Grant Agreement: 767429

# Efficient Contractual Forms and Business Models for Urban Waste Heat Recovery

WP 2
Task 2.3
Deliverable 2.3

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 767429.

Document history and validation

This page is used to follow the deliverable production from its first version until it is approved by the Coordinator. Please give details in the table below about successive releases.

| **When** | **Who** | **Comments** |
|---|---|---|
| 12/06/2019 | Edward Wheatcroft | V1.0 |
| 14/06/2019 | Edward Wheatcroft | Review by IVL (Kristina Lygnerud) V2.0 |
| 18/06/2019 | Edward Wheatcroft | Review by Tractebel (Daniela Leonte) V3.0 |
| 20/06/2019 | Edward Wheatcroft | Review by RINA-C (Giorgio Bonvinchi) V4.0 |
| 24/06/2019 | Edward Wheatcroft | Version V5.0 |
| 23/02/2021 | Edward Wheatcroft | Updated to reflect reviewer comments |

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Deliverable No. D.2.3: Public

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ReUseHeat website: www.reuseheat.eu

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

This report presents an updated version of deliverable D2.3 ("Efficient Contractual Forms and Business Models for Urban Waste Heat Recovery"). A summary of actions taken in response to reviewer comments.

**The comments and recommendations from the second review period, for D2.3, were accounted for:**

*"Thus, in order to widen the impact of the deliverable, it is recommended to provide a tentative template/s of an efficient contractual form in an annex compiling the most relevant information for waste heat recovery project"*

We feel that a contract template would have great value for those wishing to engage in waste heat recovery projects but we do not feel qualified to write a specimen contract per se. Instead, we have added, as an appendix, a guide to writing waste heat contracts. The guide is intended partly as a "check list" for items that should be included in contracts and each one has some discussion under it. We have shared some of these ideas both with ReUseHeat partners and with practitioners outside of the project. Feedback has generally been good and there has been broad agreement on the items identified.

# Introduction

The purpose of D2.3 is to consolidate information regarding contractual forms for urban waste heat recovery and to identify factors those are important for building efficient contracts. For an investment to be feasible, it is important to identify critical factors of contracts including how contractual choices are made, how to manage each element of the contract and the impacts of contracts on business models. The latter forms a key part of this deliverable.

This deliverable is structured to identify the specific characteristics that need to be accounted for in urban waste heat recovery contracts. This is done in Chapter 1. In Chapter 2, an introduction to contracts is provided and existing forms for waste heat recovery are identified. Business model theory, and the impact of contractual choices, is outlined in Chapter 3. Finally, conclusions on contracts, important factors to address and the implication of contractual choices are given in Chapter 4.

# Chapter 1- Factors of importance to efficient urban waste heat investments

In this chapter, important factors for efficient urban waste heat recovery contracts are highlighted. These factors stem from the stakeholder analysis made in D2.1 (1.1). In addition, factors that should be accounted for when undertaking high temperature heat recovery are described. This information stems from existing research in the field (1.2). Knowledge of risk in district heating is in itself an important factor when establishing efficient contracts in this area. In D2.5 the risks associated with district heating investments, and urban waste heat recovery in particular, are identified. The impact of these risks on contracts for urban waste heat recovery investments is highlighted in section 1.3.

## 1.1. Important factors of efficient waste heat contracts- input from D2.1

Urban waste heat recovery investments are different to those of conventional district heating. Conventional district heating is based on the business logic of a large production unit that is centrally located in the system, from which heat is distributed to customers in the city wide grid. Usually, the temperature of the distributed water is high (86°C or more (Lund et. Al, 2014)) and, when waste heat is fed into the system, the temperature of that heat is usually at or above the required temperature. Urban waste heat recovery targets heat with lower temperatures. Currently, such sources are wasted. In the future, as fossil fuels are phased out, district heating providers will need alternative heat sources. Urban waste heat sources are local to the district heating network and fall into several categories in the urban context. In ReUseHeat, four types of heat source, each of which can exist in a single city, are addressed: a metro system, a data centre, the cooling process of a hospital, and sewage water. Urban waste heat sources can either be used locally or upgraded to a temperature level that allows them to be used anywhere in the network. Urban waste heat recovery investment has features that are unique compared with conventional district heating investment.

In task 2.1, 76 stakeholders interested in urban district heating investments were interviewed and barriers to urban waste heat recovery investments were identified. Main stakeholders (policy makers, investors, customers, DH operators and waste heat owners) were identified and interviewed about their urban waste heat recovery experiences in eight European countries (Sweden, Denmark, Germany, France, Spain, Romania, Belgium and Italy). A set of predefined questions were used to identify barriers to urban waste heat recovery investments. Two interviewees were selected from each category in nine different countries. Subsets of the questions were asked to each category of stakeholder. The barriers are of relevance since they need to be accounted for with efficient contracts. This is outlined below.

### 1.1.1 Low maturity of the installations

In D2.1, it is explained that a lack of technical knowledge is not considered to be an important barrier. Whilst injecting low temperature heat sources into existing systems can be difficult, there are large, experienced suppliers that can provide equipment. However, the number of companies that can provide the consultancy services needed to make use of the waste heat appears to be limited. The barrier is therefore the lack of installers and qualified operators (for efficient turnkey solutions of operation and maintenance) rather than the technology.

Even though the technology itself is not new, the maturity of the installations is considered an important barrier. There are few proven installations to learn from and the maturity of the existing solutions varies. Heat pump technology is important for urban waste heat recovery, whilst the capacity and temperature ranges of urban waste heat recovery are immature areas for both heat pump providers and district heating operators. Indeed, the majority (63%) of stakeholders mentioned that replicability is very important. Until the concepts have been proven replicable, their growth will be limited.

*From the point of view of contractual arrangements, the low maturity of the installations creates additional risk compared to the conventional solution. There is uncertainty regarding the performance and efficiency of the urban waste heat recovery installations that needs to be explained to a potential investor. In a contract, the low maturity of the installations can necessitate an increased risk premium for the urban waste heat recovery investment.*

### 1.1.2 No legal framework in place and incentives for RES and CHP

In D2.1, it is found that there is no specific/standardised permit procedure for urban waste heat recovery. There are no standards linked to urban waste heat, and so contracts need to be drawn up from scratch, potentially causing delays, uncertainty and increased risk to involved parties. In France, there is a legal framework for waste incineration plants that valorises the heat recovery for the company's own use, but no specific framework for external users. In Spain, there is a legal framework related to waste energy recovery without specifying clear obligations for those who are developing such solutions to be efficient in terms of energy & carbon footprint. In Sweden, there is law related to district heating. In each of these three countries, however, the legal framework does not account for urban waste heat recovery.

Another issue that has been identified is that, whilst there are direct incentives for RES and CHP, none exist that target urban waste heat recovery specifically. This can make the business case for urban waste heat recovery difficult.

*From the point of view of contracts, the fact that there is no standardised approach to valorise the urban waste heat recovery investments creates a hurdle for its undertaking. If the investment requires a lot of time and money to arrive at an efficient contract, the ambition to undertake the investment can diminish. In addition, current incentive structures targeting the European transition from fossil fuels to renewable energy does not favour urban waste heat investment.*

### 1.1.3 The value of heat is subjective

Domestic heat demand is highly dependent on weather conditions and thus demand in the winter months tends to be higher than in the summer. This means that, arguably, the cost of that heat should also be dependent on demand and, therefore the outside temperature. The value, however, is a matter of opinion. From the stakeholder interviews it was found that the outside temperature and/or season can be taken into account when calculating the price paid to the heat provider. This was reported for district heating schemes in several cases during the interviews. In one case in Sweden, it was written into the contract that no heat would be purchased if the outside temperature exceeds 7 degrees Celsius. In another case, the contract was written such that heat is provided for free during the summer months. In the latter case, there is a dependence on the season rather than the specific temperature, making the situation more predictable and thus less risky for the heat provider.

