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Achieving EU 2030 Sustainable Heating Goals in Kortrijk: A Multi-Stakeholder Perspective for Integrating a smart heat grid with aqua thermal Energy

Based on Interreg WaterWarmth

Master Thesis Water Management – MEEM

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ABSTRACT

When implementing renewable heating projects to comply with EU regulations and reduce the CO2 footprint, which is done by projects such as aqua thermal heating projects involving a (district) heat grid, stakeholder needs and priorities need to be considered for an equitable implementation with a high connection rate. This thesis explores the stakeholder needs and priorities when implementing a smart heat grid with aqua thermal and electrical energy in Kortrijk, Belgium, taking into account the feasibility and alignment with the EU 2030 sustainable heating targets.

Focusing on the Interreg WaterWarmth project using aqua thermal energy in Kortrijk, the research uses a mixed-methods approach, including a literature review, stakeholder analysis, (expert) interviews and a focus group. A detailed methodology for data collection and analysis is also provided.

This exploratory research uses the conceptual framework of energy initiatives to identify the potential impact of emerging technologies on stakeholder attitudes towards socio-technical transitions. The research covers public and private actors in Kortrijk and beyond to reach the EU 2030 CO2 targets. Based on the analysis, recommendations that enable energy corporation(s) to optimise the use of aqua thermal and electrical energy sources in regard to factors such as infrastructure compatibility, techFnological feasibility, social acceptance, and environmental impact are provided. It takes into account the specific context of each stakeholder group, including persuasion strategies, their attitudes towards connection strategies and future energy transition needs.

The findings highlight the importance of considering stakeholder needs and priorities throughout the development of the Smart Heat Grid. The research also demonstrates the need to consider the perspectives of individual stakeholder groups. This approach is crucial for successful implementation and social acceptance. Collaboration between all stakeholders, combined with continued research and development efforts, is essential for long-term success, which requires clear communication, financial incentives and assured system reliability.

Keywords: Sustainable Heating Technology, Heating Transition, Social Acceptance, Aqua thermal energy, Smart Heat grid, CO2 reduction, Kortrijk, Belgium, Stakeholder needs and priorities.

ACKNOWLEDGEMENTS

Based on my past and present experience in energy management and a search for a fitting study program that was not available in Belgium I decided to study abroad. The University of Twente was the place where I enrolled my master programme.

The MEEM programme has brought many cultures to me and enriched my socio-technical knowledge as a technical thinker combined with law, regulations, project- and water-management providing me a good base to build further upon.

I would like to thank all the people who contributed to the research and the guidance in writing the thesis (and proposal). I also would like to thank the interviewed stakeholders for their willingness to spend 30 minutes of their time thinking about their perspectives and idea's. A special thank you to the Howest University in Belgium and the City of Kortrijk for the close connection and for letting me participate in the Interreg Partner meeting in Caen (France). Last but not least I also want to thank my supervisors Dr. César Casiano Flores and Dr. Kris Lulofs from the UTwente, who gave useful feedback and a stable hand to hold during the process.

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LIST OF ABBREVIATIONS

ACT	Actor network theory
AE	Aqua thermal Energy
CO2	Carbon dioxide
EU	European Union
EMS	Energy Management System
GHG	Greenhouse Gas
IEA	International Energy Agency
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
NREL	National Energy Laboratory
SMT	Social movement theory
VREG	Flemish Energy Regulator

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1 INTRODUCTION

1.1 THE QUEST FOR HEAT FROM RENEWABLE SOURCES

According to recent reports from the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), global warming is occurring due to anthropogenic greenhouse gas (GHG) emissions from routine activities such as heating and cooling, transport and more (IPCC, 2018). In response to the global challenge of climate change, the EU has set itself the goal of becoming climate neutral by 2050, taking a leading role in development with the so called 'Fit for 55' package (European Parliament, 2020). The package, proposed in July 2021, calls for a fair and socially equitable transition that maintains and strengthens the innovation and competitiveness of EU industry. Tough maintaining a strong focus on climate change mitigation with the commitment to achieve a 55% reduction in emissions combined with a 40% share of renewable energy in the overall energy mix by 2030 (European Parliament, 2020; Evans, 2021). The package translates into an expected increase in renewable energy use of 0.8% per year per Member State until 2026, rising to 1.1% from 2026 to 2030 (European Parliament, 2020).

