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Business models and contractual arrangements for REUSEHEAT demonstrators (2)

WP 2
Task 2.3
Deliverable 2.4 (M54- with inclusion of monitored performance data in M60)

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ReUseHeat website: www.reuseheat.eu

Summary

This report presents an updated version of deliverable D2.8 ("Business models and contractual arrangements for Reuseheat demonstrators"). The work on business models and contracts was initiated when the project started, and early experiences were collected in D2.8 (M21). This update (D2.4) was foreseen from proposal stage with the ambition to reflect the most recent information on the demonstration sites towards the end of the project and to summarize contractual and business model learnings.

This deliverable was updated in M37-39 and in M52-53. Information has been collected by means of interviews with demosite partners. In M60, information on payback of demonstrators was added (in line with suggestion from reviewers in review period 2) from D4.5 and D6.4. Also, other performance data as per D4.5 was included into the deliverable.

On the note of contracts, urban waste heat recovery is news and therefore the level of standardization in contracts is low. The experience from ReUseHeat is that long-term contracts between the involved parties is important as well as mutual trust. The waste heat provider trusts the DH company to do the waste heat recovery efficiently and the DH company trusts the waste heat provider to provide the volumes and temperatures of waste heat outlined in the contract. It is possible that contractual lengths can be reduced as waste heat recovery contracts are increasingly standardized. Shared incentives around the carbon footprint are possible in the waste heat recovery context as green energy is valuable both to the DH company and the waste heat provider. It is concluded that the fewer the stakeholders involved in the heat recovery, the more efficient the contracts can be. Over time, as the urban waste heat recovery is standardized it is likely that fewer stakeholders need to be engaged which facilitates the contract writing.

On the note of business models, it is identified that the low temperature waste heat recovery can be integrated into an existing solution and that it adds value to it (for example by reducing the use of fossil fuels and by avoiding investments in additional heat production). Indeed, the low temperature heat supply can be complimentary to an existing district heating network. ReUseHeat results confirm the tendency detected elsewhere in the DH industry; the tendency to focus on technical viability over business case viability. An example of this is that the green value (carbon footprint) of urban waste heat usage is not capitalized through, for example, a differentiated price model. Instead, the conventional, large scale and centralized business logic is applied to the urban waste heat recovery context. Another feature of the urban waste heat recovery investment is the necessity of a close relationship with the waste heat provider, they become key partners. Also, it has been identified that it is very important to study the heat supply closely before engaging in the waste heat recovery. It is important that it is stable and provides foreseen volumes and temperatures. It is also important that it is not too far away from the heat customer as pipelines erode cost efficiency.

Overall conclusions are that the absence of an EU level framework outlining how to consider urban waste heat (answering the question of if it is comparable to a renewable energy supply or not) and a lack of explicit political support of recovering waste heat drive risk. Compared to incentivized investments in renewable heat supply the urban waste heat recovery investment case is eroded.

Summary of actions after the second review report (RP2: M19-32)

This section of the document summarizes actions taken to update D2.8 based on European commission review comments:

- "In D2.4 the conclusions are quite generic. There is a request for revision in order to generalise the findings and derive lessons that could be transferable or concretely usable in other contexts".

We have included lessons learned for each demosite by means of a concluding "key learnings" box. We have also included a section where lessons of relevance for contract and business model design are drawn from other ReUseHeat deliverables (section 5).

- "As the deliverable is not updated in terms of demosites (metro demo should be included), the contract and business models of the replacement demosites for urban waste heat recovery should be included in the future update….In the future update of D2.4 (M54 according to last Amendment DoA), it is recommended to include the contract and business models of the replacement demosites for urban waste heat recovery apart from, as stated, identifying what choices the demosites made in regard to contract and business modelling and how efficient the choices are".

We have included information on the final demosites of the project. We have made an assessment of the efficiency of contractual and business model choices made for each demonstrator. The demosites have progressed over time. We have held interviews with the demosite owners to update the information in months 37-39 and 52-53.

- "It is recommended to include the final pay-back period estimation in the last project report as it is considered a major barrier for the exploitation of the project results".

Information on payback was included in M60 in agreement with the Project Officer who reopened the deliverable from M54.The payback information was taken from D4.5 (Evaluation) and 6.4 (Techno economic analyses). Also, other performance data from D4.5 was included.

Contents

1. Introduction to demosites

1.1 Datacenter heat recovery

The Brunswick demonstrator exploits waste heat from a data centre to provide heat for 400 newly built homes and a shopping center in the outskirts of the city. BS|Energy is a local energy company that provides heat and electricity to the city. The low temperature network connecting the newly built houses to the DH system was built, owned and is operated by BS|ENERGY. It is a joint venture between Veolia, who owns 50.1%, the city of Brunswick, who owns 25.1%, and municipal company Thüga, who owns 24.8%.

Around 40% of the city's heating demands are met through a high temperature district heating network powered using a high efficiency cogeneration plant (CHP). The electricity generated from the CHP supplies electricity to the electrical grid. The rest of the heating demand is met by gas boilers, powered with natural gas, which is also supplied by BS|ENERGY. The demosite is of interest to BS|ENERGY since it allows for the provision of DH to the newly built area without expansion of the current DH capacity. Instead, a low temperature DH network is built in the format of an 'island' that is linked to the existing DH distribution network. This is a long-term risk management strategy since the urban waste heat recovery investment only meets the baseload demand and any additional demand can be supplied through the high temperature network.

Data centres produce large quantities of heat and require significant cooling to avoid equipment damage. Cooling therefore contributes a great deal to the overall running costs. By supplying a district heating network with excess heat, a win-win solution is established: the data centre reduces its cooling costs, and the DH company obtains heat that can be used to increase the heat capacity without additional investments in large scale production capacity. There is great potential for this kind of arrangement, particularly given the rise in demand for cloudbased services and online storage (which directly increases demand for data centres).

The data centre provides warm water at 25 °C which is piped to the "energy station" where the temperature is increased to 70 °C via a heat pump. The return water holds a temperature of 18°C which reduces the need for cooling of the data centre. The hot water produced by the heat pump is piped to the residential and commercial areas to provide heating. The water returns to the energy station at a temperature of 40°C. A Buffer tank is used to store hot water so that it can be distributed when required (at the cost of some degree of heat loss).

The aim of the system is to provide enough heat to cover the summer baseload of heat demand for both the houses and a commercial centre. The rest of the heat demand will then be supplied by the existing DHN. It was decided that the heat from the data centre would provide only the base load in order to avoid the significant extra cost of purchasing a bigger heat pump with no guarantee that the extra heat would be needed. This is risk management against uncertainty of the level of demand.

In the future, there is potential to add a smart control solution to take real time data from the customer substations into account and to improve the efficiency of the heat pump through control.

In M60, performance data was available for the demonstrator: the data centre demonstration site was impacted by delay as a result of the data centre scaling up slower than expected, further aggravated by the Pandemic. As a result, the heat recovery was started at partial load and full volumes were at the end of the ReUseHeat project not met. The monitoring remains after project closure, but 12 months of monitoring data could not be presented in M60.

The monitored numbers measured at partial load are provided as well as an estimation of full year data based on an extrapolation of the real data for a full year (for information on the method applied for extrapolation of numbers and calculations of key performance indicators please review deliverable 4.5. The energy prices applied in the calculations are from 2021).

Comparing the intended result with the estimated values for a complete year at full load it is identified that demonstrator site numbers are well aligned to the estimations made. The large positive deviations occur in the primary energy saving where more than double the MWh/yr were saved compared to intentions and the CO2 emissions saved are 36% higher than intended. The payback of the installation is also lower than foreseen (3 years instead on 8 years).

One larger deviation is related to the electrical consumption according to monitored data where it is 36% higher than foreseen. A result of the reconfiguration of the hydraulic system to make the heat pump work within the operative temperature ranges.

Table 1.1: Performance data from data centre demonstrator site.

Demonstration case	Impact	Intended Result	Achieved based on real monitoring period	Estimated values for a complete year
Data centre in Brunswick (Germany)	Heat supply [MWh/yr]	2, 300	345	Partial load: 903 Full load: 2 451
	Waste heat recovered [MWh/yr]	1 750	239	Partial load: 603 Full load: 1 660
	Electrical consumption according to moniotired data [MWh/yr]	580	106	Partial load: 300 Full load: 791
	Primary energy saved [MWh/yr]	1, 284	379	Partial load: 939 Full load: 2 602
	CO_2 emissions saved [tonnes/yr]	304	60	Partial load: 147 Full load: 412
	Simplified payback period [Years]	8	Not possible to be calculated	Partial load: 9.16 Full load: 3.05

1.2 Hospital heat recovery

The Madrid demonstrator recovers heat from a hospital building for use in a local district heating network to provide heating and cooling for the hospital. A hospital was chosen because it is a common urban tertiary building with local district heating and cooling infrastructure and therefore the potential for replication is high. Southern European hospitals have high cooling needs throughout the year whilst there is also a high thermal energy demand. During the winter, cooling is still needed for surgery rooms and other areas with special air requirements. Furthermore, heating demands are high, not only for space heating in the winter, but also for domestic hot water production as well as for process heat (e.g. sterilization and cleaning) over the whole year.

The hospital chosen is the Hospital Universitario Severo Ochoa, in Madrid. The hospital is situated in the municipality of Leganés and is a public university hospital that offers a variety of medical services to citizens in Madrid. The Hospital is connected to a local network, supplying all of the buildings with heating and cooling.

The Madrid demonstrator recovers heat from a cooling system. The project has been developed and executed by ASIME who are currently responsible for maintenance of the hospital's cooling and heating systems. ASIME is also the hospital's energy manager and negotiates the prices the hospital pays for electricity and natural gas. ASIME produces heating and hot water using the DHN and supervises the booster heat pump. The DHN connects the maintenance workshop (where the heating-cooling production is placed) and the hospital, through an underground tunnel network.

In M60, performance data was available for the demonstrator: the hospital heat recovery experienced a long commissioning period. As a result, the monitored data shown below does not cover 12 months. The monitoring remains after project closure, but 12 months of monitoring data could not be presented in M60.

Estimated values for a complete year are included in the right column of the table (for information on the method applied for estimating full year numbers and calculations of key performance indicators please review deliverable 4.5. The energy prices applied in the calculations are from 2021). Reviewing the numbers foreseen with the numbers that are assumed for a full year of operation all key performance indicators but one are better than intended. The heat supplied is 3.5 times higher than intended. The waste heat recovered is more than 3 times higher than intended. The primary energy saved is almost 7 times higher and as a result the saved CO_2 is more than 4.5 higher than intended. The payback is also significantly reduced from estimated 15 years to 1.87 years.

The electrical consumption is more than 3 times higher than foreseen as a result of an underestimation in the proposal stage. This is aligned with the increase in thermal energy production.

Table 1.2: Performance data from hospital demonstrator site.

Demonstration case	Impact	Intended Result	Achieved based on real monitoring period	Estimated values for a complete year
Hospital in Madrid (Spain)	Heat supply [MWh/yr]	770	1 888	2 704
	Waste heat recovered [MWh/yr]	532	1 227	1 751
	Electrical consumption [MWh/yr]	238	537	789
	Primary energy saved [MWh/yr]	554	3 213	3 768
	CO_2 emissions saved [tonnes/yr]	154	601	721
	Simplified payback period [Years]	15	Not possible to be calculated	1.87

1.3 Visualization of waste heat from sewage (dashboard)

The dashboard demonstrator is a means to communicate DHCN relevant information to end-user and the wider public, as energy performances achieved from low temperature waste heat recovery. The objective of the dashboard is to create awareness amongst building owners and end-users (tenants) of heat that it is possible to recover waste heat from urban sources and to understand the working principles of LT DHCN more in general. The dashboard is a collaboration between a local authority (the Metropolitan authority of Nice, with the ambition to create awareness amongst its residents), an energy company (EDF, interested in providing a new service to DHCN operators) and a research organization (CSTB, supporting the design and simulation of the dashboard). The dashboard demonstration site is complimentary to the others, hands-on waste heat recovering, demonstrators in ReUseHeat.

It was foreseen for a low temperature district heating network with waste heat from sewage water as main source and to be located in a larger area of development (the Grands Arenas in the city of Nice) where construction of tertiary, commercial and residential buildings (student housing) was planned. The dashboard is designed to be applicable to any renewable or waste heat low temperature network (regardless of low temperature heat source). When the construction in the Grands Arenas was delayed, it was necessary to shift it to a sea-water based (also low temperature) district heating and cooling system. It was relocated in the very same metrological conditions as Nice, being validated in Toulon.

EDF envisages two potential benefits of the dashboard. Firstly, it intends to make revenue from the direct clients, via the local authority or the district heating operator through its integration into the overall exploitation contract. Secondly, EDF hopes that the wider public, independently if end-users or not, will visit the dashboard and that it will enhance acceptance of this technology and impact location choices (renting or house ownership). Therefore, one aim of the dashboard is to secure a future customer pool. EDF aims, in a future stage, to incorporate other meaningful information to end-users (for example weather forecast information) into the dashboard, thus providing customers with information that is tailored to their demand and allowing them to reduce their energy bills, by understanding better how the network operation is related to weather conditions.

