with ACS as they are currently in a contract with another supplier. This limits the DH company's ability to expand its control at the customer side and to further optimize the system.

Its organizational link to Unareti should allow easy access for maintenance of the waste heat recovery installation. The recommendation for ACS at the Gadio site is the same as at the Balilla site: ACS is recommended to apply for the contract service and maintenance for all municipal buildings when the current contract with another company is expired, which would then include the aquarium. If ACS connects another waste heat supplier in the future, it is recommended that they try to own as many of the heat recovery components as possible, to achieve the maximum optimization.

- Energy performance contract

The municipality-owned aquarium only needs heat during winter and EPC could be a too complex contract for a small delivery of energy. Depending on the baseline of the building, other energy efficiency measures could be included in an EPC contract. Same as for Balilla, the customer in Gadio does not have energy as core business and in the business model values related to carefreeness appears.

From ACSs perspective the suitability of an EPC is the same for Gadio as for Balilla.

An EPC is probably an overly complex contract and less likely to be profitable because the volumes of heat supplied. If ACS wins a contract with the municipality to perform energy services on all the municipality-owned buildings, the aquarium would be included as part of a larger building stock.

4.6 Sweden- Helsingborg

The demo site in Helsingborg is summarized in Table 17. Following a short introduction to the demo site are the five topics in focus in the REWARDHeat project: Innovation & development, Business model canvas, The green value, Servicification and Contracts & ownership.

Table 17: Helsingborg - Summary of the demo site.

Helsingborg	Innovation & development	Business model canvas
New low temperature network connected to the conventional DH network of Helsingborg. The network is owned by Tornet, a private company.	Technical: The boreholes can be utilized as storage by the conventional DH company to optimize their production (increased flexibility). Customer: The business set-up creates a flexibility service to the customer (the conventional DH company).	Utilizing the boreholes to optimize the production of the conventional DH network necessitates a close relationship. New values are created and Tornet are guaranteed the lowest price of heat.

The green value	Servicification	Contracts & ownership
The green value creates a flexibility that is valuable both to Tornet and the conventional DH company. At this point there is no additional revenue stream from the green value.	A new business set-up where the conventional DH company is the customer of the flexibility services.	Necessary to have a clear contract for the collaboration. It would be more beneficial if the DH company owned and operated the boreholes.

4.6.1 Sweden: Input from PESTLE analysis and customers' perspective

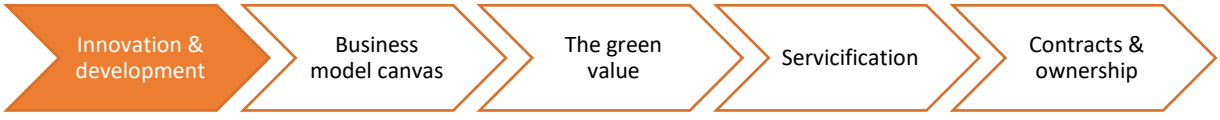
Conclusions from the PESTLE analysis (Fransson, Sandvall et al. 2021) that is relevant for business model development:

- Green energy is an important value to attract investment capital for low temperature DH
- Pricing structure should focus on transparency and fairness as customers are often focusing on cost
- Establish a clear value proposition against alternative heat supply options

Conclusions from the customers' perspective (Fransson and Lygnerud 2021) that is relevant for business model development:

- Most customers want the same price even if heat supply is greener
- Customers want an incentive-based pricing scheme
- Customers need more information about the benefits of increased service to mature
- Private customers want maintenance as a service

4.6.2 Business model innovation and development



Tornet is multi-family building owner in Helsingborg that owns the 4 four buildings at the demo site. In the initial design Tornet used DH at peak load only and used a heat pump and a borehole storage for most of its energy needs. A set-up that is challenging to the DH provider. The innovation in REWARDHeat is to charge the borehole storage when it is beneficial for the DH supplier. For example, when there is excess heat available, which is mainly during the summer season. The advantage for the DH company is to be able to utilize more excess heat and to reduce the peak load capacity. The shift in boundary condition between the DH company and the building owner is an innovation in integration of activities. A challenge is to establish an efficient control system for optimizing operations in the system, especially in relation to the borehole storage. For Tornet the

benefit is a guarantee to get the lowest price on heat and therefore a more cost-efficient energy solution. This flexibility and shifting boundary conditions of the DH operator and the building owner (i.e., their integration of activities) are news in Sweden.

A legislative issue identified by Tornet in Helsingborg when performing the business model innovation is the requirement on the amount of purchased energy defined by the Swedish building code: Boverkets byggregler (2011:6). In REWARDHeat PV-T panels have been installed at the site with the sole purpose of reducing the purchased energy to meet the requirements. The legislation states that energy from wind, solar, ground, air and water within the building or its surrounding ground is not to be included when calculating the buildings energy usage. Installing PV-T panels adds risk to the site, especially with the solar thermal energy produced that requires large amounts of water to circulate to the roof of the building (risk of leakage). Producing solar thermal energy at a site with large amounts of excess heat available during summer is considered inefficient from a systems perspective and it is the results of suboptimization to meet the legislative requirements.

In Sweden, there is no market for heat flexibility and there are no incentives to capitalize the values that flexibility can generate. It would, for example, be relevant with incentives to refrain from using electricity when electricity prices are high: allowing the capitalization of flexibility in DH. The regional electricity network owner E.ON has an electricity flexibility market promoter. To handle the problem of power peaks in the electricity system, electricity consumers are reimbursed for refraining from using electricity during established periods.

The two Swedish sites are examples of flexible heat solutions where DH is included. In Sweden, the use of HPs (both small and large) is standard hence this is not the main issue. Through modelling later in the project, the following topics are relevant to address 1) how efficient it is to overcharge the boreholes and its impact on COP of the HPs. 2) how can the power demand be minimized by combining systems for heating, cooling and electricity. 3) A sensitivity analysis of the impact of changing electricity prices on the system.

During a pitch session performed during a REWARDHeat conference in Helsingborg in June 2022 a "modular model" was proposed for increased replicability of the solution developed by Tornet in Helsingborg. The proposed business set-up is described in Annex 8.4.

4.6.3 Business model canvas

- Value proposition

The owner of the buildings (Tornet) allows the DH provider (Öresundskraft) to use the borehole thermal storage to store energy when it is beneficial for them. Mainly during summer when there is much excess heat available. For Öresundskraft the boreholes provide maximum flexibility. Before Öresundskraft were able to charge the boreholes when there was excess heat, Tornet only used heat from the conventional DH network during peak hours. With the new solutions this is avoided. For Tornet the value is lowest price guaranteed for the purchased heat.

- Customer segment, relationship, and channels

It is the DH company, Öresundskraft, that is utilizing the flexibility solutions provided by the borehole storage owned by Tornet. The relationship is built around a tailor-made solution where

a dependency is established between the building owner and the energy provider. The processes of the two stakeholders are shifted closer to one another making it impossible for either of the stakeholders to perform its activity without the collaboration of the other. The channel used for communication is personal contact and ongoing dialogue.

- Key resources, activities, and partners

The value experienced by the DH company is due to the borehole storage and the boreholes are therefore the most important key resource. The storage and its ability to serve as a flexibility reserve is the foundation of the business case. Important activities are the charging/discharging of the boreholes and the continuous dialogue between the stakeholders. The key partner needed to offer the value to the DH company is the DH company itself. The PV-T panels and the energy produced by them is a key resource to meet legislative requirements.

- Cost structure and revenue streams

In the case of Tornet, the boreholes are already in place. They are a sunk cost, to exploit their flexibility creation is an added value to the original, foreseen use of the boreholes. The revenue stream is not yet decided upon. It can be a fixed fee per month to the DH company to use the boreholes or a flexible fee based on the benefit harvested by the DH company (linked to, for example, seasonality).

- Business model canvas

Table 18: Helsingborg - Business model canvas.

<table>
<tr><td rowspan="2">Key Partners

DH provider (Öresundskraft)</td><td>Key activities

Charge/discharge of boreholes

Dialogue with DH company</td><td rowspan="2">Value Proposition

Value of green (more excess heat can be utilized due to energy storage)

A customer that does not only demand heat at peak load</td><td>Customer Relationship

Closer</td><td rowspan="2">Customer segment

DH provider (Öresundskraft)</td></tr>
<tr><td>Key Resources

Boreholes

PV-T (to meet legal requirements)

Staff with new skill set</td><td>Channels

Direct, personal contact</td></tr>
<tr><td colspan="3">Cost structure

Guaranteed lowest price for purchased heat.</td><td colspan="2">Revenue streams

No revenue streams.</td></tr>
</table>

4.6.4 The green value

The intervention in REWARDHeat in combination with having a low temperature network enables higher heat storage capacity to become a green value for Öresundskraft. More heat can be extracted from solar collectors installed during REWARDHeat. As the network is low temperature the distribution losses are lower.

To Tornet the green value is important as they can offer it as a service to their customer Öresundskraft with this set-up. To Tornet the green value is visible as is enables the lowest price on purchased heat.

The heat storage capacity in the boreholes provide a green value to the customer Öresundskraft. The green value appears in the possibility to utilize more industrial waste heat and better adapt production planning with the storage.

The boreholes enable a greener heat supply in the fuel mix for Öresundskraft and therefore provide a greener heat than the alternative without the storage. The solar collectors further contribute to green heat at the demo.

Both Tornet and Öresundskraft reduces their costs due to the flexibility service offered in the business model. The green value arising from the flexibility service is however not exploited in the business model as Tornet does not charge Öresundskraft for utilizing the boreholes storages.

4.6.5 Services offered to customers

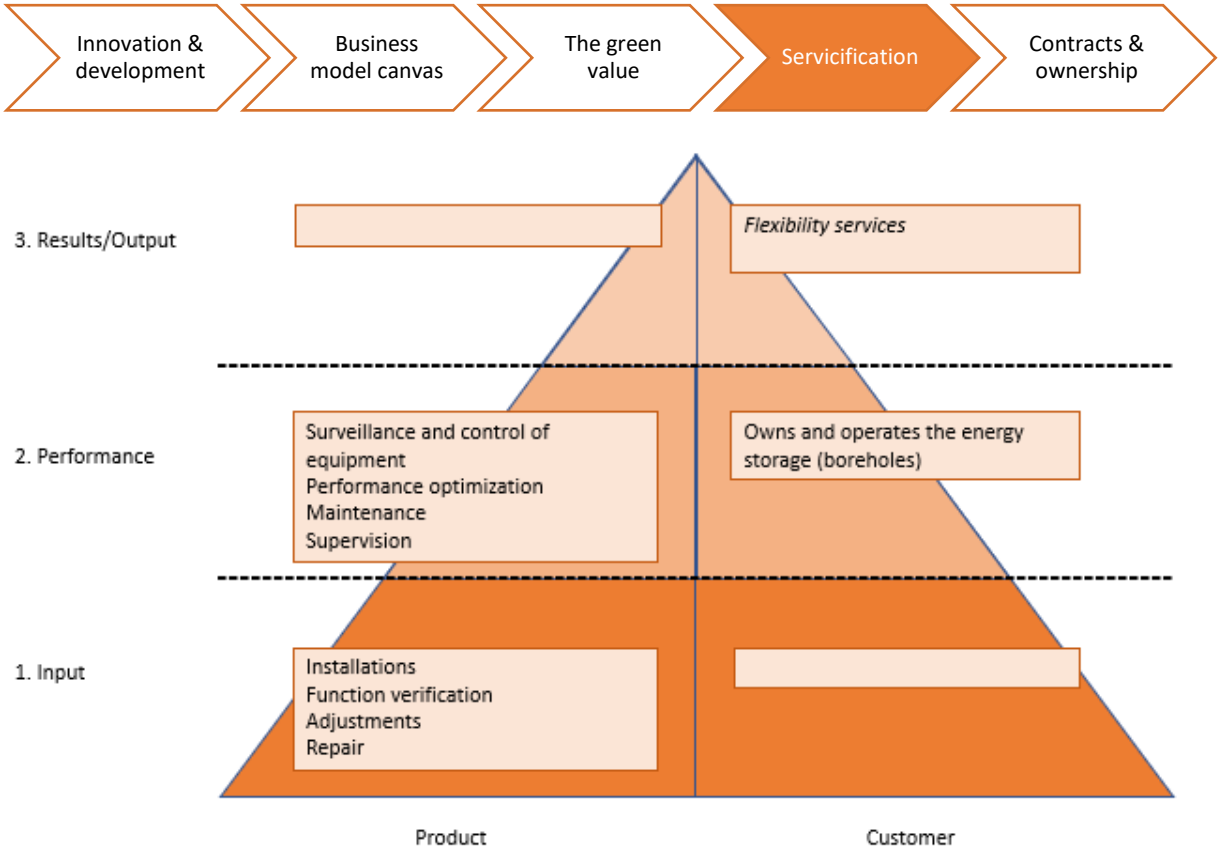


Figure 11: Helsingborg - The servicification triangle.

Figure 11 visualize the servicification triangle for the demo site. Italics represents what is new in services offered to customers in REWARDHeat.

Tornet owns the borehole thermal energy storage and offers a flexibility service to the DH provider, Öresundskraft. Öresundskraft can utilized the boreholes by charging them when it is beneficial for them. This improves production planning and better utilize the large amounts of industrial excess heat available to the DH network. The service offered requires a high level of integration between the partners processes. A collaboration with integrated processes requires shared incentives and the establishment of common goals for the optimization of the utilization of the boreholes.

Table 19: Helsingborg - Advantages and disadvantages with new services

Advantages with proposed services at demo site	Disadvantages
An advantage for Tornet is a higher utilization rate of the boreholes along with decreased cost of purchased heat. To the DH provider it increases the flexibility in the network and enables a higher utilization of waste heat.	Resource heavy to get contracts in place as well as perform optimisation. Requires specific competence within the companies. Integrated processes increase the dependencies and complexity.

Shared incentives and common goals require a close and long-term relationship	A risk with integrated processes is that one partner changes their mind, for example because of a change in ownership.

4.6.6 Ownership & Contractual considerations

Öresundskraft and Tornet need to have a well-functioning and clear contract for their collaboration on the use of the boreholes as a flexibility resource in the DH mix. The factors affecting the contract are considered below.

1. Low maturity of the technical solution

The novelty of the constellation is not the borehole energy storage, but instead it is the collaboration between energy company and building owner on managing the flexibility resource provided by the borehole and integrating the resource into the DH production planning. Close dialogue is imperative for the collaboration to function well.

2. No legal framework

The lack of framework for low temperature DH and waste energy recovery affects both Swedish demo sites but neither obstructs nor promotes such solutions. However, the required contract between Öresundskraft and Tornet must be formed without the guidance the legal framework could have provided.

3. The value of waste heat is subjective

The value of flexibility that the borehole provides to the DH network is subjective and needs to be agreed upon by both parts at the site. The value of flexibility in this case is manifested in the agreement as Tornet receives a guaranteed lowest price of heat in return for their cooperation. Further consideration could involve whether Öresundskraft should pay a fee to Tornet for utilizing the borehole storages.

4. The payback period

The demo site has formed around an already-existing borehole and therefore the upfront investments were fewer and smaller than in the other cases where entirely new systems need to be established. To minimize the payback period of future replications, it is recommended that the borehole should be included already in the plans of new DH connections.

5. Asymmetric information

The building owner owns and operates the borehole and thus has easier access to the information concerning its dynamics. It is important for Öresundskraft to strive for an accurate integration of the borehole into their control system and a good understanding of its flexibility. Communicating how the borehole is used back to the building owner could in turn create transparency of how the flexibility is contributing to the DH network and how the building owner is rewarded.

6. Shared incentives

The site entails a natural incentive in exploiting the flexibility of the borehole which is shared between the energy company and the building owner. Like the above discussed value of the flexibility, this aspect needs to be reflected in the contract between the parts. By offering the best possible price to the building owner, Öresundskraft could make use of this shared incentive to secure a strong relationship with the building owner and the willingness to collaborate.

7. Termination of heat recovery

Though there is no waste heat that could be terminated, there is a risk of the termination of the collaboration between the building owner and the energy company. The consequence of this scenario is assessed as lo impact on both parties. If the borehole is no longer available to Öresundskraft, the resilience of the DH mix is capable of compensating for this loss of resource.

- Ownership

The current ownership layout, where the building owner owns the borehole and its auxiliary equipment, leads to Öresundskraft having less control over the flexibility and are less able to optimize their system. On the other hand, if the collaboration would end as result of the building owner disconnecting from the DH supply, the termination is simplified by the current placement of the system boundary. Though the ideal structure for Öresundskraft would be to have full ownership of and agency in the installation, the borehole could still be used in an optimal way if the building owner and Öresundskraft are collaborating well. A long-term, stable relationship between the parties is beneficial. Moreover, Öresundskraft's control of the borehole has still increased compared to the previous setup where Tornet only used DH at hours of peak demand.

In future projects based on the same technology, Öresundskraft is recommended to aim for full ownership where they can use, access, and optimize the system. This requires dialogue already in the earliest planning phase of any new customer connections.

- Energy performance contract

The energy performance contracting (EPC) market in Sweden is relatively small and static but mature (Moles-Grueso, Bertoldi et al. 2021).

For the business model in Helsingborg the focus is on storage and the connection to Öresundskraft who are the main customers for the flexibility services offered by the borehole thermal energy storage. An EPC is therefore not applicable in this case.

4.7 Sweden- Mölndal

The demo site in Mölndal is summarized in Table 20. Following a short introduction to the demo site are the five topics in focus in the REWARDHeat project: Innovation & development, Business model canvas, The green value, Servicification and Contracts & ownership.

Table 20: Mölndal - Summary of the demo site

Mölndal	Innovation & development	Business model canvas
New low temperature network connected to the conventional DH network in Mölndal. The network is owned by Husvärden, a private company.	Technical: Increase the flexibility in the network with more components (more storage – charged by DH return pipe and expanding the network). Customer: No innovation towards the customer.	Increased flexibility, mainly through increased storage, reduces the operational costs of the network.
The green value	**Servicification**	**Contracts & ownership**
The green value creates a flexibility that is valuable to Husvärden. Having a green, energy efficient network is valuable to customer.	The demo is offering a high level of service to customer where some rents a space with ”all-inclusive”. No new services are offered to customer.	Husvärden has ownership of the entire district and signs contracts with the tenants where everything is included and with the conventional DH network for supply of heat.

4.7.1 Business model innovation and development

Husvärden owns a district in the city of Mölndal. The district is the former site of a large textile factory. Today, the area has a mixed building stock composed of offices, residential buildings, and a hotel. There is a mixture of very old (the former industry buildings) and new buildings. The owner of the district has built its own DH network which integrates several technologies: high temperature heat from the local DH company (to the old buildings), heat pumps, waste heat from

cooling equipment (small amounts, freely available to use by Husvärden) and borehole storages. The borehole storages are charged with heat from the return pipe enabling a high cooling (delta T) from the network owned by Husvärden. The system is very flexible and designed in such a way that its owner can capitalize on the flexibility saving energy and cutting costs.

As in Helsingborg, flexibility is also the innovation in focus at Husvärden demo site as the owner of a buildings is also the owner of the DH network which integrates multiple technologies to enable high level of flexibility to save energy and reduce cost. In REWARDHeat the network is expanded with more boreholes and buildings.

4.7.2 Business model canvas

- Value proposition

The owner of the DH network (Husvärden) provides different values to different customer categories. To the professional customers renting an office space in the buildings owned by Husvärden, a comfort service agreement is included in the renting cost. The customer pays a fixed fee to rent a heated space and the supply of hot water. The value to customers is a complete carefreeness. The hotel is supplied with heating, cooling and hot water and is charged per energy unit. The private residential customers are supplied with heating and hot water and charged per energy unit. The flexibility in producing and storing energy within the local grid, as well as having a high delta T to the surrounding DH network, creates lower operating cost for Husvärden which is seen by the customer as a lower cost.

- Customer segment, relationship, and channels

The customers are those using the buildings owned by Husvärden. They can be private customers or professional customers (offices, hotel). The relationship is standardized and not tailormade to customer need. The main communication channel is the invoice for rent or heat and hot water use.

- Key resources, activities, and partners

Key resources are the buildings themselves and the components making up the local energy grid (like heat pumps). Important activities are building maintenance and to harvest the flexibility potential of the local energy grid. Key partner to provide the heated building solution is the local DH company, they are important as the link to the city-wide DH network reduce the risk of the micro grid not being able to be heated with the heat generated from the buildings of Husvärden.

- Cost structure and revenue streams

For Husvärden, the heat and hot water cost is part of the monthly rate paid by the residents of building space. It can be a variable component to incentivize desired behavior at different seasons and outdoor temperatures. The cost for upgrading/erecting the buildings is substantial and will remain for a long period of time (the major cost component).

The flexibility in producing and storing energy within the local grid, as well as having a high delta T to the surrounding DH network, creates lower operating cost for Husvärden.

- Business model canvas

Table 21: Mölndal - Business model canvas.

<table>
<tr><td rowspan="2">Key Partners

Equipment providers

DH provider</td><td>Key activities

Monitor and operate network by optimizing flexibility

Building maintenance</td><td rowspan="2">Value Proposition

Heating, cooling, hot water
Comfortable indoor climate
Security of supply

Offices: Building space with carefreeness

Value of green (flexible heat production - increases with more storage)</td><td>Customer Relationship

Arm’s length</td><td rowspan="2">Customer segment

Private, Professional

Commercial (Hotel)</td></tr>
<tr><td>Key Resources

Buildings and local energy grid

Boreholes

Staff (operate system)</td><td>Channels

Invoice</td></tr>
<tr><td colspan="3">Cost structure

Driven by fixed costs, maintenance, and operation of energy system

Operational cost of the system decreases with more storage available</td><td colspan="2">Revenue streams

Offices: Monthly fee

Others: Fixed tariff in combination with variable tariff depending on consumption.</td></tr>
</table>

4.7.3 The green value

In REWARDHeat the network is expanded with more boreholes and connect more buildings. Because the network is low temperature it has lower distribution losses, enables a higher heat storage capacity and less electricity to be used in heat pumps. As the boreholes are charged using the return pipe of the conventional network more electricity can be generated in the CHP plants and more heat can be recovered from the flue gas condensation.

Customers of the DH network can see the green value of the network as it relates to a lower bill as the operational costs of the networks are less because of the flexibility in operation. To the hotel and other commercial actors renting building space within the network the green heat can be used in marketing.

The alternative DH production in the area is Mölndal Energi. The network owned by Husvärden offers a greener heat supply to its customers in comparison to the fuel mix in Mölndal as the supply is flexible utilizing heat from return pipe and local production optimized via the storage. The flexibility in the network creates a green value. Indirectly the green value creates an attractiveness to establish in the area, but the green value is not exploited in business model. Husvärden is selling a service to offices visible as a revenue stream, but they are not selling the green value created.

