applied sciences

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Contracts, Business Models and Barriers to Investing in Low Temperature District Heating Projects

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Received: 25 June 2019; Accepted: 1 August 2019; Published: 2 August 2019

Abstract: Approximately 1.2 EJ of energy are potentially available for recovery each year from urban heat sources in the EU. This corresponds to more than 10 percent of the EU's total energy demand for heat and hot water. There are, however, a number of challenges to be met before urban waste heat recovery can be performed on a wide scale. This paper focuses on the non-technical issues related to urban waste heat recovery and is written on the basis of opinions gathered from stakeholders in the field. Three non-technical issues are focused upon. First, a number of important barriers to wide scale urban waste recovery are identified, and where applicable, recommendations are made regarding how to overcome these barriers. Second, important issues and challenges regarding contract design are identified and discussed. Key elements of heat supply contracts between the district heating company and the owner of the waste heat are described. Finally, the impact on business models of properties specific to urban waste heat recovery are discussed. Data were collected from two separate sources, both related to the ReUseHeat Horizon 2020 project, which addresses the application of urban waste heat recovery in existing district heating networks. First, a number of interviews with stakeholders were carried out. Second, information was collected from demonstrator sites involved in the ReUseHeat project. It was concluded that, for urban waste heat recovery to be taken up on a wide scale, there is still a large amount of work to do to overcome these major issues. This paper is novel in that key non-technical issues of urban waste heat recovery are discussed from the perspective of a large sample of actual stakeholders and practitioners in the field.

Keywords: urban waste heat recovery; barriers; contracts; business models

1. Introduction

Approximately 50% of the energy consumed in the European Union (EU) is in the heating and cooling sector [1]. The carbon footprint of heat supplied through district heating depends heavily on its source. Over time, a shift from fossil fuel heat sources to renewable sources has been observed. This shift is most visible in Nordic countries where biofuels dominate the fuel mix [2]. One important feature of district heating networks (DHNs) is that waste heat from other processes can be recovered and distributed through the network. According to a survey aimed at quantifying the potential use of waste heat in the EU, the technical potential could be up to 2.7 EJ/year [3]. The use of waste heat is advantageous in reducing carbon emissions, and therefore in meeting climate targets. Industrial waste heat is often of a high temperature, which facilitates effective recovery into district heating systems. Waste heat at an urban level provides an alternative source. Urban waste heat stems from commercial processes or from structured operations that are undertaken daily. For example, heat can be recovered from data centres and sewage water [4–10]. The main challenge of urban waste heat recovery is that the heat is normally low-enthalpy (around 20–40 °C). This temperature is lower than the heat distributed in conventional DHNs (around 90 °C) [11]. According to the definition of 4th

Generation DHNs provided by Lund et al. [12], future DHNs may need to supply low-temperature heat for space heating and domestic hot water (DHW) to energy-renovated existing buildings and new low-energy buildings. Heat from urban waste heat sources is able to be upgraded to fulfil end-user requirements and is thus expected to play a fundamental role in meeting global thermal energy demand [13]. However, urban waste heat recovery implementation is at an early stage and its feasibility needs to be demonstrated for the purpose of scaling up. New urban waste heat recovery system solutions are currently being designed across Europe. In an ongoing International Energy Agency project (the TS2 project on 4th generation district heating technology implementation), over 130 low temperature district heating installations have been identified (www.iea-dhc.org), confirming that urban waste heat recovery is an upward international trend.

The ReUseHeat project, on which the authors of this paper are partners, is a Horizon 2020 EU funded project (see acknowledgements) addressing the input of urban waste heat into existing district heating networks through the implementation of four demonstrator sites. The ReUseHeat project aims to provide answers to open issues regarding urban waste heat recovery investments. It demonstrates the techno-economic viability of four large scale systems enabling the recovery of heat from urban heat sources (data centres, sewage water networks, metro stations and hospitals). At this stage, due to technical difficulties, the metro station demonstrator site is in a less developed state than originally envisaged, and thus results from this site are not currently available.

