H2020 Work Programme

D3.3 - REPORT ON CURRENT CONTRACTUAL ARRANGEMENTS FOR WH/C EXPLOITATION

Lead Contractor: VEAB

Date: 29/05/2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 847097. The content of publication is the sole responsibility of the author(s). The European Commission or its services cannot be held responsible for any use that may be made of the information it contains.

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

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. (RINA-C)		
Website	https://sowhatproject.eu/		

Deliverable details			
Number	3.3		
Title	Report on current Contractual Arrangements for WH/C exploitation		
Work Package	3		
Dissemination level[1]	PU = Public	**Nature**	Report
Due date (M)	M12 – 31.05.2020	**Submission date (M)**	29/05/2020
Deliverable responsible	**VARBERG ENERGI AB (VEAB)**		

[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	Sofia Klugman (Swedish Environmental Research Institute – IVL)*
Contributing Author(s)	S. Klugman (IVL), J. Nilsson (IVL), S. Gutiérrez Caballero (CAR), N. Purshouse (IESRD), K. Lygnerud (IVL), K. Hallström (VEAB)
Reviewer(s)	O. Neu (IESRD), K. Hallström (VEAB), P. Santos (2GOOUT), S. Fiorot (ENVI), F. Morentin (CAR), E. Mamut (MEDGREEN)
Final review and quality approval	F. Peccianti (RINA-C, 29/05/2020)

* The deliverable preparation has been prepared by IVL while VEAB supported it

Document History			
Date	**Version**	**Name**	**Changes**
05/05/2020	1.0	S. Klugman (IVL)	Consolidated draft
26/05/2020	1.1	S. Klugman (IVL)	Adjustments according to the comments of the reviewers.
29/05/2020	2	F. Peccianti (RINA-C)	Minor changes and formatting

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

DH: District Heating

DHC: District Heating and Cooling

DLT: Distributed Ledger Technology

ESCO: Energy Service Company

P2P: Peer-to-Peer

WH/C: Waste Heat / Cold

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 objective of this report is to present possible contractual arrangements to support collaboration in exploiting industrial waste heat and cold (WH/C) resources. Contractual arrangements may be designed to overbridge barriers to collaboration. Barriers were identified in the report D3.1 – Report on current barriers to industrial WH/C recovery and exploitation, which is based on literature study and interviews with the SO WHAT demosites. Experiences from successful contracts within existing WH/C collaboration have been provided by the Swedish Lighthouse cluster, viewpoints of possible collaborations have been collected from the SO WHAT demo sites and information has also been collected from the REUSEHEAT (H2020), a project dedicated to urban waste heat recovery investments.

To support WH/C exploitation, smart contracting and digital technologies applied to new efficient energy markets are included in the study of contractual arrangements. An introduction to distributed ledger technologies and how to use them in the scope of energy trading is included in this chapter. Also, a description of the business models associated to this P2P energy trading based on blockchain has also been included.

Main results achieved are that barriers such as large initial cost, requirements for a short payback period for investments and difficulties to agree om pricing have potential to be handled in the contractual arrangements. When pricing the heat or cold the guiding principle should be to make the arrangement a win-win.

The contract period of the collaboration should reflect the pay back of the district heating company and the size of the excess heat supplier's investment. Ten years has been suggested by most of the demo sites due to high initial costs. Ten years is also the initial 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.

From experiences regarding contractual arrangements for excess heat valorisation for cooling, e.g. through absorption chillers, no specific contract is needed regarding the used heat to produce cold. From the district heating companies view, both contracts with industries and cold or heat end-users is a question of weighing business risks. If one part takes a bigger risk, for example the vast part of the initial investment, the other part needs to give more, for example in terms of a long contractual period. When planning for district cooling, the most important factors are capacity (MW) and temperatures.

It is identified that uncertainty due to the risk of the heat source (the industry) closing down or the risk of end user changing to another source of heat or cold, can be mitigated by contractual arrangements such as an "exit paragraph". For example, it can be stated 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 between the partners. The results from the REUSEHEAT project is that in the event of the heat provider terminating its activity, the sanction that should 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 heat source, the new owner will be obligated to continue to supply 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

Although close communication is more important than paragraphs for a successful cooperation, there are reasons to clarify the stakeholders' commitment in the contract. For example, if staff is changed over time or an entity gets a new owner. Results from the REUSEHEAT project shows that identification of the heat provider's processes and planned maintenance periods is important. Also, compensation for deviations from determined volumes etc. needs to be stipulated in the contract.

Another of the greatest barriers to WH/C collaboration, is lack of funding for non-core business investments. Both this, and the barriers due to uncertainty due to new technology, could be overbridged by involving a third party in the contractual arrangement. If no district heating company (which core business is energy) is involved in the collaboration, an alternative is to involve an ESCO to take responsibility for construction and operation of heat or cold network and other related equipment.

In some cases, a barrier to WH/C exploitation is the difficulty to get 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 DH company can guarantee, that they are buying the heat supplied by the WH company. This may persuade the banks to give a loan.

Distributed Ledger Technologies (such as blockchain) allow the involved stakeholders to set transparent and secure peer-to-peer transactions, keeping track of what is being shared in the network. Applications of P2P energy markets using DLTs has been only for electricity markets and applying this to the market for heat/cooling should be considered highly innovative. Despite this, 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. Using this kind of technologies, users will 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.

In order to facilitate the exploitation of waste heat and cold, the SO WHAT tool could propose alternative contractual arrangement, including the following aspects:

- Alternative ways of pricing of heat or cold could be proposed, based on models for sharing of profit.
- Alternatives on risk sharing (e.g. due to ownership of pipes and other equipment, back up heat or cold production units etc)
- Different stakeholder setups (e.g. including an ESCO)

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

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

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

In this report, contractual arrangements to support collaboration in exploiting industrial waste heat and cold (WH/C) resources are presented. The focus is on the opportunities to exporting WH/C resources off-site, through a heat/cold distribution network. Information on barriers from D3.1, input from the lighthouse cluster and from the REUSEHEAT project have been collected to meet the main objective of this deliverable i.e. to study how contractual arrangements may be designed to overbridge barriers to collaboration. In addition, this report includes a description of Distributed Ledger Technology (DLT), such as blockchain, for smart contracting and peer-to-peer (P2P) energy trading. The report is a collaboration between IVL, GOTE, VEAB, RINA-C, CAR, IESRD and the demo site partners of SO WHAT.

2 Methodology

The methodology of the study is presented in Figure 1. First information was collected from the REUSEHEAT project (coordinated by IVL). Then, to gather experiences from the Swedish lighthouse cluster and viewpoints from the demo sites, interviews were performed. The respondents answered questions regarding their experiences of and viewpoints on contractual arrangements. The questions were formulated with starting point from the barriers that were identified in D3.1, including how these barriers could be overbridged by contractual arrangements. Also, the findings in the REUSEHEAT project on important contractual issues to consider were used to formulate questions included into demo site interviews. For example, questions were asked about how to derive a correct price of the excess heat/cold and what would be a suitable length of efficient contracts.

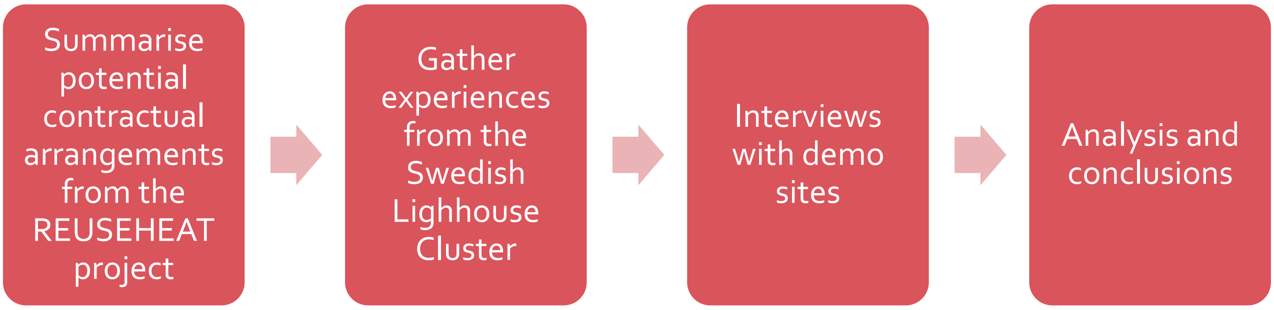


Figure 1 Overview of the methodology.

The interviews were semi-structured following a defined interview guide (enclosed as Appendix A: Questionnaire to the demo sites). The lighthouse cluster interviews were performed in person at the IVL office in Gothenburg in December 2019. Both VEAB and GOTE were present at the time of the interview and responded to the questions asked by IVL. The demo site partners of SO WHAT were interviewed during January/February 2020 by using digital media solutions. All interviews were summarized in writing in conjunction to the interview being performed.

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 Aspects of contractual arrangement for WH/C exploitation

When designing efficient contracts regarding excess heat recovery in district heating network, the involved parties need to take several associated barriers into account. In this chapter, the barriers for WH/C exploitation which were identified in D3.1 are described in terms of whether these could be overbridged by contractual arrangements. Furthermore, findings from the REUSEHEAT project regarding important contractual aspects to be considered are described.

3.1 Overbridging the barriers identified in SO WHAT D3.1 by contractual arrangements

The SO WHAT demo sites are facing different barriers depending on the sector, location, level of earlier experiences and infrastructure of DHN etc. The barriers which were identified through interviews with the demo sites cover a wide range of areas and issues. Some of the barriers could possibly be manage by contractual arrangements and some of them need to be handled by other measures. In the following, the focus is on the first category.

Firstly, all the respondents perceived requirements for a short payback period for investments as an essential barrier to WH/C collaboration at their demo site. Related to this barrier is the large initial cost for piping and other equipment. A long-term commitment of the end users of heat or cold is required due to the large initial cost. It is regarded as a barrier that end users may choose another heat source after some time. Also, most of the respondents identified different views of suitable contractual length as a major barrier.

In some cases, there are financial barriers. For example, bank allowance may be difficult to get if the end users cannot guarantee a long-term commitment.

A major barrier is that energy is non-core business for the industries. Other priorities in the company is a great barrier to WH/C exploitation. There is a lack of funding, capital and manpower for non-core investments even if there is a good business case.

Another important element is to agree on pricing of the industrial waste heat/cold that both the energy provider and the district heating and cooling company agree with.

Lack of knowledge or understanding of each other's systems, processes etc were considered as essential by almost all demo sites. Related to this, is the different views on delivery quality that may be a barrier in some cases.

The risk of industries shutting down, resulting in the industrial excess H/C deliveries terminating, is one element that must be accounted for when designing the contract. However, even if there is little risk of the waste heat provider shutting down, there could be risk of delivery failures.