4.7.4 Services offered to customers

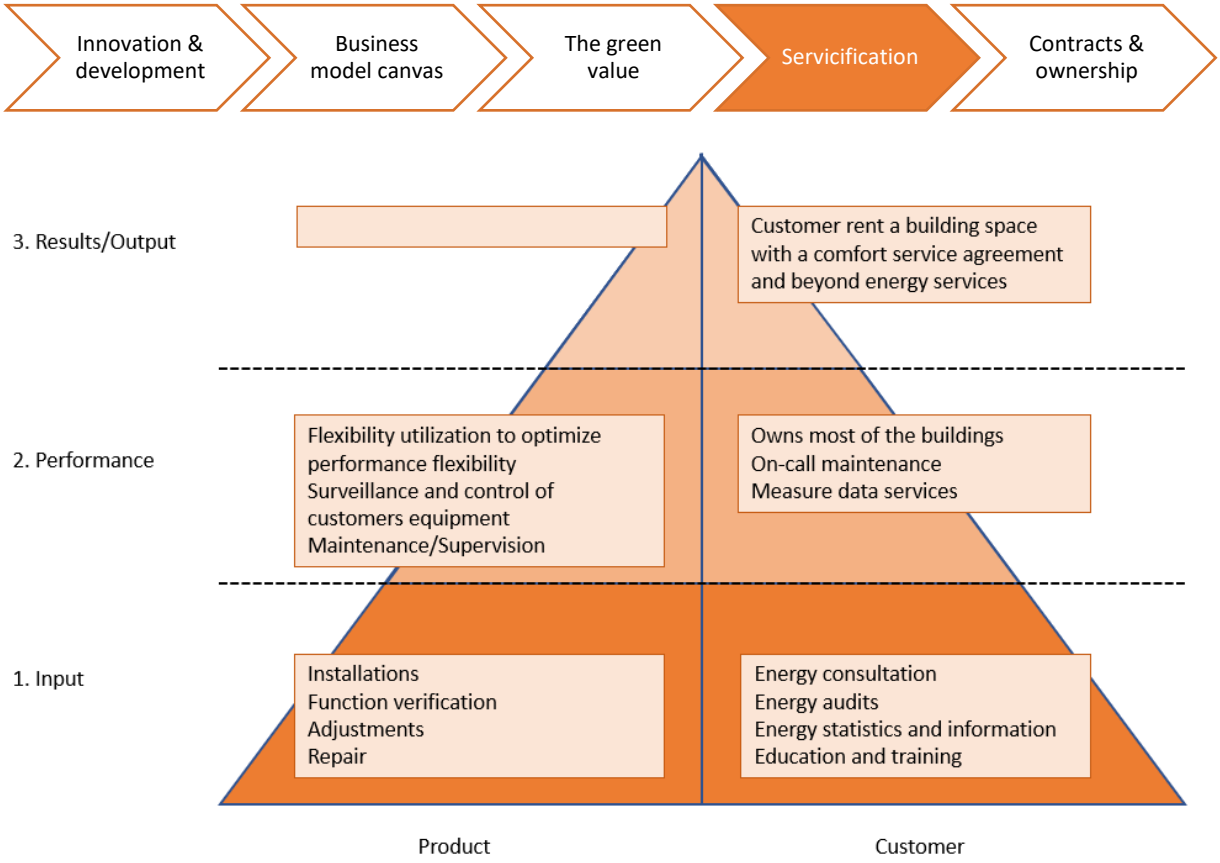


Figure 12: Mölndal – The servicification triangle

Husvärden is an example of a local and small-scale DH network. By owning and operating both the network and most of the buildings Husvärden can optimize from a system perspective.

With regards to services offered to the customers, Husvärden is at the top of the triangle offering a comfort service agreement where the customer is totally carefree and only pays for renting a space at a set temperature. The motivation for improving the energy efficiency in buildings which in other cases could come from an EPC contract here arises from the fact that Husvärden owns the buildings and energy efficient buildings are required to keep the costs for heating, and hence the cost for renting, down to be competitive for space renting on the market.

The boundary condition between Husvärden and its customers is the furthest to the customer of all demo sites in REWARDHeat. Husvärden owns and operates both the DH network and the buildings. This requires a high level of monitoring and optimization in the network to be apply to price the service and keep costs and risks down. Data acquired needs to supply a high level of knowledge about the customer and the customers processes. However, the business set-up does not require the same involvement in the customers processes as can be seen in other business models.

Beyond REWARDHeat Husvärden could consider expanding the service offer to include more of the connected customers.

Table 22: Mölndal - Advantages and disadvantages with services

Advantages with proposed services at demo site	Disadvantages
For Husvärden there is an optimization advantage in having full control and ownership of the DH network as well as the buildings.	Husvärden has a wide portfolio being both an energy company and a real estate company. It requires resource in competent staff to manage the diverse assets and the complexity
From the customer perspective the business model is totally carefree, and no risk is assumed by the customer.	All the risk is on Husvärden to properly manage the buildings and to deliver the agreed upon temperature to customers. This has been the set-up in the business model from the start.

4.7.5 Ownership & Contractual considerations

In Mölndal demo site, contracts are required between the company Husvärden and its tenants, and between Husvärden and the conventional DH company for supply of heat. The factors affecting these contracts are considered below.

1. Low maturity of the technical solution

In Sweden, the combination of a low temperature network connected to a conventional DH network is uncommon. However, the risk associated with the low maturity is in part mitigated by the ownership structure at the site, with Husvärden as the only actor, thus controlling the entire system and carrying all risk and all benefits that result from the installation. Moreover, the organization can build knowledge of the concept in-house and thus integrate learnings from the initial operations. The relationship with the customers is also standardized, which makes the contract process less complex. The novelty of the low temperature local grid is further stabilized thanks to its connection to the conventional DH grid.

2. No legal framework for low temperature waste heat recovery

This factor applies to both Swedish demo sites, though the impact at this site is small. Husvärden as the owner of the entire low temperature network, including the buildings, only needs to form a contract with their customers for the supply of heat and thus the contractual context is simple especially thanks to the standardized approach provided. The contract with the conventional DH company for the supply of heat from the return pipe less standardized and requires negotiation and collaboration.

3. The value of waste heat is subjective

This factor is not relevant for Husvärden, simply because the heat supply was secured before the project was realized. The waste heat from buildings with different activities and businesses does not require additional contracts as Husvärden owns and controls the buildings and the heating equipment.

Although residential customers have a different model in their agreement, they still benefit from the waste heat in the system as their heat bills are lowered.

4. The payback period

In REWARDHeat the network is expanded with more boreholes and buildings. The expected payback is less than 10 years and is foreseen to be shorter in future replications.

5. Asymmetric information

There should not be a case of asymmetric information at this site provided the ownership structure. Still, dialogue with the customers is important to ensure that all activity is correctly reflected in the control system. Both Husvärden and the conventional DH company has energy as core business and their collaboration should not be impacted by asymmetric information.

6. Shared incentives

By taking the ownership of the entire system, there is less incentives for Husvärden's customers to contribute to any consumption targets the company might have and they are also less able to, compared to cases where the customers own their heating system.

It is beneficial for the DH company, to have Husvärden connected to the return pipe and thus reducing the return temperature in the network. The resulting increased efficiency should be shared between the parties.

7. Termination of heat recovery

The risk of termination of heat recovery is only present in the case where a tenant whose operations are a source of waste heat was to move out or end the agreement. In this case, Husvärden is left with an unutilized resource, which is the heat recovery equipment, and with no revenues. On the other hand, since they already own all the buildings, this is a risk that can be managed and planned for.

- Ownership

Husvärden's holistic ownership is beneficial for the organizational efficiency at the demo site. By owning all components and installations (and the buildings themselves) Husvärden is able to fully optimize its system and consider the consumption (and production) patterns of their customers. Conversely, this also means that Husvärden carries all the risk of the investments. Moreover, the customers are paying for a certain indoor temperature and therefore have less incentives to behave in an energy efficient way. A future recommendation could therefore be to maintain the ownership layout and offer the maximum service level to their customers, but also to investigate whether the price could be differentiated based on hourly or seasonal variation in order to promote customers to save energy when it is beneficial on a system level.

- Energy performance contract

Husvärden owns both the network and the buildings and therefore an EPC to customers is not applicable.

4.8 Netherlands- Heerlen

The demo site in Heerlen is summarized in Table 23. Following a short introduction to the demo site are the five topics in focus in the REWARDHeat project: Innovation & development, Business model canvas, The green value, Servicification and Contracts & ownership.

Table 23: Heerlen - Summary of the demo site

Heerlen	Innovation & development	Business model canvas
Existing low temperature heating and cooling network in the Netherlands owned by Mijnwater (owned by local government through an energy fund). The main energy source is abandoned mines.	Technical: The demo was foreseen to realize the construction of a large energy storage. Customer: No innovation was foreseen towards the customer.	The energy storage would mainly have impacted the activities and resources for the DH company. The increased flexibility would have created a more optimized and greener heat supply.
The green value	**Servicification**	**Contracts & ownership**
The green value that would have been created by the flexibility of the storage would have resulted in lower operational cost for the DH company. A greener heat supply is valuable to the customers.	The level of service being offered to customers is decreasing. The risk was considered too high by the DH company. Instead, collaboration with a local ESCO will be considered.	Mijnwater owns the entire network and the heat source therefore contracts are only required between Mijnwater and its customers.

4.8.1 Netherlands: Input from PESTLE analysis and customers' perspective

Conclusions from the PESTLE analysis (Fransson, Sandvall et al. 2021) that is relevant for business model development:

- People and partnership are important for low temperature DH
- Value of improved air quality and reduced dependency on import by utilizing local resources is important
- A heat supply that provides good energy performance to connected buildings is an important value proposition

Conclusions from the customers' perspective (Fransson and Lygnerud 2021) that is relevant for business model development:

- Most customers are not willing to pay more for greener heat
- Customers want an incentive-based pricing scheme
- Customers are unwilling to receive increased service with their heat supply
- An opportunity could be to increase the level of knowledge about service offers and start building trust with maintenance of H&C equipment as customers are requesting it

4.8.2 Business model innovation and development

The network in Heerlen owned by Mijnwater is a large low temperature network supplying hot and cold water in two parallel systems mainly to residential customers but also tertiary such as office buildings, supermarkets, industry, and theater. The demo site is a cluster of low temperature heat recovery solutions based on four old mines that are now filled with water. The technical innovation in REWARDHeat was planned to increase the efficiency of the system by shaving peak load by utilizing a large heat storage as a buffer. The associated investment costs were foreseen to be high, which previously has resulted in projects not being realized in the system. This could be the result of the investment cases sometimes including refurbishments within the building, for example radiator systems and floor heating systems, as part of the investment cost. There are different approaches to determine where the investment starts and ends (should heat be delivered in the basement of the building or at the door of each apartment). The site was foreseen to use heat from solar energy located at a customer site (the University) and high temperature excess heat from an industry.

It was decided during spring 2022 by the management of Mijnwater that the foreseen energy storage would not be built and therefore the demo site could not be realized. The change of plans is due to a new strategic direction at Mijnwater. Still, there are many findings and learning to be extracted from the Heerlen demo site, both from the site as it is and from the planning process behind the decision for the buffer. These findings and its related changes in the business model are still of relevance to the development of low temperature networks in other sites.

4.8.3 Business model canvas

- Value proposition

Heating, cooling, and hot water is provided as a service to a few large customers and as a commodity to most. It has been decided that services beyond the substation will no longer be offered to customers as it is considered too risky. Mijnwater still has the ambition to assume ownership, maintenance, and operation of the substation at the customer site creating a value of

carefreeness for the customer and the possibility to further optimize the system for Mijnwater. The green value of the energy is important, and DH networks with sustainable energy have a natural role in the replacement of the current usage of natural gas. Mijnwater tries to utilize low temperature heat sources as much as possible.

- Customer segment, relationship, and channels

The customers in the demonstration are building associations, professional customers (e.g., industry), private building owners (often organized into energy cooperatives). The buildings generally have a high level of energy efficiency as they are new construction or newly refurbished.

According to the Dutch heat law, private customers of a DH network must get a price comparable to the natural gas price. Large customers (more than 100 kW) are on a free market and the offers can be customized. Mijnwater offer larger customers tailor-made arrangements from full-service offers where an indoor climate is guaranteed to less extensive offers, for example only including maintenance services. The relationship with private customers is standardized and the main communication channel is the invoice. For larger customers there is a tailor-made dialogue and personal meetings. With the decision to decrease services offered the relationship is moving to becoming more standardized to all customers.

Prosumers exist in the system and are seen as a special customer category rather than as a partner.

- Key resources, activities, and partners

The existing heating and cooling clusters, including pipes, pumps, measuring equipment and buffer tanks are important resources and are owned by Mijnwater. Booster heat pumps mounted in each apartment is a key resource. The booster heat pumps are the property of the individual apartment owners. Employees that manage the system and the customer dialogue are an important resource. Key activities are the delivery of hot and cold water as well as managing the individual service agreement (reclining amount). Identification of more low-temperature waste sources are a key activity.

Key partners are the local government in Heerlen, permitting bodies and EU project partners.

- Cost structure and revenue streams

The costs to cover are linked to the networks and to the operation. Mijnwater purchased all the electricity used to operate the network and this cost is included in the price of H&C. The price structure is a combination of variable and fixed costs, but the company has previously tried to get as much fixed costs per m^2 as possible. Revenue streams are standardized for small customers, who pay the same price, and customized for the large customers depending on different service ranges. The fixed price per m^2 is calculated based on some parameters relating to the building, for example the energy efficiency of the building. The tariff for DH is regulated by the Dutch Authority through a maximum level calculated based on the natural gas price. Cooling is an additional revenue stream to hot water. Funding from EU projects as well as the city of Heerlen are considered important revenue streams.

- Business model canvas

Table 24: Heerlen - Business model canvas.

<table>
<tr>
<td rowspan="2">Key Partners

Local government in Heerlen

Permitting bodies

EU project partners</td>
<td>Key activities

Monitor and operate network

Service equipment at customer site

Identify heat sources

Optimize using the energy storage</td>
<td rowspan="2">Value Proposition

Heating, cooling Comfortable indoor climate Security of supply

Carefreeness (rent substation)

Value of green (geothermal heat source - increases with more flexibility, RES, and waste heat)</td>
<td>Customer Relationship

Armlength (private customers) and dialogue (larger customers due to different services offered)</td>
<td rowspan="2">Customer segment

Building associations

Professional customers (e.g., industry)

Energy cooperatives (private building owners)

Waste heat suppliers/Pro sumers (industry)</td>
</tr>
<tr>
<td>Key Resources

Network, Monitoring eq., Energy storage/Buffer

Staff (to make large customer dialogue)</td>
<td>Channels

Invoice, webpage, info meetings

Customer dialogue (larger)</td>
</tr>
<tr>
<td colspan="3">Cost structure

Driven by fixed costs

Reduced operational cost due to energy storage</td>
<td colspan="2">Revenue streams

Fixed tariff in combination with variable tariff depending on consumption.

Customized solutions for large customers (level of services offered is declining)

Funding (EU, city of Heerlen)</td>
</tr>
</table>

4.8.4 The green value

Because the network is low temperature distribution losses are lower and more waste heat can be extracted from the mine water. The construction of a new buffer in the neutral temperature network and the integration of waste heat/RE sources would have enabled the following green values: less electricity used in heat pumps, more waste heat can be extracted, and more heat obtained from solar collectors.

The concept of DH in Heerlen is built on being a low temperature network with a green value proposition and the storage enforces it. To Mijnwater the green value is a valuable aspect in marketing.

To the customers (building associations) the green value enables the building to receive energy certificate. The legislation for an energy efficient building can be met by investing either in improving the building itself or having a greener energy supply. Most customers are however not willing to pay more for a greener heat supply.

The heating supply in the Netherlands is dominated by natural gas and with the Netherlands turning away from natural gas, a green and efficient DH network provides additional value to customers compared to conventional heating technology.

The business model in Heerlen was developed based on being a low temperature supplied with heat from abandoned mines and therefore the value is embedded in the business.

4.8.5 Services offered to customers

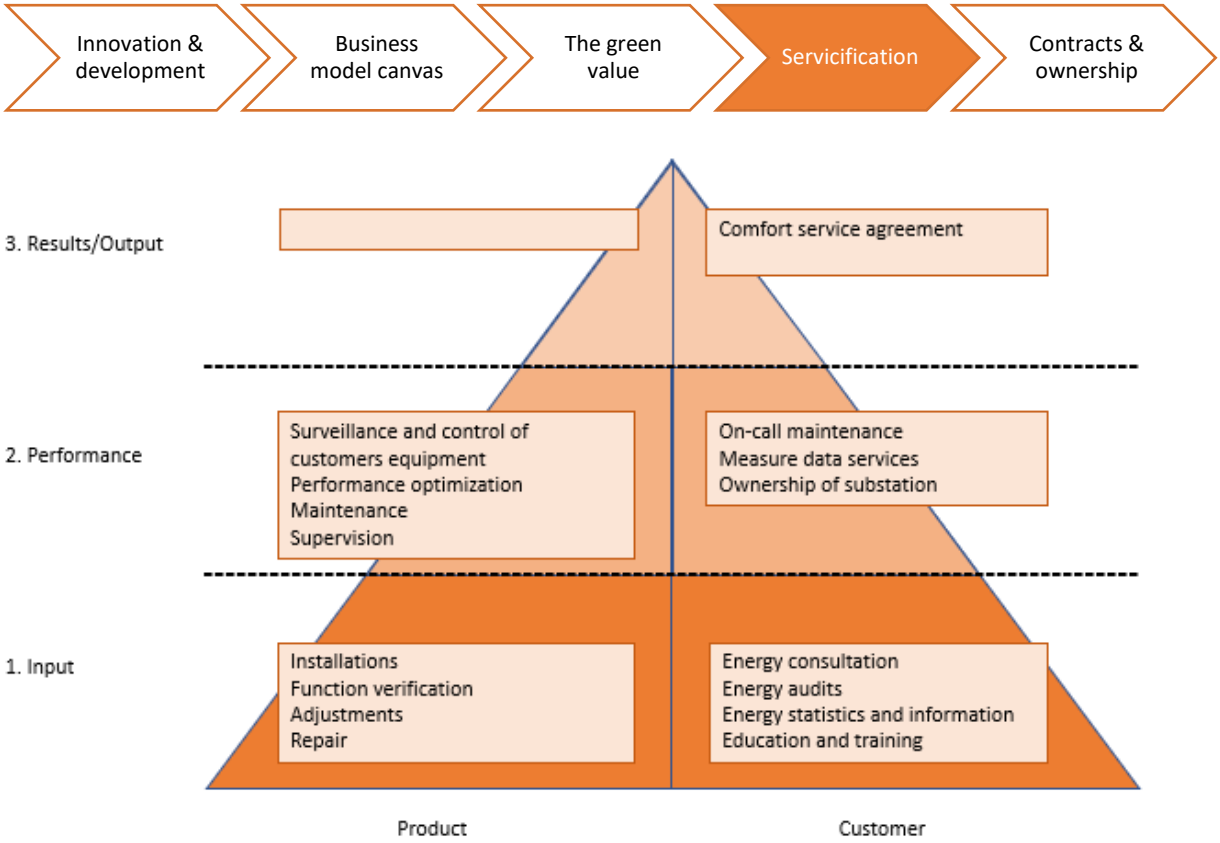


Figure 13: Heerlen – The servicification triangle.

Mijnwater has offered service agreement to the larger customers connected to the network but as a strategic decision this will no longer be offered. In the past both simpler service, such as maintenance agreements, as well as comfort service agreements have been offered. The associated risk with supplying customers with a high level of service where the DH company integrates with the customers processes was assessed to be too high and that Mijnwater did not have the competence or willingness to assume the role of an ESCO. Especially the risk related to owning equipment for supplying drinking water to customers was considered extensive due to the risk of legionella. Mijnwater would rather develop a collaboration with local ESCOs than offer these services in-house. Mijnwater still has the ambition to own, operate and manage the substations located at the customer site because of the possibilities in optimizing the performance of the network. The business model boundary condition between the DH company and the customer will be drawn by the substation and not go further into the customers building.

Table 25: Heerlen - Advantages and disadvantages of the services

Advantages with proposed services at demo site	Disadvantages
Comfort service agreement enables a carefree heat deliverable where the cost is fixed and necessities a closer customer relationship creating loyalty.	More complex business with increased service and higher risk to deliver a temperature. Mijnwater has assessed the risk as too high and will reduce its scope of services being offered to customers.

4.8.6 Ownership & Contractual considerations

Currently, the contracts required are between Mijnwater and its customers and between Mijnwater and the waste heat suppliers. The factors affecting these contracts are considered below.

1. Low maturity of the technical solution

The solution where heat is stored in and recovered from the disused mines and distributed in a low temperature network is a novel technology which has not been tested in many places (the United Kingdom and Spain being a few instances where this has been demonstrated). Therefore, the demo site is affected by the low maturity, which much be considered in the drafting of the contracts between Mijnwater and its customers and with local maintenance companies if they and Mijnwater are to form a collaboration on the maintenance on the customers' secondary systems.

2. No legal framework for low temperature district heating

Thus far there is no regulation on residual heat in the Netherlands. However, the legislation will be reviewed in the near future, although it is not certain that any suggested amendments will target residual heat.

3. The value of waste heat is subjective

Mijnwater owns their main energy resource (the mines) and has full access without having to negotiate the value of the heat source. The waste heat resource integrated in the system (e.g., data centre) requires negotiations on price.

4. The payback period

The long payback period affects this site and is one of the reasons the foreseen energy storage could not be realized. Like the examples of Gardanne and Balilla, Mijnwater has an ownership structure where the municipality is included and this theoretically should allow for a longer payback period, provided its longer patience capital.

5. Asymmetric information

Asymmetric information impacts the demo site through the waste heat providers (e.g., data centre) as they do not have energy as core business. The remaining resources in the network are owned by the same organization. This enables Mijnwater to have a high level of control and knowledge of the system.

6. Shared incentives

With the waste heat providers there are shared incentives. The data centre, for examples, requires cooling and by integrating with the DH network this is achieved while at the same time reducing the need for primary energy to be utilized in the network.

As heating and cooling is provided in the same network, customers provided with cooling are simultaneously supplying heat to the network (prosumers).

The shared incentives should be reflected in the contractual arrangements.

7. Termination of heat recovery

The geothermal energy recovered from the old mines is considered a stable heat source and the risk of the termination of the heat recovery is therefore low. The municipal ownership of Mijnwater also forms a stable organizational structure that should imply a low risk of the termination of the heat network operations.

There is always a risk of waste heat sources terminated and the contract should regulate how far in advance information on termination must be communicated.

- Ownership

The ownership layout at the demo site has low complexity: Mijnwater owns the main heat supply and distributes the heat, and the system boundary is drawn at the substations at the customer sites. Contracts are required with the waste heat supplier.

One idea investigated within the project was a PV installation at a customer sites and integration of high-temperature waste heat from a nearby industry. This would have complicated the ownership structure and would require contracts between the waste heat supplier and Mijnwater and between Mijnwater and the customer where the PV would be built. If this would be investigated further, Mijnwater is recommended to strive for owning or co-owning the heat recovery units to allow for easier access and optimization.

Mijnwater is recommended to aim for ownership of the substations and heat pumps at each customer site to improve control and optimization of the network.

- Energy performance contract

The energy performance contracting (EPC) market is mature but static in the Netherlands (Moles-Grueso, Bertoldi et al. 2021).

The main customer segment in Heerlen is privately owned building associations. The building stock has a high level of energy efficiency which could make it more difficult to make an EPC profitable. As Mijnwater offers comfort service agreement to some customers in this segment they have monitoring in place and a high level of knowledge on the baseline of the buildings. The customers do not have energy as their core business and could benefit from receiving external assistance from an ESCO in performing energy efficiency.

Mijnwater offer extensive service offers to customers today, but it has been decided by the company to reduce its responsibilities on the secondary side (customer side). It will no longer be offered to new customers.

Progressing in the direction of an EPC could be an option for Mijnwater to pursue in Heerlen. However, it has been decided by the company to not progress in the direction of becoming an ESCO.

4.9 Poland – Szczecin

The demo site in Szczecin is summarized in Table 26. Following a short introduction to the demo site are the five topics in focus in the REWARDHeat project: Innovation & development, Business model canvas, The green value, Servicification and Contracts & ownership.

Table 26: Szczecin - Summary of the demo site.

Szczecin	Innovation & development	Business model canvas
Greenfield low temperature DHC network in Poland owned by SEC (co-owned by E.ON and the municipality). The heat is supplied by the conventional DH network and later also by waste heat sources and the buildings themselves.	Technical: New low temperature DH network with the possibility to balance heat within the network (when more customers are connected). Customer: Ownership and maintenance of substation at customer's site.	As waste heat suppliers are connected and buildings become prosumers close, long-term, personal, and frequent contact is required. Staff to manage the balancing of the network and the customer relationship is new. New value as customers can purchase also cooling from SEC (first time).
The green value	**Servicification**	**Contracts & ownership**
The green value is important to the DH company and the city (part-owner) as well as for customers connecting to the grid. Initially the price of heat will be higher in the network but foreseen to decrease with more green heat sources.	The DH company will have ownership of the substation at the customers' site. It is necessary to control the substation for the heat balancing to function.	Establishing a win-win contract with the waste heat supplier is necessary to establish a long-term relationship. More waste heat sources and prosumers are foreseen creating a need for multiple contracts.