In D2.1, another issue relating to seasonality was identified. Some heat providers may still require heat to be extracted during the summer months when demand for heat is low. In extracting the heat, the heat provider receives a service in cooling making significant cost savings. If the receiver is no longer able or willing to receive that heat, the provider must make alternative, usually more expensive, arrangements.

One German owner of excess heat states that the value of the heat is based on a calculation of flow, temperature levels, period, etc. Two Swedish owners of excess heat companies have a well-defined pricelist for the energy produced from the DH Company and urban waste heat is considered a green heat production.

*In terms of efficient contracting, the value of the heat needs to be well defined. If the value is linked to seasonal demand, it should be accounted for in the contract. To manage heat extraction during summer, it can be written into the contract that the heat receiver must receive at least a fixed amount of heat all year round.*

### 1.1.4 The payback period is long

In D2.1 it is was explained that the payback period for urban waste heat recovery investment is difficult to estimate. The responses of the interviewed stakeholders who were able to quantify the payback period of the investment (9 interviewees) indicates long payback periods for urban waste heat recovery installations (15 years or longer). This is depicted in the figure below.

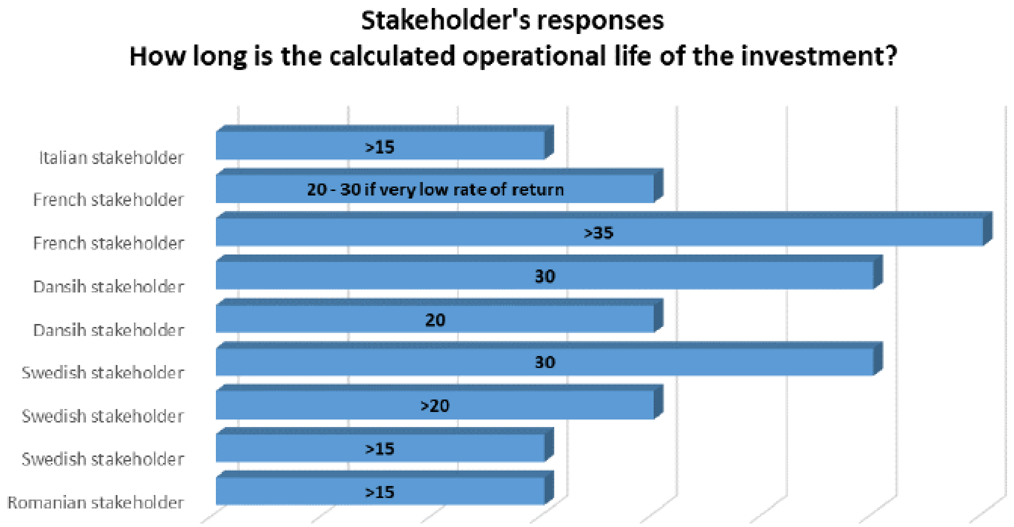


*Figure 1: The payback of urban waste heat recovery investments, based on experiences from stakeholders in different countries*

*From a contractual point of view, it is important to include a renegotiation clause. Over long time periods, many unexpected things can happen that impact urban waste heat recovery investment. A renegotiation clause can make the investment more attractive to investors since it reduces the investment risk.*

## 1.2. Important factors in efficient waste heat contracts- input from existing research

### 1.2.1. Asymmetric information

Theory confirms the findings from 2.1, that the provider and the district heating company often hold different views of the quality of the excess heat. The industry tends to claim that the available heat is of premium quality, which should be reflected in the price, whilst the district heating company may disagree.

Another level of complexity concerning excess heat recovery investments is asymmetric information regarding the inputs and outputs of each party in the collaboration (Viétor et al, 2015; Meggers and Leibundgut, 2011).

*It is critical to arrive at a mutual understanding of the value of the waste heat for successful urban waste heat recovery. This is a challenge that is already present in high temperature waste heat recovery. It is also important for all parties to understand each other's business and processes in order to account for factors such as annual maintenance periods, time spans of lower/ higher activity etc.*

### 1.2.2. Shared incentives

To arrive at a profitable excess heat recovery investment, shared incentives are imperative (Lygnerud, 2018). Incentives that target the operational phase address several aspects identified also in D2.5. Such aspects are linked to supply, operation, maintenance, pricing, insurances, quality assurance, monitoring, billing, renegotiations and settlement of disputes.

*Split incentives of different aspects need close monitoring. This is also relevant for low temperature heat recovery.*

### 1.2.3. Termination of the waste heat source

The risk that the excess heat provider will terminate its industrial activities constitutes a barrier to waste heat recovery investments. In one study (Viétor et al, 2015), several respondents addressed the risk of reduced heat availability because of closure, relocation, or modification of the local production process that creates the excess heat. The risk of closure of the industry was also mentioned as a key factor in a study of factors that promote or inhibit district heating collaborations between industry and utilities (Lygnerud, 2015). It has, in at least one case, been argued that waste heat recovery can actually offset, or at least reduce, the risk of a company closing down, since remuneration for the recovered heat can become an additional revenue stream to support the industrial process (Avgerinou et al, 2017).

*The risk of closure of the heat supplier is also present in the context of urban waste heat recovery. The volumes recovered, however, are lower than in high temperature recovery which means that the loss in such a case is lower and less important. A possible advantage of urban waste heat recovery is the installation of multiple heat sources and therefore a reduction in the risk of failure. Actions and responsibilities in the event of a failure of an installation should be written in the contract.*

## 1.3. The factor of risk- input from D2.5

D2.5 covers the topic of risk and provides a more in depth discussion of this area. From a business perspective, the aim of a contract negotiation should be to maximise value and to minimise risk. Risk and expected value are, of course, intrinsically linked so an increase in the expected value of a contract may come at a cost of increased risk. The aim for the business will therefore depend on how it chooses to balance these two aspects (it should, of course, go without saying that a business should always choose to increase the expected value if that comes at no cost to the risk and decrease the risk if there is no corresponding fall in value). Entering into a contractual arrangement can carry a wide variety of different risks for a business, particularly if the contractual period is long, as can be the case in district heating in which contracts often cover a period of ten years or more.

### 1.3.1. Risk

Risk is often considered to be either exogenous or endogenous (Danielson and Shin, 2003). Exogenous risk is that which comes from outside of the system and therefore cannot be influenced and endogenous risk is that which is caused by the behaviour of stakeholders. The concept was first described in the context of financial markets which are vulnerable to both types of risk. For example, a natural disaster such as an earthquake would fall into the exogenous category since this is out of the control of those participating in the markets. Panic selling of shares leading to a financial crash, on the other hand, is an endogenous risk since it is caused directly by the actors in the market.

The concept of exogenous and endogenous risk is important in the context of contracts. Events that lead to exogenous risk cannot be influenced and thus the target in a contract negotiation should be how to deal with that risk and which party should take that risk on. Endogenous risk, on the other hand, may, in some cases, be reducible and thus the overall risk to all parties can be reduced providing an incentive for all parties to cooperate in contract negotiations.

The distinction between exogenous and endogenous risks can be made in the context of district heating. An example of an exogenous risk would be a big reduction in heat demand resulting from Government subsidies for insulation or increases in the mean temperature due to climate change. An endogenous risk, on the other hand, would be a change of ownership of one of the parties that leads to it pulling out of an agreement. The distinction between exogenous and endogenous risk is a useful one in the negotiation of contracts because it allows the parties to differentiate between those risks that can only be mitigated (i.e. exogenous) and those that can potentially be reduced (endogenous). Risk assessment refers to the process of identifying potential risks and their severity. Risk management is the process of responding to that risk. Responses to risk generally fall into one of four categories (i) Avoidance, (ii) Mitigation, (iii) Acceptance and (iv) Transfer.