To summarise, the following barriers for WH/C exploitation will be examined to determine to what extent they could be overbridged by contractual arrangements:

- Long-term commitment of end users
- Large initial cost

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

- Requirements for a short payback period for investments
- Different views of suitable contract length
- Financial barriers
- Not core business
- Difficulties to agree on pricing
- Lack of knowledge or understanding of each other's systems, processes etc
- Different views of delivery quality
- The risk of industries shutting down.
- Risk that the industry may not always supply heat

3.2 Knowledge transfer from the REUSEHEAT project

In the REUSEHEAT project efficient contractual forms and business models for urban waste heat recovery (1) were studied. Contracts will always be imperfect, but they can be used to reduce risk. One important 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 established. The most important factors can and should be agreed between all parties at the contract negotiation stage.

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 (1). A renegotiation clause can make the investment more attractive to investors since it reduces the investment risk.

From D2.3 in REUSEHEAT, there are known, important factors to consider when making urban waste heat recovery investments. Urban waste heat is often of lower temperatures than waste heat from industrial processes. The lower temperatures make the urban waste heat recovery more challenging than the average high temperature industrial waste heat recovery. The number of factors of importance for drafting contracts that were identified in the context of the REUSEHEAT project is therefore higher than for the industrial waste heat recovery business case. Hence, resorting to the listed factors of relevance in REUSEHEAT, all factors of importance in the SO WHAT context should be covered.

From REUSEHEAT, factors that need to be accounted for in the contracts are identified, see Table 1. If the factors are managed in the contract 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. How the factor is relevant for the SO WHAT demo sites is explained in the middle column.

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 Contractual choices of importance to urban waste heat recovery investments. Result from the REUSEHEAT project (1)

Factor to consider	Factor of relevance to SO WHAT demo sites Y/N	Proposal for managing the factor
1. Low maturity of the installations	Y- the sites are new to the waste heat recovery	The low maturity of the installations necessitates 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	Y- there is limited legal information on waste heat and how to treat it	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	Y- the owner of the heat has one perception and the purchaser of the heat another	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	Y/N- depends on the payback period of the demo sites	Long pay back necessitates a renegotiation clause in the contract.
5.Asymmetric information (theory)	Y- two parties who do not know eachother's industries	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) a) supply b) operation c) maintenance d) pricing e) insurance f) quality assurance g) monitoring h) billing i) renegotiation	Y- shared incentives facilitate the possibility to mitigate problems when the occur. Determining details on a-i facilitate the contractual writing.	Shared incentives can be related to one or several aspects: 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

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

		plans for when heat cannot be supplied, e.g. due to a breakdown at the heat source. b) 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. c) 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). d) 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. e) 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. f) 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. g) It is often necessary to monitor the supply process. For example, in urban heat recovery the contract should specify the hours at

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

		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. h) 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. i) 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)	Y- this risk is larger than in the urban waste heat recovery context as the volumes often are larger in the industrial waste heat recovery context	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.

Returning to the SO WHAT proposal, two risks were highlighted in it, namely the risk that the heat source will stop operating or that ownership will be transferred to a party that is less keen on continuing the relationship and the risk that there is disagreement on the price of the waste heat between the energy company and the waste heat provider. Based on the REUSEHEAT experience it is concluded that contracts can be written with clear sanctions in the case of waste heat recovery termination and clear directions on ownership of different parts of the equipment

In addition, the value of heat is an aspect that need to be agreed upon. 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 in REUSEHEAT it was found that the outside temperature and/or season

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

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 (1). Altogether, the price depends on the source at hand and the incentives for both heat user (energy company) and heat provider (industry).

Another issue relating to seasonality was also 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 (1).

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).

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 Knowledge transfer based on contractual arrangements within the Swedish lighthouse cluster

In this chapter, the contractual arrangements for WH/C exploitation at the industrial demo site of Gothenburg and Varberg, including a detailed analysis of the Gothenburg site regarding arrangements for excess cold are presented. The information was collected in a common interview with both of the sites in December 2019. The focus of task 3.2 is on how to price the heat and what suitable contractual lengths are. Therefore, the presentation below is focused on the two items but other related issues are also addressed.

4.1 Gothenburg, Sweden (GOTE) – Multiple heat source DH/C

Table 2 Description of the site in Gothenburg

Name, Partner	Location	Sector	Process	Temperature
GOTEBORG Multiple heat source DHN (GOTE)	Gothenburg (Sweden)	DHN, Heat from waste incineration and excess heat from refineries	GOTE DHCN is linked to different industrial facilities covering 90 % of the city demand. It is willing to expand this service.	70 - 100 °C

4.1.1 Background regarding contractual arrangements at the site

The excess heat collaboration in Gothenburg was established in the 1980's. Currently there is a surplus of heat in the system, i.e. there is not enough heat demand to justify an increase of the excess heat recovery. The excess heat recovery is dimensioned on the district heating demand, not on the district cooling. In Gothenburg the district cooling market is small compared to the district heating market. The energy company Göteborg Energi (GOTE) offers district cooling since the mid 1990's.

The incentive of the refineries Preem and St1 to join the collaboration is the required cooling of their refinery processes. For GOTE, the excess heat collaboration means that it can reduce its investment costs by avoiding investments in heat boilers and be able to phase out peak production during the winter.

4.1.2 New potential collaborations

Currently, the potential of excess heat is larger than the heat demand. According to the climate strategy program of the City of Gothenburg, all district heating in 2030 will be produced by energy from renewable sources, waste incineration and excess heat. The district heating demand will according to GOTEs forecast increase to year 2035 by 2 %.

One way of exploiting the excess heat potential for GOTE, is to extend the amount of district cooling to the network based on absorption chillers driven by excess heat from industries which in summer months is not demanded for district heating. The plan is to do this in parallel with free-cooling (cooling towers or river water) and compressors in order to offer a reliable service. By 2021, GOTE will need to expand their cooling production by another 20 MW to meet the sales forecast. Two types of absorption machines are under consideration. GOTE also look at the possibility of utilising low

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

temperature heat for district heating network (i.e. data server rooms, data test cells). The demand of district cooling is predicted by GOTE to increase with 200 % to 2035.

4.2 Varberg, Sweden (VEAB) – Pulp mill DH

Table 3 Description of the site in Varberg

Name, Partner	Location	Sector	Process	Temperature
Pulp Mill DHN (VEAB)	Varberg (Sweden)	DHN, Excess heat from Pulp Mill	VEAB DHN is linked to the nearby pulp mill providing excess heat via heat exchanger.	80 - 95 °C

4.2.1 Background regarding contractual arrangements at the site

The excess heat collaboration in Varberg started in 2001 and was initiated by the pulp mill Södra Cell Värö (SCV) who contacted Varberg Energi (VEAB). Before the collaboration the excess heat was cooled off without heat recovery. Due to a new water purification process that needed a maximum temperature of 45 °C, the water needed to be cooled off further. With the collaboration SCV could both meet the cooling demand and recover the heat. An additional incentive for the collaboration (from both companies) was to become more environmentally sustainable.

The transmission pipeline to connect the pulp mill with the district heating network in Varberg is 20 km and was partly financed by a state aid[2]. The transmission line was written off in 10 years, which is faster than common district heating lines.

The collaboration between the two actors has developed over time. Both companies have invested in the collaboration (for example SCV owns the first pumps after the pulp mill, and VEAB owns the others and the transmission line).

4.2.2 New potential collaborations

Potential new options for collaboration in Varberg are:

- **Increase the volume of excess heat.** Currently there is occasionally a demand for peak load, but the transmission line is not dimensioned to cover it.
- VEAB is interested in **DC produced from excess heat**.

4.3 Lighthouse cluster experiences of contractual arrangements

According to GOTE and VEAB the perceived time frame from idea to implementation (with permissions, land owners, transmission line etc.) was 3-4 years, of which at least a year for designing the contractual arrangements. The contracts include the excess heat supplier and the district heating company.

4.3.1 Contractual arrangements to price the excess heat/cold

Experiences from both VEAB and GOTE is to split the profit between the actors and by that make the contractual arrangement a "win-win". This is crucial to how the price is set. The first step is to develop a common profitability calculation, then negotiate system boundaries and ownership of the equipment. Further negotiations can involve how much (or little) the industry should run its plants, rather than negotiate the price.

[2] LIP

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

4.3.1.1 GOTE

See common answer above.

4.3.1.2 VEAB

Changes have been made in the contracts over time. In the first contact the temperature was set on 78 °C which has increased successively to 90 °C today. Initially VEAB ordered steam from SCV but left it over time. In the contract only approximate temperatures are set, not the volumes of energy in MW or MWh. SCV only has requirements on delivery when the pulp mill is operating. If the pulp mill would change location, there would be no requirements of delivery. VEAB is noticed when the pulp mill is not running. The reading of the heat supplies is automatic, and VEAB contacts SCA if any disruption would occur. Due to this risk of disruption to VEAB, the price of the heat is set lower than if the contractual arrangements were designed for different conditions. The renegotiation of price and quality takes place every second year. The ownership of facilities reflects the risk diversification (VEAB owns the transmission line).

4.3.2 Suitable contractual lengths

The suitable contractual lengths depend on the size of the investment, and it is important for both parties with long-term conditions. At both sites (Gothenburg and Varberg) a general contractual length for this kind of collaboration is 10 years (due to the expected pay back of 10 years), and then they can be renewed. VEAB describes that long contracts mitigate the risk of SCV to terminate the heat recovery. GOTE also points out that the arrangement varies, in some cases GOTE takes the entire investment cost and in some cases the heat supplier takes a large share of the investment. If the heat supplier is interested in a short contractual length, the supplier also takes a larger share of the investment in the beginning.

According to the conditions at the sites of GOTE and VEAB there is no need for special exit paragraphs in the contract in case of one of the actors want to leave the collaboration. The contractual arrangements are set for the negotiated time frame.

In the annual business plan, as one of the items on the agenda, VEAB discuss solutions in the case of SCV terminating the excess heat supply.

4.3.2.1 GOTE

The current contractual length is 10 years (based on the expected pay back is 10 years) but depends on the size of the investment. The contract period reflects the pay back of the district heating company and how much the excess heat supplier has invested. The risk assessment is made by the excess heat supplier by hiring an external consultant as a light due diligence before the collaboration begins. The arrangement varies, in some cases GOTE takes the entire investment cost and in some cases the heat supplier takes a large share of the investment. If the heat supplier is interested in a short contractual length, the supplier also takes a larger share of the investment in the beginning.

4.3.2.2 VEAB

The main contract is renewed every 10 years. Long contracts mitigate the risk of SCV to terminate the heat recovery. In the renegotiation of the main contract larger adjustments regarding volumes are agreed upon. Based on the main contract the collaborating parties meet every two year to renegotiate the price. If VEAB and SCV together require an adjustment in the description regarding

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

temperatures or volumes before the main contract is expired, the parties can include the preferred updates in the appendix when renegotiating the price agreement.

The decision of investing in the district heating network was based on the access of industrial excess heat, without that crucial factor the district heating network would not be developed. The political incentives overcame the risks of the investment. The trust between the two parties has been an important factor of the collaboration.