In terms of monitoring data in M60, the dashboard was established on time and there is a full year of monitoring data for the LTDHN that it visualizes. The dashboard visualizes energy usage and provides knowledge to users on the functionality of LTDHNs. The dashboard is online and can be found at https://reuseheat.dcrmed.fr/en/. For information on the data for the LTDHN that the dashboard visualized please view deliverable 4.5

1.4 Metro heat recovery

This text features the third metro heat recovery site in ReUseHeat. The demonstrator was to recover waste heat from a metro tunnel in the west of Berlin city centre. The heat would have been used for a three-story building owned by the metro operator and connected to a low-temperature, local network.

Metro systems produce a great deal of heat from electric motors, breaking equipment and ventilation on the trains that pass through. This can make metro stations uncomfortably hot in the summer months. Modern metro stations are typically equipped with ventilation systems, but these can be costly to run. In terms of metro systems, waste heat recovery, as well as providing heat for use in a district heating system, can also be beneficial for the owner of the heat source. Recovery of heat naturally provides cooling, thus either reducing running costs or providing cooling that wouldn't otherwise have been provided, therefore increasing the comfort of the customers.

OPES, experts in heat pump installations, was to develop an innovative heat recovery system reusing waste heat from a tunnel in the metro network in Berlin. The waste heat source foreseen was a tunnel in which the temperature is 8-15°C in the Winter and 27°C in the Summer. The heat recovery was to be realized with an air to water heat exchanger as the source and a water-to-water heat pump during the Winter season. The heat recovery system would be made with a multi fan-coil unit which would be placed on a platform within the tunnel. The recovered heat would be used in a local district heating network, heating a three-story building owned by the Metro operator (Berliner Verkehrsbetriebe) containing office-space and rectifier-rooms. The local district heating network was a low temperature network (50°C) extending approximately 200 meters. The installation would be established for the local, low temperature grid but, through the buffer tank, a link would be prepared to connect the ReUseHeat heat recovery to the city-wide district heating network of Berlin (approximately 2,000 kilometers long), one of Europe’s oldest and it operates at high temperatures.

There were a number of stakeholders involved in the Berlin demonstrator. Berliner Verkehrsbetriebe (BVG) is a company which owns and operates the metro, bus and tram systems of Berlin and, consequently, is the waste heat owner. OPES is a heat pump manufacturer which would tailor make the heat pump that to be placed in the metro station. Vattenfall is a major multinational power company that, at first, would be taking an advisory role but later was foreseen to take over the heat recovery at the end of the ReUseHeat project. The demonstrator proved impossible to realize as the involved stakeholders BVG and Vattenfall did not find it an economically viable installation and withdrew from its installation.

2. Methodology: contracts and business model

The way in which contracts are designed impacts the business models that can be used. Below, we outline the methodology we have applied to understand the contractual arrangements of the demosites and their corresponding business models.

2.1 Methodology for contractual analysis

The aim of the contracts section of this deliverable is to discuss the contractual choices made by each ReUseHeat demonstrator. In order to gather information about each demonstrator, and therefore to identify efficient contractual solutions, a questionnaire was created and sent to parties responsible (identical for D2.8 and 2.4). The questionnaire was designed to capture aspects that were identified in D2.3 (focus on contracts for urban waste heat recovery) as important to urban waste heat recovery investments. These factors are illustrated in Table 2.1 below. The responses to the questionnaires formed the basis of further discussions with the demonstrators, both in person, through visits to the sites, and via conference calls.

A number of important aspects of contracts were identified in D2.3. These are shown in table 2.1. In sections 3.1-3.4, these are discussed individually for each of the four ReUseHeat demonstrators. Updates for each demonstrator were made in M37-39 and M52-53. An assessment of the efficiency of the contractual choices made in the demonstrators is made in conjunction to each demosite.

Factor to consider	**Impact on the business model**
1. Low maturity of the installations (D2.1): e.g. the combination of a heat pump and low temperature heat recovery is a system innovation	The low temperature heat recovery system will require new equipment and relevant skills among employees to use it. This impacts the **key resources** and **key activities** of the district heating provider. Depending on contractual choices of ownership, the equipment will belong to the district heating provider.
2. No legal framework in place (D2.1)	The absence of a legal framework means that close interaction with the waste heat supplier is required. A close and frequent customer dialogue can help to manage the shortage of legal boundary conditions. Closer interaction between the waste heat supplier and the customer generates a new **key partnership**.
3. The value of heat is subjective (D2.1)	The manner by which the price of heat is decided will depend on a multitude of factors such as the price of electricity, seasonality and the perceived value of the waste heat provider. To arrive at a price that is agreeable to both parties, a close dialogue is required. This impacts the **key partnership** and **income structure** of the business model. Given that the proposed value to the waste heat provider is the opportunity to monetise its waste heat, the **value proposition** of the canvas is impacted.
4. The payback period is long (D2.1)	Long payback periods are risky to project funders and this can have a big impact on partners with relatively short horizons. One potential solution is to agree for some partners to be paid off before others. A discussed case in the district heating industry is the collaboration between the Danish district heating company VEKS and the company CP Kelco whereby the latter had their investment paid off first[1]. Design of the repayment plan will impact the **income structure**.
5. Asymmetric information (theory)	Asymmetric information in any part of the business model is detrimental to its success. Ideally, as much information as possible should be outlined in the contract. The business model can then be built around this information. This impacts **all parts of the canvas**.
6. Shared incentives (theory) Examples: supply operation maintenance pricing insurance quality assurance monitoring billing renegotiation	Shared incentives will have an impact on the business model canvas with the impacted sections depending on the nature of the shared incentives within the contract. If, for example, the shared incentives are on the **supply side,** this is related to the **key resource** of urban waste heat coming into the district heating provider's network. If it is on the **operations side**, the **key activities** undertaken by the district heating company will have an impact on shared incentives. **The same applies for the maintenance aspect**. Incentives linked to **pricing** will impact the **value proposition** and the **income structure**. Incentives related to **insurance** will be linked to **key resources**. **Quality assuring** incentives will be linked to the **key activities** undertaken **as will incentives directed towards monitoring** activities. **Billing** incentives are linked to the **income structure** and **renegotiation can be linked to any part of the canvas**.
7. Termination of heat recovery (theory)	In the worst case, established solutions cannot keep the business model afloat if the heat recovery is terminated. One consequence is then the termination of both the contracts and the business model.

Table 2.1 Important aspects of contracts and business model configuration (from D2.3)

2.2 Method for business model analysis- the business model canvas

In this section, the different components of the business model canvas concept are explicitly addressed. In Figure 2.2, elements of importance in a conventional district heating scheme and in an urban waste heat recovery scheme are provided (Lygnerud, 2018). The latter are in italics.

<table>
<tr>
<td rowspan="3">Key partners
Fuel providers
Waste heat providers
Customers
Support organizations</td>
<td rowspan="2">Key activities
Production & distribution of heat
Distribution of waste heat
Heat pump maintenance</td>
<td rowspan="3">Customer Value
Heat and hot water
+ Value of green</td>
<td>Customer Segment</td>
</tr>
<tr>
<td>Customer Relationship
Provider-consumer (arms' length)
Long term, mutually beneficial</td>
</tr>
<tr>
<td>Key resources
Production unit & network
Network
Heat pump
Staff with new skills</td>
<td>Customer Channel
Invoice, website, phone, campaigns
Dialogue, prosumers</td>
</tr>
<tr>
<td colspan="4">Cost and income structure
Fixed costs (network)
Fuels (less important & prosumer heat)
Maintenance (heat pump)
Cost of electricity
Optimized operation (control: peak shaving, prosumers...)
Price (differentiated?)</td>
</tr>
</table>

Figure 2.2 The business model canvas with features for conventional DH and urban waste heat recovery investments

On the customer side, the customer value shifts from heat and hot water to also include the value of a green solution. The main customer segment remains professional customers (often building owners) but with an increased potential for private homeowners since the urban waste heat recovery is more local than the conventional DH. The customer relationship will go beyond that of the provider-consumer and will become a long term, mutually beneficial relationship. The channel by which communication takes place will develop from invoice, website, communication campaigns and phone calls to a dialogue.

On the district heating company side, new resources are the heat pump and staff with new competencies (to manage the immature urban waste heat recovery solutions). New activities are the distribution of waste heat, heat pump maintenance and customer dialogue. New partnerships are built with waste heat providers, the customers themselves and organizations supporting urban waste heat recovery (by, for example, subsidies).

At an overall level, the cost and income structure are impacted by fuel costs being lowered since urban waste heat replaces heat that was otherwise produced in the district heating production plant. Maintenance costs for the heat pump need to be added as well as increased electricity costs (from adding heat pumps). Including urban heat sources into an existing district heating system means that the temperature of the system will be impacted as well as the pressure (including multiple smaller heat sources); these are aspects that call for increased operational control systems. This is something that, in turn, can empower customers to become "smart users" of energy. Last but not least, the green dimension of the urban waste heat recovery makes it possible for district heating providers to offer differentiated prices[2] that are dependent on the carbon footprint of different heat sources.

In (Averfalk et al., 2021) nine cost saving items are identified for low temperature in the district heating grid. These occur from heat source to heat supply and it is frequent that only some of them are pointed out (like lower distribution loss for example). However, aggregating the costs savings they can be substantial. The items are relevant to mention as several of them applies to the datacenter demonstration site and would have applied to the metro demonstrator. The nine items are:

1. *More geothermal heat can be extracted from wells since lower temperature geothermal fluid can be returned to the ground*
2. *Less electricity used in heat pumps when extracting heat from heat sources with temperatures below the heat distribution temperatures since lower pressures can be applied in the heat pump condensers*
3. *More excess heat extracted since lower temperatures of the excess heat carrier will be emitted to the environment (waste heat being recovered and not sent into the ambient air)*
4. *More heat obtained from solar collectors since their heat losses are lower, thereby providing higher conversion efficiencies*
5. *More electricity generated per unit of heat recycled from steam CHP plants since higher p-t-h ratios are obtained with lower steam pressures in the turbine condensers*
6. *More heat recovered from flue gas condensation since the proportion of vaporised water (steam) in the emitted flue gases can be reduced.*
7. *Higher heat storage capacities since lower return temperatures can be used in conjunction with high-temperature outputs from high-temperature heat sources*

[2] In a study (Lygnerud 2019), it has been identified that low temperature demosites across Europe (6 cases are considered) assume a technical focus. Attention is given to make the technology work which means that the added values possible from low temperature waste heat recovery are not accounted for in the business model. Furthermore, none of the six cases studied diversified their low temperature offer in the price model.

8. Lower heat distribution losses with lower average temperature differences between the fluids in heat distribution pipes and the environment

9. The ability to use plastic pipes instead of steel pipes to save cost (plastic in most parts). If existing system has higher supply temps than 130 Celcius and lower it, you can use less special insulation materials which is also a cost saving

Updating the business models of the demonstrators in M52-53, an assessment of the potential savings from points 1-9 have been addressed. For the datacenter, item 2 is applicable to the low temperature district heating system where the waste heat from the datacenter is recovered. Item 3 is also relevant as the demonstrator allows increased waste heat recovery for the company as a whole. Item 7 is also relevant for the buffer tank of the heat pump. Item 8 is applicable in the low temperature network compared to the high temperature network and the low temperature network was built with plastic pipes (item 9). For the hospital only item 3 is applicable, the amount of waste heat at the hospital increases with the demo. For the metro demonstrator, a number of items would have applied for the foreseen micro grid.

To identify the business model concept of the four demonstrators, interviews have taken place between the demosite owners and IVL. Three sets of interviews with representatives from each demosite have been undertaken in the time frame of M1-M21 and resulted in input for D2.8 (M21). For this update (D2.4) additional sets of interviews were made (in M37-39 and in M52-53). The information collected in the interviews has been summarized for each of the nine parts of the business model canvas framework and mapped into a business model canvas for each of the demosites.

Each demosite section was concluded with a number of open questions related to the business model concept of the demonstrator in the first version of the deliverable (D2.8, M21). The questions were addressed and answered for this update (D2.4, M54). In conjunction to each demosite the efficiency of the applied business model is assessed.

3. Contracts for the Reuseheat demosites

In D2.3, seven factors of importance for the design of urban waste heat recovery investment projects were identified. These are described in table 2.1 and discussed in the context of each demonstrator below.

3.1 Datacenter

1. Low maturity of the technical solution

The risk from the low maturity of the technical solution is managed by attaching the new low-temperature DH network to the existing network. This is an action undertaken by BS|ENERGY and is a carefully designed technical scheme. The operators of the data centre are not involved in this activity and decisions are made purely by the energy company which bears all the associated costs.

In terms of ownership and operation, the energy company owns all of the infrastructure other than that which lies within the data centre and inside the property of the end user. Investment for the infrastructure was provided by the energy company along with some EU funding as a part of the ReUseHeat project. Whilst the project was close to being viable without additional funding, the EU funds were able to push the project over the "threshold of viability". BS|ENERGY sees great value in the project, and it is believed that the knowledge and experience will reduce the risk enough for similar future projects to be viable without additional funding.