4.9.1 Poland: Input from PESTLE analysis and customers' perspective

Input from the PESTLE analysis performed in D3.1 and customers perspective performed in D3.2 are not available for Poland as the demo site was included in the project after the deliverable D3.1 and D3.2 had been completed.

4.9.2 Business model innovation and development

The demo site is located in Łasztownia and it is a joint installation by SEC & E.ON. The site is developed based on E.ON's concept, Ectogrid. In the middle of the city, on a river island, a low temperature DHC network has been built during the REWARDHeat project. This greenfield site is the first low temperature DH network to receive concession in Poland. The first objective of the site is to supply heating and cooling to the Maritime Science Centre (MSC) which is the first customer to be connected. An initial estimation identified that the final H&C demand on the island will be around 3 MW of heating and 2MW of cooling. The low temperature DH grid will supply heat to the building's internal installation via heat exchanger and it further forms a heat sink for the cooling machines covering comfort cooling demand. MSC has its own hot tap water sources, but for future customers heat pumps will provide the required temperatures. The Heat Balancing Station (HBS) is the heart of the network. In its initial phase the network will receive heat from the conventional DH network but as more buildings are constructed on the island (residential and offices) and connected to the grid the network will work more independently. The conventional DH network can still be used to supply heat at peak loads during the heating season.

An inventory of the available waste heat on the island is being carried out. A chocolate factory was identified early in the project as a potential source of waste heat and almost one year of monitoring data is available (in autumn 2022). Another source that has been identified is a logistics centre that potentially could supply both waste heat and cool. Monitoring is foreseen to be initiated at this site.

4.9.3 Business model canvas

- Value proposition

The value to the customer is heating, cooling and optionally domestic hot water solution that increases security of supply and offers a greener solution. Because SEC has ownership and performs maintenance of the installation the value of carefreeness is created for the customers. The solution replaces dry coolers which improves the aesthetics which is especially important in historically protected areas and reduces the noise level. The system collects data enabling customers to analyze their heating and cooling demand.

- Customer segment, relationship, and channels

The customer is initially the Marine science center. Over time the island will be populated by other buildings and the customer segment can expand. It is foreseen to be both public buildings and privately owned buildings. The new buildings being erected on the island must connect to the grid according to city regulation. The main part is foreseen to be B2B. The relationship with the customers' needs to be close (during spring 2022 SEC has weekly contact with customers) and based on dialogue with the customer needs in focus.

- Key resources, activities, and partners

Key resources are the network itself and especially the Heat Balancing Station that constitutes the brain of the network. To manage the system personnel are needed to manage the technical aspects (the digital solution), the customer dialogue and to develop and negotiate efficient contracts with both prosumers and waste heat providers. Customers in the network are at the same time prosumers in the Ectogrid concept and become partners in the network. With only a few prosumers planned to be connected, an important activity for the site to function properly and provide as much internal balancing as possible is to attract and connect more prosumers with diversified needs for heating and cooling.

The heat from the conventional DH network is foreseen to be replaced with locally available waste heat and RES. The first waste heat source to be integrated is a chocolate factory on the island. As of September 2022, the monitoring phase is almost completed (one year of data available) and contracts are under negotiations.

- Cost structure and revenue streams

The low temperature DH business case is new to the operator. SEC will cover the CAPEX of the grid and the Heat Balancing Station. The client will pay the connection fee. The price of heat in the initial phase will be higher than the conventional network. With more green heat sources connecting over time the price is expected to decrease. As DH is a regulated market in Poland, the heat price will be based on a tariff calculated by the company and accepted by the customer.

When there is empirical data, the business case can be upgraded to efficiently reflect the low temperature network in an adjusted business case.

- Business model canvas

Table 27: Szczecin - Business model canvas.

<table>
<tr>
<td rowspan="2">Key Partners

Equipment providers

Conventional DH company

Prosumers

Waste heat suppliers</td>
<td>Key activities

Manage customer dialogue

Operate the network

Attract prosumers and waste heat suppliers</td>
<td rowspan="2">Value Proposition

Heating, cooling, DHW
Comfortable indoor climate
Security of supply

Carefreeness

Value of green (urban waste heat, RES, lower distribution losses)

Improved aesthetics and reduced noise

Data analytics</td>
<td>Customer Relationship

Close, long-term, and frequent contact</td>
<td rowspan="2">Customer segment

Prosumers

Municipality building (Maritime science center)

Upcoming:

Public and private building owners</td>
</tr>
<tr>
<td>Key Resources

Network, monitoring eq., heat balancing station

Staff with adapted skill set</td>
<td>Channels

Direct and personal contact</td>
</tr>
<tr>
<td colspan="3">Cost structure

Driven by fixed costs</td>
<td colspan="2">Revenue streams</td>
</tr>
</table>

Lower operation costs due to lower heat losses than conventional network	Fixed tariff in combination with variable tariff depending on consumption.

4.9.4 The green value

Low temperature in the network enables less electricity to be used in the heat pumps, more waste heat can be extracted and lower heat distribution losses. The connection to the conventional DH network in Szczecin creates lower return temperature resulting in more heat recovered in the flue gas condensation and more electricity can be generated in the CHP plant. The low temperature further enables easier integration of RES.

To the publicly owned Maritime Science Centre a greener heating and cooling supply is valuable to achieve emissions targets. To professional customer the value for green can be important, especially if it certifies the newly constructed buildings for energy certificates or to meet regulations.

To the DH company (SEC together with E.ON) the value of green is at the centre of the Ectogrid concept and an important part of marketing the concept.

The heating supply in Poland is mainly from coal and natural gas. Customers supplied be the network in Szczecin will receive a greener heat supply produced with an increasingly share of renewable and recovered heat.

The green value is not exploited to the customers at the initial stage as conventional DH business model is applied.

4.9.5 Services offered to customers

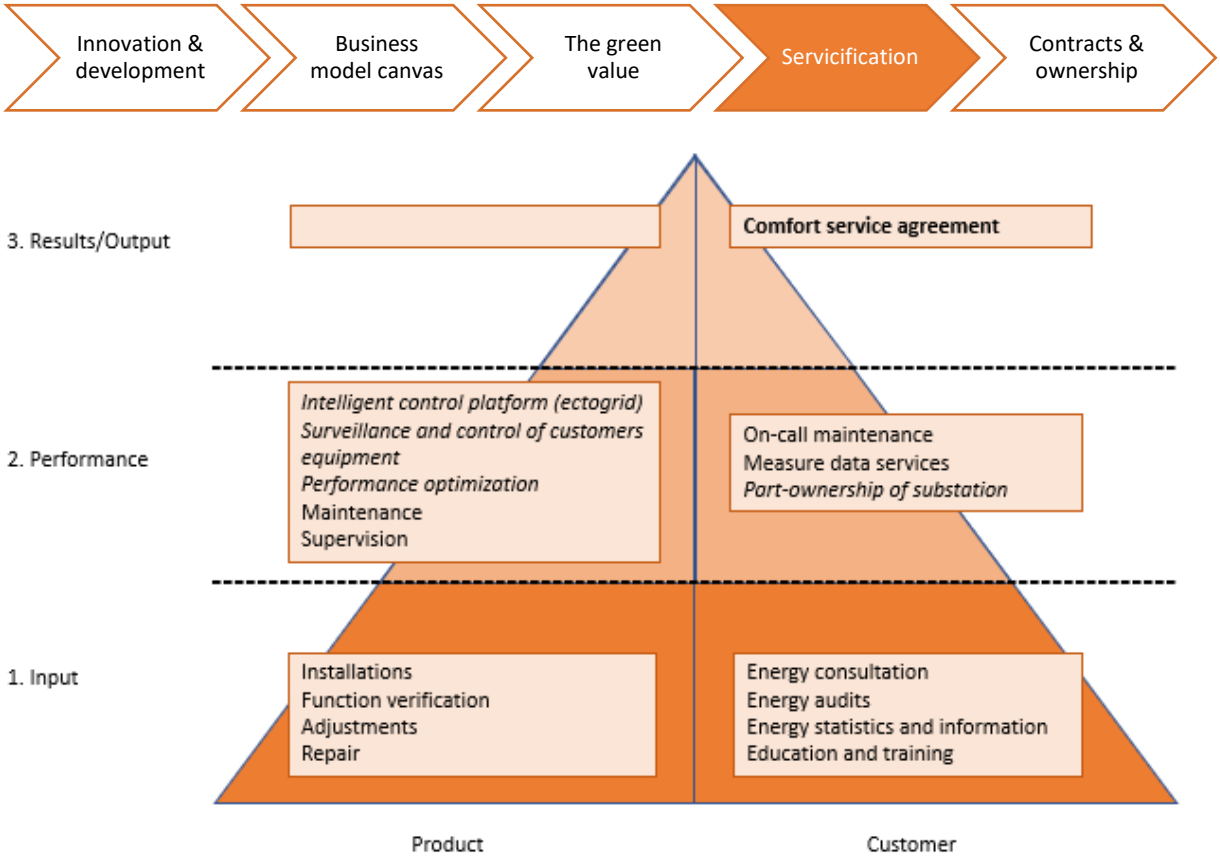


Figure 14: Szczecin - The servicification triangle.

Figure 14 visualize the servicification triangle for the demo site. Italics represents what is new in services offered to customers in REWARDHeat and bold represent possibilities beyond REWARDHeat.

The Ectogrid concept integrates each building into the system for circulating heating and cooling so already when implementing the concept there is an integration of processes and a dependence of each other in the prosumer relationship. The boundary condition between the DH company and the customers is at the substation. The machine room is currently owned by the MSC, however in the future, and for new customers, it will be owned by the company. The substation is owned by the DH company, who operates and optimizes it. It is a service to the customer and a necessity for the grid.

The buildings connected to and foreseen to be connected to the network are newly built and are therefore less suitable for an EPC. It is not the ambition of SEC to develop into an ESCO and the strategy is to focus on delivering heating and cooling through the grid in an optimized way. It is an ambition of SEC to be able to offer customers a set indoor temperature, a comfort service agreement, after gaining more knowledge about the network and the customers. SEC and E.ON are different companies with different processes, and it needs to be decided who takes leads in ownership of services to customers. E.ON can offer advanced services to customer today and SEC has to develop in competence and experience together with customers to be able to supply advanced services.

Table 28: Szczecin - Advantages and disadvantages with services

Advantages with proposed services at demo site	Disadvantages
The shift in boundary condition to integrate each building into the Ectogrid allows for better optimization of the network.	There could be an unwanted lock-in effect for customers by integrating the buildings. Should a customer change heat supply the Ectogrid would lose one of its components.
High level of services and a prosumer relationship necessitates a deeper and long-term relationship with the customers.	A higher level of services comes with a higher level of risk for the DH company. Increased cost as increased service requires more resources (e.g., personnel, fault detection equipment).

4.9.6 Ownership & Contractual considerations

At this demo site, contracts need to be in place between the waste heat supplier (chocolate factory) and SEC and between SEC and their customers. The factors affecting the contracts are considered below.

1. Low maturity of the technical solution

The Ectogrid solution developed by E.ON and the use of waste heat from the chocolate factory is a low temperature innovation, although the concept has been implemented in other places. Thus, the demo site is affected by low maturity and the novelty of the concept. Continuous and close dialogue is therefore required and collaboration between both waste heat supplier and energy company, and between energy company and customers is necessary to develop efficient contracts. However, the risk associated with the low maturity is in part managed thanks to the island network's connection to the conventional network, functioning as a back-up.

2. No legal framework for low temperature district heating

The absence of a legal framework is applicable also in the case of Poland and the contract is therefore drafted with neither support nor hindrance from legal framework. The demo site in Szczecin is the first low temperature DHN to receive concession in Poland making it a novelty. Continuous dialogue both with prosumers and waste heat providers is required to negotiate contracts.

3. The value of waste heat is subjective

The close dialogue between the owner of the waste heat source (the chocolate factory) and the energy company is important to unify perception of the value of the waste heat. The customers are at the same time prosumers, customers provided with cooling are supplying heat to the network and a dialogue is required to establish shared incentives to agree on the value of the heat.

4. The payback period

The foreseen payback time due to various reasons is 10 years, however in replicated solution it might be shorter. SEC is partially owned by the municipality of Szczecin and thus has a larger patience capital and could accept longer a payback period compared to the chocolate factory which

is a private actor. A structure similar to what is described by Wheatcroft, Wynn et al. (2020) between a local energy company (VEKS, partially owned by the city) and a pectin producer (CP Kelco) could be obtained, where an agreement was reached where the pectin producer would receive its return on investment before the energy company, which in turn facilitated the realization of the collaboration.

5. Asymmetric information

This aspect affects the demo site as waste heat from the factory is integrated into the network and requires consideration through close dialogue. The DH company has long experience with energy production and distribution whereas the chocolate factory does not have energy as core business. Both parts need to be aware of technical requirements and preconditions and moreover the nature of the heat source and whether temperature and volumes change throughout the year. It is imperative that resulting data from the monitoring that has been performed is understandable also to the chocolate factory.

6. Shared incentives

There is a natural shared incentive for both the waste heat provider and SEC to exploit as much of the available heat in the heat source as possible. The contract must reflect this so that there is economic benefit for both companies to draw from the investment. The customers are at the same time prosumers, customers provided with cooling are supplying heat to the network and a dialogue is required to establish shared incentives to agree on the value of the heat supplied.

7. Termination of heat recovery

The sudden termination of the collaboration between the waste heat supplier and the energy companies is a risk prevalent in this case. Even though the conventional grid is still available as a back-up heat supply. The risk could be mitigated by including more sources of heat, such as the utilization of the surrounding river water through a heat pump. At the initial stage of the network only few customers are connected and with the concept of circulating energy between buildings every customer is an important part of the network. It is important to properly manage the customer relationship to avoid customers disconnecting. The risk will decrease as more customers connect to the network.

- Ownership

The complexity of the ownership and the contracts increases with the number of involved parts. In this case, SEC owns and operates the heating grid while the waste heat supplier owns the heat source. A future option could be to design and implement co-ownership of the heat recycling equipment, which would promote collaboration between all parts through sharing of both risk and benefit and would allow easier access to information and improved control of the system from SEC's perspective.

SEC is partially owned by the municipality of Szczecin and thus has a larger patience capital and could accept longer a payback period compared to the chocolate factory which is a private actor. A structure similar to what is described by Wheatcroft, Wynn et al. (2020) (Wheatcroft, Wynn et al. 2020) between a local energy company (VEKS, partially owned by the city) and a pectin producer (CP Kelco) could be obtained, where an agreement was reached where the pectin producer would receive its return on investment before the energy company, which in turn facilitated the realization of the collaboration.

As more buildings are constructed on the island and connected to the network more prosumer contracts need to be signed with them. It is necessary that SEC has control of the substation at the customers site in order to optimize the network and circulate the energy.

SEC are also looking at integrating more waste heat available on the island, for example a logistics center. The recommendation is for SEC to try and assume ownership of as much of the heat exchanging units at the new customers' site as possible, to promote the optimization of the system.

- Energy performance contract

Poland has a small but developing market for energy performance contracting (EPC) (Moles-Grueso, Bertoldi et al. 2021).

As of now the only customer is the Maritime Science Center, which is publicly owned and was built recently. Customers foreseen to connect to the network are a mix of newly built privately and publicly owned tertiary buildings. The type of buildings and the ownership of buildings are suitable for an EPC but because all buildings are new construction the baseline is likely already at a high level of energy efficiency no "low hanging fruits" would be available.

The network has a lot of data monitoring and competence that could be utilized to carry out EPCs. SEC is a large organization, as is E.ON, and should have the suitable competence to become an ESCO. It is, however, not the ambition of SEC to develop services beyond the delivery of heating and cooling.

The DH company could develop into an ESCO but the baseline of customers buildings is probably already at a high level because of new constructions. An EPC could be a suitable development longer down the road if SEC changes its strategy to expand services.

4.10 Croatia- Topusko

The demo site in Topusko is summarized in Table 29. Following a short introduction to the demo site are the five topics in focus in the REWARDHeat project: Innovation & development, Business model canvas, The green value, Servicification and Contracts & ownership.

Table 29: Topusko - Summary of the demo site.

Topusko	Innovation & development	Business model canvas
Existing low temperature network in Croatia owned by the private company Health Spa Topusko. The heat source is geothermal wells.	Technical: Improving the efficiency of the network. Customer: No innovation towards the customer.	Monitoring and control are new activities and resources for the DH company resulting in new values for the customers and lower operational costs in the network.

The green value	Servicification	Contracts & ownership
Increased efficiency creates a greener value. It is valued by the DH company as lower operational costs and closer to meeting legal requirements on discarded water temperature. Green heat is valued by the city and by professional customers but not by private.	The installation of control and monitoring equipment increases the services offered to customers. Still the services offered are at a comparatively low level but with the potential to grow.	Topusko is the owner of the network and has a water permit from the state for use of the heat source. Contracts are therefore only required with the end-customer. Energy performance contracting (EPC) could be a possibility beyond the project.

4.10.1 Croatia: Input from PESTLE analysis and customers' perspective

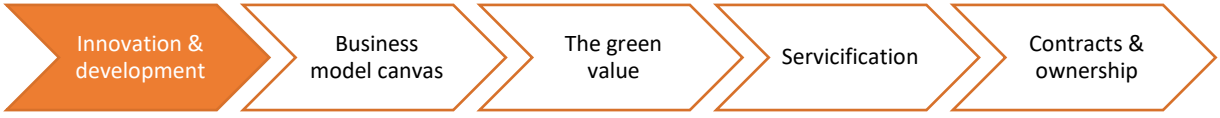
Conclusions from the PESTLE analysis (Fransson, Sandvall et al. 2021) that is relevant for business model development:

- The business case is very important to attract investment capital as state-based financial support and access to capital is lacking
- Profitability is achieved by low system losses and a cheap source of heat
- A heat supply that qualifies for NZEB energy requirements is an important value proposition

Conclusions from the customers' perspective (Fransson and Lygnerud 2021) that is relevant for business model development:

- Customers want an incentive-based pricing scheme
- Customers are unwilling to receive the heat supply as a service
- More information about increased service is necessary for customers to mature increase customers propension and
- Maintenance offers are requested (especially by private customers) and could be a starting point to build stronger customer relationships and increase services

4.10.2 Business model innovation and development



The demo site leader in REWARDHeat is Ljeciliste Topusko (Topusko). Topusko is a 100% geothermal based low temperature DH network supplying a health resort and part of the nearby village. The geothermal water is at 64 °C and after utilization the water is cooled in cooling towers using electricity from 50 to 35 °C and then discarded into the sewage system. The health resort,

who owns and operates the entire system, wants to avoid the need to cool the water because it is costly and an unnecessary use of resources. The DH system is supplying the health resort and by single pipeline parts of the nearby village with a total of 210 private and public customers. There is a possibility to expand in the village, but it is a poor area where many still burn wood for heat and it will be difficult for people to invest in the connection even if the heat could be cost-competitive. The health resort is the single biggest consumer of the system and external customers in the village includes a church, school, one smaller industry and private residents. The geothermal source produces approximately 7.7 GWh/year, with approximately 25% going to the health resort and the rest to the city. The DH network prior to REWARDHeat suffers high energy losses due to lack of control and maintenance in the system as well as the lack of a return pipe from the external customers in the city.

In REWARDHeat the focus is on improved efficiency of the current system and the focus is internally on the spa. There will be new pipelines replacing existing ones in the Health Spa area and increased monitoring activity for the DH operations. It will lead to increased customer comfort and savings of geothermal heat. The innovations realized in the existing heat centre are of a technical character and will impact the key resources and key activities of the current business model. The current business model will not be upgraded to reflect the new resources and activities. The price charged to customers will remain the same. A modernized business model with increased customer engagement could be realized post project.

Post REWARDHeat it is likely that a return pipe will be designed for Topusko and possibly installations of low temperature islands linked to the existing system (all 4 wells: in REWARDHeat there is focus on one well). Depending on energy market development the business model could be updated when the return pipe is in place but in general potential customers in Topusko are unwilling to pay more and updates of the pricing scheme is governed by regulation.

4.10.3 Business model canvas

- 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 Thalassotherapy treatments. The heating and hot water is supplied by green energy from geothermal wells and an additional customer value is the green value.

Today controlling flow rates and temperatures is done manually and increased control and monitoring of the system is implemented as part of the REWARDHeat project. Smart control will improve the efficiency of the system and improve the indoor climate at the spa facility (now customers open a window if it is too warm since there is no other way to regulate the heat). The improved efficiency results in a lower operational cost for the spa and better utilization of the energy per volume. As a result, less electricity needs to be spent on cooling the water before disposal into a partially open water channel that goes into a nearby river. The change in the system enables less energy that needs to be used from the geothermal well and therefore less volumes of water that needs to be disposed of into the river. New pumps will be installed, and the improved

pumping system will increase security of supply for both internal and external customers to the network.

- Customer segment, relationship, and channels

The customer segments are 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). The relationship with customers is at arm's length and the main communication channel is via invoice. When developing the business model beyond REWARDHeat the aim for Topusko is to develop a stronger customer relationship.

- Key resources, activities, and partners

The key resource is the existing DH network and the central heating station around well 4 (the largest of the 4 geothermal heat sources). Added resources will be new pre-insulated pipes provided by Thermaflex, monitoring equipment and pumps. Important partners are the municipality where a dialogue is required on the disposal of the geothermal water. The change in the network enables less volumes of water that are needed to supply the same amount of energy and the water to be disposed of will be at a lower temperature than before from the spa, thus meeting the legal requirements. A return pipeline from the external customers will still be required as the disposal temperatures are still too high.

- Cost structure and revenue streams

The cost structure will change in terms of added assets and monitoring activity. However, because of REWARDHeat investment the costs will not need to be covered by increased price levels. In REWARDHeat there will be no changes to the revenue streams and pricing structure and conventional DH business models will still be applied.

- Business model canvas

Table 30: Topusko - Business model canvas.

<table>
<tr><td rowspan="2">Key Partners

Equipment providers

Municipality</td><td>Key activities

Manage legal requirements

Monitor, control and improve performance in network (e.g., improved pumping)</td><td rowspan="2">Value Proposition

Heating, hot water
Comfortable indoor climate (increases)
Security of supply (increases)

Value of green (geothermal heat source - increases with improved energy efficiency)</td><td>Customer Relationship

Arm's length</td><td rowspan="2">Customer segment

Spa (focus in REWARDHeat)

Private building owners, industry, and municipality</td></tr>
<tr><td>Key Resources

Geothermal wells

Pumps

Monitoring eq.</td><td>Channels

Invoice</td></tr>
<tr><td colspan="3">Cost structure</td><td colspan="2">Revenue streams</td></tr>
</table>

Driven by fixed costs Lower operational costs due to more efficient system	Fixed tariff in combination with variable tariff depending on consumption

4.10.4 The green value

The monitoring and control system creates a more energy efficient system with less distribution losses. It reduces the need of cooling water prior to discarding it into the river thus saving electricity. Further, the temperature of the water, and the volume, disposed to the river decreases. Because the network is low temperature more geothermal energy can be extracted from the wells. Beyond REWARDHeat, when a return pipeline is likely to be installed, system losses will decrease.

For the DH company the green value comes from increased energy efficiency and passing the legal requirements of water temperature disposed into the river (will be fully met only after return pipeline is installed).

The green value is assessed to be important to customers and especially important to the city to meet emissions target. Greener heat seems to be a value to other professional customers in the network, but most private customers do not see it as a value. A geothermal-based DH network is eligible for meeting the nZEB criteria in new buildings. Professional customers are willing to pay a little bit more for a greener heat supply whereas private customers want the price to remain or decrease.

The heating in Croatia is mainly supplied by biomass and gas. Gas is also the main supply in DH and most DH networks have high thermal losses. By offering a geothermal based heat supply to customer they are receiving greener energy than in alternative DH. When the return pipeline is in place the thermal losses will be reduced.

The value of green is not exploited in the business model to customers.