4.3.3 Contractual arrangements to overbridge other identified barriers

Except for pricing the excess heat/cold and suitable contractual lengths, lack of knowledge of the parties' systems, processes and traditions could be a barrier for efficient excess heat collaboration. This barrier is associated to asymmetric information about input and output of the parties in the collaboration. One of many other risks to regard is if the industry is not able to deliver heat continuously. GOTE and VEAB highlights the importance of handle planned maintenance periods/stops in the industry in the contractual arrangements. The energy company focus is on deliver heat during the winter, and the available excess heat from the industry is particularly high during the summer.

4.3.3.1 GOTE

It is important for the district heating company to be informed of the industries planned revisions and stops. To ensure the readiness if e.g. the largest boiler would stop operating, the district heating company makes an action plan for the district heating system. At the site unplanned stops are uncommon, but if the situation would occur GOTE is able to compensate the heat outage with other facilities. GOTE and the heat suppliers have a close dialog regarding the operation of the heat supply to ensure the right temperature etc of the delivery. This arrangement is important to minimize complications due to miscommunication.

To avoid different views on the quality of the heat delivery it is important to agree on specified conditions which the collaboration can make plans based on. The elements energy (MWh) and capacity (MW) are agreed upon. A meeting is arranged if the heat supplier fails to deliver the complete volume to discuss the issue.

4.3.3.2 VEAB

To prevent the risk of unpredicted outages of the excess heat the following arrangement has been developed. SCV is the only excess heat supplier connected to the district heating network, and accounts for 80-85 % of the total heat delivery. VEAB has invested in reserve capacity (2 wood boilers and gas boilers) to be able to handle the situation of SCV not operating during the coldest winter day. The gas boiler can start with short notice. The wood boilers need a day to start, but if they are already running, they can be adjusted to maximum capacity during the same day. An alternative of this solution would be that the excess heat supplier would invest in a boiler to mitigate the risk, but VEAB wanted the boiler in the city instead of placing it at the pulp mill. The contractual arrangements conclude that planed audit periods for SCV cannot be performed between November to March. The unpredicted outages per year varies, but during the expansion of the pulp mill more stops occurred and the risk for VEAB increased by that reason.

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

4.3.4 Contractual arrangements for excess cold valorisation - GOTE

Contractual arrangements for waste cold valorisation are completely innovative and GOTE current situation has been analysed in order to improve and to replicate the arrangements they currently propose.

The development of district cooling in Sweden since 1996 is presented in Figure 2. District cooling is based on the same principles as district heating but instead of circulating hot water, cold water is used. There are several ways to produce district cooling. Three of the methods are free cooling, absorption chillers and compressor chillers.

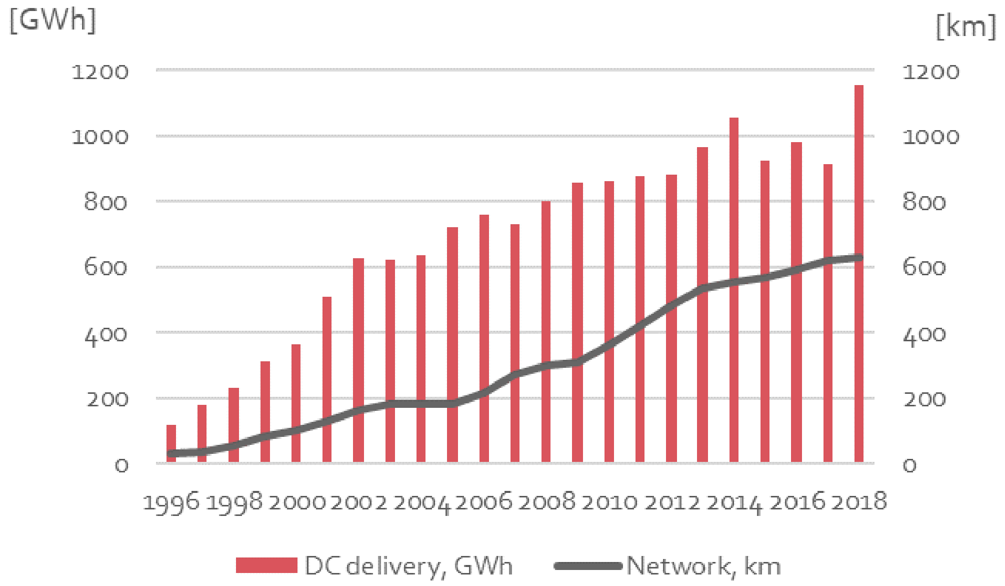


Figure 2 District cooling deliveries and network in Sweden 1996-2018 (2)

In the city of Gothenburg, GOTE offers district cooling to the consumers. The aim is to make the deal a win-win. The customers can choose how they prefer to share the risk of the investment in connection to the district cooling network, i.e. the pipeline and the substation. Either the customer takes all the initial cost and thereby get a shorter contractual period, or they let GOTE take the initial cost and thereby get a longer initial contract period. In the latter case, the initial contract period is about 10 years and then followed by two years periods. The temperature and pressure are more flexible for district cooling compared to district heating. Hence, it is important for GOTE to own the substations for district *heating* to be able to control them, but that is not as important for district *cooling*. In general, the bigger cold customers prefer to own the substations themselves, while smaller customers prefer GOTE to own them.

Since the cold is produced from the same industrial excess heat sources as the heat to district heating, there is no specific contracts for the part of the heat that is used to produce cold. The industrial excess heat is used in the absorption chillers owned by GOTE in order to make use of the excess heat during the warm season when the demand for district heating is low.

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

GOTE has one contract for each industrial partner they collaborate with. As described above, the initial contractual length was 10 years, and then followed by 2 years contract periods. Due to the relatively short contractual length, there is no need for a specific exit paragraph. The contract is renegotiated every second year anyhow. When deciding on the pricing of the excess heat, the starting position is to split the profit; the whole concept is based on a win-win deal. The heat suppliers have the technical possibility of cooling the heat themselves, although it would be costly. Exporting excess heat from the industries, is a cost-reducing measure.

When designing contracts related to use excess heat to produce district cooling, the most important factors are capacity (MW) and temperatures to clarify the available access of the heat. Based on this information, the district cooling operation can be planned.

To achieve a successful collaboration then adaptation to the specific site conditions are crucial. Inspiration can be taken from other similar collaborations but needs to be adjusted to actual preconditions at the site. This applies to both excess cold and heat collaborations.

4.3.5 Summary of the Lighthouse cluster experiences of contractual arrangements

Both partners in the lighthouse cluster stress that there is a high degree of trust between partners. In a partnership it is important to respect and reinforce a good relationship. One of the lighthouse partners developed a contract over time, as the volumes of waste heat recovery increased whereas the other partner established a detailed contract early on. In 2020, the situation is such that both lighthouse partners recommend a contract to be drafted before a collaboration is initiated.

Table 4 Summary of the Lighthouse clusters experiences of contractual arrangements

Factor to consider	**Proposal from the Lighthouse cluster to manage the factor**
Pricing the excess heat/cold	Make the contractual arrangement a "win-win". It is crucial to how the price is set. • Develop a common profitability calculation. • Negotiate system boundaries and ownership of the equipment. The ownership reflects the risk diversification. • Negotiations how much (or little) the industry should run its plants, rather than starting with negotiating the price. • Agreement on the periodicity of renegotiation of the price and quality.
Suitable contractual lengths	• The suitable contractual length depends on the size of the investment, and it is important for both parties with long-term conditions. Long contracts can mitigate the risk of the industry to terminate the heat recovery. • Let the contract period reflect the pay back of the district heating company and the size of the excess heat supplier's investment. • Possibility to renew the contract when the time is expired. • The trust between the two parties is an important factor of the collaboration. In the annual business plan, discuss

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

	solutions/alternatives regarding the case of the excess heat would terminate. • Renegotiation clause
Asymmetric information about input and output of the parties	• It is important to handle planned maintenance periods/stops in the industry in the contractual arrangements. • Make agreement on the quality heat delivery to avoid different views of it. Depending on the collaboration, the involved parties can negotiate about one or more of the following aspects: temperature, energy (MWh) and/or capacity (MW). • Establish an action plan for the case of heat outage. Prepare back up facilities to compensate when needed. • Establishment of a close and open dialog between operators of the involved parties is a key.
Arrangements for excess cold valorisation	• The most important factors are capacity (MW) and temperatures to clarify the available access of the heat, when designing contracts related to use excess heat to produce district cooling • When deciding on the pricing of the district cold the starting position is to split the profit and make the deal a win-win. • With contractual length of 2 year there is no need for specific termination or renegotiation clauses in the contract. If one of the parties would deviate from the agreements in the contract a renegotiation would occur. • Inspiration can be taken from other similar collaborations but needs to be adjusted to actual premises at the site to achieve a successful 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

5 Views on contractual arrangements at the SO WHAT demo sites

The demo sites within the SO WHAT project represent several industrial sectors and are in an initial phase of considering excess heat/cold exploitation. The demo sites have been asked if they, in January/February 2020, have considered how contractual arrangements can overbridge the barriers to excess heat/cold cooperation. The result is presented in sub-chapters 5.1 to 5.9. In chapter 5.10 a summary of the perceived relevance of selected contractual arrangements, according to the demo sites, is presented.

However, three of the demo sites are not interested in or have opportunity for excess heat/cold collaboration, Case 3 in Figure 3. Also, the demo sites that are interested in collaboration, have different opportunities depending on if a district heating or cooling network is located nearby (or planned to be built in the near future), Case 1 in Figure 3, or if the collaboration opportunities are more of bilateral character, i.e. directly with one or a few end users of heat or cold, Case 2 in Figure 3. Note that the UK demo site had not yet been chosen as per end of January 2020 and is therefore not represented in Figure 3.

The answers from the demo sites interested in excess heat/cold collaboration are described in this chapter. For the demo sites which will focus on energy recovery within the same company (Case 3 in Figure 3), the questions were not applicable or are just briefly commented. For some demo sites it was too early address the questions, as shown in the descriptions in this chapter.