Tough the targets are set they are not taken in to account that seriously. According to the Environmental Implementation Review from the European Union, Belgium is lacking behind on investments in eco-innovation and does not meet the EU targets (Environment EC Europe, 2022). The need to find less polluting energy and heating solutions, and the need to ensure energy security for all and provide economic stability, has been further enhanced by the global conflicts experienced over the years, including the Russian invasion of Ukraine (Liao, 2023). As a result of the conflict, Liao (2023) states the conflict has led to increased investment and attention in renewable energy in Europe especially by the Nordic countries.

In Belgium, the buildings sector accounts for ±21% of emissions (EU Climate Action Progress Report, 2023), in Flanders specifically, 29% (12.6 Mt CO_2-eq) goes to the buildings sector, making it the second largest sector in terms of Flemish ESA GHG emissions (Flanders, 2023). Currently, more than 90% of residential and public buildings in Flanders are heated with natural gas or fossil oil (VRTNWS, 2022). To reach the 2050 targets, 100,000 connections per year will have to be converted to renewable heating techniques. According to the Flemish government, heat networks will in the following years be used to heat buildings using residual or centralised green heat, with the government playing a key role in promoting initiatives, removing regulatory barriers and providing financing (Flanders, 2023; VREG, 2018).

1.2 WATERWARMTH IN KORTRIJK: INTERREG PROJECT CONNECTION

This research project is based on the Interreg WaterWarmth project that explores the potential of aqua thermal energy which is a sustainable and clean alternative to conventional heating methods, as it utilizes the natural heat stored in water (Extraqt, 2024). The project takes place in the European North Sea region and is adopted by several partners (see Figure 1) who develop pilot projects that showcase the potential of aqua thermal energy and aim to equip local (energy) communities with the knowledge and know-how to further integrate aqua thermal energy into their operations and use, ultimately reducing dependence on fossil fuels (Interreg NorthSea, 2023). This study focuses on Kortrijk which is the 'largest' implementation case in Interreg WaterWarmth and consists of two main projects, namely Kortrijk Buda Tip and Kortrijk Havenkaai/Weide (See scope and sample selection).