One key finding of the ReUseHeat project is that heat recovery potential from unconventional waste heat sources in the EU is significant. There is potential to recover 1.2 EJ/year from data centres, metro stations, service sector buildings, and waste water treatment plants. This corresponds to more than 10 percent of the EU's total energy demand for heat and hot water, which is approximately 10.7 EJ [14].

There are a number of known barriers to investment in industrial waste heat recovery. One obvious barrier is the absence of a DHN in the proximity of the heat source. Other barriers are the existence of cost competitive heat supply alternatives and policy incentives for other forms of heat supply such as biomass or waste fueled CHP plants. There are also barriers to the technical installations themselves, e.g., more complex solutions being needed than foreseen, the temperature of the waste heat being lower than expected or expensive transmission pipes [15–18]. Some barriers are linked to the interaction between the district heating company and the waste heat provider. It has been found that the quality of the heat (volatility of volume and temperature) is often perceived differently by the district heating company and the waste heat owner. The latter tends to claim that the heat is of premium quality, whilst the district heating provider will often disagree. Complexity is added by the existence of asymmetric information about the heat flow of each party involved in the collaboration [19]. Split incentives between project partners appears to be important when implementing waste heat recovery schemes [18].

Investment in waste heat recovery also competes with alternative uses of investment capital [20–22]. The risk that the heat source will terminate its core activity or move premises is often mentioned as a risk and therefore a barrier. In [23], the authors assessed the risk of Swedish industrial waste heat recovery for the period from 1974–2014. The analysis verified that terminated industrial activity is a risk factor and that, in combination with cases in which there was a substitution for another heat supply, approximately 6% of all annual heat recoveries were lost. Other risk factors that were identified include a lower than predicted annual heat recovery and the use of heat pumps.

Systems for urban waste heat recovery often rely on the use of a heat pump, which creates a dependency on electricity, making volatility and trends in the price of electricity a key factor. An advantage of urban heat sources is that they are typically local to the network. For example, data centres, sewage water treatment plants, underground stations and service sector buildings are usually in urban areas.

The volume of heat that can be recovered from urban heat sources is usually lower than the volume available from large industrial processes. However, the fact that the heat sources are local and small has its own advantages. First, there is an opportunity to make use of multiple local

heat sources, reducing the reliance on a single source, and therefore increasing the resilience of large DHNs. Second, to harvest the local heat source, close customer dialogue is needed. This builds trust and long-term engagement, which can create a competitive advantage for district heating providers over other heat suppliers who depend increasingly on digital interaction with customers [24]. Third, and most importantly, urban waste heat sources are fossil free (although the electricity used to power a heat pump may come from a non-renewable source) and readily available. Urban waste heat recovery is challenging but the potential fossil free energy potential of 1.2 EJ/year is a great incentive to overcome those challenges.

Much attention has been given to the technical side of urban waste heat recovery. This is a natural consequence of the need for validated technical solutions in a newly emerging area. However, other aspects regarding risk, contracts and business arrangements are equally important. In this paper, results are presented regarding the issues of barriers to investment, contractual arrangements and business models. The results come from research developed during the ongoing ReUseHeat project. Urban waste heat recovery suffers from issues of technical performance as well as challenges with efficient contracting and business modelling. This technical uncertainty is further aggravated by a lack of legislation and standardisation of urban waste heat recovery investments. The contractual uncertainty is increased because stakeholders other than the district heating company and the waste heat provider are often engaged in contractual arrangements, and the uncertainty of the business model is reflected in an over-reliance on the logic of business models for conventional, high temperature heat recovery.

The novel aspect of this paper is that non-technical issues from the perspective of a large number of actual stakeholders are reported. This is key because it provides a summary of the practical barriers to urban waste heat recovery, important contractual issues, and issues related to current business models from the perspective of those actually engaged in its practice or who might be engaged in the future.

2. Methods

The ReUseHeat project demonstrates advanced, modular and replicable solutions enabling the recovery of waste heat available at the urban level. The demonstrator sites at an advanced enough stage to gather information at the time of writing are:

- Heat recovery from a data centre in Brunswick, Germany to supply 400 new residential buildings.
- Heat recovery from a hospital cooling system in Madrid, Spain to supply heating and hot water for the same hospital.
- Demonstration of an online energy dashboard, in relation to heat recovery from sewage water to supply heat to a new district in Nice, France.

