H2020 Work Programme

D3.7 – REPORT SUMMARIZING ECONOMIC DRIVERS

Lead Contractor: IVL Swedish Environmental Research Institute

Date: February 2022

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 847097.

Project title Supporting new Opportunities for Waste Heat and cold valorisation Towards EU decarbonization			
Project acronym	SO WHAT	Start / Duration	June 2019 / 36 months
Coordinator	RINA Consulting S.p.A		
Website	https://sowhatproject.eu/		

Deliverable details			
Number	3.7		
Title	Report summarizing economic drivers		
Work Package	3		
Dissemination level[1]	PU	Nature	Report
Due date (M)	33	Submission date (M)	28/02/2022
Deliverable responsible	IVL		

1 PU = Public
CO = Confidential, only for members of the consortium (including Commission Services)

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

	Beneficiary
Deliverable leader	IVL Swedish Environmental Research Institute
Contributing Author(s)	Klugman S, Nilsson J, Nilsson A
Reviewer(s)	RINA-CMEDGREEN, 2GOOUT
Final review and quality approval	28/02/2022 (DATE)

Document History			
Date	Version	Name	Changes
07/02/2022	1.0	Sofia Klugman (IVL)	First draft
11/02/2022	1.1	Arianna Amati (RINA-C)	
14/02/2022	1.2	Pedro Santos (2GOOUT)	
24/02/2022	1.3	Sofia Klugman (IVL)	Final

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

Abbreviations

CBA: Costs and Benefits

CHP: Combined Heat and Power

DH/C: District Heating / Cooling

DHN: District Heating Network

DLT: Distributed Ledger Technologies

EPC: Energy Performance Contracting

ESC: Energy Supply Contracting

ESCO: Energy Service Company

GHG: Green House Gas

IEC: Integrated Energy Contracting

LCOEH: Levelized Cost of Energy/Heat

MW: Megawatts

N/A: Not available

O&M: Operation and Maintenance

P2P: Peer-to-Peer

PV: Photovoltaic

RES: Renewable Energy Sources

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

Executive summary

The objectives of WP 3 in the SO WHAT project are to generate important information for attracting investments and for realizing industrial waste heat/cold recovery investments. This deliverable D3.7 is a final report summarizing the economic drivers. Starting from the earlier delivered reports in WP3, different stakeholders' perspectives are applied in terms of drivers. In the end of each chapter this perspective is elaborated.

First, a barrier analysis was made on industrial waste heat/cold recovery. It encompassed political, economic, social, technological, environmental, and legal factors for the countries of the demo cases (D3.1 is presented in chapter 2.1). From existing industrial waste heat collaborations, it is known that establishing efficient contracts is a challenge, but also a way to handle barriers and risk. Based on experience from ongoing heat collaboration within the Swedish lighthouse cluster and the prerequisites for the demo site, the most important aspects of contractual arrangements were summarized (D3.3 is presented in chapter 2.2) and all investments include business risks. The specific risks with investments in industrial waste heat recovery were examined based on the demo cases and experience from Sweden (D3.4 is presented in chapter 3.1) as well as financing schemes and business models of industrial WH/C recovery (D3.5 in chapter 4.1). Finally, a concluding discussion is presented in chapter 6.

The result of this report is that although the general driver, a strive for efficient resource use, is valid for all stakeholders, there are specific drivers for different stakeholders such as industries with excess heat, end-users of heat or cold, and intermediary stakeholders such as energy service companies. To highlight the advantages of heat collaboration for each involved stakeholder, these specific drivers are important to respond to in the SOWHAT tool. By emphasising the benefits in an adapted manner for different kinds of stakeholder, investors are attracted, and the great potential of industrial waste heat recovery can be realised more rapidly.

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

TABLE OF CONTENTS

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

1 Introduction

There is a general driver to make efficient use of resources and not waste anything valuable. It is frustrating to see vast amounts of industrial excess heat go up in smoke or be released into the sea. Especially, it is gruesome to see this at the same time as energy prices are rising and heating of buildings starts to be too expensive for both industries and citizens. Also, to a large extent, heating of buildings is made with fossil fuels causing release of greenhouse gases. In this report we look specifically at the economic drivers to industrial waste heat recovery, and they are found to depend on which stakeholder's perspective you are looking from.

From the industrial perspective, there is a demand to remove heat from processes in a technically and cost-efficient way. Instead of using cooling towers, which involves both investment and operational costs, an alternative could be to deliver the heat to a stakeholder outside of the industry. If the heat is released to water, e.g. a river or the sea, there is often a limited amount of heat that is allowed to be released due to environmental permits. To be able to expand the industrial production, again, there is need to deliver the heat somewhere else. In addition, sale of excess heat may be a new revenue stream for the industry.