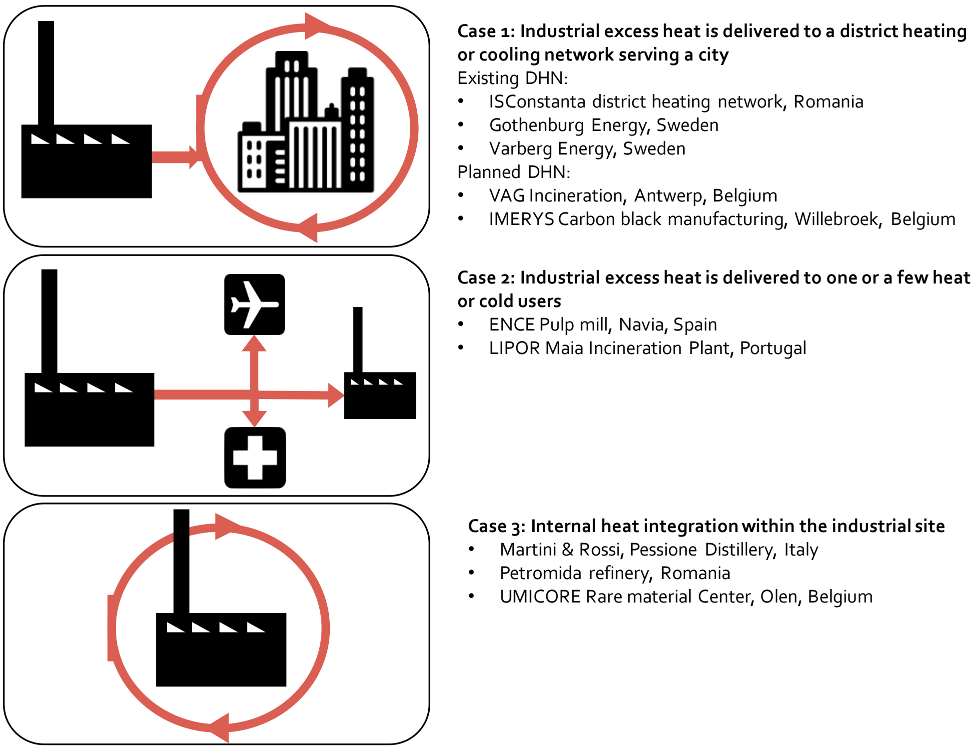


Figure 3 Overview of the three alternative cases which the demo sites are interested in. For Case 1, some of the district heating or cooling networks are existing (Gothenburg, Varberg and Constanta), while the Antwerp and Willebroek are not yet existing but planned district heating networks.

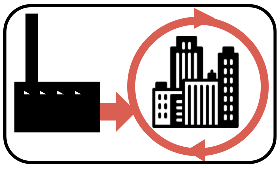
Horizon 2020
European Union Funding
for Research & Innovation

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

The following respondents have been interviewed:

Country	Respondent	Demo site
Belgium	Kelvin Solutions	ISVAG, UMICORE and IMERYS
Spain	Cartif and Eleukon	ENCE
Portugal	2GoOut	LIPOR
Romania	Medgreen	RADET and Petromidia
Italy	Envipark	M&R
UK	MPI	MPI

5.1 Antwerp, Belgium (ISVAG) – Waste to energy plant



5.1.1 Description of demo site

Currently there are no existing WH/C collaborations in the demo site region. At the demo site the first steps are being taken now, no discussions prior the SO WHAT-project. In the project ISVAG wants to explore the potential for using waste heat and expand the grid by selling and distribution the heat from the waste incineration. The first step is the construction of a small scale DHN powered with heat from the existing WtE plant. ISVAG is also planning to scale up the heat production and wants to sell the heat and at a later stage expand the heat network to Antwerp.

Discussions held between ISVAG and a logistic partner, which are interested in receiving the heat from the plant, have resulted in the logistic partner now is connected and receives heat from ISVAG. Feasibility studies are performed which look at the possibilities to expand the grid to the surrounding cluster of small companies (beverage, logistics etc). The demo site partners in the SO WHAT-project are ISVAG and the logistic partner.

Table 5 Description of site in Antwerp

Name, Partner	Location	Sector	Process	Temperature	WH/C collaboration or internal heat recovery
ISVAG Incineration (KELVIN)	Antwerp (Belgium)	Waste to Energy	ISVAG superheated stream power plant valorise via incineration local wastes and WH from the boilers.	400 °C	WH/C collaboration

5.1.2 Comments on contractual arrangements

- **Contractual arrangements to price the excess heat/cold.** The price arrangements of the heat will depend on the initial investment cost. If the grid is existing or not, will have effects on the level of the price for the waste heat. Once the infrastructure of the heat net is established it will be much easier to exploit the heat. The waste heat is available, but a problem occurs when the keenest users are not close by. In larger projects when a grid needs to be built (with large investment and distribution costs) the price of the excess heat in the

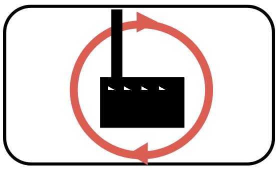
Horizon 2020
European Union Funding
for Research & Innovation

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

network must be very low, the respondent estimates that it would be preferable with a price level of about 1/3 of the natural gas (which is the competing heat source today). The price of the excess heat is important for long term commitment between the parties.

- **Suitable contractual lengths.** ISVAG perceive long term commitment as important for a WH collaboration. The respondent estimated a contractual length of 10 years minimum, with the option to extend with the same length. However, there are not many industrial players that want to commit to more than 10 years.

5.2 Olen, Belgium (UMICORE) – High tech manufacturing



5.2.1 Description of demo site

Currently there are no existing WH/C collaborations in the demo site region. Discussions have been held on high level regarding the demo site. The company will initially invest in a local DHN. Possibly this grid can be extended at later stages.

Umicore will in the SO WHAT project see best practices and possibilities to use the excess heat outside the demo site, but the first focus is to build the heat grid within the demo site.

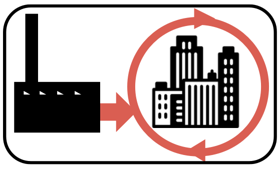
Table 6 Description of site in Olen

Name, Partner	Location	Sector	Process	Temperature	WH/C collaboration or internal heat recovery
UMICORE Rare material Centre (KELVIN)	Olen (Belgium)	High tech manufacturing	UMICORE's Olen site revolves around recycling and production of high-tech materials based on cobalt and germanium.	50 – 265 °C	Internal heat recovery

5.2.2 Comments on contractual arrangements

At the site there are different business units within the same company, that will pay for the heat delivered. There will be commitments within the company but no contracts, and the heat division must deliver heat 24/7. Due to this arrangement within the company the questions regarding contractual arrangements to pricing the heat and suitable contractual lengths are not applicable.

5.3 Willebroek, Belgium (IMERYS) – Chemical manufacturing



5.3.1 Description of demo site

Currently there are no existing WH/C collaborations in the demo site region. A feasibility study regarding possible heat consumers located in the area and economic evaluation, conducted by the municipality as a part of SO WHAT, is in the final stage. The next step is to discuss potential heat users around IMERYS and investigate the cost of a possible heat grid that could be constructed.

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

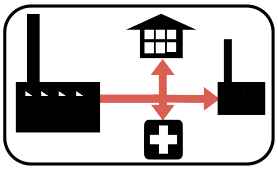
Table 7 Description of site in Willebroek

Name, Partner	Location	Sector	Process	Temperature	WH/C collaboration or internal heat recovery
IMERYS Carbon black manufacturing (KELVIN)	Willebroek (Belgium)	Chemical manufacturing	IMERYS manufactures Carbon Black producing a mixture of H_2 and CO as by-product which is currently burned in a furnace whose excess heat could be recovered.	600 °C	WH/C collaboration

5.3.2 Comments on contractual arrangements

At the time of the interview, it was too early in the process for the respondent to address the questions about specific contractual arrangement to price the WH/C or suitable contractual lengths for the demo site.

5.4 Navia, Spain (ENCE) – Pulp mill



5.4.1 Description of demo site

The region where the demo site is located has been the biggest coal production area in Spain. At this point the coal mines and thermal plants fuelled with coal are successively closing. There is no existing district heating network in the region. The regional government is currently pushing for waste heat recovery. Initial discussions regarding industrial waste heat recovery have been held on high level meetings since the beginning of 2019 between stakeholders as ENCE pulp mill, Veolia (international ESCO company) and Unossa (Spanish ESCO company), but currently no deeper studies have been performed on the matter. Unossa is the owner of most of the coal mines in the region.

ENCE would like to sell the industrial excess heat, preferable with a third party (an ESCO company) between them and the heat users. ENCE gave a proposal in the beginning of 2019 of giving the excess heat away for free if the collaborating company would take responsibility for the pipes etc. An important question to be addressed in a potential collaboration is which party will pay for the initial cost. Will it be the industry, the ESCO company, the end user or the government?

Table 8 Description of site in Navia

Name, Partner	Location	Sector	Process	Temperature	WH/C collaboration or internal heat recovery
ENCE Pulp Mill (ELEUKON/ CARTIF)	Navia (Spain)	Pulp Mill	This is the mill with the largest production capacity belonging to ENCE Group (535 ktons/year) and the most efficient pulp mill on the eucalyptus market in Europe.	70 - 230 °C	WH/C collaboration

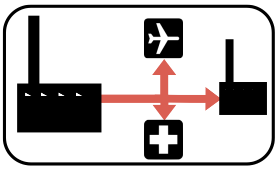
Horizon 2020
European Union Funding
for Research & Innovation

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

5.4.2 Comments on contractual arrangements

- **Contractual arrangements to price the excess heat/cold.** The natural gas is cheap, and the price of excess heat needs to be competitive to it. The maximum price will be set by the price of natural gas.
- **Suitable contractual lengths.** Currently it is not set which contractual lengths that will be suitable at the demo site. It is possible, according to the respondents, that ENCE would prefer a shorter contractual length than the ESCO.

5.5 Maia, Portugal (LIPOR) - Waste to energy plant



5.5.1 Description of demo site

In the region of the demo site no WH/C cooperation currently exist and in Portugal there is in total one district heating system. The waste incineration company LIPOR is studying, together with representatives from the airport and INEGI – Institute of Science and Innovation in Mechanical and Industrial Engineering, related with Oporto University, the possibility to recover the heat and share it. LIPOR is discussing different types of collaborations, mainly with Oporto Airport. The Oporto Airport is a large consumer of energy and needs heating and cooling all around the year. Before the discussions will continue, assessment will be done on the costs, including investments, operational cost etc. LIPOR also considers collaborations with the hospital, pools and industries for example. There is no infrastructure yet, and LIPOR are looking into it with help from third parties and the INEGI. LIPOR wants to assess the possibilities to share the heat with actors in the surrounding within the SO WHAT project, and understand business models, contractual and financial agreements and map possible clients.

Table 9 Description of site in Maia

Name, Partner	Location	Sector	Process	Temperature	WH/C collaboration or internal heat recovery
LIPOR Maia Waste to Energy Plant (LIPOR)	Maia (Portugal)	Waste to Energy	Two incineration lines in a continuous and almost automatic operation burn and treat 380,000 tons/year of municipal waste.	Outlet Flue gases 150 °C Steam to turbine 395 ºC Condensates 55 to 60ºC	WH/C collaboration

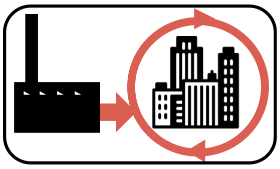
5.5.2 Comments on contractual arrangements

Contractual arrangement such as pricing and contractual length is considered too early to discuss for this site.