With *avoidance*, the aim is to make changes to avoid the risk entirely. For example, in district heating, increases in the cost of electricity can be a risk if an electric heat pump is in use. This could be avoided by finding a solution that does not use a heat pump. Risk can be *mitigated* by taking steps to reduce its severity either by reducing its likelihood of occurrence or its impact. For example, this could involve building more resilient infrastructure that is less vulnerable to extreme events. A stakeholder may choose to *accept* the risk and budget for its potential cost. For example, an energy company may choose to increase its cash reserves for such an event. A risk can be transferred to someone else through some contractual arrangement. For example, an energy company may decide to buy an insurance policy to insure against damage to its infrastructure.

### 1.3.2. Contract negotiations are transfers of risk

A contract negotiation is largely about transferring risk between two parties. The risk transfer approach taken will impact the adopted business model. In chapter 3, attention is given to business modelling. Below, risk management approaches are listed.

It is in each party's interests to maximise the value to them and to minimise its risk. There are two ways to do this. Firstly, a party can negotiate a greater proportion of the overall value of the project and/or a lower proportion of the risk. This, of course, would have a negative effect on other involved parties and so the success of this would depend on their negotiating position, skill at negotiating etc. The other way a party can improve its position is to work together with other parties to increase the value and/or reduce the risk of the entire project and to maintain the same proportion of each. In theory, it should be in each party's interests to maximise the combined value for all involved parties whilst minimising the combined risk. Of course, the strategy that maximises the combined value will almost certainly not be that which provides satisfactory value and risk to all parties individually. In that case, carefully chosen contractual arrangements can be made to spread both the risk and the expected value in some mutually agreed way. As such, if all parties agree to such an approach, each one can improve their position.

The steps in the process described above are as follows: (i) All involved parties agree on a number of different possible solutions. The parties work together to assess the overall economic value and risk of each solution and find ways to optimise them, (ii) Each party decides what proportion of the value and risk they believe they should receive and enter into negotiations and (iii) All parties attempt to agree on the apportioning of value and risk and find ways to transfer them.

Of course, the above process makes a number of assumptions that may not hold in practice. For example, the economic gain and risk expected by a party, particularly in the private sector, will very often be confidential as it tries to maximise its negotiating position (as well as to protect from other competitors not involved in the project). This makes working together to increase the overall value and reduce the risk far more difficult. Nonetheless, such a strategy seems a clear and sensible basis for contract negotiations.

A central role of contracts and to the process described above is the ability to transfer value and risk between parties. Within a project, transfer of risk and value can either be considered to be done `internally', that is between partners on the project or `externally', that is with other parties that are not involved in the project. In some cases, it may be possible to find simple ways to reduce the risk of the project without transferring it to another internal or external party.

In D2.5, categories of risk related to district heating projects are identified and discussed. For all district heating investments the risks listed below need to be accounted for (for details review D2.5).

1) Engineering risks
2) Project risks
3) Operations risk
4) Demand/ revenue risk
5) Supply risk
6) Environmental risk
7) Financial risk

8) Natural disaster risk
9) Performance risk
10) Legal risk
11) Regulatory risk
12) Political risk
13) Ramp up risk
14) Competitive risk

In analysing the ReUseHeat demosites, a set of risks specific to urban waste heat recovery investments was identified. Not all of the risks can be accounted for in a contract. Assuming that the contract targets the period after the project installation (e.g. targets the operational phase) there are four important risks to consider when writing the urban waste heat contract, displayed below. In conjunction with each risk, a possible way to manage it in a contract is provided.

1) *Failure to agree terms between partners*: Important factors are known (see 1.1 and 1.2) and should be specified in the contract
2) *Failure to agree transfer of responsibility for financial issues*: For example, the value of the heat must be decided upon, foreseen heat volumes and who is liable to compensate who if the heat recovery fails
3) *Unforeseen difficulties from novelty of the project*: The technical performance expected from the installation should be agreed upon as well as measures to take if there is a deviation.
4) *The heat source ceases to provide excess heat*: Include information on responsibilities and sanctions to take if the heat source ceases to exist

# Chapter 2- Contract theory

Contract Theory studies the way economic actors create contractual arrangements, often in cases in which each actor has different information available to them. Contract theory is closely related to the `theory of the firm' (Coase, 1937) which studies the reasons for the existence of businesses rather than arrangements in which transactions are conducted over a market. Coase (Ibid) argued that, in a perfect market, there would be no need for firms and that, rather, entrepreneurs would enter into contracts with other agents as and when they needed to. The barriers to such an argument are `transaction costs', that is the cost of entering a market. Many transaction costs are directly related to the need for contracts. For example, contracts can be expensive to draw up and negotiate whilst ensuring that other parties are fulfilling their obligations can also be costly. Other transaction costs are related to contingencies that occur as a result of incomplete contracts, some of which are described below.

## 2.1. Complete and incomplete contracts

An important part of contract theory is the concept of complete and incomplete contracts (Grossman and Hart, 1986; Hart, 1995; Hart and Moore, 1990). A complete contract is an arrangement in which the rights and responsibilities of each party are set out for every possible eventuality. In practice, there are many barriers to the creation of complete contracts in the real world. Firstly, the number of possible eventualities is usually very high and thus it would be very difficult and time consuming to list them all. Secondly, even if a comprehensive list was attainable, it would be prohibitively time consuming and expensive to agree on a course of action in each possible case. Thirdly, in reality, there are always likely to be eventualities that have not been considered before and thus are not able to be covered in the contract.

Any contract that is not complete is defined as an incomplete contract. Since complete contracts are extremely rare in practice, almost all contracts in the real world are, by definition, incomplete. The result is that, in any contractual arrangement, the parties must be willing to negotiate at some point in the future to resolve contingencies not covered by the contract. This can be an expensive and time-consuming process and mediation is sometimes required.

## 2.2. Implications of Incomplete Contracts

Incomplete contracts can have a profound effect on the behaviour of different economic agents. The hold-up problem arises when an uncontracted contingency can be resolved to the mutual benefit of both parties but when at least one party is concerned that this will lead to another party having increased bargaining power and thus restraining from entering into that arrangement.

This is related to the game of `chicken', as described in game theory, which is often presented as a game in which two drivers head towards each other and must either continue or swerve. If neither driver swerves both driver die whilst, if one driver swerves and the other does not, the former is labelled a `chicken' (a slang term for a coward) and thus the other driver is said to gain in some way. In the context of contracts, the most beneficial outcome for both parties is that they both act to resolve the uncontracted dispute (i.e. both swerve) but they may not do this out of concern that the other party may take the opposite action and thus gain bargaining power over them.

Incomplete contracts can also affect the structuring of the supply chain from production to the supplier. Commonly, different parts of the supply chain are better conducted by different parties. For example, in a heating network, one firm may be best suited to the installation and maintenance of pipes whilst another may be well suited to servicing customers. For such an arrangement to succeed, however, contracts must be drawn up between various parties in the supply chain. If those contracts are expected to be significantly incomplete, those parties may be unwilling to enter into such an arrangement and may, instead, choose to manage a larger part of the supply chain. This process is called `vertical integration' and can make the supply chain less efficient.