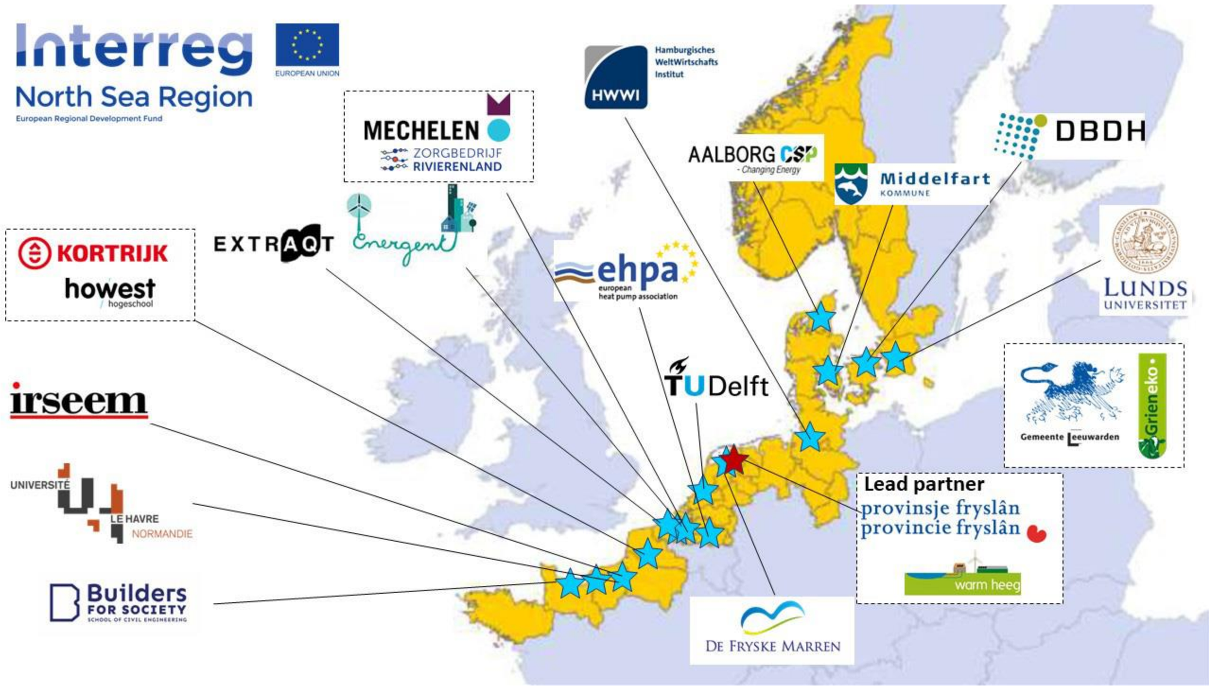

Figure 1 - Interreg Waterwarmth Project sites (TUdelft, n.d.)

Belgium is lacking in regulatory policies to address heating needs, phase out gas heating and implement alternatives in new buildings (Mouton et al., 2024). Kortrijk, like many other cities in Belgium, contains numerous older buildings, which contribute significantly to carbon emissions due to their often low levels of insulation combined with a heavily polluting heating infrastructure.

To meet the future 'green' heating needs, an effective integration of a sustainable and efficient district heating system, such as a smart heat grid, is needed. According to the IPCC (2020), the climate challenge is largely an energy challenge and is shared globally, so action is needed all around the world. The 2008 economic crisis saw the largest jump in emissions, with heating and cooling emissions rise due to financial life choices.

The aqua thermal debate, while gaining traction in certain areas in the Netherlands (Energy.nl, 2018), remains a relatively unexplored technology within the broader renewable energy and heating discourse in Belgium (Du et al., 2019). While studies have demonstrated the technical feasibility of extracting heat from water bodies (Energy, 2022), the successful transition from theoretical concepts to practical applications is hindered to this moment by factors such as the up-front investment required for infrastructure development and stakeholder opinions and uncertainties (Chiu et al., 2022). In addition, the potential environmental impacts, such as changes to hydrological systems and induced seasonality, have raised public concerns and scepticism about heating energy using water bodies (Extraqt 2, 2024) which leads to a slow uptake of aqua thermal energy on a larger scale.

Belgium's socio-economic landscape is characterised by a strong emphasis on social welfare, sustainability and innovation that is created by all kinds of stakeholders in the Belgian society (Van Assche et al., 2012). As a result, stakeholders are increasingly demanding governmental actions that promote social equity, environmental protection and economic growth. In order to meet these expectations, governmental bodies need to engage in a continuous dialogue with stakeholders to identify their priorities and concerns (Van Assche et al., 2012). Understanding these needs and priorities of stakeholders is needed for successfully implementing initiatives such as community development projects and greening projects (Bryson, 2018) in Kortrijk.

1.3 RESEARCH OBJECTIVE

This research aims to identify stakeholders and analyse their needs and priorities to support the energy transition and adopt heating (and cooling) using the new aqua thermal/electrical energy. This exploratory research uses the energy initiatives conceptual framework to determine the possible impact of emerging technologies on stakeholder attitudes towards sociotechnical transitions and is exploratory. The research covers public and private actors in Kortrijk and beyond. This public such as the Kortrijk Weide swimming pool, the Howest and Ugent university, city building and more, and private actors such as local residents, economic actors and more to reach the EU 2030 CO2 targets. Based on the analysis, recommendations that enable energy corporation(s) to optimise the use of aqua thermal and electrical energy sources in regard to factors such as infrastructure compatibility, technological feasibility, social acceptance, and environmental impact will be provided. It takes into account the specific context of each stakeholder group, including persuasion strategies, their attitudes towards connection strategies and future energy transition needs.

1.4 RESEARCH QUESTIONS

Based on the problem statement, objective, and the scope this research project has the following research questions.