The final demonstrator relates to heat recovery from a metro station. Results from this demonstrator are not reported since the project has been delayed.

The ReUseHeat project focuses on both technical and non-technical aspects of urban waste heat recovery. The focus of this paper is the latter; in particular issues regarding contracts, business models and barriers to investment.

The results presented were gathered from the project in two ways: an analysis of urban waste heat recovery stakeholders and through discussions with the demonstrators themselves. More details on each are given below.

2.1. Stakeholder Analysis

A key part of the ReUseHeat project is to gather information and opinions from stakeholders of urban waste heat recovery around Europe. Interviews were therefore conducted with a range of stakeholders. Five stakeholder groups were identified as particularly relevant to urban waste heat recovery investments. These are:

- policy makers
- investors
- district heating companies
- waste heat owners
- customers

Stakeholders in each of the five categories were identified in eight EU countries:

Sweden, Germany, Denmark, France, Italy, Spain, Belgium and Romania. Interviews were carried out in each country. The target was to obtain two interviews per stakeholder category in each country. Eventually, the consortium was able to interview a total of 76 respondents. The distribution of respondents is shown in Table 1.

Table 1. The distribution of the respondents

Country	Customer	District Heating Company	Investor	Policy Maker	Waste Heat Supplier	Number of Respondents
Sweden	2	2	2	2	3	11
Romania	3	2	2	2	2	11
Italy	2	2	2	1	2	9
France	1	2	2	1	2	8
Germany	2	2	1	3	1	9
Denmark	2	2	2	2	2	10
Spain	2	2	2	2	2	10
Belgium	1	1	2	2	2	8

The interviews were undertaken on the basis of a set of questionnaires designed with the aim of gathering perspectives on both technical and non-technical aspects of urban waste heat recovery. Responses to each question were recorded for later analysis. To account for new legislation on data protection (GDPR), all respondents were asked to sign an informed consent document before the interviews were performed.

2.2. Demonstrator Interviews

One of the aims of ReUseHeat is to gather and share the experiences of the demonstrator projects on issues regarding contracts, business models and barriers to investment. As such, regular contact has been maintained between the demonstrators and those working on less technical parts of the project. Through site visits and regular online communications, the perspectives of those working on urban waste heat recovery were gathered and these form a key part of the results presented in this paper.

2.3. Extracting Stakeholder Perspectives and Demonstrator Experiences

Both the stakeholder interviews and discussions with demonstrators provided a great deal of information that needed to be condensed into a number of key points. The stakeholder interviews took place at an early stage of the project, and as such, inspired the direction of discussions with the demonstrators. In order to condense the contents of the interview transcripts, each one was reduced to a short set of notes containing key details from the interviews. These were then able to be analysed formally to extract important themes by searching for key words, counting the number of respondents in agreement with each question, etc.

The overarching aim of both the stakeholder interviews and discussions with demonstrators was to gather knowledge and experience from those who are actually engaged in the field and dealing with these issues on a daily basis. It was envisaged that the conclusions would be helpful in identifying challenging issues and helping stakeholders to consider these issues at an early stage. It was also hoped that the issues identified might lead to future research avenues and more in-depth solutions.

More information on the topics discussed in this paper are available in deliverables from the project that are publicly available on the ReUseHeat webpage (www.reuseheat.eu).

3. Results

The combination of the stakeholder analysis and discussions with the demonstrators yielded a number of common themes related to the three issues addressed in this paper (barriers to the uptake of urban waste heat recovery, contract design and business models). These common themes are described further in the following three subsections.

3.1. Barriers to Urban Waste Heat Recovery

3.1.1. Low Technical Maturity of the Existing System Solutions

Due to the low technical maturity of urban waste heat recovery systems (e.g., there are a limited number of precedents for the combination of heat pumps and DHNs) and the fragmented legal framework, policy makers are an important stakeholder group moving forward. They have the power to generate the correct incentives to support the technology. Perhaps the most efficient way to do this would be to create direct urban waste heat recovery incentives (e.g., through subsidised electricity for heat pumps), and/or to increase the cost of emitting CO_2 (this of course would benefit all green technology). Investors have the power to invest in green projects, which makes them very important in the context of urban waste heat recovery investments. Greater demand for green investments and bonds may eventually increase opportunities in this area.