## 2.3. Contract Management

Contract management is the process of an organisation monitoring contracts to ensure that the arrangement in question is still providing good performance in terms of risks and returns. Although this is usually done only with the interests of an organisation at heart, reducing exogenous risks and maximising the financial benefits of an entire project can be good for all parties involved. Contract management can also help to ensure that the parties most suitable to take on risk continue to do to so. In this document, it is argued that modelling and monitoring should be used to write contracts. It is also the case, however, that monitoring should be used in the context of contract management. Significant changes in the basis on which contracts were written may lead to the desire to renegotiate and, in many cases, this can be done through monitoring. Contracts often contain various obligations of different parties in the arrangement. By monitoring, it can often be ensured that these obligations are met.

## 2.4. Contractual choices

To summarise, there are known, important factors to consider when making urban waste heat recovery investments. The factors need to be accounted for in the contracts that are established. Doing so, the risks of (i) failure to agree terms between partners, (ii) failure to agree transfer of responsibility for financial issues, (iii) unforeseen difficulties arising from the novelty of the project and (iv) the termination of the heat source, can be managed. In the table below, the risk factors to account for, and proposals for how to deal with them, are provided.

| **Factor to consider** | **Proposal for managing the factor** |
|---|---|
| 1. Low maturity of the installations (D2.1) | The low maturity of the installations necessitate carefully thought out technical schemes. It is important to resort to existing knowledge and for the parties to agree on the system installed as part of the contract. |
| 2. No legal framework in place (D2.1) | There is no single legislation or standardised framework on how to manage urban waste heat recovery investments. It is imperative to know if there is any other heat legislation in the country where the urban heat recovery will take place, as well as any other relevant legislation to account for in the contract. |
| 3. The value of heat is subjective (D2.1) | The margin on the low temperature heat source is low and it needs to be contrasted with the cost of electricity to operate heat pumps. It is important to outline the effect of the season on the price of heat as well as on the price of electricity. |
| 4. The payback period is long (D2.1) | Long pay back necessitates a renegotiation clause in the contract. |
| 5. Asymmetric information (theory) | Identification of the heat provider's processes and planned maintenance periods is important. Compensation for deviations from determined volumes etc. needs to be stipulated in the contract. |
| 6. Shared incentives (theory)<br><br>a. supply<br>b. operation<br>c. maintenance<br>d. pricing<br>e. insurance<br>f. quality assurance<br>g. monitoring<br>h. billing<br>i. renegotiation | Shared incentives can be related to one or several aspects:<br><br>a) In the context of urban waste heat recovery, this would be an agreement for the heat supplier to supply heat at a fixed or variable price. If the price is variable, the contract may also specify a maximum price. The temperature of the heat, the hours over which the heat is supplied and the volume of heat would need to be specified in the contract along with details of contingency plans for when heat cannot be supplied, e.g. due to a breakdown at the heat source.<br>a. In the case of urban waste heat recovery, this would need to contain details of which party operates infrastructure such as heat pumps and pipes. In some cases, different parties might operate different parts of the infrastructure. The contract can also outline how a non-delivery of waste heat can be managed.<br>b. In the case of urban waste heat recovery, maintenance routines should be determined. It is, for example, possible that some periods during the year are better suited for maintenance than others (taking the process generation waste heat into account as well as the customer heat demand).<br>c. Pricing for waste heat supply, that is the amount paid per unit to the supplier, depends very much on the |

| | |
|---|---|
| | source and there is a need for innovative pricing models which are realistic in terms of the price for the customer and incentives for the supplier.<br>d. Clauses requiring that certain parties have some type of insurance are often included in contracts. For example, it may be necessary for the heat supplier to have a certain level of public liability insurance or to insure for any losses caused by irregularities in heat supply that results in damaged equipment belonging to other parties.<br>e.<br>f.<br>g. A contract should specify minimum requirements on the quality, quantity, or, in the case of district heating, temperature, of a supply. For example, a clause might be entered to state a minimum level of waste heat that should be supplied by the heat supplier. The Heat Trust (Heat trust, 2019) is a voluntary scheme in the UK set up in 2015 that 'sets out a common standard in the quality and level of customer service that heat suppliers should provide their customers'. Membership of such a scheme should be stated in the contract between operators of the network and the end user.<br>h. It is often necessary to monitor the supply process. For example, in urban heat recovery the contract should specify the hours at which heat should be supplied and at what temperature. In the contract, it should be stated which party has responsibility for monitoring and confirming that what has been promised in the contract is actually being supplied. Care should be taken to avoid conflicts of interest.<br>i. Details of how payments will be made should be stated clearly in the contract. This should include the dates of each payment, the amount to be paid, formulas for payment increases and what should happen in the event of non-payment. This also applies for urban waste heat recovery investments.<br>j. Contracts, in the real world, never contain details on all possible eventualities (i.e. are always incomplete) and thus events that are not covered must be resolved in some way. The contract should contain details of a process to be followed to allow such eventualities to be resolved. Significant effort should be made to ensure that, after such renegotiations, the scheme is still viable and the cost of heat is kept affordable for the end user. This is true for urban waste heat recovery investments. |
| 7. Termination of heat recovery (theory) | The sanction that should be applied in the event of the heat provider terminating its activity must be specified, along with information regarding who owns different parts of the installed equipment. |

*Table 1: Contractual choices of importance to urban waste heat recovery investments*

## 2.5. Analysis of existing contract models

Ownership is an interesting parameter to investigate to understand contracts and business models in urban waste heat recovery. Both Jönsson (1986) and Andersson & Werner (2005) account for different forms of ownership in district heating but, in summary, DH companies can be owned by a private party, a municipality, the state or by different combinations of public and private parties. Urban waste heat recovery investments are likely to be undertaken between two private parties (both waste heat provider and district heating company are private in this context) or between a private party (the waste heat provider) and a public party (the district heating provider). It is probable that the urban waste heat recovery investments will be undertaken in countries in which there is knowledge and precedent of industrial waste heat recovery. Out of the EU28, Sweden and Germany recover the largest volumes of industrial waste heat (REF). Both markets are mature heat markets characterised by widespread municipal/ regional ownership of district heating companies. Hence, it is assumed that Public-Private-Partnerships (PPP) are the most relevant framework for designing efficient contracts for urban waste heat recovery. An analysis of known examples of PPP contracts in district heating is outlined below (2.5.1), along with analyses of energy performance contracts (2.5.2) and other forms of contractual arrangements between private parties (2.5.3).

### 2.5.1. Examples of contracts in Public-private-partnerships

PPPs have a number of advantages and disadvantages when compared with projects managed and financed by either the public or private sector alone (Rodriguez, 2019). PPPs allow each sector to do what it does best. A private entity often specialises in designing, building and/or managing certain types of infrastructure, knowledge and experience that is often not available from the public sector. The public sector, on the other hand, may be better placed to represent the interests of the general public, provide cheaper finance (although very large private firms may be competitive) and have more influence on giving concessions such as use of land. Another potential benefit of PPPs is that private entities can be incentivised by the public sector to work efficiently and to a high standard. In theory, this should lead to fewer time over runs as the private entity is expected to work to maximise its profits. The combination of the private and public sectors working together to search for innovative solutions can also be highly beneficial. Perhaps one of the biggest benefits of PPPs to the public sector is the transfer of risk to the private sector, which may be better placed to deal with that risk. This shift can allow a previous politically or financially infeasible project to go ahead.

There are also a number of disadvantages to PPPs. When only a limited number of private entities are able to bid to partner with the Government (when the infrastructure project is very large or prohibitively specialised for example), the benefits to be gained from competition can be lost. Another potential disadvantage is that it can be difficult to assess the ongoing performance of the project either during the construction process or during operation. PPPs can also be difficult to justify politically as much of the general public may be opposed to such arrangements due to objections about private profit making. Perhaps one of the biggest risk of PPPs to the public sector is the failure of contractual arrangements with the private sector. All contractual arrangements in the real world are incomplete and thus some form of renegotiation must be performed with the occurrence of events not covered by the contract. This can be problematic because the private sector is often better placed for such renegotiations through greater experience or access to more expensive legal teams. The results of renegotiations are very often increased costs for the public sector.