Research question: "*What are the key stakeholder needs and priorities when implementing a smart heat grid utilizing aqua thermal energy in Kortrijk, Belgium, to support the energy transition and achieve EU 2030 sustainable heating goals?*"

By addressing the following sub-questions, this project aims to consider needs and priorities of stakeholders in implementing a smart heat grid that is not only technologically sound but also considers the social aspects:

Sub questions: "*What are the current and past lessons upon how to connect the technical design process of a smart heat grid with stakeholders in the region of North Europe?*"

"What are the specific needs and priorities of stakeholder groups regarding the implementation of a smart heat grid in Kortrijk?"

"What are the most effective strategies for persuading residents and stakeholders in Kortrijk to connect to a smart heat grid, considering their consumption patterns and overall performance?"

"What technical, infrastructural, social, and educational elements should be included in the aqua thermal design to further facilitate the energy transition in Kortrijk, Flanders, based on the needs and priorities of local stakeholders?

The research sub-questions follow a logical order and build on each other. The aim of the first research question is to draw a picture of the socio-technical feasibility of an energy corporation and smart heat grid based on current other Interreg Waterwarmth or related projects (Interreg NorthSea, 2023), following with a second and third sub question on social acceptance, stakeholder needs and stakeholder persuasion strategies in implementing the socio-technical transition to an aqua thermal heat grid where consumers (public/private) can connect to. Finally, the last sub-question ties it all together by foreseeing future needs for stakeholders and residents in their day to day use patterns and expectations. Based on these four sub-questions, the main exploratory question of what the stakeholder's needs and priorities are can be taken into consideration when implementing the properly operationalised aqua thermal heat grid can be answered.

1.5 THESIS OUTLINE

The structure of the thesis is as follows and is shown in Figure 2, starting with an introduction that flows into the approach, followed by the results and finally the conclusion. Chapter two describes the conceptual framework and details the specific sub-questions of the research. Chapter three describes the research design and methodology. Chapter four presents the results of the research and each of the sub-questions, where they are also analysed and discussed. The conclusions are presented in chapter five. Following chapter two, the research framework is established and presented to answer the sub-questions, based on a multi-stakeholder perspective for the integration of a smart heat grid with aqua thermal energy, which includes the different steps to achieve the results of the sub-questions that is gain in the results section.