Looking from the perspective of a district heating and/or cooling company, the use of industrial waste heat has both upsides and downsides. Industrial waste heat may be a reliable base production with low operational cost since no fuel is required. In that sense, the risk exposure to volatile energy prices is decreased. However, the heat production is partly outsourced to an external partner and not controlled by the company itself, which may be perceived as a risk increase. If the heat or cold delivery to the company's customers is adventured, it involves risk of punishment fees or even losing customers.

For single stakeholders that wish to use industrial waste heat, e.g. an airport or a hospital, the drivers are similar to that of a district heating company described above. The main driver is to obtain a reliable source of energy to a low and predictable price.

In addition, there is an ownership dimension which affects the drivers. Weather the organization investing in a waste heat project is public or private, affects the character of the economic drivers as well as the financing opportunities. Publicly owned companies tend to apply a more long-term perspective on investments and include environmental considerations to a larger extent. However, an increasing environmental awareness is seen in privately owned companies as well. Not the least due to customer requirements.

In this report, we will summarize the business aspects that have been examined in the SOWHAT project. Looking from different stakeholders' perspective and suggesting how to overcome barriers, manage risks and construct contracts, the report will generate important information for attracting investments and for realizing industrial waste heat/cold recovery investments.

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

2 Barriers and contracts

Drivers are closely related to barriers in the sense that a barrier could be a lack of drivers. For example, barriers which risk to increase investment costs or operational costs weaken the economic incentive of an investment. To overcome barriers and formalize the sharing of economic profits and risks, contracts could be used.

The main conclusions of two deliverables, D3.1 (on current barriers) [1] and D.3.3 (on contractual arrangements) [2] in the SOWHAT project are presented in this chapter.

2.1 Conclusions from Deliverable 3.1 - Barriers

In the report D3.1 (1) current barriers to industrial waste heat and cold (WH/C) recovery and exploitation, based on the experiences of the SOWHAT demo sites, are presented. Interviews were conducted both with project partners from the Swedish lighthouse cluster and the other national clusters involved in the SOWHAT project.

Previous studies show that barriers could be of different character depending on the location and other specific prerequisites of the industrial site. Sometimes the barriers weaken the business case, but even with a good business there can be barriers of non-economical character.

Most of the barriers found in literature and experienced by the Swedish lighthouse cluster, as being presented in Table 1 Barriers identified in D3.1 , based on earlier studies and experience in the Lighthouse cluster

Economic barriers (directly deteriorating the business case)	Lack of existing infrastructure
	Low prices for the competing energy sources
	Current policy incentives promote other forms of heat supply
	Long distance between supply and demand (large initial cost for piping)
	Supply and demand not matching, not sufficiently high-grade heat, and varying seasonal demand
	Risk that the excess heat provider will terminate its industrial activities
	High transactional cost in terms of required time for design contract etc
Non-economic barriers (financial and organisational)	Lack of financial funding
	Low priority to non-core business
	Lack of trust between the stakeholders
	Different views of the value of the heat (price and quality)
	Lack of knowledge about heating issues
	Lack of knowledge about the amount of excess heat
	Lack of knowledge about business arrangements
	Requirement for a short payback period (Different views on suitable contractual length)
	Different views on how to plan revisions/stops for the excess heat

To overcome the most difficult barriers some mitigation strategies were suggested. Most important is to identify a win-win business case for the excess heat collaboration. For the industries in the SOWHAT collaborations, there is a great value in replacing the cooling equipment on site by external excess heat delivery to a district heating network. In addition, the district heating systems within the Lighthouse cluster are owned by municipalities, and they had a political will to promote the excess heat collaboration. The municipalities regarded this as both a way to use local resources more efficiently and to promote local industries.

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

However, due to low cost of heating alternatives and the high initial investment cost for piping etc., it could be a challenge to find a profitable business case. Also, according to the interview respondents, a major barrier to a profitable business case is that policy promotes other energy alternatives than industrial excess heat. A standardised excess heat recovery policy in the EU would significantly reduce this barrier.

One way to improve the business case, is to consider both the supply of heating and cooling and hence make use of the excess heat a larger number of hours per year. Generally, in southern Europe where several of the studied countries are situated, the cooling requirements are large. Cold production with heat, e.g. through the use of absorption chillers, could replace electric chillers. In all EU countries the electricity price is higher than the price of natural gas which makes this an interesting option.

Lack of experience of excess heat recovery technologies or district heating and cooling networks is one major barrier in many of the demo site countries. Knowledge transfer and development of tools to evaluate the techno-economic feasibility, through for example similar projects like SOWHAT, can potentially contribute to reduce this barrier in the long run.

In the Swedish lighthouse cases, an important enabling factor was trust between the collaborating parties. The experience is that a close cooperation and transparency between the parties are keys to establish a successful collaboration. Trust also makes other barriers easier to overcome. On the other hand, lack of trust would be a barrier which makes other barriers even larger. One part of building trust is to increase the understanding of each other's systems through transparent communication. For example, for a district energy company one the most important things when planning for a heat/cold collaboration, is to clarify the availability of excess heat in terms of capacity (MW) and temperatures.