Below are examples of standardised PPP contracts (Wikipedia, 2019):

(a) Build Operate Transfer

A Build-Operate-Transfer (BOT) is a project financing arrangement in which a private entity is given a concession to finance and build some facility and then operate it for a fixed period of time, called a concession period, during which the initial investment can be recouped. After this period of time, ownership of the facility is transferred to the public sector, usually without any money changing hands. In order for a BOT arrangement to go ahead, the Government usually gives a concession, such as permission for land use. Rather than recouping all costs through charges to customers, the private entity often receives a fee from the Government over the concession period. The concession period is typically long, lasting several decades.

(b) Build-Own-Operate-Transfer

A Build-Own-Operate-Transfer (BOOT) arrangement is similar to a BOT but differs in that the private entity owns the facility during the concession period. This can be a more attractive proposition for a private entity than a BOT because it allows them greater financing guarantees as a result of being the owner of the facility over the concession period.

(c) Build-Own-Operate

A Build-Own-Operate (BOO) arrangement is similar to a BOOT except that ownership of the facility does not transfer to the public sector at the end of the project. Under this arrangement, the Government does not provide any form of financing to the project but may provide favourable conditions such as tax breaks and other forms of preferential treatment (Gov.uk, 2019).

(d) Build-Lease-Transfer

Under a Build-Lease-Transfer arrangement, a private entity builds a facility and then leases that facility to the Government. At the end of the leasing period, the facility is sold to the Government at a previously agreed price.

*(e) Design-Build-Finance-Operate*

Design-Build-Finance-Operate (DBFO) is an arrangement in which a private entity designs, builds and finances a facility and is responsible for its operation but, at no point, owns that facility.

*(f) Design-Build-Operate-Transfer*

A Design-Build-Operate-Transfer (DBOT) arrangement is similar to a BOT except that the design of the facility is also carried out by the private entity. This sort of arrangement often occurs when the Government does not have the expertise or does not wish to be involved in the design process.

*(g) Design-Construct-Manage-Finance*

A Design-Construct-Manage-Finance (DCMF) arrangement is similar to a DBFO but the private entity also manages rather than simply operates the facility. This kind of arrangement is common for the building and operation of prisons and hospitals.

### 2.5.2. Energy Service Companies (ESCO) and Energy Performance Contracts (EPC)

An Energy Service Company (ESCO) is a company set up with the purpose of supplying energy or delivering energy savings. ESCOs can be of a commercial nature, i.e. aim to make a profit, or non profit-making, with the aim of providing a public service. An ESCO can be owned by a single party or multiple parties which can be in the public or private sectors. Often, an ESCO is jointly owned by public and private sector companies and are thus an example of a public private partnership. This is the case for the Brunswick demonstrator on the ReUseHeat project, for example, which is owned and operated by Braunschweig Energy, an ESCO jointly owned by Veolia (75 percent) and the city of Brunswick (25 percent).

The creation of an ESCO has a number of advantages. Since it is a separate entity to its owners, it has limited liability meaning that losses are capped by the capital of the company and thus the risk is lower. This is particularly attractive to the public sector who are likely to be highly cautious about risks to the taxpayer. One potential benefit of a publicly owned ESCO is that, by owning its own company, the public sector can control to whom the energy generated is supplied and its cost. This can have a positive social effect with potential as a tool to tackle fuel poverty (Cirell, 2016).

An energy performance contract (EPC) is a contract for delivering energy efficiency savings to businesses that do not have the ability to fund it themselves (European Energy Efficiency Platform, 2019). The energy service can be provided by an ESCO. Under an EPC, energy efficiency improvements are made by the provider and the client repays the cost using savings resulting from the increase in energy efficiency. The service provider often guarantees the level of efficiency savings, thus reducing the risk to the client.

The UK government, for example, provides a standardised energy performance contract along with detailed guidance notes which can be tailored to the specific needs of the involved parties (Gov.uk, 2015). Energy Performance Contracts provide a potential basis for the provision of energy efficiency savings via urban waste heat recovery. This is particularly true in a case in which an existing district heating network seeks to connect to a new heat source.

### 2.5.3. Examples of contracts between private actors

The PPP solution is common in the mature district heating markets (like Sweden and Germany). In markets that are new to district heating, private solutions are more frequent. One market in particular that is inclined to private ownership is the UK. Based on an in-depth study made by The Carbon Trust, a not-for-profit private company which aims to help organisations reduce their carbon emissions, relevant ownership model for district heating have been identified (Carbon Trust, 2019b). These are described below.

*(a) PipeCo Model*
Under the PipeCo Model, in a district heating scheme, the pipes are sold by the original developer to a different party. The owner of the pipes then charges a fee to the developer for their usage. The idea is that the pipes, which have a long life time of up to 60 years, and the heat generation infrastructure, which has a lifetime of typically 15 to 20 years, appeal to different kinds of investors.

The pipes are generally very expensive to install but require little maintenance and are thus a high cost-low risk asset with a predictable yield. Such an investment may appeal to a pension fund for example. At the same time, the original developer is not required to have the large outlay of laying the pipes on its books in the longer term and can therefore spend the money in other places instead. The PipeCo Model can also be of benefit when multiple nearby networks are built and designed to be connected at a later date.

*(b) AssetCo Model*
The AssetCo Model is very similar to the PipeCo Model but all of the assets are sold by the original developer to third parties who also operate and finance those assets. The original developer is only responsible for the retail of heat to customers and pays for the use of the assets. The potential benefit to the AssetCo over the PipeCo is the further easing of their balance sheet and the transference of risk to other parties.

*(c) Regional Framework*
To a district heating developer, both the PipeCo and AssetCo models pose a potential problem in that, in order to operate a viable business model, they require a number of projects to fund given that they may eventually sell some or all of their assets to third parties. The Carbon Trust's Regional Framework model proposes a model with which to bring together key partners to build multiple district heating schemes, each with a similar structure. One of the benefits of this model is the opportunity for economies of scale achieved from reduced capital costs, procurement costs and lowered risk. The increased number of projects can also make the investment more attractive for larger investors. The success of the Regional Framework relies on the existence of enough players in the market to provide adequate competition.

*(d) National Framework*
The National Framework is similar to the regional framework but is coordinated through a national coordinator. Under this model, financing and technical partners go through a process to be recognised under the national framework. Member organisations can then call on those partners thereby avoiding a costly procurement process. In the United Kingdom, the Government's Heat Networks Delivery Unit (HNDU) provides support to local authorities at the planning stage of proposed district heating schemes (Gov.uk, 2019).

## 2.6. Summary of essential contractual elements

The following list provides a summary of elements that should be included in heat supply contracts for urban waste heat recovery:

- Customer segments
- Key participants
- Key activities (operation of the production infrastructure, optimisation of production, sale of the thermal energy, etc.)
- Supply basic details: who will supply what to whom, how much they are required to supply etc. and for what price. The temperature of the heat, the hours over which the heat is supplied and the volume of heat, details of contingency plans for when heat cannot be supplied)
- Cost structure
- Key resources (sources of waste heat, electricity, water consumption, etc.)
- Technical and financial key performance indicators
- Mitigation
- Customer Relationships (Contractual relationship between heat producer and client, maintain the heat consumption during the project lifetime, assuring an efficient thermal energy supply service, etc.)
- Quality assurances
- Communication Channels
- Monitoring
- Renegotiation

# Chapter 3- Business model theory

The contractual choices made can impact the way that business models for urban waste heat recovery investments are designed. This is the topic of this chapter.