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

5.6 Constanta, Romania (RADET) – DHN, WH from local industries



5.6.1 Description of demo site

WH cooperation has been discussed between the district heating company RADET and two companies: CELCO and Dobrogea. CELCO is a manufacturer of construction material (autoclaved cellular concrete). The discussions with CELCO started one year ago. The dialog with Dobrogea (a bread and bakery company) started in November 2019, and the response have been positive. Dobrogea will continue the discussions of collaboration with RADET in the SO WHAT project. RADET is also in the process of identifying other partners.

Dobrogea has a bakery with an area where the bread shall cool as a potential source of waste heat. Additionally, Dobrogea has its own plant for producing heat (natural gas boilers) but have very low usage. There is a possibility of optimizing the load of these boilers and inject heat into the DHN.

Table 10 Description of site in Constanta

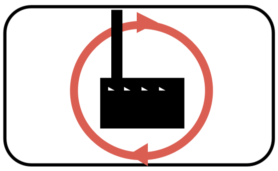
Name, Partner	Location	Sector	Process	Temperature	WH/C collaboration or internal heat recovery
Constanta DHN (RADET)	Constanta (Romania)	DHN, WH from local industries	RADET aims to renovate this old DHN valorising local industries WH.	70 - 250 °C	WH/C collaboration

5.6.2 Comments on contractual arrangements

RADET has not at this point considered how contractual arrangements can overbridge the barriers to WH/C cooperation at the demo site. Based on the analysis with different possible partners there were identified the following options:

- The owner of the WH energy is investing into necessary equipment to connect to the DHN and is directly managing the injection of thermal energy based on a thermal energy supply contract with RADET;
- An ESCO takes over the investment implementation activity and becomes the interface between the supplier and RADET;
- RADET invests in the connection of the WH energy supplier to the DHN, under certain conditions that may be established in the thermal energy supply contract;
- The development of a crowdfunding scheme for attracting investors in the conversion of some of the existing thermal energy distribution stations into small scale production systems from renewable sources that will be developed and operated by RADET.

The respondent mentioned that at present is carrying out simulation activities for the estimation of the costs regarding the alternative scenario that have been mentioned above. In Romania it is expected a new law for thermal energy that is under debate in the Romanian Parliament and some of the provisions of the law may offer a possible new framework.



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

5.7 Navodari, Romania (Petromidia) – Refinery

5.7.1 Description of demo site

Petromidia refinery is located far away from a DHN and thereby their focus in the SO WHAT project will be on internal energy recovery.

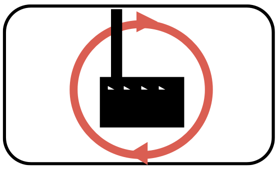
Table 11 Description of site in Nayodari

Name, Partner	Location	Sector	Process	Temperature	WH/C collaboration or internal heat recovery
Petromidia refinery (GREENMED)	Navodari (Romania)	Refinery	Petromidia is the largest Romanian refinery, and one of the most modern refineries in South East EU.	140 - 550 °C	Internal heat recovery

5.7.2 Comments on contractual arrangements

Since the energy recovery will be achieved within the same company, the questions regarding perceived barriers to DH/C collaboration between a heat supplier and a heat user for this deliverable are not applicable to the demo site.

5.8 Pessione, Italy (M&R) – Distillery, food and beverage



5.8.1 Description of demo site

M&R is evaluating different solutions for heat recovery and valorisation internally with the incentive of energy saving. Four cases of heat recovery are under investigation. No external solutions are under consideration because no factories or public buildings are located nearby.

Table 12 Description of site in Pessione

Name, Partner	Location	Sector	Process	Temperature	WH/C collaboration or internal heat recovery
Pessione Distillery (M&R)	Pessione (Italy)	Distillery, Food and beverage	M&R Pessione plant processes requires heating (distillation, bottle warming etc.) or cooling (product, CO_2 injection, conservation etc.).	-8 - 60 °C	Internal heat recovery

5.8.2 Comments on contractual arrangements

The heat and cold recovery will be used and valorised internally. Due to the energy recovery will be achieved within the same company, the questions regarding perceived barriers to DH/C collaboration between a heat supplier and a heat user for this deliverable are not applicable to the demo site.

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

5.9 Middlesbrough, UK (MPI) – Steel industry

5.9.1 Description of demo site

At the time of the interview, the decision of which steel industry that will test the SO WHAT tool was not taken. It is not certain if industrial waste collaboration will be considered, or if the focus will be internal recovery. It will be decided in the beginning year 2021. Thereby the respondent had no information regarding specific contractual arrangements to price the excess heat/cold or suitable contractual lengths.

Table 13 Description of site in Middlesbrough

Name, Partner	Location	Sector	Process	Temperature	WH/C collaboration or internal heat recovery
Innovation in steel industry pilot (MPI)	Middles-brough (UK)	Steel industry	MPI operates pilot steel industry plant including electric arc furnace and continuous casting plant, the former used also for small scale commercial production, beside research activities.	1,600 °C	WH/C collaboration

5.9.2 Comments on contractual arrangements

Too early to address. However, due to the need to focus on core business within the industry, initiatives like Energy performance contracting could be a way forward. When an external party can do a great deal of the work and take the financial risk, less of the industry's personnel need to be removed from core business and the investment capital can be used for core business investments.

5.10 Summary of the input regarding contractual arrangement from interviews with the demo sites

Some of the SO WHAT demo sites consider it too early to address contractual arrangements at this stage of the project. However, viewpoints were given on a list of suggested contractual arrangements and input on local prerequisites for heat collaboration was shared. Five of the nine SO WHAT demo sites are considering heat or cold collaboration. For the demo sites UMICORE in Belgium, Petromidia in Romania and M&R in Italy issues of contractual arrangements were not applicable due to energy recovery will be achieved within the same company.

The respondents were asked to rank a list of suggested important factors to include in contractual arrangements using a scale ranging from essential to less important. The answering demo sites consider that the definition of volumes and temperatures is essential in contractual arrangements. Most of the sites consider that it is essential to include a paragraph to address what happens if the contract is not followed. Less essential but still important is to include an "Exit paragraph", i.e. to specify how long in advance the exit of the cooperation need to be announced. The demo sites considered it as important to include paragraphs for updating possibilities in the contract.

In addition, the following contract issues were raised in the interviews by some of the demo sites.

- "It is important to define the ownership of the facilities (pipes etc.)." This issue relates to the barrier of which stakeholder that will pay for the initial cost.

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

- "Some users cannot afford that the supply is stopped, and it is important that uptime and availability of heat delivery from the network is taken into consideration in the contract."
- "A binding paragraph that states the way which the DH company can guarantee, in any condition, that they are buying the heat supplied by the WH company." It could be e.g. a complement in the loan application to the bank.

In the regions where there is neither a nor a planned existing district heating or cooling network, the demo sites would prefer to invite a mediating part to construct and operate the technical parts of the heat/cold collaboration. For example, a company such as an ESCO, who's core business is energy, could be invited. Figure 4 illustrate an overview of the stakeholders in such an alternative.

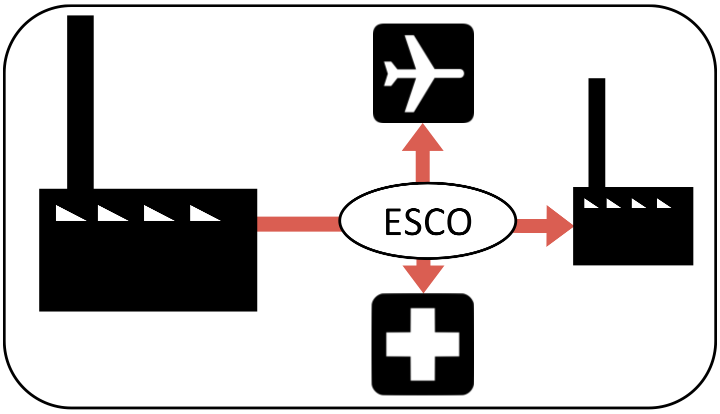


Figure 4 Overview of a suggested stakeholders alternative. When no district heating or cooling company is involved, the demo sites would prefer an ESCO to manage the heating or cooling network.

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 Distributed Ledger Technology for smart contracting and P2P energy trading

An introduction to distributed ledger technologies and how to use them in the scope of energy trading is included in this chapter. The idea is to allow those stakeholders involved in the energy trading to set transparent, secure peer-to-peer (P2P from now on) energy transactions, keeping track to what is shared in the network as well as promoting the prosumers[3] approach and the sale of WH/C and/or surplus RES production in the industrial and urban environments. A description of the business models associated to this P2P energy trading based on blockchain has also been included.

6.1 Introduction to Distributed Ledger technologies and Smart Contracts

Distributed Ledger Technologies (DLT from now on) and, in particular, blockchain technology, have the potential to transform the energy sector. The World Economic Forum, Stanford Woods Institute for the Environment, and PwC released a joint report (2) identifying more than 65 blockchain use-cases for the environment. These use cases include new business models for energy markets and, even more, moving carbon credits or renewable energy certificates onto the blockchain.

A distributed ledger is a database that exists across several locations or among multiple participants, instead of a traditional approach where a centralised database is used in a fixed location with a single point of failure. As stated in (3), "DLTs are technologies enabling parties with no particular trust in each other to exchange any kind of digital data on a peer-to-peer basis with fewer or no third parties or intermediaries". These participants to not necessarily trust each other, but they have to follow the same rules (consensus).

The aforementioned "digital data" can represent any kind of transaction concerning buying and selling goods and services or any other type of transaction or asset that can be translated into a digital form. One DLT will keep track of all the transactions and those transactions will be recorded and verified between the members of the network. A simple distributed ledge for financial transactions is shown below:

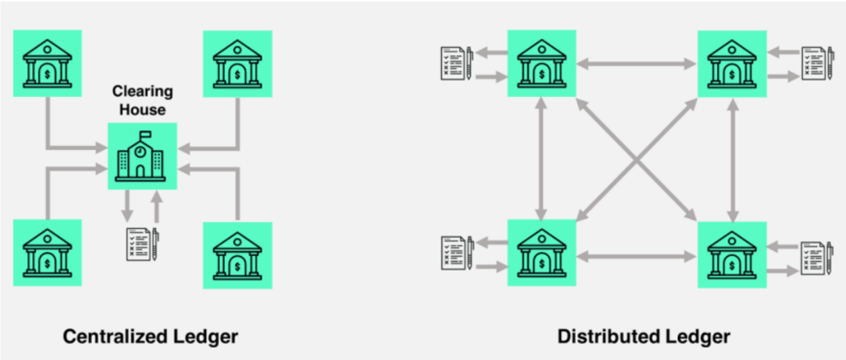


Figure 5 Simple DLT example (4)

In the traditional approach, the central authority processes, validates and authenticates transactions, whereas if organisations use distributed ledger technology to for these activities these records are only ever stored in the ledger when the consensus has been reached by all the parties involved. All

[3] Prosumer: A prosumer is a person who consumes and produces a product.