In the countries or regions with no or limited tradition of building district heating networks, the lack of regulations is mentioned as a barrier. Development of the regulatory framework is essential for the exploitation of industrial excess heat, e.g. permission process for piping. As a result, both national and local authorities play an important as enablers of an increased excess heat recovery.

, are found at the SOWHAT demo sites as well. However, depending on local prerequisites, the barriers take different shapes and occur to a varying degree from site to site. Major barriers that deteriorate the business case are low costs of heating alternatives, particularly natural gas, and high initial investment costs for piping etc. To overcome barriers, it is important to focus on identifying a win-win collaboration opportunity, considering both the costs and benefits of the potential partners. One opportunity identified is to use excess heat for cooling. Since cooling currently is supplied by electric chillers in most cases and the electricity price is much higher than the gas price across central and southern Europe, it appears interesting to examine the opportunity to use excess heat for cooling, e.g. through absorption chillers. Focusing on cooling can overcome economic barriers, however there are also major non-economic barriers. One is the lack of understanding of the systems of involved parties' (e.g. heat provider and energy company) and lack of trust between the partners. In the countries where district heating is not an established technology, the lack of technical know-how and lack of regulatory procedures have also been identified as significant barriers.

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

Table 1 Barriers identified in D3.1 [1], based on earlier studies and experience in the Lighthouse cluster

Economic barriers (directly deteriorating the business case)	Lack of existing infrastructure
	Low prices for the competing energy sources
	Current policy incentives promote other forms of heat supply
	Long distance between supply and demand (large initial cost for piping)
	Supply and demand not matching, not sufficiently high-grade heat, and varying seasonal demand
	Risk that the excess heat provider will terminate its industrial activities
	High transactional cost in terms of required time for design contract etc
Non-economic barriers (financial and organisational)	Lack of financial funding
	Low priority to non-core business
	Lack of trust between the stakeholders
	Different views of the value of the heat (price and quality)
	Lack of knowledge about heating issues
	Lack of knowledge about the amount of excess heat
	Lack of knowledge about business arrangements
	Requirement for a short payback period (Different views on suitable contractual length)
	Different views on how to plan revisions/stops for the excess heat

To overcome the most difficult barriers some mitigation strategies were suggested. Most important is to identify a win-win business case for the excess heat collaboration. For the industries in the SOWHAT collaborations, there is a great value in replacing the cooling equipment on site by external excess heat delivery to a district heating network. In addition, the district heating systems within the Lighthouse cluster are owned by municipalities, and they had a political will to promote the excess heat collaboration. The municipalities regarded this as both a way to use local resources more efficiently and to promote local industries.

However, due to low cost of heating alternatives and the high initial investment cost for piping etc., it could be a challenge to find a profitable business case. Also, according to the interview respondents, a major barrier to a profitable business case is that policy promotes other energy alternatives than industrial excess heat. A standardised excess heat recovery policy in the EU would significantly reduce this barrier.

One way to improve the business case, is to consider both the supply of heating and cooling and hence make use of the excess heat a larger number of hours per year. Generally, in southern Europe where several of the studied countries are situated, the cooling requirements are large. Cold production with heat, e.g. through the use of absorption chillers, could replace electric chillers. In all EU countries the electricity price is higher than the price of natural gas which makes this an interesting option.

Lack of experience of excess heat recovery technologies or district heating and cooling networks is one major barrier in many of the demo site countries. Knowledge transfer and development of tools to evaluate the techno-economic feasibility, through for example similar projects like SOWHAT, can potentially contribute to reduce this barrier in the long run.

In the Swedish lighthouse cases, an important enabling factor was trust between the collaborating parties. The experience is that a close cooperation and transparency between the parties are keys to

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

establish a successful collaboration. Trust also makes other barriers easier to overcome. On the other hand, lack of trust would be a barrier which makes other barriers even larger. One part of building trust is to increase the understanding of each other's systems through transparent communication. For example, for a district energy company one the most important things when planning for a heat/cold collaboration, is to clarify the availability of excess heat in terms of capacity (MW) and temperatures.

In the countries or regions with no or limited tradition of building district heating networks, the lack of regulations is mentioned as a barrier. Development of the regulatory framework is essential for the exploitation of industrial excess heat, e.g. permission process for piping. As a result, both national and local authorities play an important as enablers of an increased excess heat recovery.

2.2 Conclusions from Deliverable 3.3 - Contractual Arrangements

The objective of the report D3.3 [2] was to present possible contractual arrangements to support collaboration for exploiting industrial waste heat and cold (WH/C) resources. Contractual arrangements may be designed to overbridge barriers to collaborations. Experiences from successful contractual arrangements within existing WH/C collaboration was provided by the Swedish Lighthouse cluster, while viewpoints of possible collaborations were collected from the SOWHAT demo sites and from REUSEHEAT (H2020) [3], a project dedicated to urban waste heat recovery investments. In this section, the main conclusions of deliverable 3.3 [2] on contractual arrangements are presented.