4.10.5 Services offered to customers

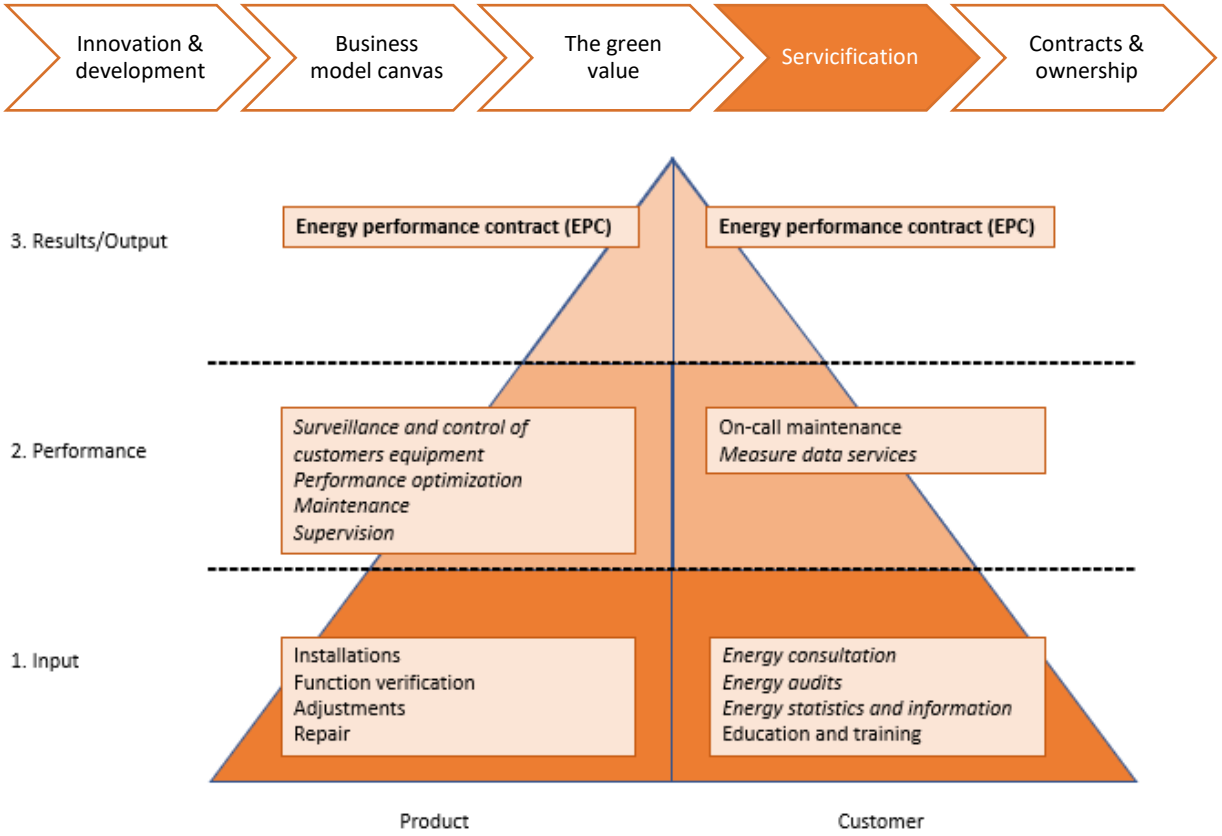


Figure 15: Topusko - The servicification triangle.

Figure 15 visualize the servicification triangle for the demo site. Italics represents what is new in services offered to customers in REWARDHeat and bold represent possibilities beyond REWARDHeat.

Topusko is a small company that started at a low level of services offered to customers. In the REWARDHeat project, Topusko are reaching higher by adding monitoring and control systems, improving processes, and increasing energy efficiency services at the Spa site. The learning curve will continue beyond REWARDHeat with increasing the efficiency of the system further.

In the long term, Topusko has the possibility to aim high in the servicification triangle especially when a return pipe has been added to the network and more knowledge has been acquired. A first step could then be to offer an EPC to the city-owned buildings connected to the network. Together with the city common goals for energy efficiency could be decided and the collaboration would be a learning process for both Topusko and the city. With the knowledge acquired, Topusko could serve as a lighthouse example of geothermal-based DH network in Croatia. The interest for geothermal energy as an available renewable energy resource is gaining traction in Croatia and has been recognized in the Croatian Recovery and Resilience plan. There are already known and other potential geothermal wells that can be suitable for serving a DH network. Topusko could expand to share their gained knowledge with other similar sites around Croatia and foresees that many sites can improve how they make use of the geothermal energy and what can be offered to external customers.

Table 31: Topusko - Advantages and disadvantages with services

Advantages with proposed services at demo site	Disadvantages
Offering increased services to customers provides possibilities to better optimize the system.	Staff with the right competence to offer more advance services to customers must be recruited or educated in the company as it is lacking today.
Developing an EPC where Topusko matures together with the customer and common goal for improve energy efficiency are developed creates a deeper and long-term relationship.	Increased cost and risk as increased service requires more resources (e.g., personnel, fault detection equipment). Necessary to perform enough service to reduce the risk of failure.

4.10.6 Ownership & Contractual considerations

The contracts required at this site are between Topusko/Health Spa and their customers. The factors affecting these contracts are considered below.

1. Low maturity of the technical solution

The installation of control equipment to improve energy efficiency in the network is mature technology and thus the site is not affected by low maturity.

2. No legal framework for low temperature district heating

Though the factor is true and there is no legal framework for low temperature DH in Croatia, it has limited effects at the demo site, provided that the applied technical solution is mature.

3. The value of waste heat is subjective

The demo site is not affected by this factor. The heat source is geothermal wells that are free for Topusko to use.

4. The payback period

The payback for the current system is short thanks to its limited complexity. The investment required for monitoring equipment and additional pipes in REWARDHeat is partly covered by the project. However, if a return pipe is established in the future, the payback period is expected to be of considerable length. The high investment cost of the return pipe is the reason for not constructing it within the REWARDHeat project.

5. Asymmetric information

The heat source is both owned and distributed by Topusko and thus the information about the heat source and operations is readily available. The factor is not applicable.

6. Shared incentives

On the heat source side, there are no shared incentives because there is only one part involved with the operation and distribution of the heat, nor with the customers receiving the heat. To

implement shared incentives with the customers, e.g., through the implementation of a motivational or seasonal tariff, could lead to improved compliance with current regulation of the water that is let out into the ocean and to the customers showing appropriate behavior already before a return pipe is installed.

7. Termination of heat recovery

The demo site heat source is geothermal energy and is therefore to be considered stable.

- Ownership

The distribution network, the central heating station, and the pipes, are owned by Topusko. Topusko owns the land where the geothermal wells are located but require a water permit for the utilization of the heat source. Topusko also owns the area of the spa section, which facilitates the installation of the improved system. Other investments, like return piping, would engage the city and different landowners and could be a difficult process.

There is potential for further optimization in the network apart from building a return pipe through a shift in ownership of equipment at the customer sites. If Topusko took on the ownership of the customer substations, improved control and efficiency could be achieved while providing carefreeness to the customer. The recommendation is for Topusko to investigate this opportunity.

- Energy performance contract

The energy performance contracting (EPC) market is mature and developing in Croatia (Moles-Grueso, Bertoldi et al. 2021).

The customer segment of the DH network are a mix of public buildings, industry, and multifamily houses. Especially the public buildings could be a suitable target segment for an EPC contract and an opportunity is to include multiple similar buildings under the same contract. A first step could be to establish a baseline of the building's energy efficiency to identify possibilities for improvement. The city does not have energy as core business and an external contractor could provide value with energy efficiency services.

The competence level of Topusko is increasing in the REWARDHeat project with increased data monitoring and control systems which is improving the processes and energy efficiency in the buildings connected to the Spa. For Topusko to advance in the direction of becoming an ESCO additional learning within the REWARDHeat project is required as well as beyond the project by expanding the knowledge within the spa and increasing energy efficiency in the system also to external customers. Further Topusko would need to acquire personnel with competence on contract development and project management.

The city does not have energy as core business, and with multiple buildings connected to the DH network, Topusko could offer its competence gained in the REWARDHeat project on improving energy efficiency to its customers. This would be a possibility to explore beyond the REWARDHeat project. In the long term Topusko could expand to become a local ESCO to the niche market of geothermal spa centers in the region.

5 Discussion

The key takeaways from the discussion, based on the experiences from all demo sites, is summarized in Figure 16 for each of the five topics in focus in the REWARDHeat project: Innovation & development, Business model canvas, The green value, Servicification and Contracts & ownership.

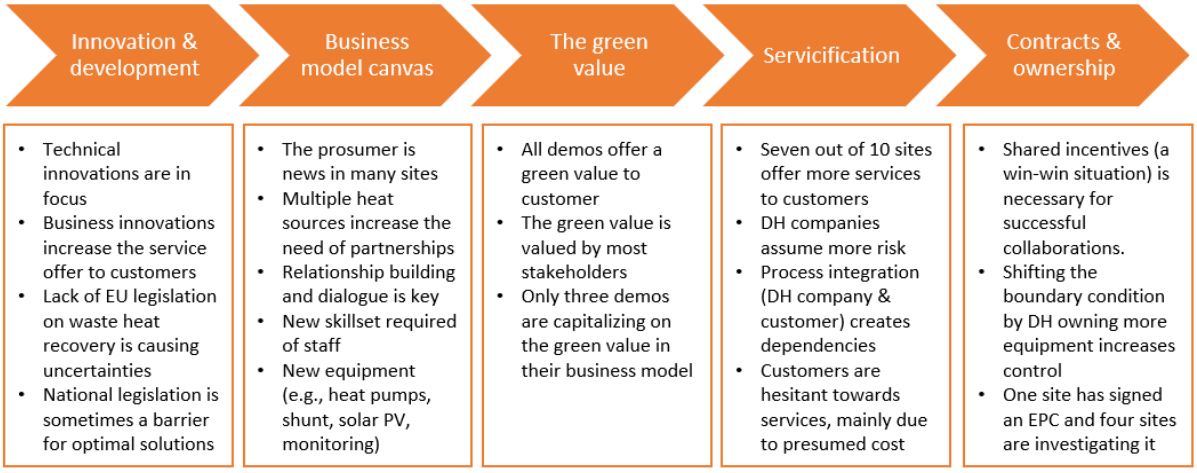


Figure 16: Key takeaways from the discussion

5.1 Innovation is mainly focused on technology

The demonstration sites are innovating technical solutions. In Gardanne, Szczecin, Balilla and Gadio the innovation is to include locally available waste heat and renewable energy sources in new networks. Waste heat integration is a key topic also in Albertslund and Heerlen. At the demo site in Albertslund the innovation is lowering the distribution temperature in a section of the conventional grid. In the two Swedish demo sites the innovation is increased flexibility. In Mölndal an already very flexible network with multiple production and storage units is further expanded and in Helsingborg the innovation is that the borehole storage owned by a building owner can be utilized in the conventional DH network. Flexibility is also an important aspect at the demo site in La Seyne-sur-Mer, Gardanne and Heerlen through optimized use of energy storage. The foreseen storage in Heerlen would have been optimized to reduce peak loads in the network.

Performance optimization is the main topic for La Seyne-sur-Mer, achieved through the development of an online platform for control and optimization. This is also important in Gardanne, where forecasting of solar energy production is integrated into the performance optimization, enabling a high level of renewables in the DH network. Finally, in Topusko, the energy efficiency is improved by means of a control system and measuring equipment.

All demonstration sites develop technical innovations and seven simultaneously develop the business innovation towards customers.

Business model innovation towards the customer appear in seven of the demonstration sites: La Seyne-sur-Mer, Balilla, Gadio, Szczecin, Helsingborg, Albertslund and foreseen in Gardanne. In La Seyne-sur-Mer the business model innovation is mainly to the prosumer customer through the signing of an EPC. In Balilla and Gadio the shift in boundary condition when the DH company takes over ownership and maintenance of the substation at the customer site is an innovation creating carefreeness for the customer. This is also the innovation seen by customers in Szczecin and increasingly in Albertslund. The set-up of the demo in Helsingborg is an innovation where the customer (the conventional DH company) can use the boreholes located at the demo site. In Gardanne the foreseen innovation is for customers with solar PV to be able to do solar peer-to-peer electricity trading. The innovation is an enabler for end-consumers to act as energy citizens if they would like to. Noticeably, most business model innovation towards the customer relates to an increased level of service being offered.

The business innovation towards customers relate to an increased level of service.

5.1.1 *Impact of legislation on innovation in low temperature schemes*

A conclusion from Lygnerud, Nielsen et al. (2022) is that the main barrier for waste heat recovery is the lack of EU level legislation on the topic. The policy uncertainty is creating risk in the business model (are investments in waste heat as sustainable as investments in renewable energy investments) and makes it more difficult to attract investors. This impacts all demo sites and is further discussed in section 5.5.

The lack of an EU legislation on waste heat recovery to DH networks is creating uncertainties in the business model.

Another legislative barrier for waste heat recovery into DH networks was identified in the Albertslund demo. According to legislation in Denmark an administrative process (called a project proposal) is necessary to integrate waste heat of a certain volume into a DH network. Initially it was foreseen that the waste heat to be collected from a supermarket required a project proposal and to avoid the administration the heat would instead be inserted directly into a municipality building. Later it was identified that the volumes were small enough to avoid the administration, but the uncertainty has caused delays and required additional resources. In the Swedish demo site in Helsingborg, where the borehole storage is charged with industrial waste heat from the surrounding conventional network, the Swedish building codes (swe: Boverkets byggregler 2011:6) limits the amount of purchased energy to a building which created a need to introduce solar PV-T panels, solely to meet the requirements. The solar panels add unnecessary complexity and risk to the site.

In the Netherlands the DH tariff is regulated by the Dutch Authority through a maximum level calculated based on the natural gas price. This was seen as a one of the barriers when assessing the possibility to recoup a larger investment in the network.

Multiple examples of national legislation being a barrier for innovation in low temperature schemes have been identified. Resulting in sub-optimal solutions, and sometimes adding risk.

Heat flexibility is a key topic at the Swedish sites and the lack of a heat flexibility market system has been identified to slow down the development of optimized energy systems.

Legislation has also been identified as a driver for renewable and efficient DH networks. Requirements on energy in buildings create a drive for efficient and green heating systems and is used as a marketing value. In Milan the ban on gasoline in heating systems is forcing a shift in heat supply and is the reason for multiple of the customers connecting to the demo sites. The environmental regulation against discarding too warm water into the river in Topusko has been one of the drivers for the demo site to improve the monitoring and control of the network.

5.2 The business logic is shifting

- Value proposition

All demo sites are expanding the value proposition to customers due to the innovations performed in the REWARDHeat project. Mainly the value creation is derived from offering a greener heating supply, discussed more in section 5.3. The value of being carefree of the energy supply appears at demo sites where the level of service offered to customer is increasing. In the demo sites where the DH connection is replacing fossil boilers, or where more advanced monitoring and control equipment is installed, the more traditional DH value proposition appears: security of supply, improved security, and comfortable indoor climate.

- Customer segment, relationship, and channels

The prosumer customer segment is in six demo sites (Albertslund, La Seyne-sur-Mer, Gardanne, Gadio, Szczecin and Heerlen), through the inclusion of waste heat or RE. In Helsingborg the conventional DH company becomes the customer of the flexibility service. 7 out of the 10 demo sites (Albertslund, La Seyne-sur-Mer, Gardanne, Balilla, Gadio, Helsingborg and Szczecin) are developing the relationship with customers to become closer, more personal and with more dialogue. This is driven by increased services and therefore a need to further integrate with the customers processes to deliver the service, and by the prosumer relationship.

- Key resources, activities, and partners

New partnerships are required all the demo sites, except Topusko and Mölndal, and are related to new heat sources. Waste heat suppliers are becoming partners in the business model as well as the owners of renewable energy sources to be utilized in the network. New activities are to manage the new partnerships, to operate and optimize the network with the addition of the technical innovations and to perform the services offered. New resources in all sites are the technical installations and in seven of the demo sites (the seven demo sites that have developed a deeper customer relationship) staff with new skill set to manage prosumer and customer dialogue is necessary.

- Cost structure and revenue streams

The operational cost for the network is expected to decrease in all demo sites due to higher efficiency in the network achieved by lower losses, better optimization. Fuel costs can be decreased by waste heat and renewable energy integration. Additional maintenance and service drives

additional costs for staff and material. Where additional services are added the revenue streams increases, except in Helsingborg where the flexibility service does not generate a revenue. In Albertslund if the cost of heat is reduced, the cost savings are distributed to customers, as DH is non-profit in Denmark.

The business logic for low temperature DH is based on relationships and customer orientation.

5.3 The green value is valuable but not always exploited

The value creation for customers with products or services that has a lower environmental impact than other alternatives is called *the value of green*. The green value of each demo site was assessed from both a technical perspective and from the perspective of different stakeholders. The technical evaluation was made by assessing the demo sites against the checklist developed in Geyer, Werner et al. (2021) on motivating factors for low temperature DH networks. The factors are listed in Table 32 and described in more detail in section 0. All sites create a green value by improving the efficiency of the network because they are low temperature. Table 32 show which factors are included at each of the demo sites, due to the selected heat source, the components, and the set-up of the network.

Table 32: Green value created because the networks are low temperature.

	Albertslund	La Seyne-sur - Mer	Gardanne	Balilla	Gadio	Helsingborg	Mölndal	Heerlen	Szczecin	Topusko
More geothermal heat extracted			x	x				x		x
Less electricity used in heat pumps		x	x	x	x		x	x	x	
More waste heat extracted	x				x			x	x	
More heat obtained from solar collectors						x		x		
More heat recovered from flue gas condensation	x						x		x	
More electricity generated in combined heat and power plants	x						X		x	
Higher heat storage capacity			x			x	x			
Lower heat distribution loss	x	x	x	x	x	x	x	x	x	x

All demonstration sites offer a greener heat supply than the average mix in the country. The sites connected to a conventional DH network (Albertslund, Helsingborg, Mölndal, Gadio and Szczecin) have a greener supply than the main network due to utilization of locally available waste heat sources, local production in heat pumps, solar or geothermal energy, flexibility creation in storages and lower supply temperature. In the sites without a connection to an existing DH network (La Seyne-sur-Mer, Gardanne, Balilla, Gadio, Heerlen and Topusko) the heat source is the main driver of the green value in combination with a low temperature network.

The green value is present at all demo sites and is further strengthened by the interventions in REWARDHeat.

The DH companies at all demo sites believe that the green value is indeed a value. Most state that having a green heat supply is useful in marketing. In the demo sites where the DH company is partly or fully owned by the municipality the green value also becomes important to the DH company, because it is valued by the owners. In some demo sites, where the development in REWARDHeat is improving the green value, it simultaneously results in lower operational cost. An example is in Topusko, where the focus is on energy efficiency. Other examples are in Heerlen where the energy storage would have resulted in lower operational cost, in Helsingborg where excess heat from the conventional grid is stored in the boreholes ensuring a low cost of purchased heat and in Mölndal where the flexibility of the system enables operation at a low cost. In Gardanne the green value is the reason that the DH company was awarded the contract.

The green value produced by the demo sites is valued by all cities that have demonstrations. With the overarching goal of the EU to be climate-neutral by 2050 there is both a pressure and a willingness at a municipality level to promote and encourage sustainable solutions. In both French demo sites, the city uses the networks in awareness creation campaign to inform about climate change. In the demo sites where the low temperature networks are connected to the return pipe of the conventional DH network, an additional value is increased efficiency in the network. This is valuable to the city through the municipality owned conventional DH network. In Helsingborg an additional value to the city is that a higher degree of utilization of excess heat is possible because of the borehole storages.

The green value is valued by all DH companies, by all municipalities/cities where the networks are located and by most customers.

In most but not all demo sites, the green value is a value to the customers. To municipality-owned buildings in Topusko, Szczecin and Gardanne the greener heat supply assists the city in achieving climate goals. To professional customers in La Seyne-sur-Mer, Mölndal and Topusko, a green heat supply is requested and used by them in marketing. A green heat supply is especially important to customers required to meet thermal regulation values or to achieve energy certificates for the buildings. This is visible in Szczecin, Heerlen, and La Seyne-sur-Mer. In Helsingborg the customer of the flexibility service is the conventional DH network, and the value creation enables a higher degree of utilization of excess heat in the system and more flexibility. The private customers in Topusko do not see a value in a greener heat supply and in Albertslund the private customers consider it as a cleanliness factor, rather than something superior. To the customers of the Italian site, Balilla and Gadio, the greener heat supply is not considered valuable but rather a must because of the ban on gasoline boilers in the city of Milan.

The green value is only exploited to customers in three of the demo sites, indicating that more business model development is necessary to capitalize on the additional value creation deriving from the REWARDHeat concept.

The green value is exploited in the business model if it is capitalized through revenue streams. This is the case in three of the business models. In the La Seyne-sur-Mer demo, in the EPC, green heating and cooling supply is part of the energy efficiency measures and as the contract increases the revenue stream for the DH company, the green value is capitalized on. In Gardanne, the customers pay a premium price for the green heat that is slightly higher than in other DHC networks. In Albertslund the green value decreases operational cost and if the overall cost decreases, the cost of heat will be reduced for customers as DH is non-profit in Denmark and hence the green value is noticeable in the revenue streams.

5.4 *Increased level of service is trending*

7 out of 10 demo sites are increasing the services offered to customers in the REWARDHeat project, visualized in Figure 17. Two demo sites have entered the highest level of service in the servicification triangle, visualized in italics in Figure 17. In Topusko the services offered to customers started at level 2 and the DH company has throughout the project developed the skill set to deliver multiple new services to customers including measuring data services, maintenance, and surveillance. In Albertslund the DH company is continuously taking over the ownership of more customers substations. In Szczecin, the DH company is the owner of the substation which is a service and a necessity to control and optimize the network. A new service expected to be introduced at the demo site in Gardanne is enabling solar peer-to-peer. At both demo sites in Milan, Balilla and Gadio, the DH company is shifting the boundary condition to inside the customers building by assuming ownership of the customers HP and substation. The service includes surveillance, maintenance, and performance optimization, pushing their offer upward in the second level of the service triangle.

7 out of 10 demo sites are increasing the scope of services offered to customers in the REWARDHeat projects and six are considering further expansion beyond the project.

The one exception where level of service is declining is in Heerlen. In Heerlen, large customers have been able to receive a comfort service agreement, but it has been decided that the risk of offering such services is too great. The DH company will therefore discontinue these services and instead try to collaborate with a local ESCO, thereby transferring the risk to the ESCO. Two sites, La Seyne-sur-Mer and Helsingborg, have entered the highest level of services in the REWARDHeat project where the energy company is integrated with the customers process, the partners have established common goals and are increasingly dependent on each other. In La Seyne-sur-Mer the new service is signing an EPC contract with the casino. In Helsingborg the flexibility services offered to Öresundkraft through the borehole storage is the other example of level 3 services. The demo site in Mölndal is already offering comfort service agreements to their customers. The customer

pays to rent a space in the buildings, carefree, and the DH company manages all surrounding aspects, energy and beyond.