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

files in the distributed ledger are then timestamped and given a unique cryptographic signature which all of the participants can view. The technology provides a verifiable and auditable history of all information stored on that particular dataset.

Blockchain is a type DLT, which, at the end, are particular distributed databases in which data is recorded, shared and synchronised. A blockchain is a shared database filled with entries that must be confirmed and encrypted. Each "block" inserted in the blockchain depends on a logical relationship to all its predecessors.

Smart contracts can be defined as "an automatable and enforceable agreement. Automatable by computer, although some parts may require human input and control. Enforceable either by legal enforcement of rights and obligations or via tamper-proof execution of computer code." (5) The rising of DLT has created a platform on which smart contracts can be hosted and executed allowing for all sides in an agreement to have a single electronic version of 'the truth' which binds both parties and neither side can change without the other knowing and accepting it. Once operational, the Smart Contract will monitor specific clauses for compliance and can then self execute penalties (or rewards) based on the performance of each party. They can be considered as a method to form agreements through the blockchain. (6) Smart Contracts use protocols and user interfaces to facilitate all steps of the contracting process. They provide new ways to formalise and secure digital relationships which are far more functional than their inanimate paper-based ancestors. Smart contracts not only define the rules and penalties around an agreement in the same way that a traditional contract does, but also automatically enforce those obligations.

6.2 DLTs and its application concerning smart contracting and energy trading

Due to increasing integration of distributed energy resources (DERs), many consumers have become prosumers, who can both generate and consume energy. As generation of DERs can be unpredictable and intermittent, prosumers may decide to store their surplus energy using storage energy devices, or supply others who are in energy deficit. This energy trading is called Peer-to-Peer (P2P) energy trading, and it is a novel paradigm of energy system generation where people can generate their own energy from Renewable Energy Sources (RES) in dwellings, offices and factories, and share it locally with each other (6). WH/C can be also be traded in a similar way to energy from RES.

All the aforementioned factors have encouraged a wider adoption of microgrids or heat/cold collaborations powered by renewable distributed energy resources, and play a part in the future of power system dispatch and storage configurations since they provide clear economic and environmental benefits (6). At the moment, most of the microgrids currently exist as a layer on top of the national grid; however, they can be separate and self-sustaining.

One of the main contributions of DLTs in the scope of P2P Energy trading is to register all the transactions in a secure and non-mutable way, and to simplify the metering and billing system of the P2P energy trading market. Blockchain can provide consumers greater efficiency (it will be more efficient if the market does not need a central entity to manage the transactions) and control over their energy sources. Additionally, an immutable ledger provides secure and real-time updates of energy usage data (e.g. market prices, marginal costs, energy law compliance, fuel prices ...).

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

The efficient operation of the aforementioned microgrid energy markets requires innovative information systems to integrate the market participants in a user-friendly and comprehensive way. Using a blockchain-based microgrid energy market eliminates the need of central intermediaries, and gives support to transaction tracking and its related contract supervision and allows energy consumers to participate in the decision of who produces their energy and by which technology is generated. Besides, and as stated in (7), one of the main advantages of blockchain technology when applied to energy markets is the transparent, distributed and secure transaction log that allows for a complete and continuous tracing of even the smallest energy transactions.

Green and Newman state in (8) that the use of blockchain technologies for electricity transactions makes microgrids more resilient by creating trust between the involved agents, and (9) demonstrates that blockchains are an eligible technology to operate decentralized microgrid energy markets. Aitzhan et al. also conclude in (10) that blockchains allow for implementing decentralized energy trading and that the attainable degree of privacy and security is higher than in traditional centralized trading platforms, and in (11) it is stated that blockchains can successfully support electricity markets.

As consumers and prosumers can keep profits from energy trading within their community, incentives for investments in renewable generation plants and for locally balancing supply and demand are expected, and all of this encourages the integration and expansion of locally produced renewable energy (9).

Concerning utility companies, it is true that they can lose their role in the energy system when independent microgrid markets ensure their own energy supply, but innovative business models can be generated in order to support microgrid markets with professional know-how from utility companies (e.g. providing ancillary services and ensuring a balanced energy system) (12).

6.2.1 Components and Business Models of P2P energy markets

Based on (13) , (14) and (9), it has been assumed that the areas of Regulation, Physical Energy Assets, and Information Systems need to be identified and defined in a blockchain-based microgrid energy market, and those components are key to define the related business models (see Figure 6).

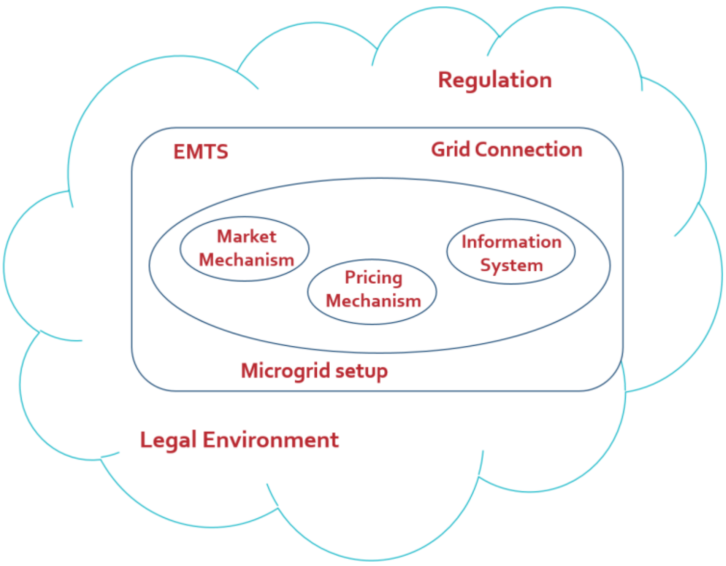


Figure 6 P2P/DLT-based microgrid energy market components

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

A. Regulation and Legal Environment

Legislative rules determine which market design is allowed, how taxes and fees are distributed and in which way the market is integrated into the traditional energy market and energy supply system. Governments can support microgrid energy markets to boost the efficient utilization of local resources and to decrease environmental degeneration by regulatory changes (e.g. introduction of subsidies). A PwC study in 2018 suggested that regulations concerned with P2P energy trading needs to be improved to support dynamic pricing and differentiation in the value of energy from and for different market players. They also pointed out that it would useful to have more 'sand boxes' to aid markets players to test, fail, succeed and repeat in safe environments. (15)

B. Physical Energy Assets

Microgrid setup: A clear objective, the market participants, and the form of energy traded (electricity, heat, cold or a combination of them) must be defined. A microgrid energy market requires sufficient number of market participants trading energy amongst each other. A subgroup of them needs to have the ability to produce energy. Besides, the microgrid setup has to define whether the traditional energy grid is used for energy transport or a physical microgrid is built.

Grid connection: In this sense, one or multiple connection points towards the superordinate grid are a key component and should be well defined for balancing energy generation and demand within the microgrid with the help of the superordinate grid. Energy flows towards the aforementioned connection points should be metered in order to accurately measure the performance of the microgrid. It is important to take into account the differences between physical and virtual microgrid. Physical microgrids are actual power distribution microgrids, while virtual ones simply links the microgrid participants over an information system. Virtual microgrids cannot be physically decoupled from the superordinate grid, while physical ones have a set of connection points to ensure an efficient grid connection but they can also be decoupled from the grid if needed.

C. Information Systems

Information system: An information system (working in an adequate temporal resolution) is a key element in the case we are talking about in order to connect all market participants, to provide both the energy platform and market access and to monitor the market operations. Here is where blockchain plays an important role, because it can provide a global infrastructure for decentralized applications that enables the implementation of full-scale software applications (e.g. smart contracts) without a central platform. Smart meters can also be integrated into the information system so they can write the required energy data directly into the corresponding blockchain accounts/users.

Market mechanism: Market's allocation and payment rules have to be addressed at this point, ant the defined market mechanism will be implemented and supported by the information system.

Pricing mechanism: The pricing mechanism will be implemented within the market mechanism to efficiently allocate energy supply and demand. As renewable energies typically have close to zero

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

marginal costs, prosumers can generate profits by pricing their energy above all applicable taxes and fees. Price signals should be used to indicate energy scarcity or surplus. Economically speaking, local markets are beneficial to their participants as long as the average energy price is lower than the external grid price, but if socio-economic reasons are considered, the local energy price may even surpass the grid price.

Energy management trading system (EMTS from now on): One of the main aims of the EMTS is to automatically secure the energy supply for a market participant while implementing a specific energy trading strategy. The EMTS needs access (real time, or at least "near real time") to the demand and supply data of its market participant. Based on this data, the EMTS will forecast consumption and generation, and will create the energy trading strategy. Besides, the EMTS needs to have access to their market participant's blockchain account, just to be able to introduce in the ledger the associated energy transactions. It is also possible to develop EMTSs that trade the predicted amounts of the market platform and then adjust the demand based on variable energy prices. Different strategies can be implemented (e.g. self-interested rational market participants maximize their revenue and minimize their energy costs, and a simple EMTS would always buy energy at the microgrid market when the price falls below its maximum price limit). Socio-economic factors should also be considered in the scope of the EMTS (e.g. preferred buying from local renewable generation).

6.2.2 Examples of P2P energy markets

As P2P energy markets are a relatively new and innovative concept, it can be difficult to obtain examples where they have been successfully implemented. The research conducted shows that most projects concerning peer to peer and energy markets are still small and at pilot stage, with only one large example found.

Brooklyn Microgrid (BMG) (16) an energy marketplace for locally-generated, solar energy developed in New York, USA and uses Ethereum blockchain. An initial pilot took place in April 2016 in Brooklyn with 10 homes and rooftop photovoltaics systems installed on five of the buildings to generate solar energy. All energy not used by the buildings themselves is sold to five neighbouring households. All buildings are interconnected through the conventional power grid, with transactions being managed and stored using a central blockchain. Implementation required both smart meter technology and blockchain software with integrated smart contract functionality: smart meters are needed to record the quantity of energy produced, blockchain software is needed to effect transactions between the neighbours, and smart contracts are needed to carry out and record these transactions automatically and securely. Participants access the local energy marketplace through the Brooklyn Microgrid mobile app where people can choose to buy local solar energy credits. Prosumers sell their excess solar energy to the marketplace where consumers purchase the available solar via auction. All transactions are then carried out fully automatically according to pre-agreed rules. With this new technology, the market can reach a point where a single person with a single solar panel can participate in the end user market. In the future, the project is planned to be operated by a cooperative community organisation, with neighbourhood residents being the shareholders of the company, whereas it is currently run by the private company LO3. More than 130 homeowners and tenants have registered to participate in the project and the technology is being enhanced to enable this to occur.