In ReUseHeat, business models and contractual arrangements for the demonstrators are drafted in D2.4. To do this, the business model canvas framework is utilised. This framework is presented below.

## 3.1. Business model theory

Customers (value, relationships, and segments), resources (infrastructure, activities, partners, logistics) and the cost/income structure resulting from customer and resource choices are generic elements of business models (Chesbrough, 2010; Groth and Nielsen, 2015; Schaltegger, S, Lüdeke-Freund and Hansen, 2012; Osterwalder and Pigneur, 2010; Teece, 2010). While there is no universal definition of what a business model is, they can be a source of competitive advantage (Casadesus-Masanell and Ricart, 2010; Markides and Charitou, 2004; Morris et. Al, 2005; Magretta, 2002; Christensen, 2001) at least initially, until they are imitated (Teece, 2010). Business models are not to be confused with product market strategy (Magretta, 2002) since business models describe how different pieces of a business fit together but do not account for choices made to meet competition (Magretta, 2002). Business models do, however, seem to reflect strategy (Casadesus-Masanell and Ricart, 2010), but the two are not equivalent (Teece, 2010; Markides and Charitou, 2004; Morris et. Al, 2005; Magretta, 2002; Christensen, 2001; Zott Amit, 2008). Business models are also different from products, companies, industries, networks, technology, internal organization and value chains (Groth and Nielsen, 2015). It is known that business models develop over time, and some studies promote the idea that business model development is a tool for corporate renewal (Sosna, Trevinyo-Rodríguez, and Velamuri, 2010; Sköldberg et al, 2011; Demil and Lecocq, 2010; Johnson, Christensen, and Kagermann, 2008). Successful companies, it is argued, account for changing preconditions in the surrounding world through developing their business models. Good models secure long-term competitiveness and survival (Chesbrough, 2010; Johnson, Christensen, and Kagermann, 2008; Björkdahl, 2009; Giesen et al, 2007). There is no consensus on a definition of what a business model is or on how business model development is realised. Some researchers advocate that business model development is the result of a systematic and structured process (Chesbrough, 2010; Martins, Rindova and Greenbaum, 2015; Eurich, Weiblen, Breitenmoser, 2014). Others claim that it stems from trial and error (Chesbrough, 2010; Sosna, Trevinyo-Rodríguez, and Velamuri, 2010; Blank and Dorf, 2012). Whether companies develop their business models as a response to external pressures, internal changes or a combination of both is not clear (Demil and Lecocq, 2010; Martins, Rindova and Greenbaum, 2015; Frankenberger, 2013; Sheehan, and Stabell, 2007).

## 3.2. The business model canvas

The business model canvas (Morris et. Al, 2005) provides a framework composed of nine blocks and is widely used for understanding business models. It was developed jointly by academic researchers, government officials, professionals from different industries, analysts from different sectors and consultants interested in business modelling.

The canvas is a framework that explicitly addresses the components that are deemed relevant for understanding business change in district heating. The framework has been developed jointly between academics and practitioners making it suitable for explaining the findings to district heating researchers, policymakers and practitioners.

Four of the blocks address the customer, outlining the customer segment, the channels used to reach the customers, customer relationships and the value proposition. Three of the blocks consider activities undertaken to deliver the value, the resources needed for value creation and the imperative partnerships for delivery of the product or service. The last two blocks outline the cost structure undertaken by the business and the income structure of the realised sales. The canvas is illustrated in Table 3.1.

**Table 3** The business model canvas framework

| | | | |
|---|---|---|---|
| Key partnerships<br>"Who can help you"? | Key resources<br>"What do you need"? | Customer value<br>Answers the question of "what do you do"?<br>This is where the analysis starts | Customer segment<br>"Who do you help?" |
| | Key activities<br>"How do you do it"? | Customer channel<br>"How do you reach them?" | Customer relationship<br>"How do you interact?" |
| Cost Structure<br>"What will it cost"? | | Cost Structure<br>"What will it cost"? | |

*Table 3.1: The business model canvas*

| | | | |
|---|---|---|---|
| **Key partnerships**<br>"Who can help you?" | **Key Resources**<br>"What do you need?" | **Customer Value**<br>"What do you do?"<br>This is where the analysis starts. | **Customer Segment**<br>"Who do you help?" |
| **Cost Structure**<br>"What will it cost?" | **Key Activities**<br>"how do you do it?" | **Customer Channel**<br>"How do you reach them?" | **Customer Relationship**<br>"How do you interact?" |
| | | **Cost Structure**<br>"What will it cost?" | |

## 3.3. The conventional district heating business model and its challenges

The conventional features of district heating investments are that the value for the customer is the provision of heat and hot water (often in the form of a utility function).

The largest customer segment is business to business whereas private home owners constitute a small share of the customers. The relationship with the customer is a provider to consumer relationship that is characterised by push to market rather than demand from market. The channel to reach the customers is the invoicing itself as well as specific communication campaigns. Key resources are the fixed assets (the production unit and the distribution network). The key partnerships that exist are with fuel providers. The cost structure is characterized by large, fixed costs whereas the income structure often is built around a fixed structure.

It should be noted that the district heating sector is being challenged and that a large number of changes have been initiated into its daily operations. In Sweden, for example, the industry is facing technological development (low temperature heat sources can be used; there is technology for doing it), institutional changes (deregulation of the heat market and district heating law, threat of price regulation and third party access assessments being mandatory) and market challenges (fierce competition from heat pumps, lower heat demand and changing customer requests) (Lygnerud, 2018).

The challenges have, however, not to any large extent been reflected in the business models of existing district heating ventures. The large infrastructure investments and their long operational life are effectively locking the industry into the current way of doing things, often referred to as the 3rd generation of district heating (REF).

Urban waste heat sources are low temperature which necessitates new technological solutions. In general, lower temperatures in the district heating network increase efficiency (lower distribution losses, more efficient production of electricity in combined heat and power generation and making use of urban heat sources), (REF). However, new ideas are also needed on the business model side when making use of urban heat sources, applying new technology, the boundary conditions shift (REF) and the business shifts from centrally producing and distributing heat to facilitate usage of heat locally and on demand (REF).

## 3.4. Business model choices as a consequence of contractual choices

A contract between two (or more) parties sets the framework for what kind of business model it is possible to build. In the ReUseHeat project, there are four demosites in which low temperature heat sources are recovered and used in district heating networks. Below, the impact of factors of importance for contract formulation in district heating are addressed in the context of the business model canvas, including which components of the canvas are expected to be impacted compared to the conventional district heating business model.

| Factor to consider | Impact on the business model |
|---|---|
| 1. Low maturity of the installations (D2.1) | The installation will necessitate new equipment and skills of employees to use it. It 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 necessitates close interaction with the waste heat supplier. A close and frequent customer dialogue will be able to manage the shortage of legal boundary conditions. The closer heat provider interaction generates a new **key partnership**. |
| 3. The value of heat is subjective (D2.1) | How the price of the heat is obtained will depend on a multitude of factors: the price of electricity, seasonality and perceived value of the waste heat provider. To arrive at a price that is correct and advantageous to both parties, a close dialogue is necessary, impacting the **key partnership** and **income structure** of the business model. Remembering that the value proposed to the urban waste heat provider is the possibility of offsetting waste heat, the **value proposition** of the canvas is impacted. |
| 4. The payback period is long (D2.1) | Long pay back is risky. This can be troublesome to partners who have differing time horizons. In such cases, one solution is that one partner is paid off prior to the other partner (a much discussed case in the district heating industry is the collaboration between the Danish district heating company VEKS and the company CP Kelco where the latter got their investment paid off first[1]). How the payment plan is realised will impact the **income structure**. |
| 5. Asymmetric information (theory) | Asymmetric information in any part of the business model is detrimental to its success. As much information as possible needs to be known and outlined in the contract. If so, the business model can be built around known information. This impacts **all parts of the canvas**. |
| 6. Shared incentives (theory)<br>a. supply<br>k. operation<br>l. maintenance<br>m. pricing<br>n. insurance<br>o. quality assurance<br>p. monitoring<br>q. billing<br>r. renegotiation | Depending on where in the contract shared incentives are secured, the different parts of the canvas will be impacted.<br><br>If, for example, it is on the **supply side**, it is related to the **key resource** of urban waste heat coming into the district heating provider's network.<br><br>If it is on the **operation side**, then the **key activities** undertaken by the district heating company will impact the incentives. **The same applies for the maintenance aspect**.<br><br>Incentives linked to **pricing** will impact the **value proposition** and the **income structure**.<br><br>Incentives related to **insurance** will be linked to **key resources**.<br><br>**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 sanctions cannot keep the business model afloat if the heat recovery is terminated. One consequence is then the termination of the contract and the business model. |

Depending on the contractual choices made, the business model components will be impacted. When drafting urban waste heat recovery investment contracts, it is important to understand how choices made in regards to contracts impact the business model design.