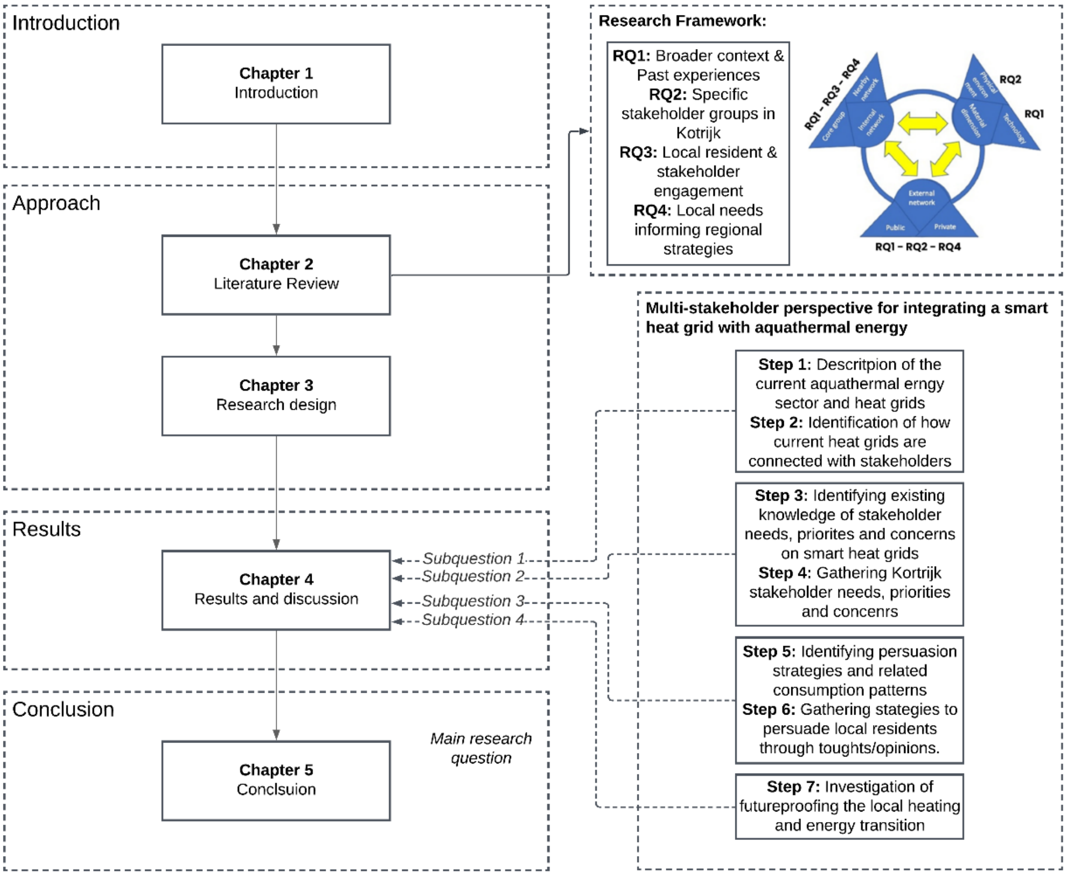

Figure 2 - Research flow diagram

2 LITERATURE REVIEW

In this section, the information and data based on the topic of the aqua thermal heat grid will be gathered in a literature review, which will be carried out based on the main and sub research questions, thus mainly consisting of a systemic review, where the 30 most relevant related articles from Scopus will be reviewed (based on the subtitle of the paragraph). This will be complemented by a state of the art review of aqua thermal energy itself as a technology for heating and cooling, as it is still an emerging technology being used in projects around the world, such as the Interreg WaterWarmth.

Firstly, the general aqua thermal energy systems combined with their social acceptance, internal, external and other related factors are discussed to provide sufficient context for the research sub questions relating to the research design and framework.

2.1 THEORETICAL FRAMEWORK

With new heating technologies comes a period of reservations, acceptance and prioritisation (Ellaban, 2016). Energy initiatives operate within a web of interactions. Understanding these interactions can be facilitated by examining different frameworks. Based on the systemic and the state of the art literature review on aqua thermal energy (heat grid), 15 of 59 Scopus documents that were most relevant to the thesis were selected and further explored for potential usable frameworks that fit with the main research question. After the first and second selection, a third selection was made by which three relevant documents were identified that included three frameworks that were of interest for the type of research that is going to be conducted and the research questions related. Those three identified frameworks in the three best fitting documents were a framework by Aalders (2021), who made a feasibility study of aqua thermal energy in the village of Leek (Netherlands), another framework by Niekurzak et al. (2022), who engaged in the effectiveness of aqua thermal energy, social collaboration and heat pumps in Denmark, and a last one by Van Der Schoor et al. (2023), which aimed to provide information on how citizen-led projects developed new heating techniques such as aqua thermal energy with their stakeholder participation and more in the Netherlands which came out at top.

The research and thesis apply societal needs, priorities and concerns. And thus, based on the aim of the research, the framework of Van Der Schoor et al. (2023) is used to answer the sub research questions. The framework combines both Actor Network Theory (ANT) and Social Movement Theory (SMT) into three bullets: the internal network, the external network and the material dimension (Van Der Schoor et al., 2023). While the ANT and SMT are fairly familiar, a connection in between is not widely used, but can be found in new forming niche markets or energy trials.

The external network (Figure 3) includes the relationships between the local heating initiative and external organisations, both public and private. Public actors, such as municipalities, play a role in granting permits and subsidies and in shaping the project through spatial planning decisions. Private actors, such as energy suppliers, consultants, contractors and financial institutions, provide expertise and management solutions in project development and operation (Van Der Schoor et al., 2023).

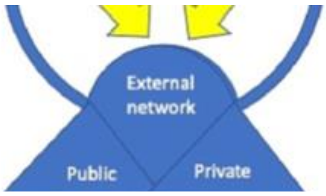

Figure 3 - External Network (Van Der Schoor et al., 2023)

The material dimension (Figure 4) refers to the physical aspects and technological capabilities required for the project. In the context of district heating, this dimension emphasises the 'how' of the project, taking into account the existing physical environment and available technologies. The dimension also emphasises the shift towards sustainable technologies and the involvement of citizens in the choice of technologies (Van Der Schoor et al., 2023).