To support WH/C exploitation, smart contracting and digital technologies applied to new efficient energy markets was also included in the study of contractual arrangements. The deliverable included an introduction to distributed ledger technologies and how to use them in the scope of energy trading. In addition, a description of the business models associated to this peer-to-peer (P2P) energy trading based on blockchain was included in the deliverable 3.3 [2].

Sharing of risk, cost and profit

Barriers such as large initial investment costs, requirements for a short payback period for investments and difficulties to agree on pricing have the potential to be handled in contractual arrangements. When pricing the heat or cold, experience from the Lighthouse cluster highlights that making the contractual arrangement a win-win should be the guiding principle to how this price is set. The initial negotiations may involve issues such as system boundaries and ownership of equipment, rather than starting with negotiating on the price. The contract period for the collaboration reflects the payback period of the district heating company and the size of the excess heat supplier's investment. The contractual length depends on how the initial costs and the ownership of equipment are shared between different actors. A contractual length of ten years has been suggested by most of the demo sites due to the high initial costs. Ten years is also the original contractual length of the two sites in the Lighthouse cluster. After the first ten years of collaboration, the contracts have been extended by two years at a time.

Handle the risks of closure and end-users changing heat source

Uncertainty due to the risks of closure of an industry supplying waste heat or the end-user changing to another source of heat or cold, could be handle through contractual arrangements such as an "exit paragraph". For example, the exit paragraph could state how long in advance a stakeholder needs to announce that it is leaving the collaboration and how costs that occur as a result of that will be divided

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

between the partners. Findings in the REUSEHEAT project [3] shows that, in the event of the heat provider terminating its activity, sanctions that will be applied must be specified in the contract, along with information regarding who owns different parts of the installed equipment. It is also concluded that contracts can be written such that, in the event of a transfer of ownership of the excess heat source, the new owner will be obligated to continue to supply heat.

A two-year period is often enough to allow the remaining party to replace a heat or cold supply by new equipment, without jeopardising the production stability. However, the experience from the Lighthouse cluster is that there is no need for an exit paragraph since they renegotiate the contracts every second year.

Clarify the stakeholders' commitment

In general, close communication is more important than paragraphs for a successful cooperation. From the experiences of the Lighthouse cluster, a close and open communication between the parties, problems that have arisen have been solved jointly by the operators of the collaborating partners. However, there are reasons to clarify the stakeholders' commitment in the contract, for example if staff is changed over time or if an entity gets a new owner.

Results from the REUSEHEAT project [3] show that identification of the heat provider's processes and planned maintenance periods is important. Also, compensation for deviations from agreed volumes etc. needs to be stipulated in the contract. In addition, the REUSEHEAT project [3] found that regarding supplies, the temperature of the heat, the hours when the heat is supplied, and the volume of heat flow need to be specified in the contract along with details of contingency plans for when heat cannot be supplied, e.g. due to an outage at the heat source. Furthermore, the REUSEHEAT project [3] concluded that clauses requiring that certain parties have some type of insurance often are desirable to include 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.

If necessary, invite additional stakeholders

Another of the greatest barriers to WH/C collaboration, is the lack of funding for non-core business investments. Both this, and the barriers created by uncertainty surrounding new technology, could be overbridged by involving a third party in the contractual arrangement. If no district heating company (with energy as core business) is involved in the collaboration, an alternative is to involve an Energy Service COmpany (ESCO) to take responsibility for the construction and operation of heat or cold network and other related equipment. According to the respondents in the interviews performed within SOWHAT, the vast part of industrial partners would prefer an ESCO to manage the heat or cold networks.

Facilitate for the bank

In some cases, a barrier to WH/C exploitation is the difficulty to get a bank loan, even when the investment is profitable. Several reasons could cause this situation. If it is due to the risk that end-users switch to other heat sources, an option could be to write a contract with a binding clause that states the way which the district heating company can guarantee that they are buying the heat supplied by the waste heat company. This could be a complement in the loan application to the bank or to other financing institutions.

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

Distributed ledger technology

Distributed Ledger Technologies (DLT), such as blockchain, have been introduced, and its application in the scope of energy trading has been analysed in D3.3 [2]. DLTs allow involved stakeholders to make transparent and secure peer-to-peer (P2P) transactions by keeping track of what is being shared in the network. With DLT, users will also be able to exchange energy without the need of a central entity that manages the exchanges, and this will avoid extra-costs and bottleneck issues.

P2P energy markets using DLTs has so far only been applied on electricity markets and applying this to the market for heating and cooling should be considered highly innovative. However, most of the concepts could be also applied concerning WH/C recovery, for example in a use case where industrial excess heat is delivered from several heat or cold producers to several heat or cold users.

2.3 Stakeholders' perspectives on barriers and contracts

The economic barriers described in Table 1, which directly deteriorate the business case, need to be overcome in order to create a profitable business case with a win-win for all the collaborating parties. One way to make sure that all benefits are included when establishing a business case, is to look at the drivers for the stakeholders and include the opportunity costs when making alternative investments in equipment. As mentioned above, this could for example be cooling towers at an industry, heat boilers at a district heating company, or electric chillers at a hospital.