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

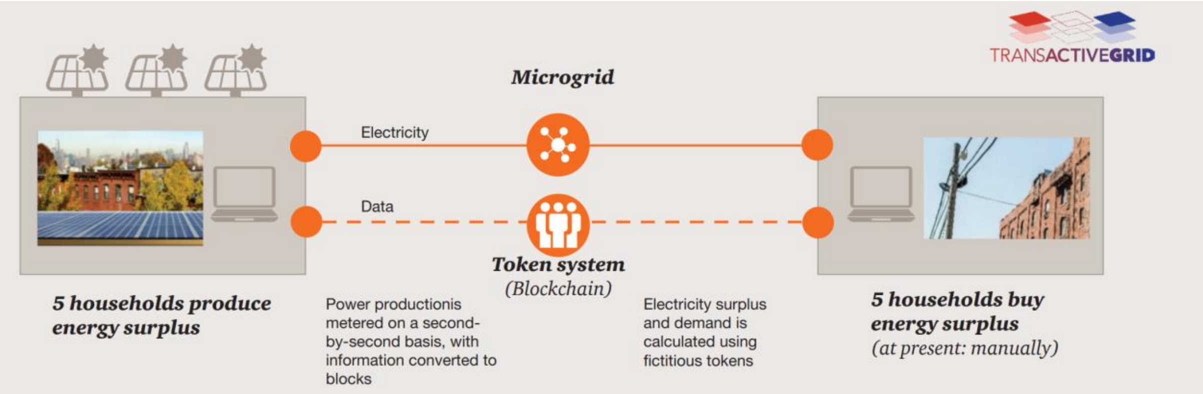


Figure 7 Brooklyn Microgrid example

An example from IES' involvement in a UK funded R&D project 'CEDISON' has also shown how blockchain can be used to benefit both customers, in terms of energy and cost savings, and the grid, in terms of demand load balancing, increased operational efficiency and reduced infrastructural costs. In the project, IES further developed its software to model electrical distribution networks of communities in Glasgow and the island of Orkney, with the inclusion of all energy consumers and producers on that network. This meant that IES software could be used to forecast electric demand a day ahead, and also allow for different communities to bid to supply the electricity from decentralised renewable community owned sources. An API was developed so that that it could also connect with a different partner's energy trading platform and Blockchain. An explanation of how this worked is given below, although it should be noted that the platform was an experimental simulator and was not used in a real life situation (17).

In the diagram below, there 5 key parties involved in enabling a peer to peer electricity market using blockchain:

- IES software (iVN): This provides forecasted electricity demand and potential supply a day ahead for given communities.
- Portfolio Aggregator: This role is an organisation that represents a community that has multiple assets, both demand in the form of buildings and renewable supply potential. For trades to occur between communities, there needs to be more than 1 Portfolio Aggregator. Using the forecasted demand/supply from IES, Portfolio Aggregators can make bids to buy/supply electricity between them.
- The Market Operator: This is the organisation who manages the overall grid network and ensures that offers are matched with bids so that the network remains balanced.
- The Settlement Party: This organisation is responsible for calculating settlements and ensuring all parties have the correct data.
- Electron (Blockchain Partner): This organisation manages all transactions and data flows using blockchain so all have transparent information.

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

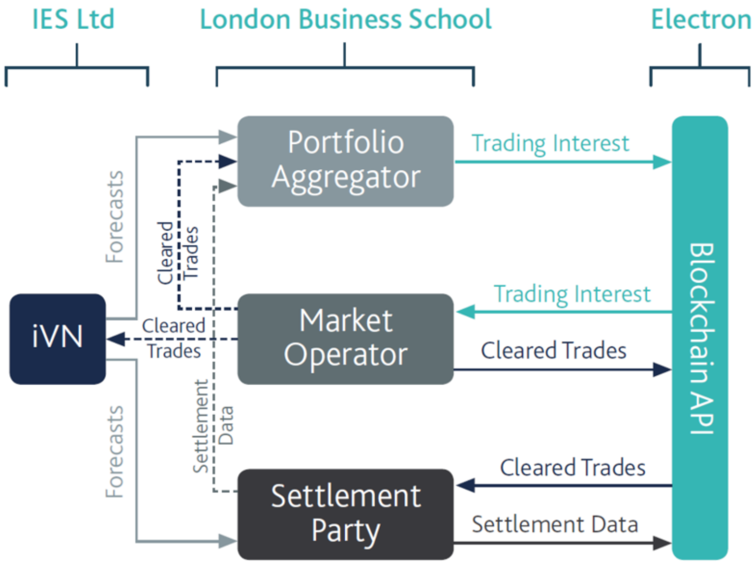


Figure 8 CEDISON project energy microgrid using blockchain

Another important aspect of this simulator in relation to SO WHAT was that the blockchain also included algorithms for Smart Contracts to ensure that agreements between parties to trade at certain prices/volumes/times of the day would automatically occur without the need for human intervention or disputes[4]. Blockchain technology makes it possible for energy networks to be controlled through smart contracts which signal to the system when to initiate what transactions. This is based on predefined rules designed to ensure that all energy and storage flows are controlled automatically so as to balance supply and demand. For example, whenever more energy is generated than needed, smart contracts could be used to ensure that this excess energy is delivered into storage automatically. Conversely, the energy held in storage could be deployed for use whenever the generated energy output is insufficient. In this way, blockchain technology could directly control network flows and storage facilities. Smart contracts could also be used to manage balancing activities and virtual power plants. (16)

In terms of smart contracts, an example from a current H2020 project involving IES may also be useful for SO WHAT. The EENVEST project is a current H2020 funded project to promote building energy efficiency investments in Europe and to allow investors evaluate building retrofit projects' profitability without requiring to dig into the technical side to increase investments in energy efficiency.

IES' role is to provide financial risk estimates based on technical information related to the project demo sites, using blockchain as a way to ensure data is validated and that the investor can be sure the data is trustworthy. As IES (or another 3rd party) would traditionally provide monitoring and validation data to the investor, the investor can never be sure how valid the data is. By using a blockchain solution that has a distributed ledger among many parties, the investor can see who has entered and altered data in the process.

[4] Innovate UK CEDISON project D2.2 End to End Process Specification

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 could be used in SO WHAT in order to provide transparent and trustworthy information to an organisation that would like to know any data (CO_2 footprint for example) associated with the production and supply of the waste heat they receive.

6.2.3 Components of P2P energy market in context of SO WHAT

It is important to note that the research conducted has found that the design, development and implementation of P2P energy markets using DLTs has been only for electricity markets and that applying this to the market for heat/cooling should considered highly innovative. Despite this, most of the concepts could be also applied concerning WH/C recovery, and an overall use case where industrial excess heat is delivered from several heat or cold producers to several heat or cold users is highlighted below (see Figure 9).

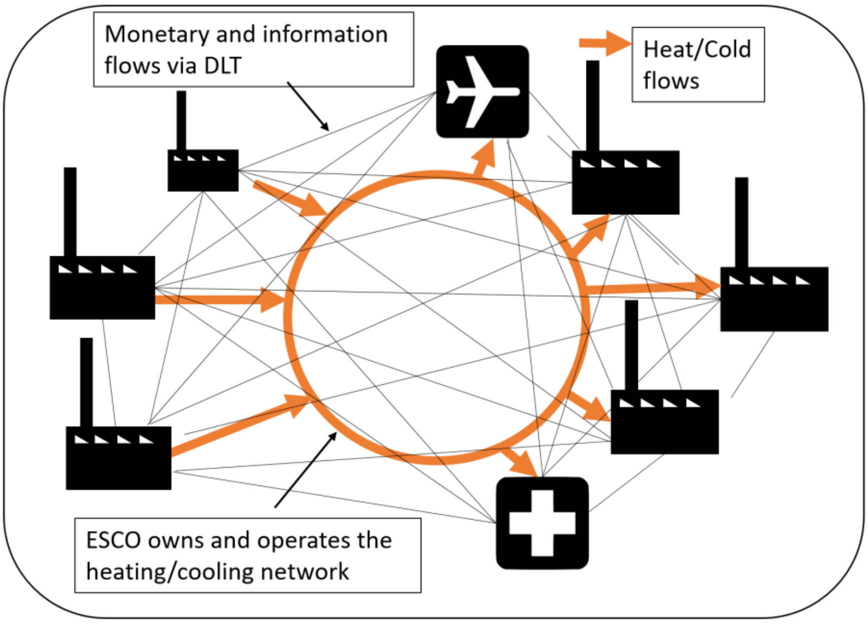


Figure 9 Blockchain-based microgrid energy market components including WH/C trading

Taking into account the aforementioned elements to be considered in the scope of a blockchain-based WH/C energy microgrid market, there are multiple stakeholders that can be involved (in one or another "step/moment" of the market) in this kind of peer-to-peer business model:

- A sufficient number of market participants trading energy amongst each other
- A subgroup of market participants with the ability of producing energy
- A high performing information system to connect all market participants, provide the market platform, provide market access and monitor all the market operations. Smart meters will be needed, and the market mechanism to be implemented by means of the information system has to be well defined. This market mechanism has to include the implementation of the smart contracts to be used to set the agreements between prosumers through the blockchain.
- Decision-makers or local governments are needed in order to define the appropriate regulation to determine how microgrid energy markets fit into the concerned energy policy.

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

- WH/C producer (source of waste heat/cold)
- End user: the WH/C is used by third parties such as administrative, commercial or residential buildings or even other industries. In this case, the main challenge is the adjustment or synchronization of the potential waste heat or cold and the demand of the third party/parties. This scenario usually appears in those processes of EII (Energy Intense Industries) industries (food, pulp and paper, basic chemicals, refining, iron and steel, nonferrous metals (primarily aluminium), and non-metallic minerals (primarily cement)) where are required huge quantities of high-temperature thermal energy and therefore the amount of waste heat exceeds the needs of this type of heat of the factory itself. In this external use-case there is the possibility of introducing intermediate actors (ESCOs) between heat producers an end users of the recovered WH/C. This stakeholder will not probably be involved in the trading process, but could be essential in the scope of WH/C recovery.
- Heat utility/network owner: In charge of adjusting and integrating with the end-user's network and transporting waste heat/cold. This stakeholder will not probably be involved in the trading process, but it is essential in the scope of WH/C recovery.
- SO WHAT tool, which will support all the process concerning WH/C.

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

7 Discussion and conclusions

In the following we discuss the possibilities to overbridge the barriers to WH/C collaboration through contractual arrangements. Also, general conclusions about suitable contractual arrangements in a WH/C collaboration are drawn and some conclusions regarding distributed ledger technologies are drawn.

In the SO WHAT deliverable D 3.1, the main barriers to WH/C collaboration is studied and analysed. Some of the barriers that were found could potentially be overbridged by contractual arrangements between the parties. Experience from the Swedish lighthouse cluster gives insight to the possibilities and interviews with the SO WHAT demo sites add with viewpoints on contractual arrangement for the possible collaborations. In addition, the results from the REUSEHEAT project gives useful input on contractual arrangement.