In M21, low maturity of the technical solution was not seen as a problem. However, it was decided early on that, in order to find a solution that is both non-toxic and non-flammable and to reduce the risk of malfunction, a heat pump with a natural refrigerant should be obtained. Since this technical specification was rare, this limited the choice to two types of heat pump. Probably now, later in the project, the heat pump market entails a larger number of such pumps to choose from.

Another technical issue encountered after M21 has been a lack of experience on the part of the data centre owners, who have only recently entered the data centre market (on for example the pace of scaling activity up). This lack of experience, combined with the refrigerant issue described above, caused delay to the process.

2. No legal framework for low temperature district heating

There is national legislation concerning the use of electricity in Germany. The electricity produced is not always from renewable sources and there is a requirement on the primary energy factor. Use of a heat pump requires electricity consumption and, due to high energy costs in Germany, this impacts the return on investment negatively. Whilst this energy related legislation has impacted the demonstrator, the absence of a legal framework for urban waste heat recovery has not.

After M21, there were some developments in Germany. At the end of 2018, the KfW-Energieeffizienz-programm (KfW energy efficiency program, 2020) was introduced, providing loans of up to 25 million euro at preferential rates for energy efficiency projects, including waste heat recovery projects. The program includes up to 27.5 percent repayment subsidies. Loans and subsidies for waste heat recovery from external sites is more generous than when waste heat is recovered internally. The Brunswick demosite would have been eligible for funding under the program. Also, the dedicated program for low temperature district heating like the Warmenetze 4.0 would be relevant for heat recovery from datacenter.

3. The value of the heat

As discussed in D2.3, it can be difficult to arrive at an agreement regarding the value of waste heat. Due to concerns regarding confidentiality, the agreed value of the waste heat (if any) is not disclosed here.

4. Long pay-back

At the proposal stage of ReUseHeat, it was estimated that the payback period of the investment would be 8 years. However, BS|ENERGY sees great value in the project and its main owner, Veolia Germany, sees low temperature heat recovery installations as important for the future of DH. Veolia is anticipating a roll-out of the ReUseHeat installation in other countries, in which it operates, if the technical and economical requirements are fulfilled.

In M60, information on payback based on monitored data was collected from D4.5. From it: *For the datacenter demo-site, the real monitoring period covers from February 2022 to May 2022, this is because of the commissioning period in the first two months and the technical problem occurred from June 2022 which did not allow to get relevant data for the analysis from that month onwards. In addition, it is relevant to remark that the system was working at partial load during the monitoring period not showing the full potential of this kind of solutions. To be able to have a coherent comparison with the impacts foreseen thanks to the implementation of the waste heat recovery solution in the data centre it is needed to have a complete monitoring period covering 1 year of data at full load. For this, an extrapolation method was defined*.

According to the estimation for full volume heat recovery for one year in D4.5 the payback is lower than the foreseen 8 years, it is 3 years. The payback at partial load for a full year was estimated to have a payback of 9 years.

Demand risk can have an important impact on payback periods. However, this is not considered to be a major problem as BS|ENERGY has a considerable number of customers in the city and is able to make accurate predictions of demand. Estimates of heat demand are also made conservatively to try to ensure that future income is not overestimated. The payback period may therefore prove to be shorter.

On the other hand, one learning in the project was that the availability of waste heat can be lower than expected (during the startup of the heat recovery) due to unforeseen circumstances. This proved to have an effect on payback periods demonstrated by the 9 years payback for partial load versus 3 years for full load computed in D4.5

5. Asymmetric information

There is an ongoing dialogue with the owner of the data centre. Due to seasonality, there is significant variability in both heating and cooling demand over the year. From the perspective of the data centre, there is no requirement to provide cooling when the outside temperature is low since the heat can simply be released into the air. There is, however, a technical benefit in allowing its heat to be used in the winter months since waste heat recovery reduces the risk of equipment-damaging dust from the outside air. There will also be a monetary benefit if the data centre owners are remunerated for the volume of heat supplied.

There was an ongoing process with the data centre operator regarding the possible waste heat volumes. It was agreed that operation starts as soon as the technical minimum waste heat load for heat pump operation can be steadily delivered (apart from maintenance in the data centre) and commissioning took place in Q4, 2021. In M54, it was identified that as a result of the housing company installing hot water storage tanks- instead of the foreseen flow through system- the return temperatures in the low temperature DHN can become too high in the Summer. Due to continuous Summer load the temperature level in the buffer tank of the heat pump rises. The heat pump can only handle temperatures up to 45 degrees Celsius on the return side. If higher, the condenser cannot transfer heat from the heat pump, and it will stop. A measure to mitigate this has been taken and it is to install a bypass. Monitoring is needed of the installation to identify if the bypass is efficient. In M60, it was known that the demonstrator experienced a technical problem causing the heat pump to stand still and Summer months were not possible to monitor.

6. Shared incentives

It should be possible to engage the waste heat owner to contribute to shared incentives (on supplied volumes of waste heat, reliable operation, maintenance periods, the price of waste heat, insurance, quality of the heat provided, customer billing and renegotiation possibilities). For the Brunswick demosite, the energy company has decided not to suggest shared incentives and, instead, accepts the operational risk.

7. Termination of heat recovery

There is always a risk that ownership of the data centre could change hands. Under this scenario, it is believed that the new owner would continue to provide heat as the contract would simply transfer to the new owners. A bigger risk is that the data centre will close down and the heat recovery will be terminated. In that event, the existing DH network would supply the heat. In the longer term, however, additional investment in alternative capacity would be needed.

Specific contractual arrangements for the demosite are now discussed. Contractual arrangements have been established between (i) the datacentre and the district heating company, (ii) the district heating company and the property developer and (iii) the district heating company and the end-user. Each of these are discussed below.

3.1.1 Waste heat provider- District heating company

Many of the details of this arrangement are confidential and thus cannot be provided. It can, however, be disclosed that the contract between the two parties sets out:

1) how much heat should be provided, under what conditions and at what cost.
2) what should happen should there be an outage of excess heat.

No information is disclosed regarding volumes of heat supplied and the price agreed upon (if any) in Brunswick. In general, there is significant variation regarding payment for waste heat from data centres. For example, in Tallaght, Ireland, where a waste heat recovery project is under construction that will extract heat from a newly built data centre, planning permission was only granted for the data centre on the condition that heat is provided for free. On the other hand, there are projects, for example in Scandinavia, in which heat is provided for a fee (see D2.1 for details).

For the Brunswick demonstrator, contract negotiations were made simple by the fact that the owners of the data centre (a large industry using the datacenter to manage own dataloads) have limited interest in the details of the project and waste heat recovery per se, instead focusing on their main business interests. The financial benefits and limited risk to them (the energy company has chosen to accept all risks as mentioned above) made the project an attractive prospect. Agreement was found as to how to manage an outage of excess heat.

In M54 and M60 the relationship between BS|ENERGY and the data centre is seen as extremely important as partnerships is a foundation for this kind of projects. There have been some discussions within VEOLIA and BS|ENERGY as to how the contract could have been written to prevent delays to the project. However, this may have created added risk for the data centre which could discourage them from agreeing to take part in the project. It became clear that a close relationship rather than a rigorous contractual arrangement was more beneficial to all parties.

Whilst no information can be given on the waste heat value, it should be noted that heat recovery is not the data centers core business and only a little share of its waste heat will be utilised for heat recovery.

Veolia is interested in future projects of a similar kind around Europe. For those, it plans to use a different business model in which it acts as a cooling provider for the data centre, in exchange for its heat. This could move the boundary such that Veolia obtains the heat directly inside the data centre rather than outside.

3.1.2 District heating company- Property developer

The properties to be supplied with heat are newly built and, in order for those properties to be fitted with district heating, negotiations must take place directly between the energy company and the property developer. Once the final property is sold, there is no need for a contractual relationship of this kind as the more relevant relationship is then between the energy company and the end user (i.e. the property owner or tenant). It is desirable for a housing developer to fit properties with district heating rather than alternative sources since the costs are often much lower than, say, installing gas boilers. For this demonstrator, the contractual arrangement is made easier by the fact that the property developer has previous experience with district heating.

The contractual relationship between the energy company and the property developer is limited in time (to the construction phase of the buildings). There are, however, still significant incentives to get the relationship right. For the energy company, the project hinges on getting agreement with the property developer. If this cannot be done, the project cannot go ahead. The benefit to the property developer is dependent on the effect of the value of its properties. If district heating can be sold to buyers as a money saving benefit, this clearly has a positive impact on the value. Since district heating is common in Brunswick, the relative value of those houses that are connected to the network and those that are not should be clear. If district heating does offer a benefit to the value of the properties, one option for the arrangement is for the housing developer to contribute towards the costs of building the network. This would transfer some of the risk from the energy company to the developer but would require assurances about the period of time over which district heating will be supplied.

When a property developer sells or rents a new build property, a contract is required between the parties. Whilst details of energy supply will not form the bulk of the contract, there will be some details of how energy will be supplied. Unlike the case of gas heating, a fee must be paid to the energy company even when a property is not occupied. The obligation to pay this fee must therefore be transferred from the property developer to the owner or occupier. In rental properties in Germany, it is common to include the price of heating in the rent, in which case this will be clearly set out in any contract between the landlord and the tenant.

3.1.3 District heating company - End users

The contract will set out a variety of details such as the cost of the standing charge, the per-unit cost, annual increases in cost etc. In Germany, the standing charge for district heating is generally higher than for standard natural gas heating. In Brunswick, however, district heating is well established and has a competitive price. Unlike other contractual arrangements, the end user has limited space to negotiate with the energy company.

As of M54 and M60, there is no provision for differential pricing to end-users for different sources of heat or different time periods. The cost of heat is constant with respect to the source, the time of day, the season and the outside temperature. The cost of heat to the end-user is identical to customers whether they obtain heat from the data centre or from the CHP (existing high-temperature-DHN). However, this need not be the case and the contract could make provisions for the price of heat to depend on its source. This would allow cost savings, if any, to be passed on to the customer, allowing them to see the direct benefits of the heat recovery.

With time, the demand for customers to have “smart” control over their energy use is likely to grow. This kind of technology opens up opportunities for differential pricing which can be used to help control demand. This can reduce demand during busy periods and increase it during less busy periods. This could help reduce the variability in heat demand allowing for a greater proportion of the heat load to be supplied from waste heat recovery. As of M54 and M60, however, there are no plans to give customers smart control over their energy usage yet.

The customers are private homeowners and a commercial area. A total of 400 houses are foreseen with a total floor area of 48,000m^2. The contract with the end user has a duration of 10 years, which is the maximum allowable by German law. BSE has entered into a contract with the building developer such that the contract will be taken over by the new owners when the properties are sold to private owners.

Key lessons on contracts for waste heat recovery from data centres

- The relationship between the data centre and the energy company is very important and goodwill reduces the risk of the project.
- To encourage participation by the waste heat owner, it is usually beneficial to write contracts such that the waste heat owner is largely protected from risk.
- Data centres produce large volumes of waste heat and so it may be beneficial to write contracts that allow future scaling up.
- Data centres benefit from heat recovery by reducing their cooling costs. This can be exploited as shared incentive to ensure that all parties gain both financially and in reducing CO2 emissions.
- The chosen mode of domestic hot water provision of the building owner will impact the efficiency of the low temperature waste heat recovery. In Brunswick the energy company was assuming a flow through system, but the building owner decided on alternative solution with heat storage tanks which erodes the efficiency of the low temperature heat recovery.
- Identified in M60, the payback of the heat recovery was lower than expected

Were the contractual choices efficient?

- The heat source in the Brunswick demonstrator is not controlled by the energy company and this complicated contract negotiations. The energy company believes that a more efficient solution would be for them to supply cooling to the data centre as a service, and thus controlling the heat source. This has the added benefit of reducing the responsibilities of the heat source. Security issues for data centres can complicate agreements for access to equipment, however. It would have been more efficient for BSE to control the heat source and to secure the applied hot water provision in the buildings (where a flow through system is preferable over a hot water storage tank solution). It is concluded that the learnings on contractual choices in ReUseHeat can lead to more efficient solutions in the future.

3.2 Hospital

1. Low maturity of the technical solution

The risk from the low maturity of the technical solution is managed by attaching the new BHP (Booster Heat Pump) installation network to the existing network. This means that, if the heat recovery fails, the existing solution can be used as a backup and therefore the risk is low.

2. No legal framework for low temperature district heating and cooling

In Spain, there is a legal framework related to waste energy recovery (linked to the energy efficiency of buildings). However, it does not specify clear obligations for those who are developing waste heat recovery solutions to be efficient in terms of energy and environmental footprint. There are also no requirements regarding temperature levels. The absence of a legal framework for urban waste heat recovery has not been an issue for the demonstrator during the life of the ReUseHeat project.

3. The value of the heat

Heat recovery is performed using heat generated by the hospital. This is fed into the district heating network where it is used for heating and cooling. This is undertaken by ASIME who already provide heating and electricity to the hospital. Heat and electricity will continue to be provided at existing rates which are based on wholesale prices and the customer is not involved in any discussion about the value of the waste heat.