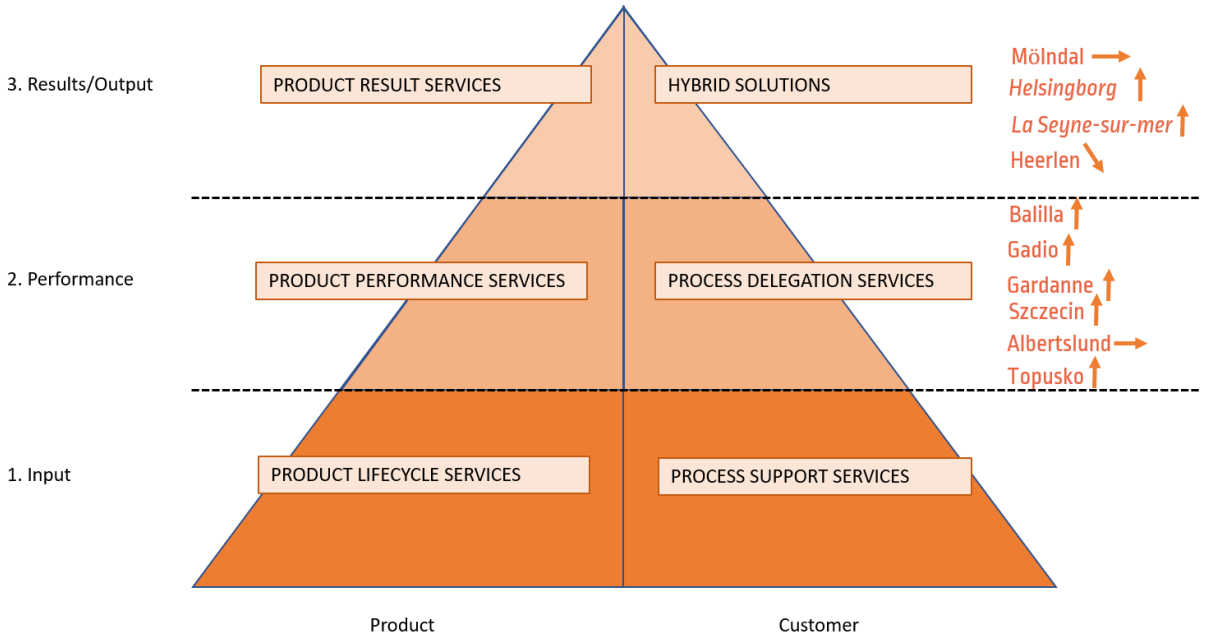


Figure 17: Visualization of the change in level of services offered to customers.

Beyond REWARDHeat, multiple sites are considering expanding their service offer to customers. Topusko demo could serve as a lighthouse example of geothermal-based DH networks in Croatia and assist others in the region to develop similar solutions. Topusko further considers offering an EPC to the municipality once they have acquired more knowledge and made further improvements on the system. In Albertslund, the DH company will increasingly take over ownership of customers' substations as the equipment needs to be replaced. It is an ambition of the DH company in Szczecin to be able to offer customers a set indoor temperature, a comfort service agreement, after gaining more knowledge about the network and the customers. The Gardanne demo site is looking for opportunities to offer EPC to customers. In Milan, the DH company would like to offer maintenance services, or even an EPC, to the municipality once the current maintenance contract with another contractor expires. Both French sites, La Seyne-sur-Mer and Gardanne, would like to expand beyond energy service and assume the role of the caretaker of the building to ensure more revenue from each customer as well as a deeper relationship.

Offering more services to customers changes most aspects of the business model canvas. The main implications are value proposition (carefree), customer relationship (closer) and key resources required at the DH company (more personnel) which is aligned with findings in Ottosson (2020). It further changes the key activities (perform service), customer dialogue (more personal with advanced services), cost and revenue structure.

5.4.1 Advantages and disadvantages with services at the demo sites

Increasing the level of services offered to customer have some common traits regardless type of service. More service necessitates more dialogue between the energy company and its customers, resulting in a closer relationship. This is important for DH companies in many countries, explicitly mentioned by the demo sites in Denmark and Sweden, to avoid customers disconnecting from the network. The advantage of additional service to the customer is mainly the value of being more carefree and reducing the risk associated with the heating supply. The value of being carefree

increases with shifting the boundary condition inside the customers building and in the REWARDHeat demo sites the entire scope is covered. From Topusko where remote controls are installed, to Albertslund and Milan where the DH company takes over ownership of the substation in the customers building, all the way to Mölndal where the customer is renting a space and is totally carefree of the building or the energy supply. For the DH company the main occurring advantage of shifting the boundary condition is increased control of the network with the possibility to optimize and possibly an increase in revenues. This advantage increases with the DH company assuming more ownership or maintenance of equipment.

DH companies assume more risk as they offer higher level of services to customers, but can gain from a deeper relationship with the customer, increased control of the network and increased revenues.

The only identified disadvantage with services from a customer perspective is when the service needs to be guarded by a more advanced contract, as in the case of the EPC in La Seyne-sur-Mer and the flexibility service in Helsingborg. The contracts are resource heavy to develop for both parties but can be particularly complex for the customer if energy is not the core business. For the DH company the main identified disadvantages in offering additional services are increased risk in the business model and that it adds complexity. By shifting the boundary condition inside the customer building more customer dialogue is necessary to deliver the service, and to perform the maintenance of equipment more staff is required with competence to manage the customer dialogue as well. By taking on more risk, additional resource such as monitoring, and fault detection equipment are required to manage the risk.

Transitioning from a company that only supplies energy as a commodity to energy as a service requires new processes and competences to be developed within the organization. Three sites have developed services highly integrating the processes of the energy company with the customers': the set-up in Helsingborg, the integration of buildings to circulate energy in Szczecin and the integration of customer solar production in the production optimization foreseen in Gardanne. The integration of processes creates a dependency and therefore a risk that one partner could terminate the collaboration.

5.4.2 The customer perspective on increased services

From the survey performed with customers in proximity to the demo sites in Fransson and Lygnerud (2021) it was identified that customers in all surveyed countries are mostly hesitant toward receiving services along with their heating supply. The main reasons being that it is perceived as more expensive but also that customers lack enough information about possible services. For example, some customers think that a comfort service agreement (fixed indoor temperature at a fixed price) would result in higher energy consumption, that energy would be wasted or that it would reduce the incentive for energy efficiency.

Customers are hesitant towards receiving services with their heat supply. Maintenance contracts can be a steppingstone from which the customer relationship can develop.

Many customers, especially private customers, would like someone else to perform maintenance of their heating equipment. Maintenance service offers are therefore proposed as a possible

steppingstone from which the customer relationship can develop. Once trust has been established, more advanced services can be discussed with the customer.

5.5 Contracts and ownership

The results from the evaluation of ownership structure and contractual considerations are aggregated and discussed below. The technical innovations at the demo sites create a need for closer and more active collaboration between all parties along the energy distribution chain, both at the energy source and the customer and this is reflected in the contractual considerations

The results are structured to address important factors for efficient contracts and ownership arrangements identified in the ReUseHeat project, targeting low temperature heat recovery (H2020), D2.3.

1. Low maturity of the technical solution

Gardanne and Heerlen are two of the demo sites affected the most by the low maturity factor: the concept of using mines as both storage and as a distribution network is realized only in a few places around Europe. The risk associated with the low maturity is however mitigated by the local government being part of the owner constellation in both cases.

In general, including a local government in the ownership constellation alleviates this factor somewhat because public instances often assume a more long-term perspective compared to a private counterpart.

In some cases, the new technology is connected to conventional DH, and this mitigates the risk of the installation since any faults or outages could be covered by the existing grid. This is the case for Albertslund, Mölndal, Helsingborg, Gadio and Szczecin.

2. No legal framework for low temperature district heating at EU level

The lack of legal framework for low temperature DH at EU level affects all demo sites to a varying degree. The parties of the agreement lack legal guidance and must find the compromises and terms without any standard to rely on. This emphasizes the previously mentioned need for close dialogue with heat suppliers, prosumers, and customers and tailoring of the contracts.

3. The value of (waste) heat is subjective

This factor is only applicable to the demo sites where the heat supply is owned by a different company than the DH company. In La Seyne-sur-Mer, Gardanne, Balilla, Heerlen and Topusko, the main heat supply is a “freely” available renewable energy source (geothermal or sea water) technically owned by the municipality. The heat is available for free; hence, the value does not have to be discussed but environmental permits are required for the utilization. In Albertslund, Gadio and Szczecin waste heat is being integrated from businesses and the value of heat must be agreed upon. In demo sites where heating and cooling is provided, the customers receiving cooling at the same time inserts heat into the network (becomes prosumers). Here it is important to agree with the customers by transparent and fair pricing. The value of the heat (as a commodity or as a service) toward customers must also be agreed upon by transparent and fair pricing of the product. The price of heat toward customers is sometimes guarded by regulations.

4. The payback period

As discussed in (Lygnerud, Nielsen et al. 2022) a long payback period (>10 years) creates a risk for project funders and could impact the realization potential of an installation and could also reduce the chance of being granted a loan. The longer payback period often associated with low temperature DHC can be managed in several ways.

In the REWARDHeat project the payback factor has had different impacts at the demo sites. In Albertslund, the installation was incentivized by the city target of decreasing the supply temperature of the district heating system by 2026 and the payback factor was of secondary importance. In Topusko and Heerlen, the long payback period foreseen for a return pipe and an energy storage, respectively, was one of the reasons for not realizing the installation.

Several of the demo sites, for example Topusko and Gardanne, were helped by project funding that shortened the payback period of the installation. The payback period foreseen at the Gadio site was instead estimated to be around the same length as the project duration (<5 years).

Most of the demo sites deemed a shorter payback period likely in the case of future replications, thanks to the improved knowledge from the current projects and being able to tailor to the local conditions.

One way to manage the payback period in an installation where the ownership constellation is a public-private partnership, is to allow the private actor to get their return on investment before the public partner.

5. Asymmetric information

To maximize the potential of the heat extraction and allow for the most efficient heat distribution and use, information about the heat source must be readily available to the energy company.

The demo sites associated with the least risk of information asymmetry at the heat source are those where the district heating company has unlimited access to the heat source or where the heat source is of steady and well-known nature. These are the circumstances for La Seyne-sur-Mer, where the main heat source is the ocean; for Heerlen, where the municipally-owned energy company Mijnwater owns the main heat source (mines); Gardanne, where the municipality owns the energy source (mine) but they are part of the joint venture that collaborates on the installation; Mölndal, where Husvärden owns all heating and cooling sources on the low temperature island and simultaneously manages the energy distribution; Gadio, where ACS and Unareti both belong to the ACS Group, which promotes their collaboration across organizational borders; Balilla where the main source is a groundwater well; and Topusko, where the Health Spa has free access to the groundwater well via a permit from local authorities.

In Albertslund, Heerlen and Szczecin, waste heat from a party that does not have energy as a core business is incorporated in the district energy system. In such cases, continuous dialogue is emphasized. The contracts between the waste heat supplier and the energy company must be drafted in a way that promotes easy access to information concerning the waste heat process to allow the energy company to use the heat source to its full potential. Meanwhile, it is equally important that communication on what information is required for process optimization is clear and transparent.

The closest collaboration is required at demo sites where aspects of the energy company's and the customer's processes are tightly connected. As partners become dependent on each other it is increasingly important to reduce the asymmetric information in the collaboration. This is the case at the Helsingborg site, due to Tornet's (the building owner) ownership of all equipment related to

the borehole. Öresundskraft, the energy company, must acquire all information required to make the best use of the borehole in the DH system and must also be able to communicate how the borehole is used and how Tornet in turn benefits from its use. The concept in Sczcecin, where energy is circulated rather than solely consumed, and in Gardanne, where customers' solar production is foreseen to be integrated (the concept of solar peer-to-peer) also requires close dialogue to make the best use of the system.

The customers at several of the demo sites act as prosumers that both use and produce heating and/or cooling and this requires more transparency and information from the energy company to the prosumer to feed the active collaboration between the parts.

To offset asymmetric information, it can be valuable to introduce clauses in the contract allowing for regular intervals by means of a renegotiation clause.

6. Shared incentives

It is important that shared incentives are created in order for the collaboration between the parties to be successful and that a win-win situation is established in the contract. If only one side gains from the collaboration it is unlikely for the collaboration to continue in the long term. This applies both at the heat source and at the customer site.

At demo sites where waste heat is integrated from businesses (Albertslund, Heerlen, Szczecin), establishing shared incentives is necessary. It is important that the contract creates a win-win situation for both parties by sharing the benefits arising from the collaboration.

Customers in Albertslund are rewarded for efficient energy consumption through a motivation tariff in the pricing structure, thus creating shared incentives for improved system efficiency.

Shared incentives are also manifested in the contracts between the greater DH network (VEKS) and Albertslund through a motivational tariff to incentivize low return temperature. Shared incentives could be applied in a similar manor in the demo site in Mölndal between Husvärden and Mölndal Energi, where the demo is connected to the return pipe of the conventional network. The EPC in La Seyne-sur-Mer has created a shared incentive for efficient energy use and a retribution for the energy the customer injects in the DHC network used to balance its temperature. A similar retribution can be applied for all sites where cooling is supplied to customer as heat is simultaneously injected into the network.

Aligning the incentives in the Helsingborg case is important due to the different perspectives of the energy company and the housing company. The aim of the collaboration for Öresundskraft (the energy company) is to increase the efficiency of the DH system and for Tornet (the housing company) to gain economically from letting Öresundskraft charge their borehole. The incentive is that Tornet gets the cheapest possible DH price whenever it consumes heat.

7. Termination of heat recovery

Apart from managing the previous factors, contracts between the owner of the energy source and the energy company must in general consider the potential termination of the heat recovery. The heat recovery could end either because the source itself seized to exist due to termination of the business that generates heat, or because the collaboration concerning the heat extraction is terminated.

The risk of heat recovery termination is lower in the cases where the heat/energy source is stable and does not depend on a business process, which is the case in La Seyne-Sur-Mer, Gardanne, Balilla, Heerlen and Topusko. In all these sites, the source of energy is either the ocean,

groundwater, or geothermal energy (including the mineshafts). However, a stable relationship between partners and collaboration on the energy recovery must still be maintained to ensure a long lifetime of the installations. The municipality is either a part owner or a full owner in the cases of Heerlen and Gardanne, which is one way to strengthen the relationship: by creating interorganizational links between the parties involved. In Gadio, ACS and Unareti are part of the same group, implying their efficient collaboration and decreasing the risk of the termination of heat recovery.

The risk of termination of heat recovery could also be managed by creating redundancy in the distribution network, for example by connecting the low temperature network to the conventional DH grid. Four of the demo sites, Albertslund, Gadio, Mölndal, Helsingborg and Szczecin include a solution where the conventional grid is part of the layout. The demo site in Szczecin will also obtain improved redundancy once more prosumers are connected to the grid.

5.5.1 Ownership structure

The ownership layout could reduce the complexity of the heat exchange by reducing the number of actors involved with the processes and could in contrast increase the complexity when more parties are involved.

Although the heat extraction and distribution processes are simplified when one actor owns most of the assets including the heat source, the ownership structure in low temperature DH is often the opposite. The more decentralized nature of low temperature DH inherently makes more actors necessary to exploit the potential of the heat sources. While this may complicate contract negotiations, the energy company of the constellation could still strive to own as much as possible of the equipment to allow for access and insight to the other actor's processes and improved system efficiency and control. Szczecin is one of the demo sites where this structure was implemented and having full ownership of the customer substation (and associated equipment) was crucial for the energy company to be able to circulate energy between buildings.

The demo site with the simplest ownership layout is Mölndal, where the housing company Husvärden initiated and installed a small, local grid where they have full control of the heat supply. They own the entire installation, including the buildings, and are therefore able to fully control and optimize their system. The only contracts required are with the tenants, who agree to be supplied with heat either in the space rental agreement or in a separate heating contract. In this shift of boundary, Husvärden takes on more risk but also more potential reward from system optimization and control. On the other hand, the layout where the heat price is included in the rental agreement creates less incentives for customers to change behavior to improve energy efficiency.

A similar shift in the boundary condition between the customer and the energy company is seen at sites such as Albertslund, Szczecin, and Milano, where the energy company takes on the ownership of equipment at the customer sites to improve performance, and La Seyne-Sur-Mer, that features an EPC with one of their customers. The boundary shift allows for customer to increase carefreeness of their heat supply, while the energy company gains from being able to optimize the system and increase the potential of connecting more customers.

Several of the demo sites benefit from having formed a public-private partnership with a local government such as a municipality or city council. In Gardanne, La Seyne-Sur-Mer and Szczecin, the cities have partial ownership of the installations and networks, which has improved the so-called *patience capital*, where an increased willingness to invest in objects with a longer payback period can be expected. For the same reason, the local government mitigates some of the risk associated with the low maturity of the installations and makes a stable partner. Partial or full

public ownership is prevalent also in Gadio, Balilla and Heerlen and helps reducing the risk that operation in those sites would fail.

5.5.2 Energy performance contracting as a starting point

Energy performance contracts were evaluated as a starting point for efficient contracts for increasing the level of services offered to customers. A suitability assessment was performed both from the perspective of the customer and from the DH company according to the criteria described in the method section. The assessments were then discussed with the demo sites.

In half of the demo sites, it was identified that EPC could be suitable to pursue, and in La Seyne-sur-Mer an EPC has been signed with the casino. In Gardanne it is an ambition of the DH company to offer EPC to suitable customers. In Balilla and Gadio EPC is a possible option to offer to the municipality the current maintenance contract expires. For Topusko it would be a large step to transition into an ESCO but possible in the long term. A possibility could be to offer ESCO services to the niche market of geothermal spa centers in the region. Topusko, Gadio, Balilla and Gardanne have older connected buildings that are publicly owned which is at first glance suitable for an EPC and establishing a baseline for the buildings together with the customer could be a first step.

Half of the demo sites were identified as suitable for EPC; one site has already pursued an EPC and the remaining four are interested to pursue it beyond the REWARDHeat project.

In Albertslund the customer segment is private building owners for whom an EPC is less suitable due to high complexity and long-term. Albertslund does not have the experience in the organization today and the transition would come with organizational barriers. In Heerlen the building associations could benefit from an ESCO offering them an EPC as energy is not their core business. The DH company has however decided not to develop the business in this direction. In Szczecin, all buildings are new and therefore the need to improve energy efficiency is low. Rather than EPC, Szczecin is interested in offering a comfort service agreement to its customers. For the two Swedish sites an EPC is not applicable. In Helsingborg the customer of the flexibility service is the conventional DH company in the city and in Mölndal the owner of the demo site network is also the building owner.

6 The generation shift conclusion

In the deliverable, business models for innovative DHC networks in Europe have been developed for the 10 demonstrations sites in the REWARDHeat project. The business models have been developed in an iterative process with the DH companies during the first three years of the project. Findings from the demo sites are examined to understand the business logic shift when transitioning from conventional DH to low temperature solutions. I.e., away from a logic of centralized and large-scale production and distribution towards a logic with multiple and distributed heat sources. For each demo site the following topics have been developed and assessed: Business model innovations, business model canvas, green value creation and exploitation, energy as a service, contractual considerations, and suitable ownerships. The findings enable the project to respond to the overarching research questions of the deliverable: *How does the REWARDHeat business model experiences differ from a conventional DH business model and what can we learn from the transition to low temperature DH solutions?*

The technical innovation is the primary focus of the demo sites while business innovation is progressing slower. Business innovations towards the customer occur in 7 of 10 sites at different levels of complexity and speed of implementation. All business innovations relate to an increase in services offered to the customer. DH development has traditionally been technically focused, but the technical shift towards low temperature can be done in tandem with an upgraded business logic: for maximized efficiency. It is not efficient to undertake technical innovation first and business model innovation later or possibly not at all (often the case as the high temperature business model is transposed to the low temperature business case and thereby eroding it).

The lack of EU legislation on waste heat recovery is causing uncertainties and adds risk to the potential investors in low temperature waste heat recovery. The uncertainty caused by the lack of classification of waste heat as a sustainable investment, or not is a hurdle effect to investors. In REWARDHeat, examples of national legislation being a barrier for innovation in low temperature schemes have been identified. This has led to sub-optimal solutions, and as a result an addition of risk.

All demo sites offer a green value to customer and the green value is valued by the project partners and other stakeholders. Energy company, cities, and often professional customers state that a green heat supply is valuable. In general, private customers are less willing to pay more for a greener heat supply, green is sometimes considered to be a cleanliness factor. Only three demo sites are capitalizing on the green value in their business model. One demo site by including green heat supply as part of the EPC revenue stream, and another by differentiating the price compared to other DHC networks. In the third case the customer is not made aware of the green value but benefits from a lower cost of heating. The remaining sites can still gain from a greener heat supply through an improved brand, but it does not impact the revenue stream. This indicates that more business model development is necessary to capitalize on the additional value creation deriving from the REWARDHeat concept. It should be possible for a district energy company to have a diversified heat portfolio where low temperature heat can be sold at a premium price because of its green aspect.

A climate-based motivation tariff was tested theoretically for one of the demo sites. The idea was to incentives customers to reduce their return temperature using both environmental and economic measures. The carbon emissions caused by an inefficient system was estimated using measurement data from the demo site and connected to different cost of carbon. Even with a very high cost of carbon from the scientific literature, much higher than EU-ETS today, the economic

incentive would not be enough to motivate investment even for a very inefficient building. The conclusion from that is that the damage cost of carbon is too low.

7 out of 10 demo sites are increasing the service offer to customers in the REWARDHeat projects. Offering more advanced service to customers necessitates a shift towards being more customer oriented. A service offered by DH companies is assuming ownership and maintenance of the substation at the customer site and thus shifting the boundary condition to inside the customers building. The service necessitates more dialogue and a deeper relationship with the customers, to build trust and to perform the service. Shifting the boundary condition creates a value of carefreeness for the customer as the DH company assumes more risk. The DH company gains from increased control of the network, something increasingly important in low temperature solutions. Because of the advantages in low temperature DH of increased control of the network components it is recommended to have an ownership structure where the DH company strives to own, or at least control, as much as possible of the equipment. Three demo sites are offering advanced services resulting in a co-dependent relationship with the customer where the collaboration requires integration of processes. These collaborations are characterized by a long term, close relationship and a win-win situation. In the future, it is likely that the boundary conditions will shift further in most district energy collaborations. If flexibility factors are to be captured it is important that energy company and customer jointly understand and see a value in identifying and harvesting flexibility gains.

As decentralized energy sources are introduced to the DH network the distribution network becomes more important and large-scale centralized production plants less important. The business logic of low temperature solutions is more on circulating available resources, utilizing the available flexibility in the distribution network, and implementing more advanced control to manage the system efficiently. The customer is not necessarily a heat sink in the network but often a prosumer. In conventional DH networks transitioning to low temperature, the conventional business logic (large scale production, push heat supply to customers) and low temperature business logic (decentralized, customer oriented) are likely to exist in parallel for some time. In the stand-alone smaller sized networks, being developed locally based on the available heat source (geothermal, sea water, waste heat) the low temperature business logic should develop from the start. REWARDHeat exhibits multiple examples of low temperature islands that have a connection to the conventional DH network. The connection to the conventional network mitigates operational risk, which can be beneficial to attract investors concerned about low maturity of the technical installation.

The main change in the business model canvas for low temperature installations in comparison to conventional DH is the necessity to manage relationships. Relationship building is required for new partnerships, due to multiple decentralized heat sources, and for the prosumer customer segment, instated from waste heat and renewable energy integration and from circulating heat and cool in the same network. The decentralized heat sources require a shift in boundary condition where the DH company includes the prosumers and heat suppliers in its processes. For collaborations to be successful in the long term it is necessary for the contract to include shared incentives, the establishment of a win-win situation, and measures to reduce asymmetric information between the partners. This, the relationship building, can prove an efficient strategy in a society where digitalization is increasing thereby de-personalizing many customer relationships.

By contrasting the REWARDHeat results to previous findings on business model changes when transitioning to low temperature DH in six studied networks, presented in Lygnerud (2019), we

identify that the business logic in REWARDHeat has shifted more toward being customer oriented and it seems an explanatory factor is increased servicification.

Lygnerud (2019) concluded that there was a limited change in the business model and that technical development was in focus. Whilst technical innovation is the focus also in the REWARDHeat demo sites, 7 out of 10 develop business innovation by increasing the service offered to customers. The service often results in the DH company having increased control of the network, something increasingly important in low temperature solutions. In Lygnerud (2019) the utility perspective was still applied, to push heat supply to customers rather than considering the customer perspective. In REWARDHeat the business models are more customer oriented, and relationship building, and partnership are key aspects. The REWARDHeat findings confirms Lygnerud (2019) that low temperature DH networks create a green value that is valued by most stakeholders. The green value was not exploited in the cases studied by Lygnerud (2019) but in REWARDHeat it is exploited by three demo sites. The prosumer was an important aspect in Lygnerud (2019) and required a new tailored customer relationship but for other customers the relationship did not change. REWARDHeat has the same conclusion for the prosumer customer but because of the increased level of service the relationship changes also with other customers and becomes closer. The engagement level of end-users was previously found to remain the same low level when transitioning to low temperature solutions. This is true also in the REWARDHeat demo sites, if anything the customer becomes less involved and more carefree of the heat supply because of the increased services. To sum up, it seems as if the business model innovations are more pronounced than in the cases studied in 2019. Possibly a result of work in tandem with technical and business model innovation in the REWARDHEAT project during the first three years of project life.