7.1 Sharing of risk, cost and profit

Barriers such as large initial cost, requirements for a short payback period for investments and difficulties to agree on pricing have potential to be handled in the 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 addressing issues such as system boundaries, ownership of equipment and the extent of the industry running its plant, rather than starting with negotiating on the price.

The contract period of the collaboration reflects the pay back of the district heating company and the size of the excess heat supplier's investment. The contractual length depends on how initial cost and ownership of equipment is shared between stakeholders. Ten years has been suggested by most of the demo sites due to high initial costs. Ten years is also the initial 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.

One conclusion is that it is possible to come to an agreement even though stakeholders may have different requirements for pay back period. An example of a solution to this is the Danish VEKS project where the investment is repaid faster for the partner with requirement for short pay back period (19).

7.2 Contractual arrangements regarding waste heat used for cooling

The Swedish energy company Göteborg Energi (GOTE) offers district cooling since the mid 1990's. In this case, the same industrial excess heat sources are used for both district heating and cooling, no specific contract is needed regarding the used heat to produce cold. The cold is produced by absorptions chillers driven by heat.

Experience from GOTE regarding contractual arrangements for excess cold valorisation suggest that, as in the case of heat collaboration, focus should be placed on making the deal a win-win. In general, larger cold customers prefer to own the substations themselves while smaller customers prefer GOTE to own them. GOTE consider that the most important factors when planning for district cooling are capacity (MW) and temperatures to clarify available access of the heat. Inspiration can be taken from other similar collaborations but adaptation to the specific site conditions is crucial to achieve a successful cold or heat 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

7.3 Handle the risks of closure of an industry and end users changing heat source

Uncertainty due to the risk of closure of an industry which provides waste heat or the risk of end user changing to another source of heat or cold, could be handle through contractual arrangements such as an "exit paragraph". For example, it 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 between the partners. Results from the REUSEHEAT project include that in the event of the heat provider terminating its activity, the sanction that should 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 heat source, the new owner will be obligated to continue to supply heat

A two years period is often enough to allow the remaining party to replace 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.

The risk for end users changing heat source is in line with the generally increasing competition in the heat sector. The risk for closure of an industry will be further elaborated in D3.4.

7.4 Clarify the stakeholders' commitment

From the experiences of the Lighthouse cluster, "safety paragraphs" have not been needed. Due to a close and open communication between the parties, the problems that have arisen have been solved by the operators together from both parties. Although close communication is more important than paragraphs for a successful cooperation, there are reasons to clarify the stakeholders' commitment in the contract. For example, if staff is changed over time or an entity gets a new owner.

Results from the REUSEHEAT project shows that identification of the heat provider's processes and planned maintenance periods is important. Also, compensation for deviations from determined volumes etc. needs to be stipulated in the contract.

In addition, the REUSEHEAT project found that regarding supplies, the temperature of the heat, the hours over which the heat is supplied, and the volume of heat flow 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.

Furthermore, the REUSEHEAT project concluded that clauses requiring that certain parties have some type of insurance often is preferable 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.

Clarification of the stakeholders' commitment in term of supply specifications, communication of deviations etc are recommended.

7.5 If necessary, invite additional stakeholders

Another of the greatest barriers to WH/C collaboration, is lack of funding for non-core business investments. Both this, and the barriers due to uncertainty due to new technology, could be

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

overbridged by involving a third party in the contractual arrangement. If no district heating company (which core business is energy) is involved in the collaboration, an alternative is to involve an ESCO to take responsibility for construction and operation of heat or cold network and other related equipment. According to the interviews, the vast part of industrial partners would prefer an ESCO to manage the heat or cold network.

To bring in a partner with knowledge and interest in energy, such as an ESCO, can overbridge lack of funding for non-core business, lack of knowledge and uncertainty regarding new technology.

7.6 Facilitate for the bank

In some cases, a barrier to WH/C exploitation is the difficulty to get 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 DH company can guarantee, that they are buying the heat supplied by the WH company. This could be a complement in the loan application to the bank or to other financing institutions .

The conclusion is that the financial sector is one of many stakeholders that need to increase knowledge about WH/C exploitation.

7.7 Distributed ledger technology

Distributed Ledger Technologies (such as blockchain) have been introduce, and its application in the scope of energy trading has been analysed. Those kind of DLTs allow the involved stakeholders to set transparent and secure peer-to-peer transactions, keeping track of what is being shared in the network. Applications of P2P energy markets using DLTs has been only for electricity markets and applying this to the market for heat/cooling should be considered highly innovative. Despite this, 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.

Using this kind of technologies, users will 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.

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

8 Input to the SO WHAT tool

In order to facilitate the exploitation of waste heat and cold, the SO WHAT tool could propose alternative contractual arrangement, including the following aspects:

- Alternative ways of pricing of heat or cold could be proposed, based on models for sharing of profit.
- Alternatives on risk sharing (e.g. due to ownership of pipes and other equipment, back up heat or cold production units etc)
- Different stakeholder setups (e.g. including an ESCO)

Figure 10 shows an overview of how the results in this report will be used in the SO WHAT project. Result will be used to develop guidelines for algorithms development in D3.6 and then further used in the development of the SO WHAT tool in WP4.

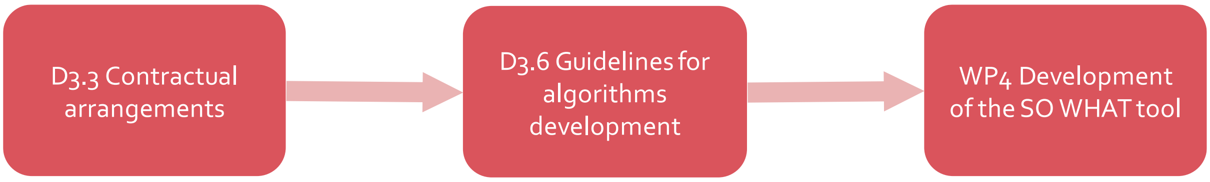


Figure 10 Overview of how the results regarding contractual arrangements will be used in the SO WHAT project.

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] **Wynn, H., Wheatcroft, E. and Lygnerud, K.** *Efficient Contractual Forms and Business Models for Urban Waste Heat Recovery WP2 Task 2.3 Deliverable 2.3* . s.l. : REUSEHEAT Grant Agreement No 767429, 2019.

[2] **World Economic Forum, Stanford Woods Institute for the Enviroment, PwC.** Building Block(chain)s for a Better Planet. [Online] 2018. http://www3.weforum.org/docs/WEF_Building-Blockchains.pdf.

[3] **European Commision: Joint Research Centre.** Blockchain now and tomorrow. Assessing miltidimensional impacts of distributed ledger technologies. [Online] July 2019. https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/blockchain-now-and-tomorrow.

[4] **Tradeix.** Distributed Ledger Technology. [Online] 2020. https://tradeix.com/distributed-ledger-technology/.

[5] **ISDA.** *Whitepaper: Smart Contracts and Distributed Ledger - A Legal Perspective* . 2017.

[6] **Blyden, B. and Lee, WJ.** *Modified microgrid concept for rural electrification in Africa; IEEE power engineering society general meeting.* 2006.

[7] **Xu, X., Pautasso, C., Zhu, L., Gramoli, V., Ponomarev, A., Tran, AB. and Chen, S.** *"The Blockchain as a Software Connector", 2016 13th Working IEEE/IFIP Conference on Software Architecture (WICSA), pp 182-191, Venice.* 2016.

[8] **Green, J. and Newman, P.** *Citizen Utilities: the emerging power paradigm.* s.l. : Elsevier Energy Policy; Vol 107, 2017.

[9] **Mengelkam, E., Gärttner, J., Rock, K., Kessler, S., Orsini, L. and Weinhardt C.** *Designing microgrid energy markets. A case study: The Brooklyn Microgrid.* s.l. : Elsevier AppliedEnergy, 2018.

[10] **Aitzhan, NZ. and Svetinovic, D.** *Security and privacy in the decentralized energy trading through multi-signatures, blockchain and anomymous messafinf streams.* s.l. : IEEE Trans. Depend. Sec. Comput., 2016.

[11] **Sikorski, JJ., Haughton, J. and Kraft, M.** *Blockchain technology in the chemical industry: machine-to-machine electricity market.* s.l. : Appl Energy, 2017.

[12] **Green, J. and Newman, P.** *Citizen utilities: the emerging power paradigm.* s.l. : Energy Policy, 2017.

[13] **Block, C., Neumann, D. and Weinhardt, C.** *A market mechanism for energy allocation in microchip grids, Proceedings of the 41st annual Hawaii international conference on system sciences.* 2008.

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

[14] **Ilic, D., Da Silva, PG., Karnouskos, S. and Griesemer, M.** *An energy market for trading electricity in smart grid neighbourhoods; 2012 6th IEEE international conference on digital ecosystems technologies (DEST).* 2012.

[15] **PwC.** Regulators: unblocking the Blockchain in the energy sector. [Online] 2018. https://www.ceer.eu/documents/104400/-/-/c1441b50-3998-2188-19f3-14dab93649d3.

[16] **PwC global power & utilies.** Blockchain - an opportunity for energy producers and consumers? [Online] 2016. https://www.pwc.com/gx/en/industries/assets/pwc-blockchain-opportunity-for-energy-producers-and-consumers.pdf.

[17] **IES.** CEDISON - Community Energy Dynamic Solution. [Online] 2020. https://www.iesve.com/research/intelligent-communities/cedison.

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

Appendix A: Questionnaire to the demo sites

Background

1. Does WH/C cooperation already exist in the demo site region? (Between which partners, what is included etc?) If yes, what was the experience and what was concluded?

2. Has WH/C cooperation been discussed between partners within the demo site or with other stakeholders in the region earlier? (Which stakeholders? When? Any results so far?)

3. Which partners are considered for WH/C cooperation within the SO WHAT project?

4. What do the demo site partners expect from the SO WHAT project? (Why have they joined the project? Do they wish to sell or buy heat or cold?)

5. What incentives do different partners in the cluster have? (Extra revenue for selling heat or cold, policy demands on industries, avoid building new heat or cold production unit, etc)

Contractual arrangements

6. Have you considered how contractual arrangements can overbridge the barriers to WH/C cooperation? Particularly:
    a. How to agree on a price of the excess heat or cold?
    b. What would be a suitable contractual length?

7. To what extent could these suggestions of contractual arrangement overbridge the barriers? Rank the contractual arrangements (Essential – important - less important)
    a) Exit paragraph (How long in advance does the exit of the cooperation be announced?
    b) Paragraphs to address what happens if the contract is not followed by one partner?
    c) Paragraphs for updating paragraphs (renegotiation clause in the contract due to long payback)
    d) Definition of volumes and temperatures in order to agree on deliveries
    e) Other?

8. The use of Blockchain technology.
   Do you think it would be interesting to include the use of Blockchain technology to set transparent and secure peer-to-peer transactions between the WH/C provider and the consumers of this WH/C? (Blockchain system would keep track of what is shared in the network automatically, without the need of any intermediaries.)

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