4. Long pay-back

According the GA the payback period for the Madrid demonstrator was estimated to be around 15 years. Funding from the ReUseHeat project has been essential to reduce the payback and therefore make the project financially viable. It is hoped that the lessons learned from the project can reduce costs and make similar projects viable without additional funding.

In M60, information on payback based on monitored data was collected from D4.5. From it: *For the Hospital demo-site, the monitoring period covers from December 2021 to August 2022, which means 9 months of monitoring data. The large commissioning period from May 2021 to November 2021 did not allow to get a complete year of monitoring data. As in the case of the datacenter and in order to be able to have a coherent comparison with the impacts foreseen thanks to the implementation of the waste heat recovery solution in the hospital it is needed to have a complete monitoring period of 1 year. Due to this reason, the approach followed was to consider the missing period from September to November similar to the period with real data from March 2022 to May 2022 considering both periods are similar in terms of hospital needs as both are intermediate periods.*

According to the estimation for full volume heat recovery for one year in D4.5 the payback is lower than the foreseen 15 years, it is just under 2 years.

5. Asymmetric information

Asymmetric information has not been a problem for the Madrid demosite. This is helped by the fact that the number of stakeholders is small.

6. Shared incentives

There is a shared incentive between the hospital and ASIME to reduce carbon emissions and costs. By reducing its reliance on gas, the hospital is able to reduce both its costs and its carbon emissions. ASIME has a similar aim. Both may want to reduce their carbon emissions so that they can be seen to be "doing the right thing" but also because, at some point in the future, there may be a carbon tax and so reducing emissions would have an additional financial benefit.

As of M54 and M60, no carbon tax has been introduced and there is no additional financial benefit to cutting carbon emissions.

7. Termination of heat recovery

Termination of heat recovery is highly unlikely. Severo Ochoa hospital is public property and therefore there is no risk of closure due to bankruptcy. The risk that the agreement between ASIME and the Hospital will break down is also low. The two parties have a contractual arrangement until 2033 and this can only be cancelled by the hospital in the event that the quality requirements established are breached. This has never happened before.

There is some risk that the heating production system (boilers) will fail. However, this risk is seen as low. There are three boilers, and each of them could fulfil the heating needs of the hospital. The probability of the three boilers malfunctioning at the same time is small. In any case, ASIME's maintenance crew can usually fix a boiler within 2 days.

3.2.1 ASIME – Hospital

In terms of contracts, the Madrid demonstrator is relatively simple compared to the other demonstrators. This is because the project is run exclusively by ASIME with whom the hospital has a long-standing existing relationship. Currently, heating and cooling is provided to the hospital by ASIME and, therefore, a contractual framework is already in place.

The existing contract lays out the cost of energy to the hospital and this is based on wholesale prices. Once the heat recovery is in place, the tariff paid by the hospital will be reduced, ASIME is currently responsible for maintenance of the heating and cooling and this will continue.

ASIME is responsible for the entire project and, as such, takes on all of the risk.

The current contract between the hospital and ASIME has no renegotiation clauses. The contract runs until 2033 and negotiations can take place then if required. Since all risks of the heat recovery are taken on by ASIME, no additional renegotiation clauses have been added.

Key lessons on contracts for waste heat recovery from hospitals

- The close existing relationship between the energy maintenance company and the hospital made contract negotiations relatively simple. The heat recovery solution simply extends the existing relationship.

- The risk of the project is taken by the energy maintenance company. This improves the attractiveness of the project for the hospital and simplifies contract negotiations.

- Both operators of public sector buildings and energy maintenance companies often see value in reducing CO2 and this shared incentive can be exploited to increase the chances of coming to an agreement.

- Identified in M60, the payback of the heat recovery was lower than expected

Were the contractual choices efficient?

- There was no change to an existing contract, possible since the risk was taken by the party best equipped to take it on (the energy maintenance company). The contractual solution for the demonstrator seems efficient.

3.3 Dashboard

1. Low maturity of the technical solution

The dashboard is considered to be built by mature technology. The concept of the dashboard has been designed with the perspective of the residents in mind (refer to D3.5 and D3.22 for more information about the dashboard design), along with information from model simulations (created by CSTB in DIMOSIM).

A technical design is in place and has been validated in Toulon. No significant issues have been caused by a lack of maturity in technology as of M54 or M60.

2. No legal framework for low temperature district heating and cooling

In France there is no specific framework for the pricing of conventional, renewable or waste heat sources. Whilst a publicly lead DHCN network would impose a clear pricing scheme, the low temperature DHCN in Grands Arenas was to be privately funded. Pricing therefore results from a negotiation process with the network developer/operator. The dashboard is not integrated into this process and only displays energy and environmental indicators. Hence, delivery of the dashboard is not impacted by the existing legislation or by the absence of a legal framework for urban waste heat recovery. Rather, the discussion is related to data ownership and securisation, which data can be used and how (taking the tightened regulation around personal data with GDPR into account). Nevertheless, this latter point has been analyzed and it resulted in that GDPR issues do not apply nor directly nor indirectly with the chosen design.

3. The value of the heat

This is not relevant to the dashboard.

The price is a result of a negotiation process between the public and private sectors. A signal, from the local policy maker, that waste heat is a valuable resource would give a signal to the local industries making waste heat recovery worth wile.

4. Long pay-back

In the techno economic analyses deliverable (6.4) the payback of the dashboard demonstrator was addressed. From this it was concluded that the payback for the dashboard itself is not relevant. The dashboard will be part of a package offer and serve as a unique selling point in, for example, public procurement tenders. However, an analysis was made to address the initially foreseen payback of the dashboard.

Information from D6.4: *The preliminary initial data shown in the table of the Grant Agreement do not match with the real information, as during the course of the project the intentions concerning the Dashboard were subjected to changes. In particular, when it has been decided to develop the Dashboard out of the more complex system to recover waste heat from sewage in Nice, a higher total capital investment cost was estimated, and some direct revenues related to the yearly fee subscription for the service were expected. In the table the expected impact related to the implementation of the Dashboard in ReUseHeat demo site are indicated, mainly considering the economic parameters, as capital expenditures, revenues and simplified payback period.*

Dashboard	
Total Capital investment Dashboard	368 000
Revenues (yearly fee for subscription to data generated from dashboard)	80 000
Simplified Payback Period [yr]	5

Following EDF intentions, the replication strategy identified for the dashboard is to include it into a larger offer to provide a value to building owner, DH operator or the municipality itself (see more in D6.7). Hence, the idea to gain direct revenues through a yearly fee for subscription was no longer seen as relevant under the current targeted business model and, in this view, no direct payback period can be calculated.

5. Asymmetric information

The demonstrator was linked to the progression of the Grands Arenas. In M21, the implementation of the dashboard suffered a delay due to a lack of obligation among customers to sign up to the DHCN service as well as a delay in the construction of the Grands Arenas real-estate projects themselves. All main stakeholders are external to the ReUseHeat Project and thus making information exchange very difficult. This resulted in a delay to the process of securing a customer to host the dashboard.

The fact that the construction of the Grands Arenas was delayed necessitated the validation to be undertaken on an alternative low temperature network. Information asymmetry between those progressing the Grands Arenas and the partners in ReUseHeat severely impacted the demonstration site in both M21, M54 and M60.

6. Shared incentives

In terms of heating and cooling retail pricing, given that the network foreseen would be a private undertaking, each customer has a potentially different pricing scheme in terms of fixed and variable fees. For the Dashboard, this is only of interest if energy solidarity can be achieved by the network operation and thus there is a potential means with which to facilitate an energy exchange between customers and creating awareness on this possibility given by the LT DHCN technology.

As of M21, it was believed that, if an end user demand could be demonstrated, it should be possible to create value that the customer, or more likely the network operator and/or the public authority, is willing to pay for. There was, however, no understanding of the value that the customer sees in the dashboard. More information would be available once the installation was complete. In M60, there were results from end user survey validating end-user interest in the service (see D6.7 for more information).

7. Termination of heat recovery

In terms of the heat recovery, the risk that a sewage water system will cease to generate waste heat is low, as concessions (delegation of service) are on a 10 to 20 years basis. The same applies for sea-water heat recovery. The supply contracts may, as a result of stable heat supply, be "long term" to hedge against a variable customer pool. The foreseen, future DHCN operator in Nice would have to ensure energy supply by any means, so a transitional or temporary solution may be needed. Hence, there appears to be little risk that the availability of the data needed to operate the dashboard will be terminated, once it begins.

Contractual arrangements have been established between the metropolitan Authority of Nice and Dalkia (who will own and operate the low temperature DH network in the Grands Arenas, 3.3.1), EDF and Dalkia (3.3.2), Dalkia and the end customer (3.3.3), CSTB and EDF (3.3.4), EDF and the end users (3.3.5). These are all described below.

3.3.1 Metropole Nice Cote D'Azur - Dalkia

A key contractual arrangement for the proposed district heating scheme in Nice was in M21 foreseen between Metropole Nice Cote D'Azur, the public owner of the waste water treatment plant, and Dalkia, who was foreseen to invest, build and operate the district heating network. In M54, the placement of the dashboard post ReUseHeat was uncertain and there was no contract in place between Dalkia and Nice. In M60, it is known that the Grands Arenas will be built. It is also known that it would be a suitable replication site for the dashboard (see more in D6.4) but there is no contract in place.

3.3.2 EDF -Dalkia

Although EDF and Dalkia, the owner of the dashboard and the operator of the foreseen district heating network respectively, have a close relationship in that Dalkia is a 100% subsidiary of EDF, a contract was still required between the two. In this regard, a data exchange agreement was signed among the parties to secure the possibility to integrate real-time data into the Dashboard. However, the nature of the relationship between the two parties simplifies the arrangement since neither party is incentivized to renege on the contract or enter any contract dispute. This contract was used for the validation of the dashboard in Toulon.

The main purpose of the contract is to set out what data will be provided by Dalkia to EDF and for what cost (if any). Key elements of that contract are:

1) Which data are to be provided by Dalkia to EDF

2) How the data flow will be put in place

3) What monetary costs, if any, have to be borne by the parties for realizing such a service.

4) Conditions surrounding the use of the data – aggregation levels, non-disclosure of certain indicators, definition of indicators' calculation algorithms.

5) To what extent Dalkia and EDF will promote each other in the marketing of their respective products.

6) The parameter of responsibility for the dashboard service development and implementation among Dalkia and EDF and possible mitigation measures.

3.3.3 Dalkia - end customer

As is standard for an energy company, the end users are required to sign a contract. Since the focus for ReUseHeat is on the EDF dashboard, the details of this contractual arrangement are not known by the ReUseHeat team. However, within privately developed DHCN, clients/customers are not legally obliged to sign up to district heating and, therefore, one of the roles of the dashboard can be considered to be to increase the number of customers that sign up, thanks to awareness rising. In any case, the heating/cooling supply contract will integrate on one side a fixed fee covering connection costs and be proportional to the subscribed power and on the other, a variable fee for the consumed energy volume. Nevertheless, the exact fees that apply can change customer by customer but, as the DHCN project is a private undertaking, it will have to be competitive against standard solutions in the market.

3.3.4 CTSB and EDF

CTSB is a research institute in France with a role in the new district heating network and urban waste heat recovery in Nice. The main aims for CTSB in ReUseHeat were to:

1) Improve the functionality of its DIMOSIM modelling tool by applying it in the context of a new site.

2) Improve the mode library of the DIMOSIM software by adding functionality for sewage heat recovery, thermo-refrigerating substations and low temperature networks.

3) Demonstrate the functionality of the DIMOSIM software for other potential users.

The objective of EDF was met when the simulations for the dashboard were finalized and a minimum viable product delivered (M18). The arrangement between CTSB and EDF was a mutually beneficial one allowing both parties to learn from each other.

3.3.5 EDF - end-user

As of M21, the exact nature of the relationship between EDF and the end users was unclear. As of M54 and M60, based on the actual development strategy, no contractual relation will be needed between EDF and end-users and stops at the relation between EDF and the DHCN operator or local authority.

In M21, EDF has considered allowing advertisements on the dashboard (but not pursued the action)- in M54 and M60 this decision was renewed.

Key learnings on contracts for waste heat visualisation

- There is believed to be a demand from network operators and public authorities for visualisation of waste heat recovery figures and awareness rising among the wider local population.
- In M60, end-user demand has been validated and the needed improvement qualified.
- If the dashboard is sold to network operators or the public sector rather than end-users, this reduces the required contracts and simplifies the replication process.
- The close existing relationship between EDF (the dashboard operator) and Dalkia (the network operator) made contract negotiations straightforward.
- There appears to be an increasing demand for "green" energy" as social and environmental responsibility contracts are settled by companies. As this becomes more important to stakeholders, reductions in emissions may start to play a more important role in contracts.

Were the contractual choices efficient?

- EDF is the sole owner of the dashboard. They are engaging in business models based on including the dashboard into a package offer. The dashboard renders a unique selling point in tenders. The District Heating operator (subsidiary of EDF) or municipality is the main customer. At M60, no contract standard was established towards customers as the replication strategy targets the integration of the results by the subsidiary DALKIA.