3.1.2. Long Payback Periods

Urban waste heat recovery investments are a product development area for district heating companies. To achieve increased market uptake, district heating companies and owners of waste heat have key roles to play. However, the low profitability of the investments triggered by long payback periods means there is limited market pressure to develop urban waste heat recovery projects. The introduction of incentives may be able to reduce payback periods and make investments of this kind more attractive.

3.1.3. Existing Incentives for RES and CHP

The long payback periods typically seen in urban waste heat recovery investments suggest a need for policy incentivising reductions in CO_2 through this kind of technology and investment proposals with beneficial terms for institutional investors. The current incentives for Renewable Energy Systems (RES) appear to disincentivise urban waste heat recovery investments over alternative solutions.

The authors of this paper know of only one case in which incentives explicitly target low temperature district heating investments. The German Wärmenetz 4.0 scheme provides funds for up to 60 percent of the cost of feasibility studies and 50 percent of eligible project costs for the realisation of those studies [25].

3.1.4. Absence of a Legal Framework for Urban Waste Heat Recovery

Urban waste heat recovery is a relatively young technology, and as such, virtually no countries or territories have legal frameworks or standardised permit procedures. This is a challenge because there is no legal clarity, increasing uncertainty and pushing up costs.

3.1.5. Absence of Standardised Contracts

There is a lack of standardised contracts for use in urban waste heat recovery. This means that contracts must be drawn up from scratch, increasing costs and extending contract negotiations. There is also an increase in risk because the probability of omitting important clauses is elevated. Contracts from other projects are typically hard to learn about for reasons of confidentiality. The development of

standardised contracts would be an extremely valuable tool for advancing the agenda to ramp up urban waste heat recovery.

3.1.6. Diverging Views on the Value of Heat

The divergence in the views of heat owners and district heating companies regarding the "value" of heat is a major barrier for industrial waste heat recovery investments, and this was commonly mentioned as a problem in the stakeholder interviews. To overcome this challenge, efficient contractual arrangements and transparency are key; something that is underlined by the local nature of urban waste heat recovery investments.

3.1.7. The Low Temperature of Urban Waste Heat

As urban waste heat recovery solutions become mature, it is likely that the temperature level of the heat source will become less important to the success of the urban waste heat recovery investment. Urban waste heat sources are local, which is a major benefit in terms of the cost of building the infrastructure. The volumes of heat that can be recovered are typically known, and thus this is not considered to be a major risk item by stakeholders. What appears to be of greater importance is to have long-term guarantees regarding future volumes (preferably in long-term contracts) of heat to increase the predictability, and thus reduce the risk of the investment.

In summary, there are currently a number of barriers to investment in urban waste heat recovery. They are summarised in Table 2.

Table 2. Barriers to urban waste heat recovery investments.

Barrier	Description
1	Low technical maturity of the existing system solutions
2	Long payback periods
3	Existing incentives for RES and CHP
4	Absence of a legal framework for urban waste heat recovery
5	Absence of standardized contracts
6	Diverging views of the value of heat
7	The low temperature of urban waste heat

3.1.8. Summary

The barriers identified above demonstrate that there is still significant work to be done before urban waste heat recovery can be widely adopted. Perhaps the most important actions that could be taken to improve the situation are:

(i) Updating the legislative framework to account for urban waste heat recovery.
(ii) Increasing awareness of urban waste heat recovery.
(iii) Introduction of financial incentives that can compete with those for renewables.
(iv) More research and demonstration to make urban waste heat recovery investments turnkey and widespread.