Also, when it comes to the non-economic barriers, the stakeholders' specific drivers are important to consider when finding a strategy to minimize the barriers. Not least when it comes to organisational barriers, such as the low priority of non-core business and requirements for short payback periods, it should be investigated if there are drivers which could give higher priority to excess heat collaborations.

For industries there could be drivers such as:

- **Environmental permits.** One identified driver for industries to assess the best option to use the excess heat is how it would affect the environmental permits in a positive way.
- **Limited possibility to release heat to water.** In some industrial cases this may limit increased production and hence the core business of the industry.
- **Environmental requirements from customers.** Many industrial sectors have an increasing customer pressure to be resource efficient and reduce their environmental impact.

For public entities drivers could be:

- **Societal and environmental benefits.** Local or regional authorities, such as municipalities which own district heating systems, can have a political motivation to promote the heat collaboration. Exploitation of industrial excess heat can be seen both as a way to use local resources more efficiently and to promote local industries.

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

3 Business risk

Deliverable 3.4 on business risks of investments in industrial waste heat and cold recovery [4] was reported in February 2021 and is summarized in the section below.

3.1 Conclusions from Deliverable 3.4 - Business risks

The objective of D3.4 [4] was to identify and evaluate business risk of industrial Waste Heat and Cooling (WH/C) recovery. The point of departure was the ongoing sites in Sweden due to their long-term experience in the area. The waste heat recovery in these sites has been ongoing for several years and there is ample information on risks to account for. To further understand the risk exposure to waste heat recovery investments pre-establishment, a mapping was made of the perceived risk exposure of the demo sites in SO WHAT. From previous work it is known that the main risk discussed in the waste heat recovery context is the risk of industrial closure terminating the waste heat delivery. Therefore, attention was given to understand this risk as well as to map other risks of relevance in each site.

In addition, concerning Renewable Energy Sources (RESs) integration with WH/C recovery, there are possible operational risks associated to the fluctuating availability of RES production. Therefore, a special section was dedicated to learning more about the risk impact of the RES volatility from the SO WHAT solutions. However, since connection to the electric grid normally remains even though PVs or wind power is installed, the risk will not increase. Rather, the combination with a heat or cold production through heat pumps or absorption chillers respectively, may be beneficial for the volatile production in PVs and windmills, since the heat or cold network may function as an energy storage. The same is valid for solar thermal installations that supply a heat network, because of its inertia.

It was identified that the risk of industrial closure, which was perceived as large in earlier studies, is as a risk with severe consequence but low likelihood. The risk of termination of industrial activities has been assessed by a study of 107 excess heat recoveries in Sweden [5]. The analysis verified that terminated industrial activities are one of two major explanations for terminated heat delivery. The other major reason is substitution by another heat supply. However, these two explanations correspond to approximately 6 % of all annual average heat recoveries. The main conclusion is that a relatively small proportion of industrial heat recovery has been lost in Sweden because of terminated industrial activities. The risk of industrial closure showed to be smaller in large-scale industrial excess heat recovery cooperation, compared to small cooperation.

The risks that were identified to have the highest risk scores (likelihood times consequence) in the risk heat mapping were the following:

- The lack of regulations or uncertainty in regulatory framework on waste heat recovery.
- The lack of technical know-how is getting high risk scores in the countries with no district heating and cooling.
- For many demo sites the process to agree on pricing is considered as high risk: this is often a result from the two parties not knowing how the technical processes of the other party work.
- The dependence on one main heat source is also getting high risk scores; simply because a strong dependency is created where the stakeholders are reliant on a resource outside of its own control.

It was identified that the importance of some risks is reduced over time. For example, the risk of industrial closure is perceived to be lower once the relationship is established and up and running. In

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

addition, a large volume of heat recovery is seen as a riskier investment before it is undertaken whereas after it has been undertaken the large volumes instead have a stabilizing effect. Post investment, other risks like perceived differences of the value of the waste heat (price) become more pronounced.

To summarise, the main finding was that that the different risks vary between European countries, industrial sectors and with choice of technology. However, a major part of the risks can be mitigated with well-designed contracts and well-thought-through partner arrangements.

3.2 Stakeholders' perspectives on business risks

For an investment to be made, the advantages need to outweigh the disadvantages. In a sense, this can be expressed as that the risk of inaction should be larger than the risk of action.

For industries, a new income stream from sale of excess heat may reduce the total business risk of the company. Also, there is a risk of inaction with regards to efficient resource use and sustainability to consider. As already mentioned, both environmental permits and customer's requirement grow stricter in these regards.

For district heating/cooling company and end users, the risk with excess heat collaboration and the reduced control of heat or cold production equipment, should be weighed against the risk with volatile energy prices for fuel or electricity to supply other boilers or chillers.