[1] See more in hot/Cool, International magazine on district heating and cooling, N01, 2019 (pp. 4-6).

# Chapter 4- Conclusions

Urban waste heat recovery investments have special traits. They are long-term investments with a payoff of 15 years or more. This kind of investment requires investors who accept the long pay back and contracts that can account for changes over time, making renegotiation clauses imperative.

The value of the recovered urban waste heat yields a lower margin than heat recovered from industrial processes that hold high temperatures. The small margins make the identification of value very important: both sides must agree on the price of the urban waste heat depending on different seasons and demand.

Urban waste heat recovery is a pioneering technology permitting the recovery of heat that is currently lost. Unique aspects of the installations are a challenge since there is no legislation or standardisation linked to them. The lack of empirical data from urban waste heat recovery installations increase the risk of the installations from the point of view of an investor and can lead to deviating operational quality (to the assumed level). The absence of legal rigour in the field of urban waste heat investments heightens the hurdle for investors to undertake the investments. Efficient and detailed contracts can be one way to lower the threshold for the investments being undertaken.

Although, in practice, contracts will always be imperfect, both in district heating and in a wider context, some action can always be taken to reduce contract risk. One obvious factor is to ensure that the most important eventualities are covered in the contract and that the rights and responsibilities of each party are clearly set out. The most important factors can and should be agreed between all parties at the contract negotiation stage. Another way to reduce the risk of imperfect contracts is to forge strong relationships between partners. If there is a high degree of trust between partners, each one will likely be reluctant to damage that relationship and will likely be more willing to negotiate for a mutually beneficial solution. In district heating, it is sometimes the case that contractual relationships are made between parties that already have a business relationship. For example, in the Brunswick demonstrator on the ReUseHeat project, the energy company and the housing developer have an existing relationship which neither party is incentivised to damage.

One of the biggest risks to district heating schemes is that the heat source will stop operating or that ownership will be transferred to a party that is less keen on continuing the relationship. Contracts can be written such that, in the event of a transfer of ownership of the heat source, the new owner will be obligated to continue to supply heat.

In this document, we have identified seven key aspects of waste heat recovery contracts. These are:

1) Low maturity of the installations

2) Lack of legal framework and incentives

3) Subjective value of heat

4) Long payback periods

5) Asymmetric information

6) Shared incentives

7) Termination of the waste heat source

Although, clearly there are other important aspects, we consider these to be the most important in the context of urban waste heat recovery contracts.

In summary, there is more to urban waste heat recovery success than technical installations. With well thought through contracts and an adjusted business model, the chances of success can be increased.

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# Appendix - A manual for heat supply contracts in low temperature heat recovery

The contractual arrangement between a supplier of waste heat and a district heating company is crucial in urban waste heat recovery. The aim of this document is to provide guidance on the nature and contents of that arrangement. In particular, a check list of important points to consider is provided with some discussion of each. Note that waste heat recovery can often require a highly tailored approach and thus additional, more specialised, clauses may be required.

First, it should be emphasised that contracts of this type should be subject to the professional advice of a lawyer who will be aware of local, national and EU regulations that might be crucial in shaping such arrangements. It is for this reason that we do not attempt to produce a specimen contract and neither do the authors accept any responsibility for the use of legal advice contained in the document.

Note that heat supply contracts with end users are typically bound by established local and national legal frameworks. This is generally not universally the case for waste heat supply contracts in which there is often a complete absence of, or a very limited, legal framework in place. When dealing with contracts, it should be kept in mind that extra regulation may be introduced over the length of the contract and adjustments may need to be made.

The following elements should be considered in waste heat contracts:

**1.Timing of the contract**

The contract should clearly set out the date from which it is effective and its expiration date. Conditions for termination of the contract should also be laid out.

Notes. Local regulation can have an impact both on the maximum length of the contract and the conditions for termination.

**2. Monitoring**

Monitoring can be used to ensure that contractual obligations are met. Contracts can also be designed with payments and obligations conditioned on monitored values. If monitored values are used to ensure that agreed conditions are met, details of actions to be taken in the event that they are not met should be clearly stated. This could include the payment of compensation, a reduction in the price paid or a contract renegotiation.

Notes. For a heat supply contract, the price of heat could be conditioned on the temperature of the supply (input) and this is typically be underpinned by monitoring.

**3. Contract renegotiation and change**

Renegotiation of contracts typically occurs when one side is unable, or no longer willing, to carry out its contractual obligations. In such a situation, the relevant party will endevour to renegotiate the contract into a more beneficial or manageable arrangement. The contract should lay out conditions for renegotiation, with a focus on the process that should occur if a clause is broken. In some cases, renegotiation at a fixed point in time might also be beneficial.

Notes.

(i) In some cases, such as in Germany, the legal length of a contract may be capped and so renegotiation, even if a straighforward formality, is necessary. A renegotiation may be appropriate in waste heat recovery contracts if the waste heat provider is no longer able to provide the agreed volume of heat but is willing to continue to provide a lower volume. In such a case, the marginal cost of heat to the district heating provider may be increased and so they may look to negotiate a lower price per unit.

(ii) Control systems may or may not be part of the basic contract. For example, extra control systems may be added following study of the active system, or arising from technological advance or network expansion. It is advisable to include reference to such changes in the original contract.

**4. Renewal terms**
All contracts are limited in time and eventually expire. It is beneficial to include clauses that allow for automatic renewal of the contract, subject to one or more agreed conditions.

Notes. In a waste heat supply contract, the district heating company may agree automatic renewal of the contract on the condition that heat was supplied at the agreed volume and temperature for a set proportion of the contract period. This provides an incentive for the waste heat provider to carry out its obligations.

**5. Heat supply specifications and units**
The capacity, quantity and temperature of waste heat to be supplied should be clearly laid out and, if applicable, linked to the price paid. There may be some small variability in the temperature of the heat provided and thus a minimum and maximum acceptable temperature over a specified period should be provided.

Notes.

(i) Units should be clearly stated and chosen according to industry standards. Temperature should be stated in degrees Celsius (°C), units of heat in megawatt-hours (MWh) etc.

(ii) It is important to include some indication of the variability of waste heat supply (e.g. mean, minimum and maximum).

(iii) Efficiency may be referred to in the contract to guard against promised efficiency of heat transfer being less than predicted.

(iv) There may be a difference between the idealised Coefficient of Performance (COP) provided by the heat pump manufacturer and the actual value achieved. This may be pending at the contract drafting stage and so it may be useful for the price of heat to be depend on the value achieved in practice and is a further reason for monitoring.