3.2. Contracts

The nature of urban waste heat recovery means that there are typically multiple parties involved. Whilst the DH company and the owner of the waste heat are the key parties, there are usually additional parties. For example, the Brunswick demonstrator in the ReUseHeat project has three parties (the DH company, the data centre and a parent company of the DH company), the Madrid demonstrator has three (the DH company, the hospital and the constructor of the technology) whilst the Nice demonstrator has five (the DH company, the owners of the online dashboard, the owner of the waste heat, a public research institution developing the software for the dashboard and the local authority).

Typically, the larger the number of parties involved, the more contractual arrangements that are required and therefore the more complex the project. This can be both costly and time-consuming and has been identified as a barrier to urban waste heat recovery.

It is probable that the low maturity and penetration of urban waste heat recovery investments is one reason for the many contractual arrangements. As the technology matures, it is likely that the need for the involvement of the public sector, research institutions, etc., will be reduced. As knowledge of urban waste heat recovery investments improves over time, it is likely that the number of stakeholders will reduce, reducing the number of contractual arrangements, and therefore, the cost of the project.

The most important contractual arrangement in urban waste heat recovery is undoubtedly that between the owner of the waste heat and the DH company. The immature nature of urban waste heat recovery as a technology means that standardised contracts are not typically available, and thus such arrangements must be drawn up from scratch. Through the stakeholder interviews and discussions with the demonstrators, the following issues were identified as key in the design of heat supply contracts.

3.2.1. Shared Incentives

It is important that both parties are incentivised to continue with the arrangement in its contracted form. This is true of waste heat contracts and should be taken into consideration in contract design. Split incentives (i.e., areas in which the two parties are incentivised by conflicting actions) should also be closely monitored.

3.2.2. Details of Supply

Details regarding supply are an important part of heat supply contracts. This section of the contract should state clearly how much heat should be supplied, at what temperature and during which hours. In some cases, payment may be made for waste heat, and thus details of the formula by which payment is made should be specified. Clauses regarding quality control may also be included along with details of who (if anyone) is responsible for monitoring the temperature of the heat. Details of maintenance activities that affect supply should also be specified.

The question of the cost of the waste heat to the DH company is an important one that impacts the level of risk to each party. From the stakeholder interviews, a wide range of approaches to this issue were identified. In some cases, the DH company has a tariff per unit of heat. In other cases, there is a more complex arrangement. For example, in one case in Sweden, no fee is paid when the outside temperature rises above 7 degrees Celsius. In another, the contract states that heat should be supplied for free in the summer and for a fixed fee per unit in the winter.

3.2.3. Resources

The contract should specify what resources are needed for heat recovery to take place and who is responsible for their supply. For example, heat pumps are powered by electricity so the contract should state who is responsible for supplying that electricity. In addition, heat is delivered via hot water and thus the contract should state who is responsible for supplying it.

3.2.4. Communication Channels

Given the long term nature of the arrangement, it is important for regular contact to be kept up to date between the parties to maintain a good relationship. To ensure this is the case, details of communication channels and the frequency of communication should be clearly written into the contract.

3.2.5. Operational Activities

It is important to consider that involvement in district heating is not the core business of the heat supplier. Whilst such an arrangement can be financially beneficial, the supplier is unlikely to be willing to spend significant time understanding the complexities of district heating and engaging in complex contractual arrangements. It is therefore important that such arrangements are kept simple.

3.2.6. Renegotiation

The long term nature of heat supply contracts makes the role of renegotiation important. Any party entering into a contractual arrangement of ten to fifteen years, as is often the case under such arrangements, takes on a significant risk. Renegotiation clauses allow for flexibility in that relationship, thus reducing the risk. It should be noted, however, that renegotiation can be damaging for some parties. The outcome of negotiations will of course depend on the respective bargaining positions of each party.

3.2.7. Mitigation

Mitigation is an important part of contractual arrangements, particularly when they extend over long periods. Actions to be taken, and by which party, when difficulties arise should be written carefully and unambiguously into the contract.

3.2.8. Simplicity of Contracts

Another key factor arising from discussions with the ReUseHeat demonstrators is that, from the perspective of the heat supplier, contracts should be kept as simple as possible. Therefore, there is a trade-off between contracts tailored towards the needs of the district heating company and the simplicity of the arrangement.