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

4 Financing schemes and business models

Some of the initial hurdles for the implementation of WH/C recovery projects by district energy companies, industries with excess heat and individual end-user of excess heat are issues related to capital investment and long payback times. Hence, assessing possible financing schemes and business models is of importance for the economic drivers and to establish a competitive business case.

In Deliverable 3.5 [5], financing and Energy Service COmpany (ESCO) models for WH/C recovery projects were assessed. The main results from the deliverable are described below and its implications for different stakeholders are further highlighted in the following section.

4.1 Conclusion from Deliverable 3.5 – Financing and business models

To enhance the market introduction of both industrial WH/C recovery and Renewable Energy Sources (RES) investments, the capital requirements for the investment, the return of the investment and type of investor were evaluated. The impact of the environmental and social aspects related to the financing decision was analysed. An economic analysis of district heating network installations was carried out. This economic analysis was based on the evaluation of the Levelized Cost Of Excess Heat (LCOEH) and on the minimum heat selling price. The evaluation of these parameters allowed us to identify the competitiveness of investments. A deep analysis of the value chains for industrial WH/C recovery and the most common RES technologies was realised, and it was applied to some of the SOWHAT demo sites. The financing schemes for WH/C or RES projects were evaluated, together with the financing schemes employed by the Swedish Lighthouse partners in the SOWHAT project. An analysis of the ESCO models, Energy Supply Contracting (ESC), Energy Performance Contracting (EPC), and Integrated Energy Contracting (IEC) was performed. For some of the SOWHAT demo sites financing schemes together with energy contracting (ESCO model) were identified. Finally, some results from D3.5 [5] have been proposed to be integrated in the SOWHAT tool.

For any kind of WH/C or RES project, a deep techno-economic analysis is fundamental to make well-informed investment decision makers. An analysis of the company's business expenses, together with the project capital budgeting evaluation, will provide economic indicators which are helpful tools in the decision-making process. A shorter Payback Period or a lower Levelized Cost of Energy/Heat (LCOEH) should always be equivalent to attractive investments.

A deep analysis of the business value chain is fundamental to determine competitive advantages, with the aim of generating added value. For the WH/C scenarios of the SOWHAT demo sites, a value chain analysis was used, see Table 2, and it was observed that both "Installation" and "Value added" activities along the value chain are considered of utmost importance for generating value, while "Planning and design" and "Operation & Maintenance (O&M)" activities are located on a lower step. "Components supply" activities is the category were considered the least important.

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

Table 2 Generic value chain for WH/C. Source: D3.5 [5]

WH/C VALUE CHAIN ACTIVITIES				
Planning and design	**Components supply**	**Installation**	**Operation & Maintenance (O&M)**	**Value added**
Energy consultants	**Hardware supply:**	**Installation companies (labour)**	**Energy Service Companies (ESCOs)**	**Local job creation**
Hardware definition:	Heat exchangers	**Hardware installation**	**Energy contracting**	**Growth of the local economy**
WH/C generation points	Absorption refrigerators	**Software installation**	**Subcontracted companies**	**Technological innovation (R+D+I)**
WH/C recovery technologies	Water pumps	**Inspections**	**Monitoring**	**Green value:**
Pump system	Piping	**Commissioning**	**Service & Maintenance**	Lowered GHG emissions
Distribution network	Measuring equipment	**Calibration**	**Metering & Invoicing**	Primary energy-savings
Software definition:	**Software supply:**			Energy efficiency
Calculation/ simulation software	Control system (SCADA)			
Control system	Visualization tool			
Permissions and licences				
Grants				
Public procurement				

The selection of the most suitable financing scheme together with the ESCO model are essential for two reasons; on the one hand determine the viability of the investment, and on the other hand the operation and maintenance (O&M) of the facility along its lifecycle. For the SOWHAT demo-sites, it can be concluded that there are possibilities of several combinations of financing schemes and ESCO models solutions, with a combination of public and private financing, complemented by EU grants, as well public and private O&M. A summary of the financing and ESCO model selection of the SO WHAT demo sites can be seen in Table 3.

Table 3 SO WHAT demo site financing and ESCO model selection. Source. D3.5 [5]

Financing and ESCO Models Selection					
Demo-Sites	**Scenarios**	**Investment Costs**	**Operation and Maintenance (O&M) Costs**	**Reinvestment Costs**	**ESCO Contract**
LIPOR Maia (Portugal)	**Not yet defined**	Owner (EU grants) + Owner Financing + Owner Loan	ESCO Contract (private financing)	Owner Financing and/or Owner Loan	Energy Supply Contracting (ESC)
ISVAG (Belgium)	**Scenario 1: Small district heating network**	Owner (EU grants) + Owner Financing	Owner Financing	Owner Financing	N/A