Figure 4 - Material Dimension (Van Der Schoor et al., 2023)

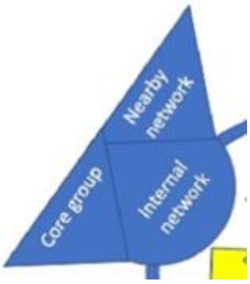

Figure 5 - Internal Network (Van Der Schoor et al., 2023)

Finally, the internal network (Figure 5) deals with the inner workings of the initiative. At the heart of this network is the core group, which is likely to be a group of enthusiasts running the project for their social/economic benefit. Their access to resources, including financial grants, expertise through members or consultants, volunteer time and skills, and a legal structure, is required in the early stages of projects to ensure the success of the project. In addition, the surrounding network, including the surrounding community and local organisations, is an important consideration. Citizen participation, a core principle of community energy initiatives, is often assessed using Arnstein's Ladder of Citizen Participation, which categorises the level of citizen involvement in the project (Van Der Schoor et al., 2023).

Figure 6 projects the framework of Van Der Schoor et al. (2023). To understand a local heat initiative, according to the framework, three things need to be considered: how the aqua thermal heat project is connected to the community (structure, resources and commitment), how the view and relationship of aqua thermal/new emerging heat technologies is and lies with outside groups (government, business), and how the technology and finances can help the environment and be persuasive to the outside world.

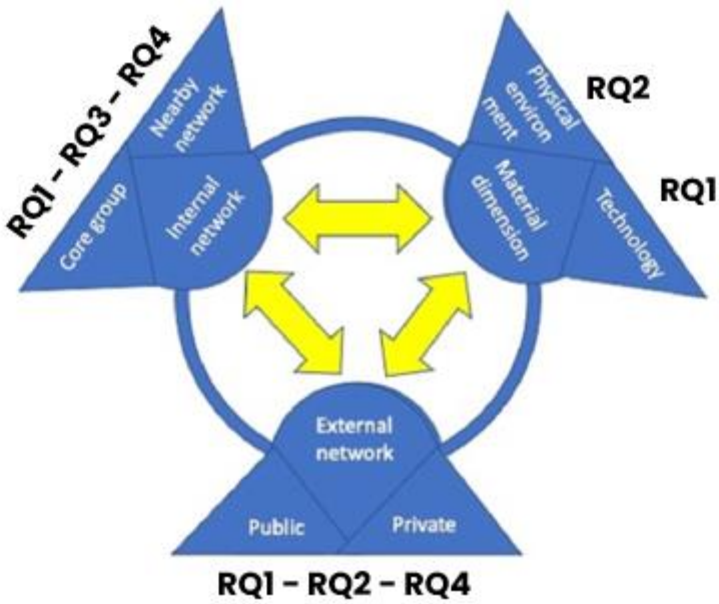

Figure 6 - Theoretical framework Aqua thermal energy corporation (Van Der Schoor et al., 2023)

It is found that this framework provides a good basis for this thesis for three reasons. Firstly, all three components play an important role in the implementation of heat projects in Belgium and more specifically in Kortrijk. Secondly, the framework can be adapted to the more specific circumstances of the Interreg project. Thirdly, the internal, external, material and community components play an important role in the framework triangle. Fourthly, the impact of an energy company can be tested against the different components of the framework. Each of the previously defined sub research questions is related to the framework visible in Table 1. The theoretical framework is thus used to further connect all the elements such as the interviews, focus group and literature review to the research sub questions.