3.4 Metro

1. Low maturity of the technical solution

Heat recovery from a metro system has low technical maturity. Heat has been recovered in London, in Islington from the ventilation shaft of a metro station (undertaken in the CELSIUS project FP7) but this is the only application the ReUseHeat team is aware of. In Bucharest it was foreseen to recover heat from the platform of a station and in Berlin the recovery would be from the metro tunnel.

2. No legal framework for low temperature district heating and cooling

In Bucharest it was identified that the permitting process would be complex. For the Berlin demosite gaining legal permits for the installation and operation of the infrastructure was identified as time consuming. Another complexity is that the also safety regulations in the metro infrastructure make internal, metro requirements time consuming.

3. The value of the heat

In Bucharest the final customer for the heat was not identified and in Berlin it was the metro operator itself. In neither case the value of the heat was discussed.

4. Long pay-back

The payback period for Bucharest was foreseen to be 10 and in Berlin 17 years. These are long time periods and therefore a good and lasting relationship is needed between project partners. Payback period will change due to emission trade terms and raising energy prices.

5. Asymmetric information

A number of sites were investigated for both the Bucarest and Berlin demosites. In both cities, there was a need for several meetings with foreseen customers to both inform about the new heating technology (waste heat recovery) and to understand customer motivation (green heat, cost efficient heat). In the case of Berlin, a first installation was decided upon and planning up to procurement was concluded. Then, with a few months' notice before the procurement, the metro informed that the location of the heat recovery would be rebuilt, and the location of the demonstrator had to be shifted. This kind of information asymmetries between the core activity and side activity like waste heat recovery is troublesome.

6. Shared incentives

In Bucharest, the point of discussing shared incentives was not reached. In Berlin, BVG, Vattenfall and OPES saw a green value in the demosite. The project would yield a reduction in CO2 of around 60 tons per year. BVG, for example, is obligated to reduce its emissions and the project would have supported them to achieve that.

BVG and Vattenfall were both interested in replicating the solution in other parts of the metro system and valued the experience and knowledge gained from the demosite. Vattenfall also had an interest in replicating the system in other metro systems in Europe. OPES hoped to cement their position as a leading supplier of heat pumps for heat recovery projects such as this.

There was another incentive to BVG in that, by allowing heat recovery to take place, BVG would be able to reduce the temperature in the metro station, providing added comfort to its customers.

7. Termination of heat recovery

The risk that heat recovery will cease is low in a metro tunnel. The metro station foreseen has been in almost daily operation since its construction in 1904. The current operator BVG has been in place since 1928 and this is unlikely to change. Short outages are also unlikely.

3.4.1 Contractual arrangements

For neither site contracts were established, and the demonstrator was not implemented. Below the contractual arrangements that would have been needed in Berlin are presented. For Berlin, an installation of a heat pump for waste heat recovery was needed as well as a transfer pipeline of 100 meters from the heat source to the customer and a micro grid supplying the metro operators building with heat.

A contract between Vattenfall and OPES was foreseen so that Vattenfall could take over operation of the heat pump post ReUseHeat. BVG is already customer of Vattenfall, and this would also be the case for the heat supply from the heat pump. Hence, a contract between Vattenfall and BVG would be needed: the intent was to keep the costs of the recovered heat at the same level as the current energy supply costs.

However, the first item was to realize agreements between OPES, Vattenfall and the metro operator. To transfer ownership of the demonstrator, in such a way that OPES would have a cost neutral solution post ReUseHeat, OPES suggested an offer to Vattenfall and BVG asking Vattenfall to purchase the heat pump and BVG to purchase the micro grid. Due to long time processes in decision making internally at both Vattenfall and BVG, the fact that the installation became more complex in the second site (including a 100 meters pipeline in the second site) and higher international material costs (post pandemic) these contracts were not realized as Vattenfall and BVG communicated that they did not see that the heat recovery was economically feasible.

Key lessons on contracts for waste heat from metro systems

- Asymmetric information can be a problem between the core activity and the heat recovery making the heat recovery more difficult than needed
- There is a shared incentive for waste heat recovery to take place. The energy company receives waste heat and the metro system receives cooling which creates a more comfortable experience for customers.
- Reduction of CO_2 is a shared incentive valued by all parties.

Were the contractual choices efficient?

- It is likely that an arrangement could have been established between the metro operator and the energy company post implementation. However, the fact that neither energy company nor metro operator were partners in the project made the transfer of ownership from the heat pump specialist, OPES, to the partners that would use the installation long term difficult. Most likely the energy company should perform the heat recovery aspart of their offer to a metro operator, not as a special arrangement.

4. Business models for the Reuseheat demonstrators

In ReUseHeat, business models and contractual arrangements for demonstrators were first drafted in D2.8 (M21). Below, an update is provided on the business models.

The structure of the sections per demosite is as follows: first, the interviews with the demosite are summarised for each component of the business model canvas. The impact of choices made (reflected in the contract discussions) and how they spread to the different parts of the business model canvas and the extent to which the parts of the canvas capture the possible value from low temperature installations is illustrated in the canvas framework. Finally, answers to questions that remained open in D2.8 are answered. The section is concluded with key takeaways and an efficiency estimate of the business model choices made by the demosites.

4.1 Datacentre

4.1.1 Business model concept for datacenter heat recovery

In this section, the information from performed interviews is summarized for each component of the business model canvas. The canvas is illustrated in figure 4.1.

1) Customer value

In the Brunswick demonstrator, the value offered to the customer remains the same as it is in the delivery of conventional district heating: heat and hot water. The residents in the new buildings will not be aware that the heat used is from the recovery of the data centre and will place their value on being guaranteed heat and hot water to have a comfortable indoor climate. This was the understanding in M21 (D2.8), M54 (D2.4) and M60. In M54, we identify that since the beginning of the ReUseHeat project, a green movement has been established. It is composed of citizens interested in the local environment and the impact of the energy supplier locally. The green movement representatives reach out to the DH provider to understand what actions are taken to mitigate climate change. This is a context that makes solutions like the datacenter heat recovery an important undertaking and it is useful to inform the end-user as well.

One reason that the customers will not identify an increase in value from the urban waste heat recovery investment is that BS|ENERGY does not apply any diversification in terms of tariffs on their customer base. No distinction is made based on where in the network a customer is located (generating higher or lower distribution costs), if the customer has a higher or lower return temperature (lower return temperatures increases district heating efficiency) or on the heat source used to generate the heat and hot water (with such a differentiation, the green value of urban waste heat recovery could have been made visible).

Even though the green value of the investment is not of any major importance to the customers, it is of significant importance to BS|ENERGY. By not extending the existing DHN that is partly reliant on a fossil fuel (gas) production unit, the environmental gains are important. The pilot that is demonstrated in ReUseHeat is important as it might prove to be a scalable concept of importance to BS|ENERGY and one of its owners; Veolia. In terms of environmental impact, the heat pump installation was also made choosing the refrigerant R744 (CO_2). This choice was a challenge as the number of heat pumps with such refrigerants on the markets were limited.

In summary, the customers in the 400 new buildings and the shopping center do not have the opportunity to value the green benefits. The value of green is not used to diversify the district heating portfolio.

2) Customer segment, relationship and channel

The customers that will obtain the heat from the data centre will, over time, be a mix of professional building owners (of the commercial site) and private home-owners. Initially, the customers are only professional (the commercial site and construction company). Over time, the customers will be professional and private home-owners (the owners of buildings at the commercial site and, when the construction company sells the houses to private investors, private home owners).

In conventional district heating schemes, the large majority of customers are professional customers (Business to Business: B2B). Research shows that the inclusion of private homeowners, necessitates another form of customer dialogue and relationship.

In the pilot demonstrated in Brunswick, a smart control system could allow customers to gain feedback in real time if there is a deviation in their heat demand making it possible for the customers to become more engaged in how they use heat (the customers are empowered). This can prove important in a long-term contractual context. Empowered customers necessitate a closer customer dialogue, something that will be explored by going beyond automated communication channels (e.g. invoices, website and inward going customer phone calls) towards offering the customers a tailor made heat and hot water offer. In the ReUseHeat demosite, BS|ENERGY is not yet attempting to increase the smartness of the energy user. Hence, the customer relationship remains unchanged (customer-provider) as well as the conventional communication channels (rather than a close dialogue).

3) Key resources and activities

New resources needed for the heat recovery in the data centre are the heat pump, the low temperature network and the staff engaged both in the dialogue with the data centre and with the customers. The new equipment will require maintenance and fitting to operate in an optimised way. The new heat source provider dialogue will encompass heat availability, cooling of the data centre process and for any technical distortions in the heat delivery process.

Tailoring the offer to the end customers can lead to the heat and hot water delivery transforming into the service of an indoor climate (seen for example in Sweden). This is something that, in the future, could be relevant and would necessitates staff with complementary skills.

In terms of existing key resources, the fact that the low temperature network is linked to the conventional DHN is one way to add flexibility to the waste heat recovery business. If there is any failure in the waste heat transfer from the data centre to the low temperature network, it is always possible to resort to heat from the existing network.

4) Key partnerships

In conventional district heating schemes, fuel providers are key partners to the district heating company. In the Brunswick demosite, the addition of waste heat from the data centre adds waste heat to the fuel mix. The close relationship to the data centre is necessary for BSE to utilise the waste heat.

In M54 and M60, the experience was such that both the Covid 19 situation and the slower scale up of the datacenter than foreseen initially resulted in much dialogue with the datacenter and a relationship based on trust. The experience of this kind of prosumer relationship has led the DH operator to consider datacenter heat recovery in other parts of Europe but with an adjustment of the boundary conditions. Next time, the district heating provider will support the prosumer by recovering the heat inside the customer building rather than taking it over from the heat provider. This approach will lower the threshold for datacenters (e.g. prosumers) to engage in activity outside of their core activity (e.g go into heat recovery). At the same time, the district heating operator will enhance the control of the timing and the volumes of the heat source.

5) Cost and income structure

In BSE there is no differentiation relating to seasonality, return temperature or the location of a customer in the network. Optimisation of these factors could improve the overall efficiency of the conventional DH scheme. In the context of urban waste heat recovery, the option to differentiate the heat price based on the heat source is important and can allow for urban waste heat to be a premium product (green). However, in the case of the demonstrator, no differentiation from the conventional DH scheme pricing is foreseen.

6) The business model canvas for the Brunswick demonstrator in M54 and M60

In italics, features of the low temperature installation. Not in italics are items that remain from the conventional business model.

<table>
<tr>
<td rowspan="3">Key partners

Fuel providers: still important since existing production creates flexibility

Data center becomes an important partner

Customers can become partners over time

Support organizations- the green value will strengthen the brand value of BSE and Veolia</td>
<td rowspan="2">Key activities

Distribution of heat from the computer center

Smart control

Computer center dialogue and over time customer dialogue</td>
<td rowspan="3">Customer Value

Heat and hot water are sold

The customers do not come in contact with the green value

Green is increasingly important to groups of consumers</td>
<td>Customer Segment

It is a mix of professional and private customers.

The share of private customers will be higher as the building company sells the houses</td>
</tr>
<tr>
<td>Customer Relationship

The customer relationship will not change apart from with the prosumer (datacenter)</td>
</tr>
<tr>
<td>Key resources

Production unit & network of the conventional DH system: both are important since the existing production has a risk mitigating effect

Heat pump, LTDHN, staff who can manage private customer dialogue</td>
<td>Customer Channel

To the customer channel customer dialogue has been added</td>
</tr>
<tr>
<td colspan="4">Cost and income structure

Fixed costs (network)- Yes: remains

Fuels: Yes: less important & prosumer heat

Maintenance (heat pump): Yes

Cost of electricity: Yes

Optimized operation (control: peak shaving, prosumers...): Yes (in future)

Price – remains same as for the conventional DH scheme</td>
</tr>
</table>

4.1.2 Open questions in M21, followed up in M54

<u>Question 1</u>: The value of green is not exploited in the demosite, it does not generate any additional income, instead, it generates goodwill for BSE and Veolia. The situation leads to the following question: What incentives are needed to address a market value for green heat? How are customers incentivized to demand a green solution?

<u>Answers in M54:</u> In Braunschweig there is a green movement, that has increased in importance since the beginning of the ReUseHeat project. Citizens want their cities to become greener. They come to the district heating provider to understand how to decrease CO2 and to understand actions taken. ReUseHeat is one way to show that progressive action is being taken. There appears to be an increasing demand for green energy.

<u>Question 2:</u> Urban waste heat recovery investment necessitates smart control. Does it indicate that decentralized heat recovery requires a more detailed business model (with differentiated prices, customer incentives for optimized behaviour and digital empowerment tools for the customers) than for conventional DH schemes?

Will it change the financial relationship with the customer?

Answers in M54: Overall, BSE is following the digitalization trend, towards smart grids. They want to increase the efficiency of the network with data from customers but it necessitates an encouragement of customers to participate in the smart offer. The company is in a starting phase but, compared to M21, there is a clear strategy and will to engage in increased digitalization. Digitalization is now part of the company's smart energy strategy.