In summary, there is a number of issues to account for to ensure efficient heat supply contracts. They are summarised in Table 3.

Table 3. Issues to account for to ensure efficient heat supply contracts

Issue	Description
1	Shared incentives
2	Details of supply
3	Resources
4	Communication channels
5	Operational activities
6	Renegotiation
7	Mitigation
8	Simplicity of contract

3.3. Business Models

From the stakeholder interviews and discussions with the demonstrators, an important conclusion is that the value of environmentally friendly solutions to the end user is not generally exploitable at the current time. This means that most customers are not willing to pay a premium for heat that comes from a renewable or recovered source. Therefore, standard business models from conventional district heating are typically used for urban waste heat recovery. Despite this, the value of green energy is a potential opportunity for urban waste heat recovery in the future.

All three of the demonstrator sites in the ReUseHeat project share a common feature, that is, development has focussed on the nature of the technology as the dominant factor. This is characteristic of demonstrator sites and is not unique to urban waste heat recovery schemes. However, if the demonstrator site developers account for added green value on the customer side of the new technology, then the value of the demonstrator site installation could be increased beyond the technological validation. The value

of using green solutions is a key incentive for the demonstrator site partners to engage in the ReUseHeat project, since, not only is this a way to improve the reputation of the company brand, but it also offers customers district heating without extending the production capacity of heat at the central production unit. It adds additional value in urban waste heat recovery investment, compared to the conventional district heating business model. The value of green is of importance to cities, politicians and the companies engaged in the heat recovery, but it does not yet appear to be in great demand by end-users, and thus cannot be used as a selling point. This makes it difficult to currently profit from low temperature district heating investment.

Another conclusion of this study is the importance of close interaction between the DH company and the heat source. In all three ReUseHeat demonstrators to date, close interaction has been key to the progression of the projects.

A key difference between urban waste heat recovery and traditional district heating is the need for heat pumps (these are used on all three ReUseHeat demonstrator projects). Urban waste heat is typically of a lower temperature and therefore needs to be upgraded. This means there is a reliance on electricity to run the heat pump, and uncertainty about the price of electricity is considered to be a key risk to urban waste heat recovery. This risk is somewhat mitigated on the Brunswick demonstrator since the DH company runs an existing CHP plant, which generates electricity alongside heat from the district heating network. Such arrangements may be useful for future urban waste heat recovery projects.

One final issue regarding business models is that the DH company will often be an existing supplier of heat in the area. This means that the introduction of urban waste heat recovery by that company may reduce its revenue in other areas and may therefore discourage investment in this area. Government incentives may help to solve this issue by making the switch financially viable.

4. Discussion and Conclusions

The technical engineering projects used for waste heat are not particularly difficult or complex, rather, it is the socio-economic environment that is unfamiliar. Stakeholders are a disparate group without long term experience of working together. As with any new business model, great care needs to be taken with contract design and new kinds of risk such as failure of the heat source, increasing electricity prices, and inadequate demand. The difficulties are compounded by a failure by governments or regulators to produce an attractive legislative environment, which would include incentives for investment. Because of the eclectic nature of urban waste heat recovery, if only because of the variety of sources, producing standardised contracts is difficult, although it can be argued that they are essential in the long run. With regard to the technical issues, there are a number of special features to consider. Perhaps the most important is the quality of the heat, namely, the low temperature and volatile nature of the sources. However, the shear range of waste heat sources is a big advantage, which given the right management, can lead to a resilient source of heat and this might be especially valuable given increasing civic awareness of carbon targets. The ReUseHeat project is fortunate to have demonstrators which have clarified many of these issues.

Author Contributions: K.L. wrote and prepared the bulk of the manuscript, lead the research into business models, assisted with research into contracts and barriers and carried out several of the stakeholder interviews. E.W. carried out much of the research into contracts and barriers to investment and wrote and edited parts of the manuscript. H.W. lead and helped to carry out much of the research into contracts and barriers to investment and assisted in writing and editing the manuscript.

Funding: This work was funded by the ReUseHeat project, grant number 767429.

Conflicts of Interest: The authors declare no conflict of interest.

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