6.1 Key takeaways

To summarize the deliverable, main conclusions are drawn in regard to the five business perspectives studied in the REWARDHeat project: Innovation & development, Business model canvas, The green value, Servicification and Contracts & ownership.

First, on the note of Innovation & development it is concluded that low temperature waste heat recovery innovations can be performed at two levels in tandem: technical and business: which indicates an increasing maturity of the energy companies understanding of what low temperature district energy is. It is more efficient to develop technology and business at the same time than only technology and thereafter apply the conventional district energy business model (will erode the business case of low temperature). Further pace of the low temperature innovation would be gained with a clear waste heat policy in the EU28.

Second, regarding the business model development in particular, the key feature for low temperature heat recovery is that close customer relationships and dialogues are key. Collaboration and creation of win-win situations are the cornerstones of successfully recovering locally available low temperature waste heat.

Third, the green value is explicit in the low temperature waste heat investments. However, only three of the demonstrators have established a business model allowing them to capitalize on the value. It should be possible to offer a diversified heat supply to customers where those interested in locally available green heat supply are willing to pay a premium.

Fourth, energy as a service appears to be an efficient solution for low temperature heat recovery offers. 7 of 10 of the demo sites have engaged in energy services at different levels of complexity.

With increased levels of energy service offers the boundary conditions will shift: the district energy companies will need to go beyond substation and into the buildings and assets of customers to gain the control of the heat supply that is necessary for efficient recovery of low temperature waste heat and for harvesting other flexibility factors.

Last, in terms of contracts, low temperature waste heat source investments necessitate shared incentives and win-win solutions. Relevant ownership formats will depend on the heat source itself as well as on the optimum configuration to lower investment risk.

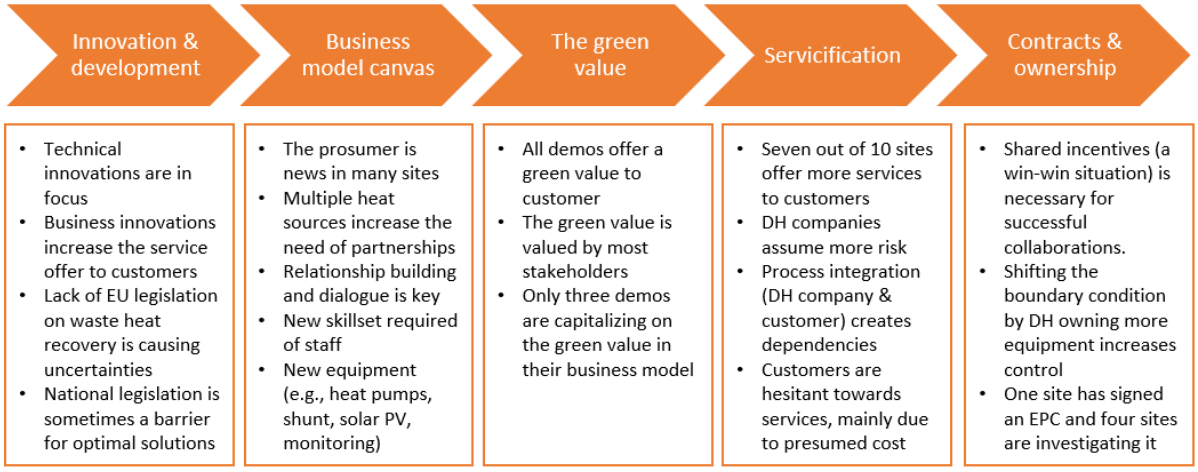


Figure 18: Key takeaways for each of the five main topics for business model development.

7 References

Bra Miljöval. (2021). "Bra Miljöval." Retrieved 2021-10-25, 2021, from https://www.bramiljoval.se/.
Brand, M. and S. Svendsen (2013). "Renewable-based low-temperature district heating for existing buildings in various stages of refurbishment." Energy 62: 311-319.
Connolly, D., H. Lund, B. V. Mathiesen, S. Werner, B. Möller, U. Persson, T. Boermans, D. Trier, P. A. Østergaard and S. Nielsen (2014). "Heat Roadmap Europe: Combining district heating with heat savings to decarbonise the EU energy system." Energy Policy 65: 475-489.
Coreynen, W. M., Paul; Von Bockhaven, Wouter (2017). "Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers." Industrial Marketing Management 60: 42-53.
Cozzini, M. B., Federico; Fedrizzi, Roberto; Buffa, Simone; Laurberg Jensen, Linn; Hussein, Ahmed (2018). FLEXYNETS Guide Book.
EuroStat. (2019, 2019-08-28). "Share of energy from renewable sources." 2020, from https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_ind_ren&lang=en.
Fleiter, T., R. Elsland, M. Rehfeldt, J. Steinbach, U. Reiter, G. Catenazzi, M. Jakob, R. Harmsen, C. Rutten, F. Dittmann, P. Riviére and P. Stabat (2017). Profiles and Baselines for heating and cooling energy demands in 2015 for EU28 countries.
Fransson, N. and K. Lygnerud (2021). Customers' perspective on REWARDHeat solutions.
Fransson, N., A. Sandvall, K. Karlsson, B. Unluturk, R. Andersson, J. Nilsson, D. Romanchenko, A. Övereng and C. Liptow (2021). REWARDHeat PESTLE Analysis.
Geyer, R., S. Werner, C. Engel, I. Best, H. Schrammel and K. Ponweiser (2021). ECONOMIC BENEFITS OF LOW-TEMPERATURE DISTRICT

HEATING. Low-Temperature District Heating Implementation Guidebook. K. Lygnerud and S. Werner, FRAUNHOFER VERLAG.
Göteborg Energi. (2021). "Fjärrvärmeavtal." Retrieved 2021-10-22, 2021, from https://www.goteborgenergi.se/foretag/fjarrvarme/fjarrvarmeavtal.
Göteborg energi. (2021). "Förnybar fjärrvärme Miljövärden för fjärrvärme." Retrieved 2021-10-25, 2021, from https://www.goteborgenergi.se/foretag/fjarrvarme/miljovarden.
Hansson, E. L., Anna (2019). Tjänsteutveckling på värmemarknaden.
Hägg, J. and r. Lagerfelt (2012). Energy Performance Contracting - -En kvalitativ jämförelse mellan kommunala EPC-projekt, Sektionen för ekonomi och teknik.
IEA (2018). Energy Service Companies (ESCOs).
IVL Swedish Environmental Research Institute (2019). D2.3 – Macro-market analysis, value chain and conceptual business models.
Kralmark, S. O., Klara. (2019). "Business plan for Lund." from http://www.cooldh.eu/district-heating/business-plan-for-lund/.
Lund, H., B. Möller, B. V. Mathiesen and A. Dyrelund (2010). "The role of district heating in future renewable energy systems." Energy 35: 1381-1390.
Lygnerud, K. (2019). "Business Model Changes in District Heating: The Impact of the Technology Shift from the Third to the Fourth Generation." Energies 12(9).
Lygnerud, k. and H. Averfalk (2021). Competitiveness of low-temperature district heating. Low-temperature district heating implementation guidebook. K. Lygnerud and S. Werner, FRAUNHOFER VERLAG.
Lygnerud, K., S. Nielsen, U. Persson, H. Wynn, E. Wheatcroft, J. Antolin-Gutierrez, D. Leonte, O. Rosebrock, K. Ochsner, C. Keim, P. Perez-Granados, D. Romanchenko, S. Langer and M. Ljung (2022). Handbook for increased recovery of urban excess heat, ReUseHeat Project, Grant Agreement 767429, European Commission.

Lygnerud, K., S. Nielsen, U. Persson, H. Wynn, E. Wheatcroft, J. Antolin-Gutierrez, D. Leonte, O. Rosebrock, K. Ochsner, C. Keim, P. Perez-Granados, D. Romanchenko, S. Langer and M. Ljung (2022). Handbook for increased recovery of

urban excess heat.
Lygnerud, K., J. Ottosson, J. Kensby and L. Johansson (2021). "Business models combining heat pumps and district heating in buildings generate cost and emission savings." Energy 234: 121202.
Lygnerud, K. W., Ed; Wynn, Henry (2019). "Contracts, Business Models and Barriers to Investing in Low Temperature District Heating Projects." Applied Sciences 9.
Moles-Grueso, S., P. Bertoldi and B. Boza-Kiss (2021). Energy Performance Contracting in the Public Sector of the EU – 2020. Luxembourg.
Münster, M., P. E. Morthorst, H. V. Larsen, L. BREGNBÆK, J. Werling, H. H. Lindboe and H. Ravn (2012). "The role of district heating in the future Danish energy system." Energy 48: 47-55.
Ostewalder, A. P., Y (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. New Jersey, Wiley.
Ottosson, J. J., Linnea; Kensby, Johan; Lygnerud, Kristina; Nilsson, Johanna; Nilsson, Anna (2020). Business models for combining district heating and heat pumps in buildings.
Rezaie, B. and M. A. Rosen (2012). "District heating and cooling: Review of technology and potential enhancements." Applied Energy 93: 2-10.
Schmidt, D., A. Kallert, M. Blesl, S. Svendsen, H. Li, N. Nord and K. Sipilä (2017). "Low Temperature District Heating for Future Energy Systems." Energy Procedia 116: 26-38.
Schroten, A. and d. B. Sander (2019). Handbook on the external costs of transport.
Schucht, S., E. Real, L. Létinois, A. Colette, M. Holland, J. V. Spadaro, L. Opie, R. Brook, L. Garland and M. Gibbs (2020). Costs of air pollution from European industrial facilities 2008–2017. Eionet Report - ETC/ATNI 2020/4.
Sernhed, K. and J. Jeppesen (2009). Från bulkleverantör till energipartner - en kartläggning av energitjänster i svenska fjärrvärmeföretag.
Smulders, E. N., Sofie; Kessels, Kris; Vanschoenwinkel, Janka (2019). D6.2: Economic assessment of business models for DHC networks operators.
Sunko, R. S., Blaž; Rutz, Dominik; Mergner Rita; Doczekal, Christian; Pukšec, Tomislav; Laurberg Jensen, Linn; Redžić, Elma; Gjorgievski, Vladimir; Batas Bjelic, Ilija (2017). D5.1 Guidelines on improved business models and financing schemes of small renewable heating and cooling grids.
The Australasian Energy Performance Contracting Association (2000). A Best Practice Guide to Energy Performance Contracts.
Trier, D. K., Magdalena; Paardekooper, Susana; Volt, Jonathan; De Groote,, A. P. Maarten ; Krasatsenka, Dana ; Beletti, Vincenzo; Nowak, Thomas; and C. S. Rothballer, George ; Terenzi, Alberto ; Mathiesen, Brian Vad, (2018). Business Cases and Business Strategies to Encourage Market Uptake: Addressing Barriers for the Market

Uptake of Recommended Heating and Cooling Solutions - Heat Roadmap Europe 4.
Wheatcroft, E., H. Wynn, K. Lygnerud, G. Bonvicini and D. Leonte (2020). "The Role of Low Temperature Waste Heat Recovery in Achieving 2050 Goals: A Policy Positioning Paper." Energies 13(8): 2107.
Wynn, H. W., Edward; Lygnerud, Kristina (2019). D2.3 Efficient Contractual Forms and Business Models for Urban Waste Heat Recovery.

8 Annex

8.1 Knowledge transfer meetings

To further enhance the development of innovative aspects in the business models at the demonstrators, six-monthly knowledge transfer meetings were held with on a voluntary basis with interested demo sites in 2021 and 2022. The meetings have been a platform for the demonstrators to discuss and compare issues and findings and to learn and gain inspiration from each other. Development and findings from the different demonstrators were shared and supplemented by IVL, as moderator of the meetings, with knowledge from other projects on low temperature DH NETWORK business models.

Topics that have been discussed in the knowledge transfer meetings include business model challenges at the demo sites (described below), aspects of pricing, EPC, flexibility in production and storage, connection to the power grid and electricity market, flexibility markets, impact of building regulation, cost of CO2, contractual aspects for waste heat, risk, and shift in boundary condition.

At the demo site in Albertslund it was identified that a particular focus for them was to learn more about motivational tariffs, especially to incentivize customers to increase delta T. A climate-based motivational tariff was developed by IVL together with Albertslund and is described more in 8.3 Albertslund: climate-based motivational tariff. Albertslund was further interested to learn about increased service and shifting the boundary conditions as they are increasingly assuming ownership of substations in the customer building.

In La Seyne-sur-Mer, DALKIA have signed an EPC with a customer. The sharing of risk with the customer and how much to efficiently include in a contract has been a desired leaning in the project. Beyond the project, DALKIA want to develop the business model to offer beyond-energy services.

In month 24 of the project, it was identified that Gardanne and the Swedish sites have similar interests. Both sites want to understand how to optimize the use of energy storages. In Sweden the demo sites have boreholes and in Gardanne a mineshaft. The demo sites are interested to learn how efficient it is to overcharge the borehole storages and how much excess energy can be efficiently stored. For both sites these questions are in relation to the amount of excess heat available in the summer that would be of interest to store to the heating season. Further, there is a shared interest to understand how efficient low temperature systems on renewables can be, the highest energy efficiency achievable is assumed to be 70% in the French sites. Furthermore, in both countries smart control for increased flexibility is a relevant topic and something that remains to understand better as well as the value of different flexibility measures.

The Swedish demo sites were further interested to discuss the impacts of building regulations on the business model and flexibility market (connection to the electrical grid).

For the Italian demo sites the increased level of service and the related shift in boundary condition when taking over ownership of substations and HPs at the customers site has been a development. The pricing component was another topic of interest in discussions. ACS is of the understanding that customers require that the new low temperature DH solutions must be cheaper than alternatives, possibly by 5-10%, and they were interested to learn more about low temperature DH schemes. It was later decided that the pricing structure for the two demo networks would remain the same as for the rest of the DH networks in Milan.

In Heerlen, the demo site wanted to learn more about how the investment decisions could be impacted by shifting the boundary condition and the associated levels of risk. The demo later decided to discontinue advanced services to customers because the associated risk was deemed too high.

The demonstration in Szczecin is the first low temperature DH network in Poland and SEC have been interested in learning more on possibilities for implementing low temperature schemes in the business model, also in relation to integration of waste heat.

Topusko have been interested to learn about both motivational tariffs (engaging customers to save energy) and how to implement low temperature schemes.

Table 33: Summary of desired learnings for business model development.

Demo site	Business model development and desired learnings
Denmark- Albertslund	Impact when shifting the boundary condition Climate-based motivational tariff to reduce return temperature
France- La Seyne-sur-Mer	Identify flexibility values and pricing structure EPC: Develop an efficient service offer (transfer of risk)
France- Gardanne	Same as for La Seyne-sur-Mer. Integration of RE (solar) at customers site
Italy- Milan – Balilla	Increased level of service offered to customer and shift in boundary condition.
Italy- Milan – Gadio	Same as for Balilla.
Sweden- Helsingborg	Identify flexibility values, especially in relation to energy storage, and pricing structure for flexibility (flexibility markets).
Sweden- Mölndal	Same as for Helsingborg
Netherlands- Heerlen	Boundary conditions impact on investment decisions and business-related risks
Poland- Szczecin	Implement low temperature schemes
Croatia- Topusko	Implement low temperature schemes Motivational tariffs (engaging customers to save energy)

8.2 Service: Packages solutions offered by Swedish district heating companies to private and professional customers

Examples of services offered by Swedish DH companies were mapped for the 10 Swedish DH companies supplying DH to grids with largest population and data is collected from the respective DH companies' webpage. Service packages including service at level 2 or 3 in the servicification triangle marketed to customers (business and private) by Swedish DH companies was included. The analysis identified that DH companies often have different package offers to customers

corresponding to different levels of service to provide customers with a suitable option depending on how much responsibility customers want to take on themselves. The range of service offers available differs for business and private customers were businesses have more options. There are still many other energy services that could be offered to customers that are not being marketed today. For example: energy efficiency (performing measures to improve energy efficiency), performance contracts (for example energy performance contract), direct load control (increase or reduction of loads at customers facility to improve energy efficiency in the system), energy service agreements (where the company takes over ownership of the substation during the contract period and performs all maintenance.

For business customers the companies are typically marketing three different service packages (some have four and some only one), often with the possibility to alter the package to better suit the needs of the customer. All companies have a package that includes only supervision/predictive maintenance (Step 0). This means that personnel from the DH company performs maintenance on the substation 1-4 times per year. Some companies include (or offer the possibility to include) maintenance of the entire heating system and technical installations for ventilation, cooling, electricity, water, sewage.

In Step 1 monitoring is in place (sometimes in combination with optimization based on at least outdoor temperature) but it is still the customers responsibility to act if a fault is detected. Some companies send out automated advice notifications when a fault is detected. In Step 2 the DH company takes on more responsibility for monitoring and will act on alarms creating a more carefree offer to the customers. Some packages have emergency support and materials included but most often it is billed separately at a discounted price at this service level. Optimization in Step 2 sometimes include the installation of sensors in the buildings to optimize the system using also indoor temperature. This also increases the customer in the building. In Step 3 the DH company is responsible for everything, and everything is included. Heat is no longer sold as a commodity but as the service “indoor temperature”, typically the pricing model is based on a fixed price per sqm and year. In one case also the reinvestment in a new substation is included.

In addition to the service packages, where the focus is on supervision/maintenance, some companies offer digital energy services only. Three of the 10 analyzed companies offer a heat optimization service where sensors are installed, and the measurements included in the optimization algorithm for the heating system. This also provides the customer with more control by being able to change settings in different sections/rooms of the building and a higher level of comfort. Two companies provide monitoring only as a service for fault detection. It is however the customers responsibility to act on the alarm.

Communication between the DH company and the business customer increases with a higher level of service. In the basic service the customer typically can ask questions and discuss with DH personnel while they are performing the supervision/maintenance and afterwards a report is sent to the customer stating some or all of the following: the work carried out, energy report and/or proposals for improvements and reinvestments. Already at the basic level it is highlighted that the customer can always call for support if a fault is detected or an emergency occur to receive prioritized assistance (at an additional, but discounted, cost). Access to some sort of digital interphase (app, webpage) where the customer can see energy usage and analyze is sometimes included at this stage, otherwise it appears in Step 1 together with monitoring function. In Step 2 or 3 when sensors are installed the digital interphase also includes functions to control. Operational meetings and a dedicated contact person at the DH company is included by some companies from Step 1 but more often introduced at Step 2 or 3.

Table 34: Service packages offered to business customers by Swedish DH companies

Business customers	Step 0	Step 1	Step 2	Step 3	Extra	Extra
What is included	Basic service	Customer responsible	Shared responsibility	DH company responsible	Heat optimization only	Monitoring only
Optimization (sensors/indoor temp)			sometimes	x	x	
Optimization (outdoor temp)		sometimes	sometimes	x	x	
Monitoring		x	x	x		X
Supervision/Predictive maintenance	x	x	x	x		
Customers manage alarms		x		x		X
DH company manages alarms			x	x		
Emergency support included			sometimes	x		
Indoor temperature guaranteed				x		
Reinvestments included				sometimes		
Company:						
Göteborg energi	x	x		x		
Stockholm Exergi	x		x		x	X
Kraftringen	x	x	x	x		
Mälarenergi	x	x	x			
E.ON Värme	xx		x		x	
Vattenfall Värme	x				x	
Tekniska verken i Linköping	x					
Öresundskraft	x		x			
Umeå Energi	x					
Jönköping energi	x	x		xx		

Private customers are not able to receive as high level of service as business customers. The offers include supervision/predictive maintenance of the DH equipment once a year down to once every third year and sometimes materials are included. Fault detection is the responsibility of the customer and emergency support is available but only included in two offers (one of which only during office hours). For emergency support, reparations and spare parts are available at a discounted price for private customers with a service offer. Heat optimization service by installation of sensors is offered to private customers by three companies. Communication between the DH company and private customers is the same as Step 0 for business customers, including the possibility to ask questions while personnel are performing maintenance and a report afterwards.

Table 35: Service packages offered to private customers by Swedish DH companies

Private customers	Step 0	Other
What is included:	Basic service	Heat optimization only
Optimization (sensors/indoor temp)		x
Optimization (outdoor temp)		x
Supervision/Predictive maintenance	x	
Company:		
Göteborg energi	x	x

Stockholm Exergi		
Kraftringen	x	
Mälarenergi	xxx	
E.ON Värme	x	
Vattenfall Värme	x	x
Tekniska verken i Linköping	x	
Öresundskraft	x	
Umeå Energi	xx	x
Jönköping energi	x	

Only one of the studied companies (Göteborg energi) offers different possibilities for ownership models of the DH technical equipment and the control system. Business customers are offered the possibility of customer-ownership, shared-ownership, or DH company-ownership. Private customers are offered customer-ownership or DH company-ownership. On their website Göteborg Energi states that it is more common for business customers to have a solution with shared ownership or DH company-ownership (Göteborg Energi 2021).

Table 36: Different ownership models offered to business and private customers by Swedish DH company

Target customers	Businesses	Businesses	Businesses	Private	Private
Ownership offer:	FV21	FV22	FV30	Own	Rent
Customers owns substation			x	x	
Customer owns control system		X	x	x	
DH provider owns substation	x	X			x
DH provider owns control system	x				x

A study performed among Swedish DH companies from 2009 identified that 61% of companies offer a service agreement and that on average 36% of customers have signed up to the service. The deviation was however large, from 0-100% between different companies (Sernhed and Jeppesen 2009). Sernhed and Jeppesen (2009) further identified that 21% of companies have a service offer where the company takes over ownership of the substation during the contract period and performs all maintenance and optimizes to achieve better energy efficiency. The DH company takes on a larger responsibility with this kind of contract but also shares in on the cost savings. Large companies that apart from DH also deliver, for example, electricity or IT, are more active in supplying energy services. Sernhed and Jeppesen (2009) further identified that of the 84 responding DH companies in Sweden, 25% have offers for improving energy efficiency at customers facilities. Most have offers towards the industry, tertiary, and multi-family customer segment. Single houses are less represented. Only four of the responding companies stated that they offered energy efficiency services as an EPC.

8.3 Albertslund: climate-based motivational tariff

The demo site in Albertslund were interested to develop a new motivational tariff to encourage customers to improve the efficiency in their heating system and thus increase the delta T. There is a motivational tariff in place today, but few customers act on it and receive the reward. It was

therefore decided that IVL together with Albertslund would develop a climate-based motivational tariff as another way of incentivizing customers by also providing an environmental incentive, in combination with an economical. Poor cooling decreases the efficiency of the network and the decrease in efficiency can be associated with an amount of CO_2. The CO_2 amount along with an associated cost of CO_2 was suggested to be displayed to the customers. The new motivational tariff would apply to all customers in the network.

- Background

About 10% of customers in the network (and increasing) are renting their equipment and they are not penalized if they have poor cooling. Removing the penalty has been used by Albertslund to nudge customer to rent equipment rather than owning. The offer is extended to customers at the point of reinvesting in the current substation. Albertslund initially thought that customers renting the equipment would have a newer heating system overall in the building (e.g., new radiators) but based on measurements they now know that some customers need to improve their overall heating system to avoid impacting the whole network negatively. Information campaigns have been targeted at customers with high return temperature but without any measurable improvement. Further, from a fairness point of view it is not wishful to have some customers being penalized for poor cooling and others not. Albertslund want to make the pricing fairer between customers owning versus renting equipment.

Poor cooling in customers heating system impacts the efficiency in the whole network. High return temperature at the customer results in increased flow (i.e., energy in pumps), increased heat losses in pipes and lower efficiency in production units (heat pumps, boilers, CHP, flue gas condensor). No data was available on exactly how return temperature impacts the DH network in Albertslund. Estimations were made based on other network to calculate how much heat losses in kWh were caused by poor delta T and this number was multiplied by three (for extra pump electricity and efficiency loss in CHP) to get the total energy cause by suboptimal heating system and then the related co2-emissions and cost were calculated. This way it will be tangible for customers to see how much CO_2 emissions arise in the system due to their inefficient heating systems. The CO_2 emissions are then connected to a suitable cost to incentive customers both from an environmental and economic perspective.