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

Financing and ESCO Models Selection					
Demo-Sites	**Scenarios**	**Investment Costs**	**Operation and Maintenance (O&M) Costs**	**Reinvestment Costs**	**ESCO Contract**
	Scenario 2: Large district heating network	Owner (EU grants) + ESCO Contract (private financing)	ESCO Contract (private financing)	ESCO Contract (private financing)	Integrated Energy Contracting (IEC)
RADET (Romania)	Scenario 1: Pellets boiler and Solar thermal	Owner (EU Funds)	Owner Financing	Owner Financing	N/A
UMICORE (Belgium)	Scenario 1: Internal use of excess heat from processes	Owner (EU grants) + Owner Financing + Owner Loan	Owner Financing	Owner Financing	N/A
	Scenario 2: Geothermal energy	Owner (EU grants) + ESCO Contract (private financing)	ESCO Contract (private financing)	ESCO Contract (private financing)	Integrated Energy Contracting (IEC)
IMERYS (Belgium)	Scenario 1: Heat recovery	Owner (EU grants) + ESCO Contract (private financing)	ESCO Contract (private financing)	Owner Financing and/or Owner Loan	Integrated Energy Contracting (IEC)
MARTINI & ROSSI (Italy)	Not yet defined	Not yet defined	Not yet defined	Not yet defined	Not yet defined
ENCE (Spain)	Scenario 1: Internal use of excess heat from causticization stage	Owner Financing	Owner Financing	Owner Financing	N/A (internal operation)
	Scenario 2: External use of excess heat from bleaching and effluent treatment stages	Owner Financing	Owner Financing	Owner Financing	N/A (reduction of the consumption of the cooling towers)
ROMPETROL (Romania)	Scenario 1: Internal recovery of heat	Owner Financing	Owner Financing	Owner Financing	N/A

5.1 Stakeholders' perspectives on financing schemes and business models

In the assessment of the value chains for the demo sites of the SOWHAT project, a number of added values have been identified from WH/C projects, see Figure 1. These can serve as economic, as well as non-economic, drivers and for attracting financing to investments in WH/C as well as RES projects. Different stakeholders may be interested in different values and who will benefit financially from these added values could be depending on the applied business model and how a collaboration contract is designed.

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

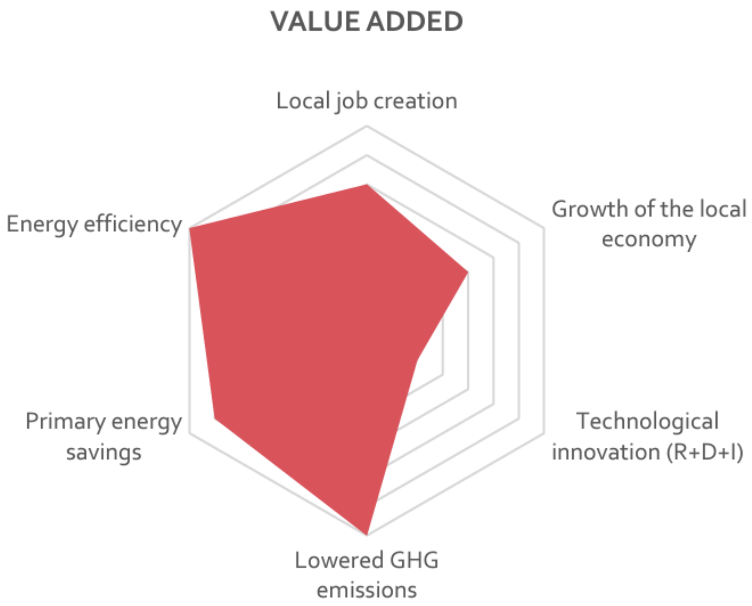

Figure 1 Values added along the WH/C value chains of the SO WHAT demo sites, Source: D3.5 [5]

A method to calculate the socio-economic costs and benefits analysis (CBA) is presented in report D3.2 [5]. The calculations include techno-economic costs of investments and operation & maintenance, as well as socio-economic benefits from reduced air emissions of greenhouse gases and local air emissions. Assessing the net welfare through a CBA could be useful for making decisions on large public sector investments and to attract financial support.

Weather the organization investing in a project is public or private also adds an extra dimension to the economic drivers for these projects. Both the ownership and operation of district heating and/or cooling network can be 100% by a local entity, 100% private, mixed public-private and in cooperative with or without the involvement of a local entity. Local entities can benefit from several aid mechanisms, both from the European Union and from national administration. District heating and cooling networks that are privately owned and operated could use financing schemes such as repayable loans, non-refundable grants, tax advantages or other benefits. Even though privately owned, attracting financing to the project could be supported by the local entity, e.g. as a contribution to the project based on a potential CO_2 reduction.