Yes- the customer will know more about their energy usage- and they can therefore decrease it. There will be a benefit in keeping the client. They can offer them more than energy and this is a long term investment. With digitalization, the customer will know more about their energy usage - they can decrease/ increase and make other adjustments to their energy usage. This transparency and customer empowerment will be a benefit in building long-term and loyal customer relationships.

Question 3: If the heat service is more tailor made, does it create a possibility of offering a service (indoor climate) rather than a commodity? Or is a fixed price for a constant thermal comfort sufficient?

Answers in M54: The old pricing schemes do not necessarily reflect future demand. Perhaps the future will necessitate a large share of flexible pricing and also another kind of offer, a service offer.

Question 4: LTDH is linked to the existing DHN. Is this necessary for future replication of the solution? The heat pump will lead to peaks (daily and seasonal) – and such peaks are not efficient. How can the HP work under constant conditions?

Answers in M54: This is why the link to the existing high temperature is important. An alternative to the link would be increased storage. Hence, this is a lesson that a buffer function is needed in a system with heat pumps - for making the system efficient.

Question 5: Over time, the number of private home-owners that are customers to the urban waste heat recovery will increase. What strategy is foreseen for empowering them and making them partners that add value to the DH company (by peak shaving, becoming prosumers etc.)?

Answers in M54: This will be part of the smart energy strategy in upcoming years.

Key lessons on datacenter waste heat recovery business modelling

- It is important to identify the efficient boundary conditions of datacenter heat recovery: it can be an advantage if the DH operator, with knowledge on heat recovery, establishes the heat recovery in the datacenter rather than asking the datacenter to provide the heat. Efficient boundary conditions reduce the risk of the heat recovery timing and volumes being unknown to the district heating operator

- The green energy solutions are increasing in demand in Germany making them relevant long-term

- The green value of the heat recovery can be capitalized (possibly with other pricing than conventional, fossil DH)

- The relationship with the datacenter is important, the heat recovery will be the result of good will from both parties

Were the business model choices made for the datacenter heat recovery business modelling efficient?

- The boundary conditions were set in a way that the heat source was not controlled by BSE. Also, the hot water provision in the buildings was not controlled by BSE. The first aspect caused delay of the actual heat recovery, the second presumably impacts Summer heat recovery efficiency.

- Much of the conventional business model logic was applied to the demosite which means that the business model logic of central production and large-scale distribution system was applied; this means that gains like closer customer relationship, empowered energy citizens and price differentiation are not capitalized on.

- The business models in future data center heat recovery investments will presumably be cooling service offers as this is deemed more efficient than the business model in Reuseheat which will improve the efficiency of the chosen business case.

4. 2 Hospital

First, the interviews with the demosite are summarised per component of the business model canvas. The impact of choices made (reflected in the contract discussions) and how they spread to the different parts of the business model canvas and the extent to which the parts of the canvas capture the possible value from low temperature installations is illustrated in the canvas framework

4.2.1 Business model concept for waste heat recovery in hospital

The hospital demosite was replaced by amendment in M28. There have been two sets of interviews for the D2.4 update (M37-39 and M52-53).

In this section, information gathered from the interviews is summarised by component of the business model canvas.

1) Customer value

In the hospital demonstrator, the value offered to the customer remains the same as it is in the delivery of conventional district heating: heat and hot water. The hospital will, however, benefit from savings in the cooling circuit, hence the value of green is valorised by the customer. The concept of recovery has remained identical between the original site in hospital La Paz and in the replacement site in hospital Severo Ochoa. The difference is the volume of the heat recovery resulting from the fact that Severo Ochoa is a smaller hospital than La Paz, which is the biggest hospital in Madrid.

The green value was of importance to the original partner Naturgy and this is why they initiated the project in the first place. The same applies to the new partner ASIME. The new partner is providing energy management to hospitals in long term contracts. There is work in the public sector in Spain to increase energy efficiency and therefore it is a sector interested in greening their energy solutions.

2) Customer segment, relationship and channel

The customer is a service sector building that is municipally owned. In the future, it should be possible to roll out the concept both in other hospitals and in other service sector buildings, both privately and publicly owned. This was already the case for the original demosite and is especially true for the new partner ASIME, as it is engaged in a large number of hospitals in Spain and in South America. There should therefore be a large potential to scale the solution up in other hospital locations.

To undertake the installation, ASIME is in charge of all technical solutions. It is therefore important to have a dialogue with the customer to find appropriate solutions.

3) Key resources and activities

For ASIME the new resource needed for the heat recovery in the hospital is the heat pump. ASIME already has staff engaged in the dialogue with the hospital. The new equipment has necessitated a lot of fitting to make the installation. After the installation, this kind of activity will change to maintenance and operation.

4) Key partnerships

In conventional district heating schemes, fuel providers are key partners to the district heating company. In the Madrid demosite, the addition of waste heat from the hospital adds waste heat to the fuel mix. The close relationship to the hospital (who is a prosumer) is necessary for ASIME to recover the waste heat.

5) Cost and income structure

ASIME has a long-term contract with the hospital (13 years) and the work in the Reuseheat project is part of the development work of ASIME undertaken at the site of Severo Ochoa. There is no particular arrangement with the hospital for the Reuseheat demonstrator.

6) The business model canvas for the hospital waste heat recovery in M54 and M60

<table>
<tr>
<td rowspan="3">Key partners

Hospital</td>
<td rowspan="2">Key activities

Energy service is offered with the extension of waste heat recovery (e.g. operating the HP) this necessitates an ongoing customer dialogue</td>
<td rowspan="3">Customer Value

Energy savings and greener energy</td>
<td>Customer Segment

Hospital (service sector building)</td>
</tr>
<tr>
<td>Customer Relationship

Tailor made solution and close relationship</td>
</tr>
<tr>
<td>Key resources

Heat pump and staff to make the recovery work and dialogue with the customer</td>
<td>Direct interaction between energy management company and customer</td>
</tr>
<tr>
<td colspan="4">Cost and income structure

Fixed costs- Yes: heat pump and fitting costs

Maintenance- Yes

There is no charge for the energy efficiency for the hospital, the ongoing service provided by ASIME to the hospital entails the Reuseheat solution.</td>
</tr>
</table>

In M21, the demosite described above was not part of the Reuseheat project and no open questions were therefore identified. Therefore, we go straight to discussion of the key takeaways and efficiency of choices made as we see them in M54 and M60.

Key lessons on waste heat recovery from hospital business modelling

- ASIME is an energy management company specialized in the hospital customer segment. As such, there are existing long-term contracts in place making the installation of innovative solutions like ReUseHeat easier to undertake than if there was no such previous arrangement.

- There are cooling towers in many service sector buildings, and it should be possible to install the ReUseHeat installation there: hence the customer segment should be able to be extended beyond hospitals.

Were the business model choices made for the hospital recovery business modelling efficient?

- The ReUseHeat innovation is implemented with no additional cost to the customer. The gain will be energy savings, something that ASIME can make upgraded pricing models for in other energy savings undertakings. The business model applied on the demosite is efficient.

4.3 Dashboard

4.3.1 Business model concept for dashboard

In this section, the information from the interviews is summarised for each component of the business model canvas.

1) Customer value

In the demonstrator, the value offered to the main customer, the district heating operator or the local authority itself, is information that can be used to show end-users the advantages and possible synergies of waste heat recovery in any district energy network. The awareness creation amongst the end users of the green aspect of their heating or cooling system would generate goodwill among all involved citizens and for the city supporting it.

For the end-user the dashboard information leads to increased awareness of the urban waste heat solution, meeting the interest citizens have towards locally sourced renewable energy, which is shared in the district. The awareness itself does not however, trigger a continuous and long-term interest in using the dashboard.

In a future in which the control system is smart enough to optimise the synergies of the low temperature network while including control of end-user located assets and communicating that to the Dashboard, the information of the latter could increase and become complete, linking end user energy use directly to the optimisation of the energy system. This would trigger demand for the dashboard’s service from the end-user. The customer value is not directly transferred from the owner of the dashboard to the end-user. Instead, the following chain applies:

EDF provides the dashboard service to district heating operators (directly or via the public authority in case of a public owned DHCN). The district heating operators extend the service of the dashboard to the general public. So, we have a chain of stakeholders between the service and the value creation. It is likely that, as the dashboard becomes further developed and mainstream, it can be provided directly by the DH operator or the local authority which could ease the interaction with the end user.

During validation of the dashboard thanks to the monitored data, some weakness came to light, regarding the DHCN operation and the overall ICT infrastructure set-up of its control system. In order to calculate the needed environmental KPIs (RES share and CO2 emissions/content), missing indicators came to light and the need of historization of certain variables. Hence, an added value was identified for the district heating operator: internal interfaces were clarified, and the process put in place to answer to the need of providing and opening-up to the public (real-time data via the Dashboard). Hence, the value of the dashboard can be created for the district heating provider and for the end user creating a double demand for the service (DH operators and end-users).

2) Customer segment, relationship and channel

The users of the information on the dashboard are in general terms the local population of a city or district with a RES based DHCN so, either an owner of a building or flat, an employee of the district, a visitor or any environmentally engaged citizen passing through the concerned district. The customer of EDF will be a district energy system operator and/or the local authority.

The replicability of the dashboard should be large and increase over time. There is an expectation that dashboards will raise in the mid-term, as public and private services mature in terms of data management and transparency towards end-users. Used in different contexts than that of ReUseHeat, the dashboard is relevant to public spaces (such as sports arenas, hospitals, schools etc.). When the control system of the network supports smart interaction with end users, it will be possible to feed in information that the end user has (on heat recovery sources for example) and to create transparency on who is recovering heat efficiently (putting peer pressure on others to invest in dashboards for awareness building and increased synergy realisation in the low temperature networks).

To collect the necessary data for the dashboard to function, and to build a control system that is capable of making sense of the data, a close interaction is needed between the district heating provider, the waste or renewable heat provider and possibly, the local authority. As of M21, the customer segment for the district heating and cooling network was foreseen to be professional building owners or other real estate investment or construction companies. In M54 and M60, for the demonstrated dashboard, it has been shown that the energy system operator and the metropolitan authority are the main customers. The channel to reach the end user was not fully determined in M21 but a web-based solution was chosen and launched. The questionnaire and the social study validated the chosen channel and gave additional input to improve end-user relation.

The business model foreseen by EDF in M60 is a B2G or B2B model, depending if a public or private tendering, respectively, is targeted. To clarify, the customer relation should pass directly through its DHCN operation subsidiary (Dalkia).

3) Key resources and activities

To make the dashboard valuable, it needs to feature information for awareness building but also, in time, be interactive and allow the end user to acknowledge the synergies enabled by the low temperature district heating installation. This necessitates continuous data from the district energy network and, with regular intervals a collection of end-user feedback (also performed within the ReUseHeat project, see more in the deliverable on exploitation, D6.7).

Similarly, communication activity to raise awareness about the Dashboard is crucial to launch acceptance of the wider public. Different key communication activities and channels have been highlighted from the end-user survey (see D6.7).

4) Key partnerships

The dashboard will not deliver any results unless data are provided from the energy system. The dashboard will make the energy transition more visible and tangible. To build and make use of the dashboard, a number of key partnerships, with a number of stakeholders as shown above are necessary.

District heating development, allowing it to be part of future smart cities, necessitates an increased dialogue with stakeholders. The dashboard provides a natural meeting point, collecting stakeholders with different perspectives. The energy provider has the advantage of being able to interact with important stakeholders in a new way and to increase the efficiency of the system in operation. The building owner can show energy savings and showcase green choices made, while educating its own staff and customers alike. The heat owner (be it a sewage water treatment plant operator or other) can be engaged to generate a win-win solution (contribute to the DHN and generate its own benefits from the prosumer relationship). The end user will see the information on the dashboard which will generate awareness of the low temperature solutions. A city engaged in dashboard information displays will enjoy empowered heat customers and be a showcase of successful work in the energy transition; indeed, the city can benefit from a reputation of being a change agent in public spaces.

5) Cost and income structure

There is a large number of agents on the market who work with data management and the sensemaking of data generated by organisations. Some focus on defined scorecards or key performance indicators, others on consumed energy amounts over different periods of time. The complexity of mapping all power fluxes in a district is an advanced task and will be the competitive advantage of the dashboard of the ReUseHeat demonstrator. In the project, the development costs are borne by the energy company, together with a national research centre. The development undertaken is to realise a visualization of the low temperature energy system synergy in using waste heat from water. Additional costs of development, beyond the project, will be to make the connection between realisation of synergy and end user engagement. Before the collection of stakeholder information in the ReUseHeat project (e.g before end of May 2022) it was assumed that once the total development cost is sunk, the charge of the dashboard can either be linked to the usage of different energy sources (with an incentive towards waste heat and renewables), to the overall volume of energy purchased or simply as part of a monthly service offer. An active end-user engagement in the operation of the DHN should result in a financial saving on the end users‘ energy bill to allow the full value of the dashboard to be realised.