- CO_2-emissions

Historic and real time data over CO_2-emissions to produce DH is available on varmelast.dk in hourly resolution. Historic data for 2021 is visualized in Figure 19 (varmelast.dk/own calculation). CO_2-emissions at varmelast.dk include electricity for heat pumps, electricity to transport heat in the network as well as fuels used in heat production. Emissions for CO_2 from electricity are yearly average emission factors from the previous year.

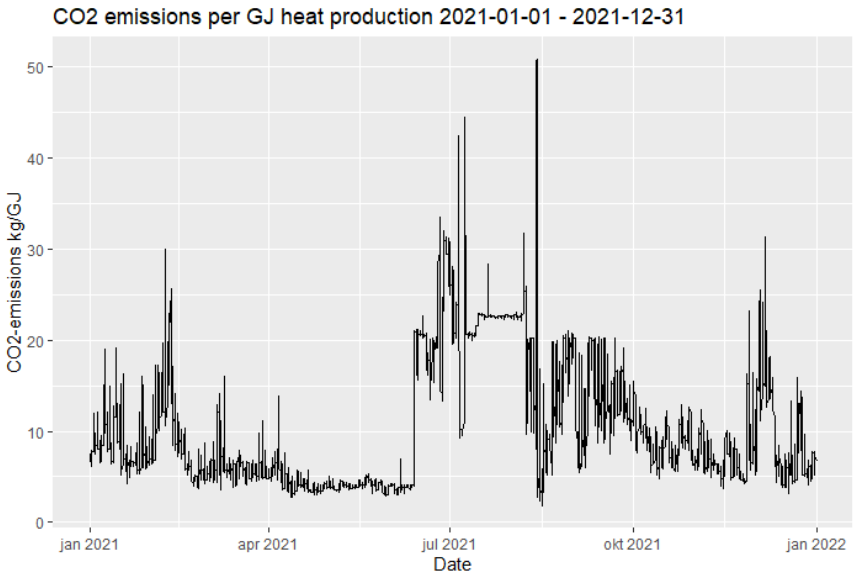


Figure 19: Albertslund - CO_2-emissions in kg/GJ heat production in the network.

- Cost of carbon

Appropriate pricing of CO_2 is key to develop a relevant climate-based motivational tariff. Damage cost approach and avoidance cost approach are the two main approaches to estimating a monetary cost associated with climate change. Damage costs assumes that no efforts are taken to reduce climate change and calculates the values of each individual physical climate effect and sums the values together. The avoidance cost approach assesses the marginal cost of achieving an emissions target for example 2 °C of global warming, corresponding to 450 ppm $CO_{2\text{-eq}}$. In Schroten and Sander (2019) the avoidance approach is recommended. Recent literature on avoidance cost was reviewed and low, central, and high values per ton $CO_{2\text{-eq}}$ were derived for both a short-to-medium term (to 2030) and for long run costs (2040-2060). Schroten and Sander (2019) use the central value for the short-to-medium run. These values are also used in Schucht, Real et al. (2020). Table 37 provides some examples of CO_2-prices, including the EU-ETS.

Table 37: Albertslund - Examples of CO2-prices

Source	Low	Central	High
Schroten and Sander (2019) – short and medium term (to 2030)	€63/t	€105/t	€199/t
Schroten and Sander (2019) – long term (2040-2060)	€164/t	€283/t	€523/t
EU carbon permit in EU-ETS (October 2021)	€60/t		

To enable predictability of a climate-based motivational tariff a linear increase of the CO_2-price is preferred by Albertslund. A suggestion could be to start at the central value for short-to-medium

term (€105) and linearly increase to the high value for the long-term (€523). A linearly increasing cost was preferred as opposed to selecting a single value or following the EU-ETS system which would be unpredictable for customers. Over time the linearly increasing CO_2-price could be compared against the EU-ETS and more recent literature to review if the values are still relevant.

- Examples of a climate-based motivational tariff

To exemplify the climate-based motivational tariff, calculations were performed using measurement data from 2021 for three buildings in the Porsager area and CO_2-emissions data available on varmelast.dk. The calculations are only supposed to provide an initial understanding of the yearly tariff for different customer groups through the selection of CO_2-price. The three building represent a house with good energy performance data, one with bad performance and one with medium performance.

Two different approaches for calculating the CO_2-cost were tried: hourly resolution and monthly average. First hourly resolution of CO_2-emissions and energy wasted was tried and then compared with total energy wasted per month and average CO_2-emissions that month. It was identified that the difference between the two approaches was less than 5% on the result per month. Hourly resolution would provide a more accurate representation of the CO_2-emissions but would require a more advanced system to implement and it was thought that it would be more difficult to explain and to be transparent to customers. It was therefore agreed that the climate-based motivational tariff should be in monthly resolution calculated using the average CO_2 emissions each month.

Table 38 displays the heat losses and the related CO_2-emissions and CO_2-cost arising due to heat losses caused by poor cooling for a good, medium, and bad performing building. A medium performing building would need to pay 2.6 times more than a good performing building and a bad performing building would pay seven times more than a good performing building. The total CO_2-cost due to poor cooling (including heat losses, additional energy in pumps and decreased efficiency in production plants) estimated in Figure 20. Table 38 shows the monthly values of total energy spent, calculated heat losses to due poor cooling and the kg CO_2 arising due to the additional heat losses. The kg CO_2 are then connected to a cost using a lower CO_2 price at €106/ton and €523/ton as the high value. The green fields represent the good building, orange the medium building and red field represents the building with bad performance. Heat losses due to poor cooling was calculated assuming 0.6% additional losses per each degree non-optimal return temperature and average network losses of 20%.

Table 38: Albertslund – Emissions caused by poor cooling at the customer site.

	Total energy [kWh]	Heat losses due to poor cooling [kWh]	kg CO2	CO_2 cost low	CO_2 cost high	CO_2 cost low	CO_2 cost high	CO_2 cost low	CO_2 cost high
January	2759	49.4	1.6	0.2	0.8	0.4	1.8	0.7	3.5
February	2610	29.5	1.0	0.1	0.5	0.3	1.5	0.7	3.3
March	2094	24.8	0.5	0.1	0.3	0.2	0.8	0.5	2.2
April	1435	24.7	0.4	0.0	0.2	0.1	0.6	0.3	1.6
May	857	15.3	0.2	0.0	0.1	0.1	0.3	0.2	1.0

June	356	12.6	0.6	0.1	0.3	0.1	0.7	0.6	3.0
July	247	9.6	0.8	0.1	0.4	0.2	1.1	0.9	4.5
August	316	11.1	0.7	0.1	0.4	0.2	0.9	0.7	3.5
September	305	11.1	0.6	0.1	0.3	0.2	1.2	0.6	2.9
October	843	20.7	0.7	0.1	0.4	0.2	0.9	0.4	1.9
November	1525	28.9	0.7	0.1	0.4	0.2	1.2	0.6	2.8
December	2301	47.6	1.7	0.2	0.9	0.4	2.0	0.9	4.6
Total	15648	285.3	9.5	1.0	5.0	2.6	13.0	7.0	34.7

Table 38 only includes the CO_2-emissions, and related cost, arising from unnecessary heat losses. Assuming the energy from additional electricity use in pumps due to additional flow of water and efficiency reductions in the central CHP plant are of similar sizes the cost in Table 38 are multiplied by three and displayed in Figure 20. Even when using a high CO_2 cost, according to scientific literature, the yearly climate-based motivational cost for a building with poor cooling would be around €100. The cost is calculated using two different costs of carbon: €106 and €523.

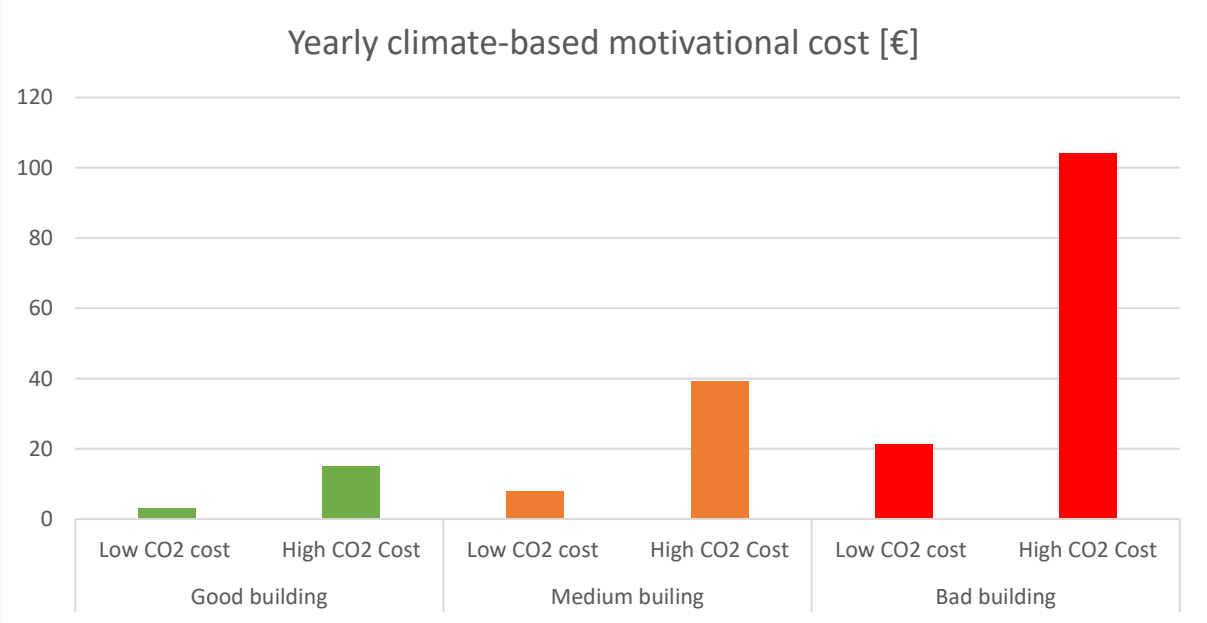


Figure 20: Albertslund - Yearly climate-based motivational cost for different buildings.

- Concluding remarks

Even when using a high CO_2 cost, according to scientific literature, the yearly climate-based motivational cost for a building with poor cooling would be around €100. The additional energy required in the network due to a single building having poor cooling is low, and the DH network in Albertslund have a production mix with low CO_2-emissions. To provide economic incentive for customers to invest resources to improve the heating system in a building the CO_2 price would need to be set higher than the social cost of CO_2 identified in literature. If progressing to implement the climate-based motivational tariff Albertslund should choose a CO_2 price that results in a yearly

amount that provides economic incentive. It is estimated that a poor performing building causes seven times more CO_2-emissions due to poor delta T compared to a building with a good delta T.

The calculations made are rough estimated of the impact of poor delta T in the DH network in Albertslund. To make the CO_2-emissions calculations more just and transparent Albertslund could simulate the impact on their network.

8.4 Helsingborg: The modular model for increased scalability

The business set-up between Tornet (building owner and owner of the boreholes) and Öresundskraft (DH provider) is providing value to both partners. Öresundskraft can utilize the boreholes to charge when it is beneficial for them and Tornet receives the lowest price on heat. The solutions should be possible to implement in additional sites. The modular offer is the flexibility offered through a borehole that is equipped with smart technology optimizing its discharge and charge in relation to the DH network. The borehole solution can be offered turnkey, and costs can be assumed by either district energy company, building company, jointly or by a third-party investor. With a modular offer, the DH company is involved already at the stage of constructing a new building quarter and ensures boreholes are integrated at the site. The DH company is preferably the owner and operator of the borehole storage even though the most important aspects is that the DH company has command of the boreholes to optimize their usage, regardless of ownership.

The set-up in the demo in Helsingborg today, where Tornet owns and operates the storage, comes with the risk of Tornet refusing to assume heat when proposed by the DH company. With this single borehole storage in the network, the implication for the DH company is small but if multiple distributed storages were integrated in the system this would pose a risk. By being the owner and operator of the thermal storages, the DH company removes this risk.

A possibility arising for the DH company with having multiple energy storage located in the network is to operate the CHP plant according to electricity demand instead of heat demand as is conventional today. The outlet for excess heat produced would be to inject into the storages and producing according to electricity demand could increase the revenue streams.

The main value creation from this business set-up is lower cost for the building owner and increased flexibility for the DH company.

8.5 Input from D3.1 and D3.2

8.5.1 Denmark

D3.1 PESTLE input: Denmark

Important for business model development:

- Establish a clear value proposition against alternative heat supply options
- Develop a fair pricing structure for the division of system cost among customers
- The value of increased efficiency (reduce cost of system) is transferred to customers as DH is non-profit

DH is non-profit in Denmark and even though there is no direct support available investment capital is accessible through the KommuneKredit. As the DH market in non-competitive, knowledge-sharing is enabled providing good opportunities for faster spread of replication and standardization of solutions. DH is well-established in Denmark and people are generally positive. The awareness of the technology (especially low temperature systems), both among politicians and customers, poses a hinderance. Financial support encouraging individual HPs is affecting the competitiveness of DH. Storytelling for DH and the benefits in a system perspective is more difficult to communicate than individual HP solutions and RE (Fransson, Sandvall et al. 2021).

D3.2 input on the customers' perspective

Important for business model development:

- Customers in Albertslund demonstration are willing to pay more for a greener heat supply (more so than other demo sites), at least by a few percentages
- Customers want an incentive-based pricing scheme
- Most customers are hesitant towards increased service

All respondents want to be able to impact the cost (for examples by incentive-based pricing). All but one respondent would be WTP more for a greener H&C system. End-users are WTP up to 6-10% more and professional customers a few percentages more than today (Fransson and Lygnerud 2021).

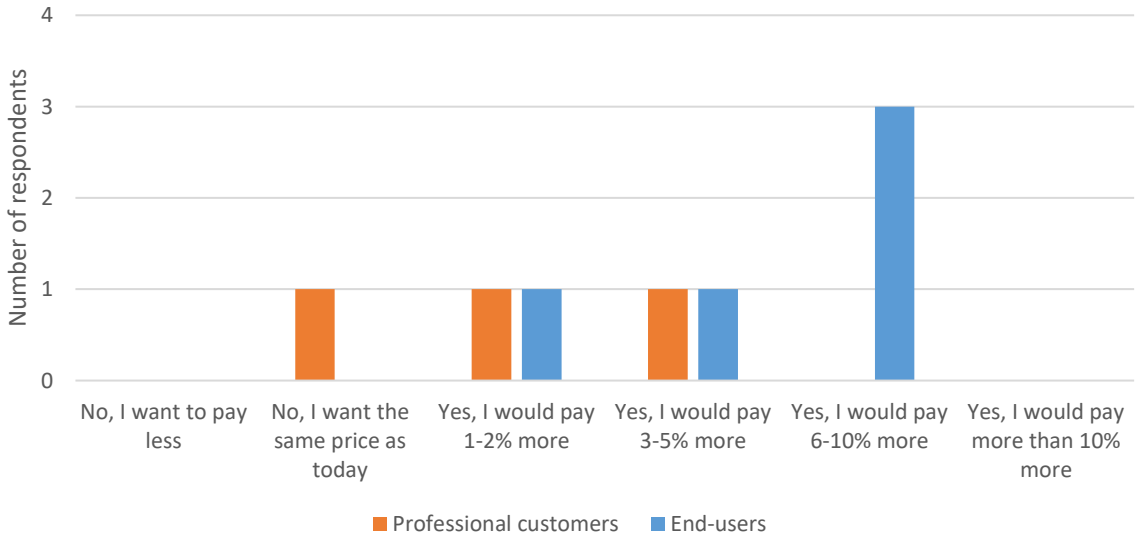


Figure 21: Denmark - Willingness to pay for a greener H&C supply

Respondents perceived benefits and risk towards a comfort service agreement (high level of servicification) can be seen in Table 39. Identified benefits are that it is easier to have increased service and that it would improve the indoor climate. Identified risks are that it lowers the incitement to perform energy efficiency measure, increases consumption and is more expensive.

Table 39: Denmark – Perceived risks and benefits toward a high level of servicification.

	Benefits	Risks
Professional customers	Easier cost distribution Better indoor climate	Lower incitement for energy efficiency measures Bound by contract None
End- users	No equipment risks Easier Better indoor climate Don't know	More expensive Increased consumption None Don't know

In Denmark respondents are in favor of receiving the space heating and/or cooling as a commodity and only two end-customer preferred to receive it as a service. Half of respondents want to manage the maintenance of the equipment themselves and the other half prefer that someone else takes care of maintenance (Figure 22).

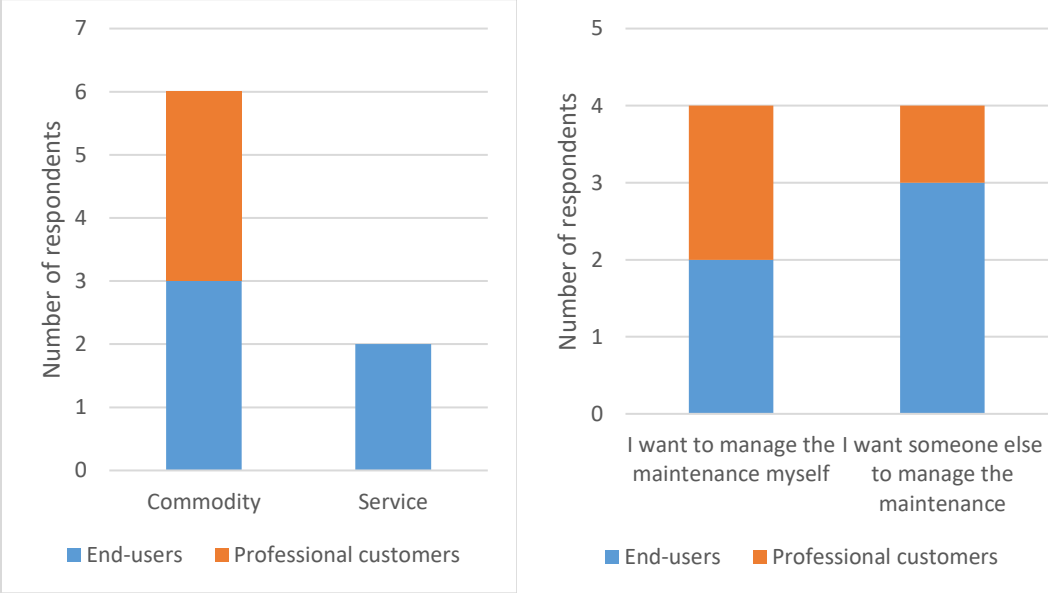


Figure 22: Denmark - Customers propension to H&C as a service (Left). Customers prefers for maintenance of H&C equipment (Right).

8.5.2 France

D3.1 PESTLE input: France

Important for business model development:

- Difficult for DH to compete with other heat supply option in price and it is therefore very important to have a clear value proposition to customers based on other values

- Different values are important to different customer segments, and this should be exploited in the business model
- The classification system is an opportunity, and the utility owner should ensure competitive pricing to buildings being renovated within the area to increase the heating base of the DH.

State-based financial support is available for both DH and DC and technologies such as the REWARDHeat solutions are encouraged in policies. Other heat supply options are often cheaper, and the main competition comes from electricity-based H&C. Customers are expecting the cost of H&C to be the same or reduced if transitioning to a low temperature DH but, the price is likely to increase, and it is a barrier that customers are not anticipating the price increase. DH is not so established in France, but the technology is mature and that spills over to low temperature DH and HP integration. The classification system states an area around a DH system where a building must connect if undergoing major energy renovations, but only if the price of DH is competitive (Fransson, Sandvall et al. 2021).

D3.2 input on the customers' perspective

Important for business model development:

- Most end-users state that they are willing to pay a few percentages more for a greener heat supply
- Customers are not so mature to increased service and it is perceived as more expensive.
- Taking over maintenance of H&C equipment could be a wanted first step.

60% of respondents want to be able to impact the cost (for examples by incentive-based pricing). All but one end-user would be WTP more for a greener H&C system with the peak at a WTP 3-5% more (Figure 23) (Fransson and Lygnerud 2021).

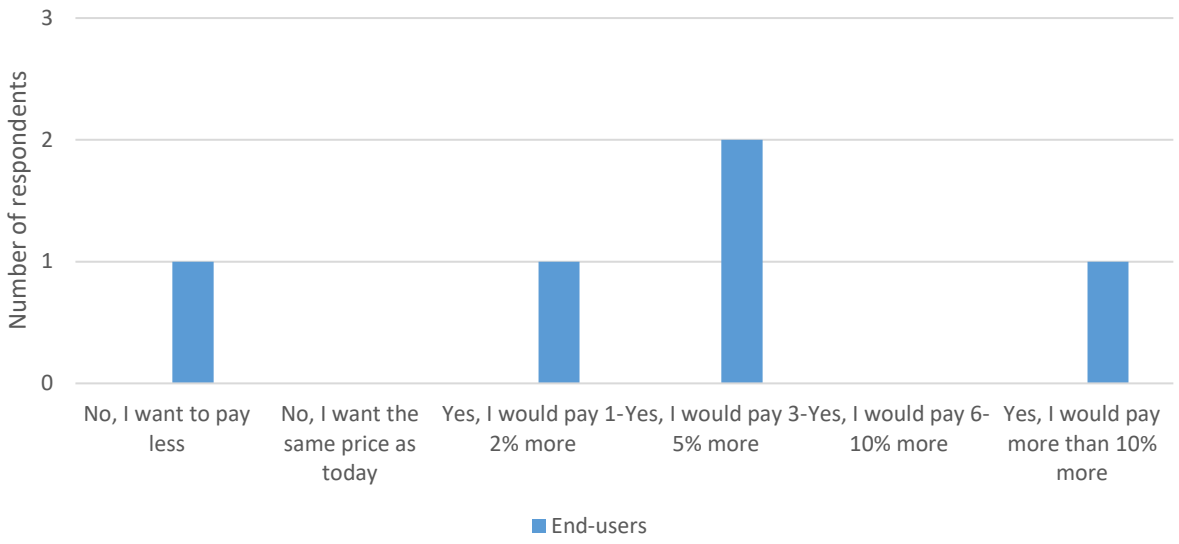


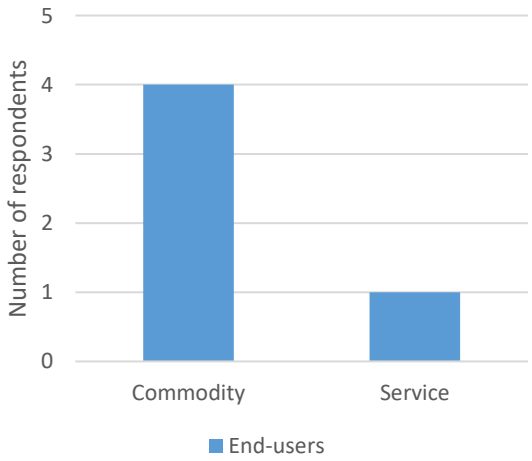
Figure 23: France - Willingness to pay for a greener H&C supply.

End-users in France see the main benefit of a comfort service agreement to be carefreeness and receiving the same comfort level. One end-user did not see any benefits. The main risk was the perception of this service being more expensive than the alternatives (Table 40).

Table 40: France - Perceived risks and benefits toward a high level of servicification.

	Benefits	Risks
End- users	Carefree/all-inclusive Same comfort level No benefits	More expensive Energy being wasted

Most end-users in France prefer to receive space heating and/or cooling as a commodity rather than as a service (Figure 24). That most customers think that increased service leads to a higher resulting cost could be a reason to prefer receiving space heating and/or cooling as a commodity. 80% of end-users prefer someone else to manage the maintenance of the H&C equipment.