**6. Price formulae**
The price paid by the district heating provider for waste heat is a crucial element of waste heat supply contracts. There are many examples of formulae for the price of waste heat and these vary in complexity. In all cases, conditions for payment should be laid out clearly and unambiguously. The main types of formulae are given below:
1. Waste heat is provided for free.
2. A fixed weekly/monthly/annual fee is paid subject to conditions on quality and consistency of supply.
3. A fixed price per unit of heat is paid subject to temperature conditions. This simplicity is sometimes welcome.
4. A combination of fixed and variable payments are made.
5. Heat is purchased only under certain seasonal or weather conditions (these conditions should be clearly and unambiguously laid out).

Notes.
(i) End-user demand for heat is highly seasonal and may affect the value of the waste heat to a district heating provider. It may be beneficial to account for this in the contract.
(ii) Demand may be split between peak load and base load requirements.

**7. Payment schedules**

If payment for the supply of waste heat is agreed in the contract, schedules for making those payments should be clearly laid out. In the case of fixed fees, it is usually beneficial to agree regular payment dates in advance. If fees are agreed conditional on the basis of certain aspects (such as the outside temperature), the period of time between that condition being met and payment being made should be clearly stated.

Notes. Care should be taken to ensure that conditions for payments are written clearly and unambiguously and with carefully chosen units.

**8. Ownership and responsibility boundaries**
In waste heat recovery, the heat is required to be transferred from the property of the waste heat provider to that of the district heating provider and there is therefore a boundary of ownership and responsibility for infrastructure. This should be fully specified.

Notes. One or more heat exchangers are usually required to transfer heat from air to water and the location, ownership and responsibility for maintenance should be clearly laid out.

**9. Location and ownership of heat pumps, exchanges and controls**
Low temperature district heating usually requires the use of a heat pump to upgrade the heat to a suitable temperature for use in a district heating network. The need for a heat pump creates a high initial outlay for low temperature heat recovery and responsibility for this outlay will be decided by the choice of business model. Ownership and responsibility for installation and maintenance of the heat pump should be clearly laid out.

Notes. In some cases, care must be taken to separate the heat exchange plan and the source of heat for security, health or safety reasons. Special clauses may be needed to protect the boundary in such cases.

**10. Combined heating and cooling**
For certain waste heat suppliers, the cooling which is the bi-product of the heat pump used to raise water temperature to supply hot water to, say, a local grid, may also be used to help cool the original unit of supply, such as a data centre. This requires a well crafted contract, balancing the value both of heating and cooling.

Notes. Combined heating and cooling is sensitive to seasonal variation and, in some cases, the heat pump may be reversed.

**11. Maintenance**
The contract should clearly lay out responsibility and schedules for maintenance of different parts of the infrastructure. Access rights for maintenance should also be agreed, if applicable. This should include details of the required warning period before maintenance is carried out and provision for emergency access should be made.

Notes. It may be agreed that each party should carry out maintenance of its own property. If this is not the case, clauses should be included stating agreed actions if damage is caused.

**12. Equipment failure**
The contract should set out details of liability for equipment failure.
Notes.
(i) It may be agreed that, if the heat pump belongs to the district heating provider and is damaged by the waste heat provider, compensation should be due.
(ii) The expected life time of the equipment should be stated along with action to be taken in the event of early failure.

(iii) An Insurance Requirement clause may be included that obligates the waste heat provider to hold insurance to cover such eventualities. This will require a separate contract between the waste heat owner and an insurer.

**13. Severability**
Severability is a provision in a contract which states that, in the event of one or more clauses being broken, the rest of the contract should remain valid. Such a provision can be helpful in ensuring the stability of a contractual arrangement but can also prevent a party leaving an arrangement that is no longer beneficial to them.

Notes.

(i) The enforcability of severability clauses can depend strongly on the jurisdiction. For example, in some jurisdictions, a contract can be declared void if the fundamental nature of the arrangement is changed by the breaking of a clause.

(ii) The inclusion and/or nature of a severability clause should be discussed carefully with a lawyer, familiar with the law of the territory in which the arrangement is made.

**14. Connection fees**
At the current time, low temperature heat recovery is in its infancy as a technology and contractual arrangements between district heating providers and waste heat providers are bespoke. However, if heat recovery becomes more widespread, it is likely that a "heat market" will emerge in which providers pay a connection fee that pays for infrastructure to connect them to the network.

**15. Law and Regulation**
In any contract of a technical nature, many areas of national and international laws and regulation may need to be referred to in the contract. Here is a generic list.

1. Health and Safety
2. Environmental:
   - pollution
   - CO2
3. Laws of contract
4. Property law
5. Financial:
   - financial probity laws and regulations
   - taxation and incentives rules
6. Land use
7. Engineering, quality and reliability standards

Notes.

(i) Changes in regulation are particularly important for low temperature district heating because frameworks are likely to be developed over the coming years. For example, if regulation were introduced obligating waste heat producers to provide heat for free, this would create a fundamental change in the relationship. Clauses in the contract should cover this.

(ii) A particular area of future change is in funding, taxation, incentives and financial clauses should try to take this into account

(iii) A list of EC directives related to district heating and cooling is given in Appendix 3.

**Appendix 1. Metrics and Units**
1. Temperature – degrees Celsius (°C)
2. Heat – Megawatt-hours (MWh)

3. Electricity - Megawatt-hours (MWh)

**Appendix 2. Modelling for contracts.**

The use of mathematical modelling in contract design, by both sides, should not be underestimated. This does not have to be carried out from scratch as there a number of modelling packages that can be used and academic papers can be used as a guide. A few modelling packages are:

1. TIMES
2. EnergyPro
3. OseMOSYS
4. TRNSYS

All of the above modelling packages include technical, financial and environmental aspects.

The main aim of modelling is to model the actual system design to optimise physical efficiency, minimise electricity consumption, optimise location and minimise CO2 with respect to capital cost (CAPEX) and operational cost (OPEX). The particular heat source covered by the contract be part of a large district heating network and it is advisable that this is recognised in the modelling. However it is not the purpose of this document to cover these issues but to point out the use in contract design and negotiation, to establish and verify as far as possible, by simulation, operational claims, hypotheses and agreements relevant to the contract. Examples are:

1. Achievability of stated output and required costs
2. Calculation of risk measures associated with the project
3. Achievability of efficiencies, e.g. of heat pumps
4. Decisions about required capacity
5. Robustness (resilience) to "local" input variation, e.g. in supply and demand, including averages, peaks and troughs
6 Robustness to long term energy, climate, demand and cost scenarios.
7. Modelling special aspects of the design which may affect contracts, such as heat storage.
8. Effect of changing regulatory requirements: eg heat pump subsidies
9. Special tables and other documents used in negotiation and/or appearing in the final contract

**Appendix 3. EC Regulations**

1. Directive 2010/31/EU on the energy performance of buildings.
2. Directive 2004/8/EC on the promotion of cogeneration, based on useful heat demand in the internal energy market, amending Directive 92/42/EEC.
3. Directive 2006/32/EC of the European Parliament and of the Council on energy end-use efficiency and energy services and Energy Efficiency Directive 2012/12/EU.
4. Directive 2008/1/EC concerning integrated pollution prevention and control (IPPC).
5. Directive 2008/98/EC of the European Parliament on waste and repealing certain Directives.
6. Directive 2012/27/EU on energy efficiency.
7. Directive 2018/2001/EC of the European Parliament on the promotion of the use of energy from renewable sources

**Appendix 4. Contractual KPI's**

1. Mean/min/max temperature of waste heat (°C)
2. Coefficient of Performance (COP) of the heat pump
3. Air pollution produced by the heat pump (NOx)
4. Payback period (years)
5. Greenhouse gas emissions (CO2e)

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