From the feedback it was identified that the main route to exploitation for EDF will be to include the dashboard into a "packaged offer" where it will generate a unique selling point for successful bids towards public procurement. Hence, it is not foreseen to charge the DH company for using the dashboard on a monthly basis. Instead, it will be a one-time cost. The ownership of the dashboard can vary but for optimised control, it is preferable that the party with access to the data and the sensemaking of the data owns it (in ReUseHeat this would be the energy company). By M54 and M60, EDF has pursued internal investments in the dashboard concept with the main customer segment being the district heating operators (in the EDF group this will be its energy services and DHCN operation subsidiary, Dalkia). Hence, EDF will start exploitation internally in the EDF Group by establishing an arrangement on dashboard exploitation with its subsidiary Dalkia.

6) The business model canvas for the dashboard demonstrator in M54 and M60

<table>
<tr>
<td rowspan="3">Key partners
Local energy system operator
Building owners
End customers
Local sewage plant operator
City administration
ICT and control system developers</td>
<td>Key activities
Awareness building and at a later stage additional data driven services
System efficiency (DH)</td>
<td rowspan="3">Customer Value
Green labelling of own operations (owning a building, operating a DHN or managing a district)
Increased end-user awareness
System efficiency</td>
<td>Customer Segment
Metropolitan/City/Local administration, DHN operator or other local energy system operator</td>
</tr>
<tr>
<td rowspan="2">Key resources
Low temperature district heating network
Design, sociology, IT development resources
ICT services</td>
<td>Customer Relationship
Tailor made solution and close relationship</td>
</tr>
<tr>
<td>Customer Channel
Direct interaction between energy provider and customer</td>
</tr>
<tr>
<td colspan="4">Cost and income structure
Fixed costs- Yes: development cost for the dashboard, ICT service initiation
Maintenance- Yes: operation of dashboard
Cost of data collection and sense making
Product development (update, amelioration, diversification)
• EDF is the sole owner of the dashboard. They are engaging in business models based on including the dashboard into a package service. The dashboard renders a unique selling point in tenders. The District Heating operator (subsidiary of EDF) or municipality is the main customer. At M60, no contract standard was established towards customers as the replication strategy targets the integration of the results by the subsidiary DALKIA.</td>
</tr>
</table>

Figure 4.3, The business model canvas for the Dashboard demonstrator

4.3.2 Open questions in M21, followed up in M54

Question 1: The value of green is exploited in the demosite, but it does not generate a direct demand from end-users for the dashboard. Hence is the effect of installing a dashboard the added goodwill for the building owner/city or DHN operator?

Answers in M54: Yes, the goodwill is important but also the creation of awareness and demand for low temperature heat solutions. Local authorities and DH operators invest great sums to provide renewable and low carbon energy solutions to citizens, which remain unaware of such undertakings. This has been validated by the questionnaire and social study.

Question 2: The efficient operation of a low temperature district heating and cooling network necessitates smart control. Does it indicate that decentralised heat recovery, transformation and storage requires a more detailed business model (with differentiated prices, customer incentives for optimized behaviour and digital empowerment tools for the customers) than conventional centralized DH schemes?

Answers in M54: The dashboard is a digital development in its own right and it can be placed on any renewable or waste heat DHCN (low temperature) as long as there is enough real time monitoring of the system. A DHCN that has a centralized architecture or is not equipped with specific metering equipment, cannot support a dashboard solution.

Question 3: By making the heat service more tailor made, does it create the possibility of offering a service (indoor climate) rather than a commodity?

Answers in M54: The dashboard offers the possibility to provide a new kind of service. Over time, it will develop to be one part of a service offer where the customer is actively engaged in his/her use of energy. The service offer is already part of the EDF portfolio, thermal energy is no longer a commodity when we are able to engage as Building Operators with a customer, beyond the parameter of being the DHCN operator.

Question 4: Over time, will the DHN operators have dashboards as part of their standard offer? Or, similarly, will public authorities require a Dashboard as part of their public call for tenders in the energy sector?

Answers in M54: This is the goal of the dashboard. Important for this goal is to engage in dissemination activities towards local authorities, usually the main driver behind district energy solutions.

Key lessons on waste heat visualization through dashboard business modelling

- There is increasing demand for green energy creating a niche to visualize the impact of green investments. The visualization will drive demand for green energy and is an important steppingstone in generating energy citizens in the EU.

- The gain of efficiency in the underlying DHCN and to achieve performance objectives is important for the content of the dashboard. Moreover, data have to be consistent and reliable, this generates an added value beyond the visualization: an efficiency gain for the operator.

- The dashboard technology can be placed on any LT DHCN where the heat sources are worth showcasing. Over time, it is likely that this kind of measurement will become standard and possibly a requirement in public procurement (something that EDF has already experienced).

Were the business model choices made for the dashboard heat recovery business modelling efficient?

- The idea of the dashboard is owned by EDF. EDF will exploit it internally in the EDF Group by letting the DH operators use it to provide data that is useful for building owners to share with end users. This makes the business model reliant on a number of stakeholders: something that adds complexity. In a future in which the control system is smart enough to optimise the synergies of the low temperature network while including control of end-user located assets and communicating that to the Dashboard, the information of the latter could increase and become complete, linking end user energy use directly to the optimisation of the energy system. This would trigger demand for the dashboard's service from the end-user.

- It is concluded in M54 that it is possible that the dashboard is before its time: it is not until the control system is optimizing that there will be a demand for the service. By M54 no clear business model exists. In addition, the DH market is small in France which makes the dashboard important as it generates awareness.

- In M60, as a result of end-user feedback on the dashboard and work on exploitation of results (D6.7) it was identified that including the dashboard into a package offer to gain a unique selling point in tendering is efficient.

4.4 Metro

4.4.1 Business model concept for metro heat recovery

The Bucharest metrosite demosite was replaced by amendment in M35 by the Berlin site. As a result, there are no drafts of business model for the Bucharest demosite but drafts were made for the Berlin case. For Berlin, two sets of interviews have been made (M37-39 and M52-53).

In this section, the information from the of interviews is summarised for each component of the business model canvas. The second site in Berlin is featured.

1) Customer value

The waste heat recovery from the metro system allows the metro operator to switch from direct, electrical heating. The value is an increased heating comfort during the winter season in combination with a significant CO2 reduction (60 tons per year) as a result of the high primary energy factor of electricity in Germany. The customer identified that there are approximately 10 similar locations in the Berlin metro system where the solution could be installed if proven successful, hence, the solution can be scaled up over time.

2) Customer segment, relationship and channel

The customer segment of metro waste heat is limited to customers that are located close enough to the heat source to be able to make use of the available heat. During the work to identify a suitable location for the heat recovery, several potential customers were identified. In the context of the first foreseen site (Bucharest) a shopping center, a hotel and the university were identified as potential customers. Similar customers were identified for the initial Berlin location (the university) as well as for the second location (a hotel). However, for the location finally decided upon, the customer was the metro operator itself.

It is difficult to access the premises of a metro operator and hence making the metro operator the heat customer facilitates the search for suitable locations for heat recovery and for identifying a suitable offset for the heat.

The relationship established with the metro operator in Berlin has become one of dialogue and mutual interest. The metro operator has spent time and effort to support the ReUseHeat partner OPES in identifying a technically feasible solution for the heat recovery. The channel of communication was personal meetings, digital meetings, phone calls and e-mails.

3) Key resources and activities

For the installation the heat pump and the line from the pump (foreseen to be installed in the tunnel where the heat source was located) to the customers and the low temperature district heating grid (micro grid) were the most essential resources. OPES is a heat pump specialist with vast heat pump experience and this expertise has proven critical for identifying an efficient installation. The air in the tunnels is full of metal dust making efficient functioning of the heat pump difficult, necessitating adjustments to existing heat pumps for minimized maintenance effort during the operational life of the heat pump. Key activities in an operational phase would be to monitor the heat recovery (volumes and temperatures) and make sure the heat transfer to the low temperature grid is efficient.

4) Key partnerships

The metro installation is not possible without the will of the metro operator. Hence, the metro operator becomes a prosumer (both providing and consuming heat) as well as the most important partner in the business model. In addition to the metro operator, there were two other partnerships needed to realize the heat installation in Berlin. The first was the subcontractor that can be on site to install the piping (as OPES was not located in Berlin). This is an important partner for the investment phase. The second partner, long term, is the district heating operator in Berlin, the company Vattenfall. Vattenfall operates the high temperature system in the city which is one of Europe's oldest and warmest networks.

Vattenfall identified that, in the future, they will need heat sources other than fossil fuels, biomass and waste. Therefore, there is an interest to learn how to incorporate low temperature heat sources into existing high temperature networks. The ReUseHeat demonstrator would be prepared for connection to the Berlin network after project end. The heat supply would be provided through a buffer tank between the low temperature heat source installation and the high temperature heating network.

5) Cost and income structure

The heating of the metro building (rectifier building) is currently performed by direct electric heating (electric fan coils), the use of the heat pump system would approximately cut by 3 the need of electricity.

Maintenance would be nominal, and the related costs would be low. Unforeseen maintenance costs of the fan coil packages as heat source could drive cost in case the air in the metro tunnel showed to be contaminated.

Waste heat use from the tunnel air would be cost free for the provider who is supplying heating energy for the BVG rectifier building.

Vattenfall was foreseen to take over operation and ownership of the installation and connect it to its high temperature district heating network. The price charged by Vattenfall to the metro operator for operating the installation was not communicated to ReUseHeat.

6) The business model canvas for the metro demonstrator - a concept

<table>
<tr>
<td rowspan="3">Key partners

Metro operator

Local DHN operator</td>
<td rowspan="2">Key activities

Waste heat recovery, monitoring of the recovery, maintenance, dialogue with the customer</td>
<td rowspan="3">Customer Value

Replacement of electrical heating and indoor comfort in Winter</td>
<td>Customer Segment

Metro operator</td>
</tr>
<tr>
<td>Tailor made solution and close relationship</td>
</tr>
<tr>
<td>Key resources

Low temperature district heating network heat pump, pipeline between heat source and customer</td>
<td>Customer Channel

Direct interaction between energy provider and customer</td>
</tr>
<tr>
<td colspan="4">Cost and income structure

Fixed costs- Yes: heat pump, micro grid and pipeline

Maintenance- Yes: low maintenance costs but still present

Monitoring activity and dialogue with customer drive costs</td>
</tr>
</table>

In M21, the demosite described above was not part of the ReUseHeat project and no open questions were therefore identified. Therefore, we move straight to the section on key takeaways and discussion on the efficiency of choices made.

Key lessons on waste heat recovery from metro business modelling

- The waste heat source in metro systems needs to have a nearby location to install the heat pump and a non-distant heat user (this is not easy to find)
- There is a risk of unforeseen maintenance costs as the installation is difficult to access without numerous permits (access to the metro tunnel environment is highly regulated)
- The metro operator becomes a key partner and, most likely, a prosumer in most metro waste heat recovery investments. A close relationship with the metro operator is a must.

Were the business model choices made for the metro heat recovery business modelling efficient?

- The installation was to be performed by a partner that would not operate it post project. The partner was chosen as a result of its expertise in heat pump installations. For future installations it is more efficient with fewer stakeholders involved, the best option is probably to have the local DHN operator recover the heat.
- The cost of operating the installation post project is not known in detail, but it should be possible for the provider of the heat recovery installation to price its service in such a way that a margin is generated. No efficient contract was realized and thereby it is unknown if the business model concept would have been efficient.

5. Implications of other ReUseHeat deliverable results on contracts and business models for urban waste heat recovery

In this section, we summarise relevant findings – to understand contract and business model choices in urban waste heat recovery investments- from project deliverables in the work packages on urban waste heat potential (WP1) and business (WP2). These work packages were performed early in the project to provide insights to the demosites on items like stakeholders, bankable investments, contracts, risks, business models and the potential of resorting to urban heat sources.

Input on potentials was provided (D1.4 & D1.9) as well as on the impact of increasing the share of low temperature district heating in the energy system at both national (D1.5) and city (D1.6) levels. Relevant information from the deliverables, when drafting contracts and business models is summarized below:

Key lessons from potential and energy system analyses

- The urban waste heat potential of low temperature heat could meet approximately 10% of the heat needed for buildings in EU 28
- The largest share of the urban heat source comes from sewage water (42%), data centers (23%), service sector buildings (19%), whilst only 2% comes from metro systems
- In both the urban and national analyses, it is shown that the total potential is bigger than what can be utilized in the countries (in a cost-efficient way)
- In national analyses of urban waste heat use in scenarios for 2050, the heat sources are equally feasible
- Urban waste heat recovery will save CO2 emissions, primary energy and costs in both the national and city level analyses

Lessons from the key takeaways on urban waste heat recovery contracts and business model design

The use of the identified potential will not be realized large scale before contracts that are standardized and applicable to all urban heat sources can be drafted. Standardization necessitates homogenized policy and legislation on waste heat recovery in Europe. Currently there is no common waste heat policy which drives risk for this kind of investment. Also, it is concluded that not all the waste heat existing is cost efficient to recover, it must be decided on a per case basis. Hence, an in-depth study of the heat source at hand is important for efficient business cases.