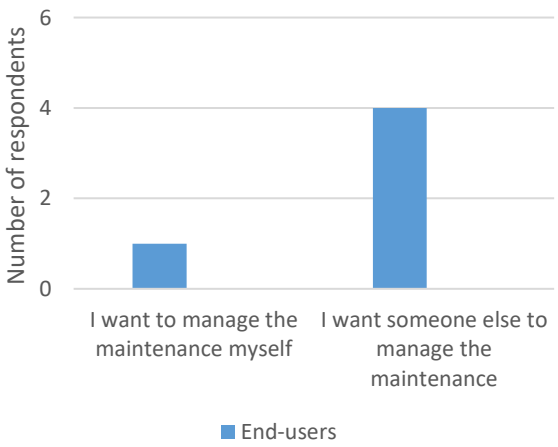


Figure 24: France - Customers propension to H&C as a service (Left). Customers prefers for maintenance of H&C equipment (Right).

8.5.3 Italy

D3.1 PESTLE input: Italy

Important for business model development:

- DH is competing with individual solutions for heating receiving state-based financial support.
- People and partnerships are important to realize DH in Italy.
- Establish a clear value proposition to all stakeholders, especially to the city and customers
- Low temperature DH should provide both heating & cooling to increase value and competitiveness against HPs

The state-based financial support is focused on building level and individual solutions on energy efficiency and renewable energy. Especially HPs are a fast-growing market. Tax incentives are available for DH networks with waste heat, solar and geothermal and the possibility for sector coupling between low temperature DH and the electricity system can provide an opportunity through policies. From a national perspective DH is not well-established and it is a barrier to realize DH in cities unfamiliar to the concept. Profitability in DH investment is competing with investment capital for natural gas, electricity etc., which is more profitable. The possibility with low temperature DH to also provide cooling is an opportunity for replication in Italy. Since DH is not so established the permission process is complex and administratively heavy (Fransson, Sandvall et al. 2021).

D3.2 input on the customers' perspective

Important for business model development:

- Most customers are not willing to pay more for greener heat
- Customers want an incentive-based pricing scheme
- Customers are unwilling to increase service offer in connection to DH supply as it is perceived to results in higher cost.
- More information could make customers more interested in services and taking over maintenance could be a wanted first step.

All respondents want to be able to impact the cost (for examples by incentive-based pricing). End-users tend to want about the same price as today for a greener H&C system, possible 1-2% more. Professional customers are spread across the range from wanting to pay less up to a WTP more than 10% more (Figure 25) (Fransson and Lygnerud 2021).

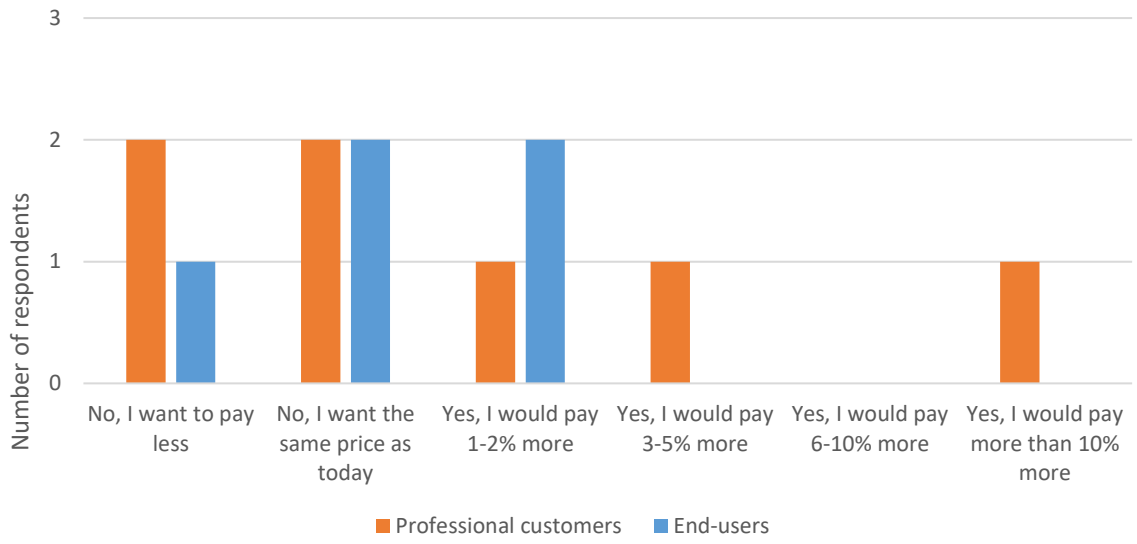


Figure 25: Italy - Willingness to pay for a greener H&C supply.

Most professional customers don't have enough information about comfort service agreements to identify any risks or benefits. Some think that it would improve the indoor climate and make it easier as they don't have to care for maintenance or management of the system. Identified risks relate to potentially increased cost and generally a higher risk, also for management issues. Most of the end-users did not perceive any benefits or do not know. Two respondents think it would improve the indoor climate and that it would be easier as the customer only needs to pay the bill. All but one end-user thinks that there is a risk of higher cost.

Table 41: Italy – Perceived risks and benefits towards receiving a high level of servicification.

	Benefits	Risks
Professional customers	Don't know Better indoor climate Easier (no maintenance or management)	Don't know Increased cost Increased risk and management issues
End- users	Better indoor climate Easier (only pay the bill) Don't know No benefits	Higher cost Don't know

All end-users in Italy would like to receive their space heating and/or cooling as a commodity whereas the professional customers opinion is divided in favor of receiving it as a service or as a commodity (Figure 26). Since end-users perceive increased service to results in a higher bill and professional customers generally are not aware of benefits towards increased service, customers need more information.

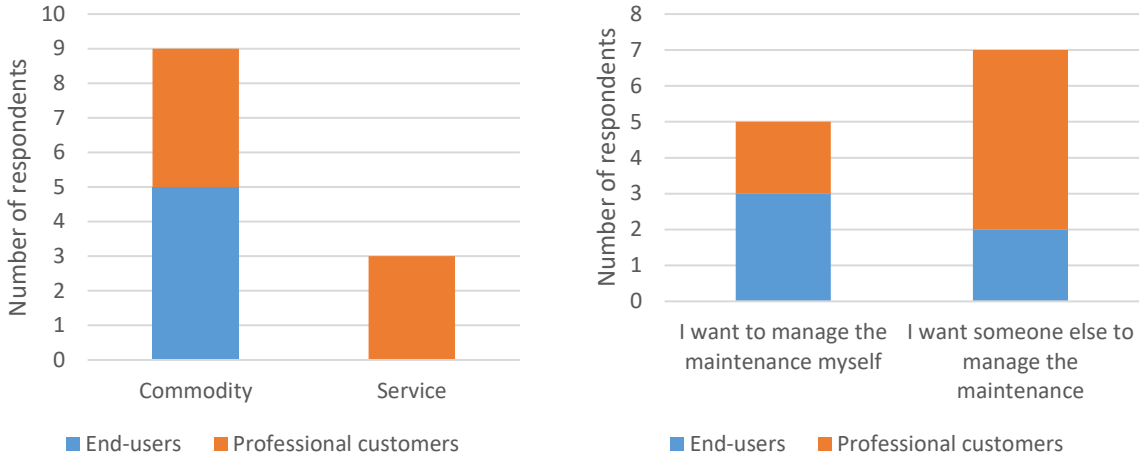


Figure 26: Italy - Customers propension to H&C as a service (Left). Customers prefers for maintenance of H&C equipment (Right).

8.5.4 Sweden

D3.1 PESTLE input: Sweden

Important for business model development:

- Green energy is an important value to attract investment capital for low temperature DH
- Pricing structure should focus on transparency and fairness as customers are often focusing on cost

In Sweden DH is well-established, the general opinion is positive, and DH make up 50% of the heat supply. The tradition and culture are to have systems based on large central production plants which is a barrier for low temperature DH to develop. Politics is still steering towards conventional DH and the awareness of low temperature DH needs to increase as well as targeted financial support. Profitability is possible, even more so if low temperature DH network is in proximity to conventional DH network or close to a good excess heat source (e.g., data centre). Both private and municipality ownership require investments to be towards green energy which is an opportunity. DH must be competitive against other heat supply option in order to connect and maintain customer. There is a tradition in Sweden of having transparent pricing structure towards customers (Fransson, Sandvall et al. 2021).

D3.2 input on the customers' perspective

Important for business model development:

- Most customers want the same price even if heat supply is greener
- Customers want an incentive-based pricing scheme
- Customers need more information about the benefits of increased service to mature
- Private customers want maintenance as a service

All respondents want to be able to impact their cost (for examples by incentive-based pricing). Most respondents want to pay the same price as today even if the supply of heat was greener. Three respondents would be willing to pay a few percentages more (Figure 27) (Fransson and Lygnerud 2021).

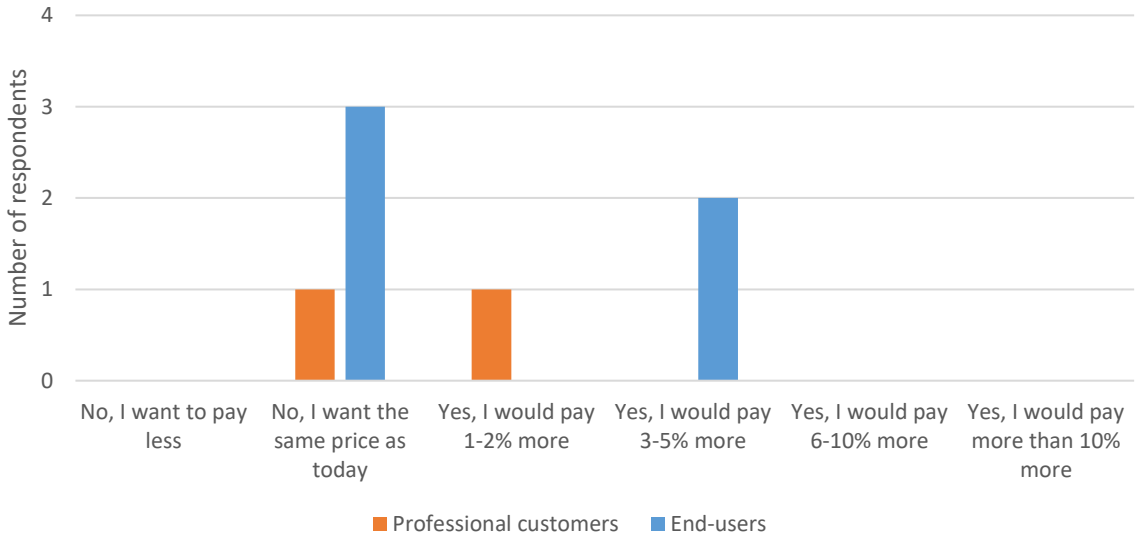


Figure 27: Sweden - Willingness to pay for a greener H&C supply among customer groups.

Most respondents did not know or did not foresee any benefits of receiving a high level of servicification through a comfort service agreement. More information about benefits is required to convince customers. Three respondents did not foresee any risk, two did not know and two saw a risk being that increased service would become more expensive (Table 42).

Table 42: Sweden - Perceived risks and benefits toward a high level of servicification.

	Benefits	Risks
Professional customers	None	None Don't know
End- users	Don't know Fixed price System better optimized	More expensive None Don't know

One end-user would prefer to receive their space heating and/or cooling as a service, all others preferred to pay for it as a commodity. All end-users want someone else to manage the maintenance of the H&C equipment and both professional customers prefer to manage the equipment by themselves (Figure 28).

Figure 28: Sweden - Customers propension to H&C as a service (Left). Customers prefers for maintenance of H&C equipment (Right).

8.5.5 Netherlands

D3.1 PESTLE input: Netherlands

Important for business model development:

- People and partnership are important for low temperature DH
- Value of improved air quality and reduced dependency on import by utilizing local resources is important
- A heat supply that provides good energy performance to connected buildings is an important value proposition

DH is the most feasible option in policies to replace natural gas as Netherlands it is a densely populated country and conventional DH is mature and established. Combustions of biomass is not very popular as is reduced air quality and the country want to reduce its dependencies on imported fuels. This is an opportunity for low temperature DH that can integrate other low-grade heat sources. A DH network based on excess heat automatically qualifies connected buildings for good energy performance. The awareness of low temperature DH is low, and no targeted support is available. Investment capital are available from the government at zero-interest but as DH must be managed as a commercial party a 7% return is required. Most of the DH market is controlled by large energy companies who also own the power grid in the municipality. The investment cost for DH is high and the heating base cannot be guaranteed as each customer must be convinced to connect. The price of DH is not allowed to exceed the price of natural gas and typically investments in other energy project, such as electricity, is more profitable. Profitability can be risky, especially if the heating base in an expansion area is low and as the price is regulated, the cost cannot be transferred to the customers (Fransson, Sandvall et al. 2021).

D3.2 input on the customers' perspective

Important for business model development:

- Most customers are not willing to pay more for greener heat
- Customers want an incentive-based pricing scheme
- Customers are unwilling to receive increased service with their heat supply
- An opportunity could be to increase the level of knowledge about service offers and start building trust with maintenance of H&C equipment as customers are requesting it

All but one respondent wants to be able to impact the cost (for examples by incentive-based pricing). Most end-users want to pay less or the same price as today even with a greener H&C system, 3 end-users are WTP a few percentages more and one is WTP more than 10% more. Professional customers want the same price or very little higher (Figure 29) (Fransson and Lygnerud 2021).

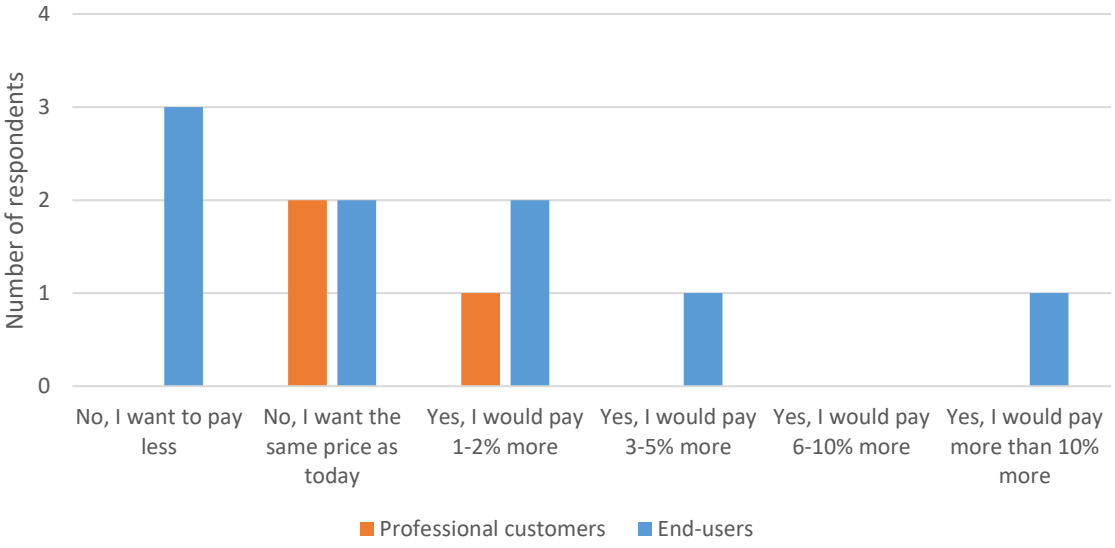


Figure 29: Netherlands - Willingness to pay for a greener H&C supply.

Professional customers identify the benefit of a comfort service agreement as shared risk and increased comfort. One professional customer saw no benefits. Identified risks are that it will be more expensive and reduce the incentive to save energy. All end-users either saw no benefits of a high level of servicification or did not know. Most did not know what possible risks could be but some perceived that it would be more expensive (Table 43).

Table 43: Netherlands - Perceived risks and benefits toward a high level of servicification.

	Benefits	Risks
Professional customers	Shared risk Increased comfort No benefits	More expensive Reduced incentive to save energy
End- users	No benefits	More expensive

	Don't know	Don't know

All end-users in Netherlands would like to receive their space heating and/or cooling as a commodity whereas the professional customers opinion is divided in favor of receiving it as a service or as a commodity (Figure 30). Given that customers generally perceive that the resulting cost will be higher with increased service and do not know or do not perceive any benefits it is reasonable that customers would like to receive H&C as a commodity.

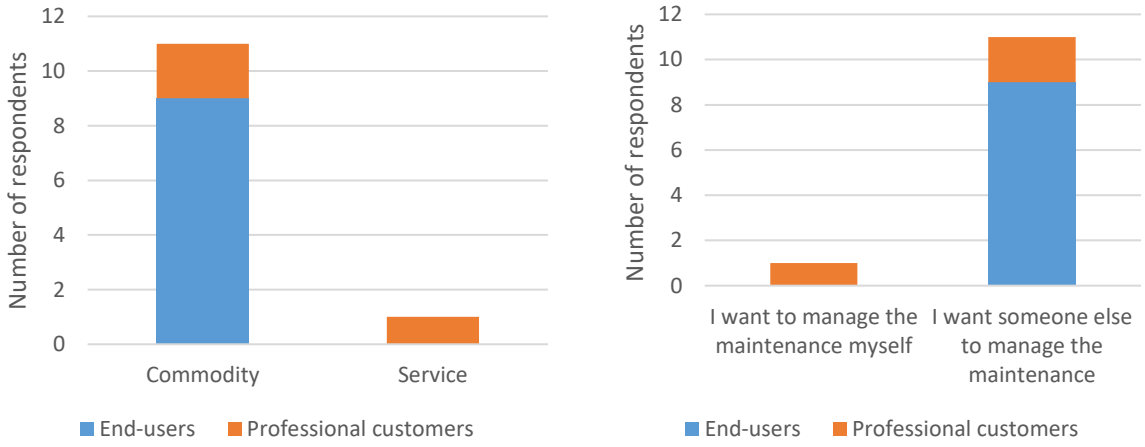


Figure 30: Netherlands - Customers propension to H&C as a service (Left). Customers prefers for maintenance of H&C equipment (Right).

8.5.6 Poland

Input from the PESTLE analysis performed in D3.1 and customers perspective performed in D3.2 are not available for Poland as the demo site was included in the project after the deliverable D3.1 and D3.2 had been completed.

8.5.7 Croatia

D3.1 PESTLE input: Croatia

Important for business model development:

- The business case is very important to attract investment capital as state-based financial support and access to capital is lacking
- Profitability is achieved by low system losses and a cheap source of heat
- A heat supply that qualifies for NZEB energy requirements is an important value proposition

Most of the Croatian DH market is publicly owned by HEP. Smaller and private companies only make up about 10% of the market. The technology is mature and established but the existing DH networks are old and inefficient which drives cost. As the price is regulated, and competing against a low price of natural gas, profitability is generally difficult. In general, the opinion of DH is not so positive because of price and unreliable old systems. DH is likely to increase in Croatia in the

coming years as fossil fuels needs to be phased out of the H&C supply and in densely populated areas DH is deemed the most suitable replacement and encouraged in policies (Fransson, Sandvall et al. 2021).

D3.2 input on the customers' perspective

Important for business model development:

- Customers want an incentive-based pricing scheme
- Customers are unwilling to receive the heat supply as a service
- More information about increased service is necessary for customers to mature increase customers propension and
- Maintenance offers are requested (especially by private customers) and could be a starting point to build stronger customer relationships and increase services

All respondents want to be able to impact the cost of H&C. A slight difference can be seen in the WTP for a greener H&C system between customer groups in Croatia where professional customers state that they would be WTP for the value of green to a larger extent than end-user (Fransson and Lygnerud 2021).

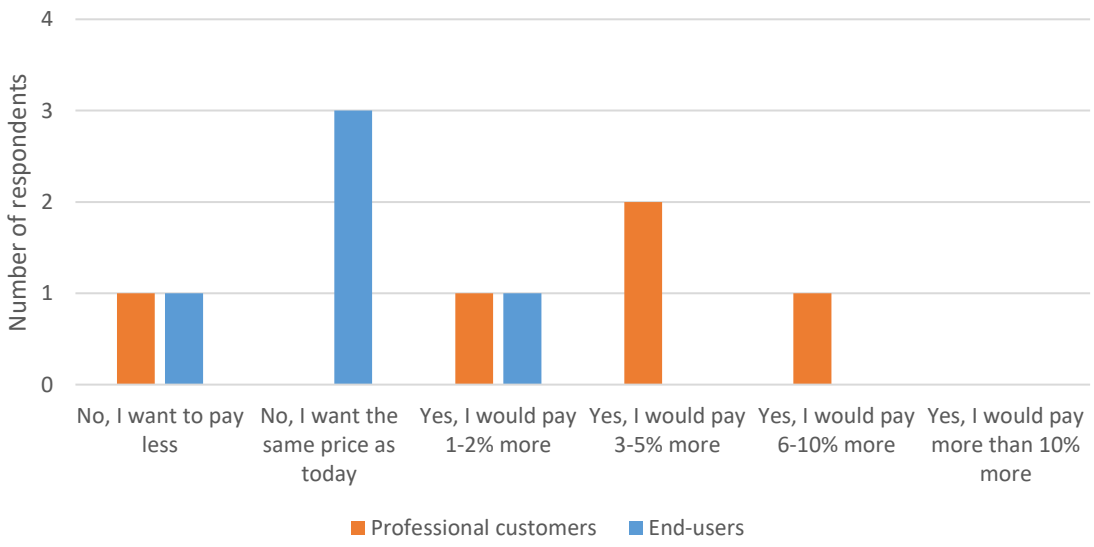


Figure 31: Croatia - Willingness to pay for a greener H&C supply.

Most professional customers are unsure about the benefits and risks of receiving a high level of servicification via a comfort service agreement. End-users perceive the benefits to be increased indoor climate, fixed price, and convenience. Most end-users are unsure of the risks.

Table 44: Croatia - Perceived risks and benefits of receiving a high level of servicification.

	Benefits	Risks
Professional customers	Fixed indoor temperature Unsure	Unpredictability of consumption Unsure

End- users	Convenient contract Fixed price for the same thermal comfort Secure supply Fixed indoor temperature	Inability to influence the amount of the bill Unsure

In Croatia customers are strongly in favor of receiving the space heating and/or cooling as a commodity and only one end-customer preferred to receive it as a service (Figure 32).One reason could be due to many respondents being unsure of the benefits and risks of increased service and require more information. Most respondents prefer someone else to manage the maintenance of the H&C equipment.

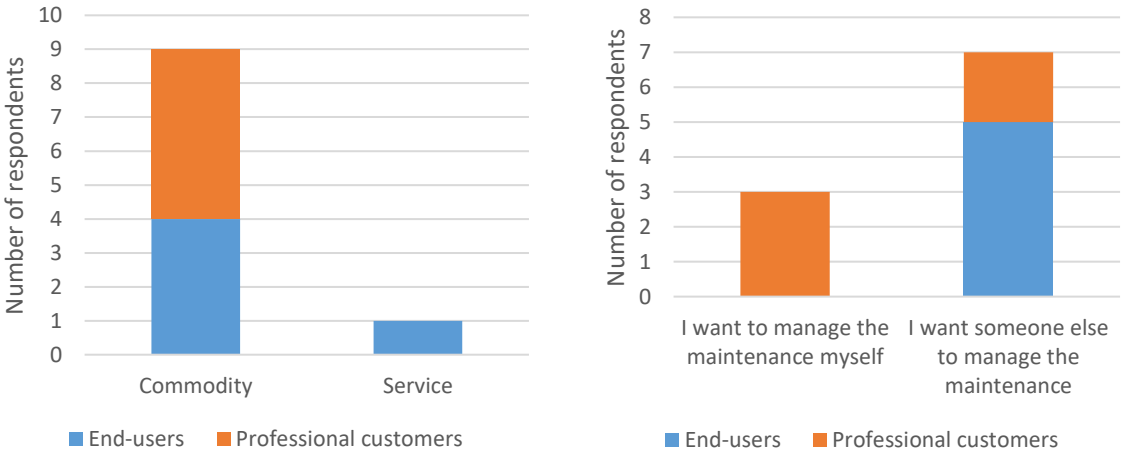


Figure 32: Croatia - Customers propension to H&C as a service (Left). Customers prefers for maintenance of H&C equipment (Right).