In a mixed public-private model, projects can benefit from the collaboration through the involvement of private actors familiar with managing risks and attracting capital and local entities that are familiar with infrastructure. There are several set-ups for public-private collaborations mentioned in D3.5 [5], among these several mentioned in the above description of the report. What is worth mentioning in this context is that different set-ups also could include different economic drivers for WH/C and RES projects. As an example, energy service contracts can be based on energy savings (such as EPCs) or supplied energy (such as ESCs) or a combination (such as IECs) during a contractual period. Therefore, the economic drivers for the actors involved in the ESCOs will differ. On the other hand, depending on the WH/C set-up different financing schemes for investment, O&M and reinvestment are the most suitable, as well as the type of energy service contract preferred. There is nothing saying that the involved actor in a contract could not be both district energy companies, industries that supply excess heat and/or end-users of excess heat.

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

Experiences from the Swedish Lighthouse cluster, represented in SOWHAT by two district energy companies with industrial WH/C collaboration, are to split the profit between actors, and create contractual arrangements that establish a win-win. A first step is to develop a common profitability calculation, and then negotiate system boundaries and ownership. This shows the importance of transparently sharing the added values among the actors involved in a WH/C collaboration.

.

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

6 Discussion and conclusions

The stakeholders in a waste heat or cold recovery collaboration, have some common drivers, such as a general strive for resource efficiency. However, as summarised below, most economic drivers are more specific depending on which sector they represent.

Industries

- **Extra revenue of selling heat.** The heat price should be set to a level which allows the industrial partner to make profit. This new revenue may reduce the total business risk for the company.
- **Reduced cost for cooling.** In some cases, industries can avoid costs for cooling, e.g. in cooling towers. This makes the business case more beneficial and should be considered in the analysis.
- **Environmental requirements from customers.** Many industrial sectors have an increasing customer pressure to be resource efficient and reduce their environmental impact.
- **Environmental permits.** One identified driver for industries to assess the best option to use the excess heat, is that it can affect the environmental permits.
- **Remove a bottle neck for increased production.** In some cases, there is a limit to how much heat that is allowed to be released into water. This may even be limiting the expansion of the industrial production. Hence, there is a driver to deliver the heat externally.

District heating/cooling companies and end users

- **Reduced and/or more predictable cost for heating or cooling.** Both electricity and natural gas prices are volatile. Hence, the risk of reduced control of heat or cold production equipment should be weighed against the risk with volatile energy prices for fuel or electricity to heat boilers or electric chillers.
- **Use excess heat instead of investing in additional boilers or chillers.** If new heat or cold production is needed to be invested in, due to expanded demand or to replace end-of-life equipment, the driver to join a waste heat or cold collaboration is specifically large.
- **Societal and environmental benefits.** Local or regional authorities, such as municipalities which own district heating systems, can have a political motivation to promote the heat collaboration. Exploitation of industrial excess heat can be seen both as a way to use local resources more efficiently and to promote local industries.

With regards to renewable energy sources, e.g. wind and solar, integrated with WH/C recovery, no specific business risks were found, as long as the connection to the electric grid remains, which is the normal situation. Rather, the combination with a heat or cold production through heat pumps or absorption chillers respectively, may be beneficial for the business case of volatile production in PVs and windmills, since the heat or cold network may function as an energy storage. The same is valid for solar thermal installations that supply a heat network, because of the inertia in the heat network.

A conclusion from WP3 is that the SOWHAT tool need to reflect the drivers of different stakeholders in an adequate way. Also, it is advantageous if all system benefits of the stakeholders are considered.

However, a profitable business case with low risk is not enough to realize a collaboration; trust between the parties is required as well. The SOWHAT tool can be a platform where the first steps for trust building can be taken. In the tool, system requirements can be shared, and a common

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

profitability calculation can be developed. When trust has been established, the system boundaries and ownership can start to be negotiated. To endure this process, from first idea to signed contract, the stakeholders need to believe in the long-term benefit of regional collaboration for future resource efficiency.

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097

References

[1] S. Klugman, J. Nilsson, A. Nilsson, B. Unluturk and K. Lygnerud, "SO WHAT D3.1 Report of current barriers to industrial WH/C recovery and exploitation," 2020.

[2] S. Klugman, J. Nilsson, S. Gutiérrez Caballero, N. Purshouse and K. Lygnerud, "Report on current Contractual Arrangements for WH/C exploitation WP3 Deliverable 3.3," 2020.

[3] S. Klugman, J. Nilsson, K. Lygnerud, A. Nilsson and N. Fransson, "Business and risk models for industrial WH/C recovery and exploitation towards replication WP3 Deliverable 3.4," 2021.

[4] P. Arias, J. López, J. Alonso, Á. Soage, D. López, J. Martínez, M. Porta, A. Díaz, V. Arnau, S. Klugman, P. Santos and A. Welti, "Financing and ESCO models for industrial WH/C recovery and exploitation towards replication WP3 Delivareble 3.5," 2020.

[5] A. Nilsson, S. Åström, M. Porta and A. Welti, "SO WHAT D3.2 Report on the CBA of Industrial Waste Heat and Cold and RES in Industry Investments in Europe," 2020.

Horizon 2020
European Union Funding
for Research & Innovation

This project has received funding from
the European Union's Horizon 2020 research and innovation
programme under grant agreement No 847097