Input on stakeholders (D2.1), bankability (D2.2), risk (D2.5), scalability and replicability (2.6, 2.7, 2.9) with relevance for drafting contracts and business models is summarized below:

Key lessons from business analyses, replication analysis and KPIs

- There are few incentives to date for end users to demand a green value: this is not facilitating the implementation of urban waste heat recovery. For prosumers, there is an added value in the possibility of making use of the heat generated as part of a core process.
- Close relationships (built on dialogue) between the DH operator and the waste heat owner are essential.
- A long-term contract with shared incentives can lower the current barriers of immature technology and the lack of a legal framework and make the business case feasible.
- Agreement on the value of the waste heat from both sides as well as payback times that do not add a disproportionate risk premium of the investment are necessary for economic viability.
- The customer segments remain the same in the urban heat recovery investment (mostly B2B)

Lessons from the key takeaways on urban waste heat recovery contracts and business model design

One important finding is that technology ready low temperature installations do not harvest the full value from the installation since conventional business model logic is applied to the low temperature case. This is a main challenge to implementation of urban waste heat recovery investments.

6. Conclusions

6.1 Contracts

Regarding contracts, the three realized demosites identified solutions that were efficient to different extents. The hospital included the ReUseHeat installation as part of their offer as energy management consultants which meant that the waste heat owner and user (the hospital) did not have to make any decisions about an energy innovation. All risk with the installation were borne by the energy management consultant company. Full risk coverage was also assumed by the energy company recovering waste heat from the datacenter. The energy company invested in the hardware (low-temperature distribution network and heat pump) and ensured their customer heat supply by means of the existing high-temperature network until the waste heat recovery was in place. Whilst the energy management consultant company could include the ReUseHeat solution into a current contract the energy company had to engage in a contract with the datacenter. A key learning was that it was important to establish a trusting relationship with the datacenter and that too many contractual clauses would have deterred the data center from engaging in the heat recovery. Both the hospital and the datacenter had no interest in actively engaging in the waste heat recovery but identified an upside in terms of green value allowing the energy management consultant company and the energy company to undertake this activity. **It can be concluded that waste heat owners are more interested in their core business than engaging in waste heat recovery. However, they can be convinced to do so if it the risk of the heat recovery is efficiently managed.** In the report in M21 (and remains in M60), it was identified that urban waste heat recovery contracts need to encompass efficient boundary conditions for the heat recovery. This is part of the risk minimization for both sides. One important learning for the datacenter heat recovery is, for example, that for future heat recoveries the energy company will offer a cooling service to the datacenter and ensure that the waste heat recovery is recovered by them, instead of by the datacenter which increases the control of the heat source (e.g. a shift of boundary conditions).

Two of the demosites were established with a large number of stakeholders. The dashboard needed to be built based on expertise of modelling experts (CSTB), the energy company (EDF) the potential end user (City of Nice) and the DHN operator (DALKIA). The metro heat recovery necessitated the expertise of a heat pump specialist (OPES), the owner of the waste heat (metro operator) and the district heating operator of the city of Berlin (Vattenfall). For the dashboard, the many stakeholders did not necessitate a large number of contracts as EDF will be the sole owner of the dashboard. For the metro, three stakeholders were involved to make the installation and to manage its use post project. Arriving at efficient contractual solutions for the three metro stakeholders was not possible even after a long process. In M21 it was concluded that **the standardization of contracts is easier when the number of stakeholders involved is limited.** In M54 it was **further identified that few partners and the establishment of trust between the parties support urban waste heat recovery success.** In both the datacenter and hospital case, there is a long-term collaboration around the waste heat recovery, this appears to be important and a way of generating mutual trust. The waste heat owner trusts that their partner will do its very best to ensure an efficient and value generating waste heat recovery and the energy management company or energy company trusts the waste heat provider to provide a stable heat supply. In M54 and M60, **we conclude that standardized contracts are important for urban waste heat recovery implementation to happen**

at a large, European wide scale. It is probably less relevant in early cases like the two demosites mentioned above as the long-term character of the relationship reduces the needs of standardized solutions. Over time, as waste heat from urban heat sources becomes increasingly standardized- and thereby less risky- the contractual lengths might actually be less important and reduced.

From the potential analyses it has been established that there is urban waste heat to harvest. In ReUseHeat it has been identified that some heat sources have higher security of supply than others: this is the case for the sewage water, buildings and metro heat recovery whereas the datacenters tend to shift location after a few years to allow for the spreading of urban areas. **From a contractual point of view the risk of heat supply should be considered to define an efficient contract.**

6.2 Business models

Regarding business models, a number of conclusions were drawn in M21 and they remain valid in M54 and M60**. An important conclusion was that the urban waste heat investments necessitate updated boundary conditions which means that new business logics are needed.** This, for example, means that the logic of central production and distribution must be revisited to value the local waste heat source efficiently. Returning to the business model canvas framework we can conclude that some components (notably customer value, customer relationship and key partnerships) are in need of an update in order to make urban waste heat recovery investments relevant for district energy companies. Below, conclusions on the different components of the business model canvas are provided.

6.2.1 Customer value

The value of green energy (carbon footprint) is one of the key drivers for the demosite partners engaging in the ReUseHeat project and it is also important for the customers: the hospital, metro operator and datacenter owner all value the positive environmental impact of recovering waste heat. The city of Nice where the dashboard was foreseen to be deployed also identified that the green value of waste heat is important enough to engage in awareness creation amongst its citizens. In M21 **we identified that the green value of urban waste heat recovery was however not being capitalized on (for example by means of differentiated customer offers with different prices for energy that reflect different levels of green) in the foreseen busines models.** This remained the case in M54 and M60. This result is not unique to ReUseHeat. In a study of 6 low temperature implementation (Lygnerud, 2019) it was identified that the energy companies focused on getting the technology right and then applied the conventional district heating business model (based on large scale heat production and distribution) to the low temperature case which erodes the low temperature business case.

Further on the topic of customer value we conclude (in M21,54 and 60) **that heat is not offered as a service. Instead, the conventional offer of heat and hot water remains** *(three of the demosites: datacentre, metro, hospital)*. To offer a cooling service to data centers could have been an efficient service offer for BSE and to offer an indoor climate could have been an alternative for the metro installation. The energy service provider ASIME is providing energy efficiency services related to the heating and cooling of the hospital. However, the offer is still heat, cooling and hot water in an energy efficient way and not an "indoor comfort service".

For the awareness creating demonstrator, the dashboard, it has been difficult to identify which business model will be the most efficient one. The reason for this is that it is uncertain if there will be sufficient demand amongst end-users to incentivize district heating operators and cities to, in their turn, demand the information that the dashboard can generate. It is assumed that as buildings and district heating networks become increasingly digital the gains of the information of the dashboard can be capitalized on. It might be that the dashboard information is too advanced to create an added value to the way that end-users are currently acting. The conclusion from the dashboard learning is that all parts of a system must be equally smart in order to benefit from being smart. There is a great potential to engage end-users and there is an ambition in the EU to create energy citizens as it is seen as a means to increase energy efficiency at the societal level. The dashboard demonstrator experience indicates that information is needed to push both technical system smartness and end-user activity: the whole idea of the dashboard in ReUseHeat. In this context, it is important that policy makers support the education of end-users by supporting waste heat recovery investments. This can be done directly via subsidies or indirectly by requesting all new industrial installations and construction of buildings to perform waste heat recovery as part of the package. **To conclude, the dashboard experiences identify a need for end-user awareness creation if EU is to reach its ambition of establishing energy citizens.** In M60, it is identified that the dashboard will be included as part of a package offer in bids for public procurement which supports the idea **that public authorities can play an important role for triggering the urban waste heat recovery demand.**

6.2.2 Customer relationship and key partners

Addressing the customer relationship, we found (in M21) that a close customer dialogue and relationship are necessary for urban waste heat recovery success. This is further confirmed in M54 and M60. **It is concluded that the close customer relationship was a success factor for both the hospital and datacenter demonstrators and it is concluded that the waste heat provider becomes a key partner.** The closer customer dialogue and relationship can be a window of opportunity to district heating providers in an energy context that overall is becoming more digitalized and more distant from the end user. In contrast, with a hands-on and tailored offering the urban waste heat recovery investment can lead to a long-term loyal customer base. We also believe that the future district energy providers will need to offer an array of tailormade business models rather than one, base case, allowing for cost coverage.

6.2.3 Key activities and resources

Three of the demonstrators were supposed to be a system innovation encompassing an urban heat source and a heat pump. Two of them were realized and in both cases the heat pump and staff with the ability to engage in the closer customer dialogue were key resources. In the datacenter heat recovery and the foreseen metro heat recovery a low temperature district heating network was needed. For all three, key activities are customer dialogue and monitoring of the heat recovery. For the energy company recovering waste heat from the datacenter savings were made as investments in high temperature heat production units were avoided and the energy management company could meet its obligations towards the hospital by phasing out substantial amounts of natural gas. **Based on the experience from the hospital and datacenter sites it is concluded that the low temperature waste heat recovery can be integrated into an existing solution and that it adds value to it.**

6.2.4 Costs and revenues

For the two demonstrators implemented there were hardware costs (e.g. heat pump for both and low temperature network for datacenter) and investments in staff to maintain the customer dialogue. Reviewing the monitored data in M60 **it can be concluded that the incurred costs had lower payback than foreseen indicating that low temperature waste heat recovery investments are attractive investments.**

A reflection that can also be made in M21, 54 and 60 is that there is a potential to differentiate the return from low temperature installations by diversifying the price to end customers. This potential was not harvested within the ReUseHeat demosites.

6.2.5 Conclusions on business modelling from other deliverables in ReUseHeat

From other analyses made in ReUseHeat, a lack of incentives for urban waste heat investments was identified. Instead, the solutions compete with incentivized investments in, for example, renewables. **To start large scale European implementation of low temperature waste heat recovery it is concluded that it is necessary to establish incentives or possibly a credit facility (suggested in D2.2 on bankability) and to establish a legal framework for waste heat.** Furthermore, it is important to harvest the added value of a heat supply with limited environmental impact by revisiting the conventional DH business model logic. **It is concluded that the low temperature heat recovery can serve as a complimentary that supports the existing heat supply increasing the attractiveness of district heating.**

6.3 Other

The ReUseHeat project is an innovation project featuring urban waste heat recovery. Innovation actions generate lessons allowing future implementations to be undertaken in a more efficient way. The project has experienced that three demonstration sites will be realized instead of the four that were foreseen. The demonstrator that is not realized is the one where the lowest level of maturity of the installation is found. One heat recovery from metro systems has been realized before (in the CELSIUS project (FP7)). In ReUseHeat, the first foreseen site in Berlin, where the heat source and heat use were closely located the heat recovery would have been efficient. It was the addition of a heat supply pipeline between heat supply and use that complicated the technical installation and eroded cost efficiency. Apart from the technical circumstance, the metro demonstrator reflects the situation of the waste heat owner being new to waste heat recovery. Metro operators have as core business to operate and maintain metro lines in a city. To engage in other activity necessitates different layers of hierarchy to make decisions about a business arrangement that is news to them. These things take time and lengthy contractual discussions: things that were not possible to achieve in the timeframe of ReUseHeat. Hence, even if a potential business case could be drafted the absence of contract hindered the implementation. In the other demonstrators recovering waste heat (datacenter and hospital) the waste heat owners were also new to waste heat recovery which caused some delay especially in the scale up of the datacenter, but this was manageable as the implementation of the technical system was manageable. **One conclusion is that immature technical systems in combination with immature waste heat owners will significantly reduce the potential of waste heat recovery. When only one of the items (the heat source owner or the technical installation is immature) the implementation is increasingly feasible.**

It is also identified that both costs and energy savings can be realized by including urban waste heat long term which shows that this kind of energy supply is an important element of the energy transition. **The vision of ReUseHeat that cities in the future can, at least partially, heat themselves with energy generated by their citizens doing their daily chores can be concluded to be a realistic one.**

7. References

Averfalk et al (2021) Annex TS2 Implementation of Low-Temperature District Heating Systems, Fraunhofer

Lygnerud, K. (2019), *Business Model Changes in District Heating: The Impact of the Technology Shift from the Third to the Fourth Generation*, Energies, Online open access: https://www.researchgate.net/publication/327290123_The_Status_of_4th_Generation_District_Heating_Research_and_Results

ReUseHeat deliverables resorted to:

D1.4 Report on the amounts of urban waste heat accessible in the EU28 (HH)

D1.5 Report on the energy planning analyses on future energy system in the demo countries (AAU)

D1.6 Report on future scenarios for the urban energy system integrating waste heat sources (IVL)

D2.1 Stakeholders analysis and proposal for overcoming existing market barriers (TRA)

D2.2 Guidelines for evaluating bankability of urban waste heat recovery investments (RINA-C)

D2.5 Evaluation models for assessing risk of urban waste heat recovery investments and suitable ownership and funding models for urban waste heat recovery investments (LSE)

D2.6 Report on scalability, replicability and modularity requirements for the demonstration cases in REUSEHEAT & its update (D2.9) (TRA)

D2.7 Scenarios for the future scale-up of the REUSEHEAT demonstrators (TRA)