Table 1 - Framework Justification connection sub research questions

Research Question	Framework Dimension	Justification for Fit
SUB Q1: *"What are the current and past lessons upon how to connect the technical design process of a smart heat grid with stakeholders in the region of North Europe?"*	External Network (Public, Private), Internal Network (Core Group and Resources), Material Network (Technolohgrgy)	This question does not only focus on Kortrijk, but on a wider region (Northern Europe). By understanding past links between initiatives and external organisations (public and private) proposals can be delivered. In addition, the resources of the core group and the knowledge gained from previous projects are valuable.
SUB Q2: *"What are the specific needs and priorities of stakeholder groups regarding the implementation of a smart heat grid in Kortrijk?"*	External Network (Public, Private), Material Network (Physical environment)	The focus of this research question is specifically on the needs and priorities of stakeholder groups in their physical environment of Kortrijk. Both public (e.g. municipalities) and private organisations (e.g. energy suppliers, consultants) can be stakeholders with different interests.
SUB Q3: *"What are the most effective strategies for persuading residents and stakeholders in Kortrijk to connect to a smart heat grid, considering their consumption patterns and overall performance?"*	Internal Network (Nearby Network and Citizen Participation)	This question centres on local resident and stakeholder engagement with the persuasion strategies within Kortrijk.
SUB Q4: *"What technical, infrastructural, social, and educational elements should be included in the aqua thermal design to further facilitate the energy transition in Kortrijk, Flanders, based on the needs and priorities of local stakeholders?"*	External Network (Public), Internal Network (Nearby Network and Citizen Participation)	This research question links the local (Kortrijk) and regional (Flanders) levels. Public actors at the regional level (Flanders) have a significant influence on the energy transition. Understanding the needs and priorities of residents (internal network) in Kortrijk will help to identify elements that can be incorporated to facilitate a broader energy transition in Flanders.

2.2 AQUA THERMAL DESIGN AND THEIR IMPACT ON SOCIETY

A first search term is aquathermy combined with the societal impact of a new heating system. For this an analysis was conducted on Scopus based on the 30 most relevant articles to 'Aquathermy', 'Heat Grid' and 'Social connection'. Aquathermy is the technology of using a water source that is extracted to produce heating and cooling for storage, distribution and usage (in buildings) is a relatively new technology that has not yet been researched as thoroughly as other renewable energy sources (Goossens et al., 2021).

2.2.1 Aqua thermal energy – Technical design process

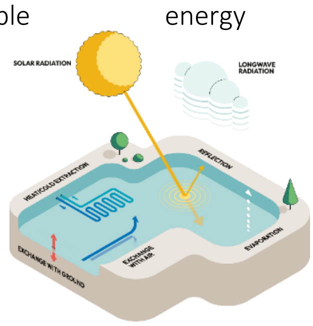

Figure 7 - Aqua thermal energy cycle (Extraqt,

The aqua thermal energy cycle consists of solar radiation captured by water, indirectly heating the water (visible on Figure 7). When the water temperature is between 7 and 25°C, a heat exchanger extracts the heat energy from the water and transfers it to a closed water circuit (Interreg NorthSea, 2023). Once the heat is extracted from the water, it can be stored or raised to a higher temperature using a heat pump, where it is then delivered to 'customers'. There are three possible sources for aquathermy: wastewater, river water and drinking water. Sewage and drinking water have a lower potential compared to surface water (Manktelow et al., 2023).

For Kotrijk Havenkaai, streaming river water is used and the technical design is as follows: The system combines two systems, aqua thermal energy and a geothermal field for heating. The basis of the system lays with the geothermal field, which provides heat to the houses and the school buildings. The

Aqua thermal energy is used to reheat the geothermal field and provide urgent heat in summer. The in winter extracted heat from geothermal field exhaust the soil and has the need to be refilled which is done with aqua thermal energy during hotter periods (7°C water temperature or more) as the ground works as a heat buffer/battery. The aqua thermal system has in total with 210 kilowatts of heat capacity (Denagel Jaffe, 2024).

Before there is an implementation to the project there is a need to check if the heat source is suitable for the area. The interreg NorthSea (2023) project made a quick scan tool which made it possible to research the possibility of working with aquathermy and the feasibility for the watercourse. If all desired and collected parameters are fulfilled, the Lys as an energy source is a very feasible heat carrier. There is only a 0.25°C cooling of the Lys water if the full capacity of the proposed systems in Kortrijk are used for heating. This is visible on Figure 8.

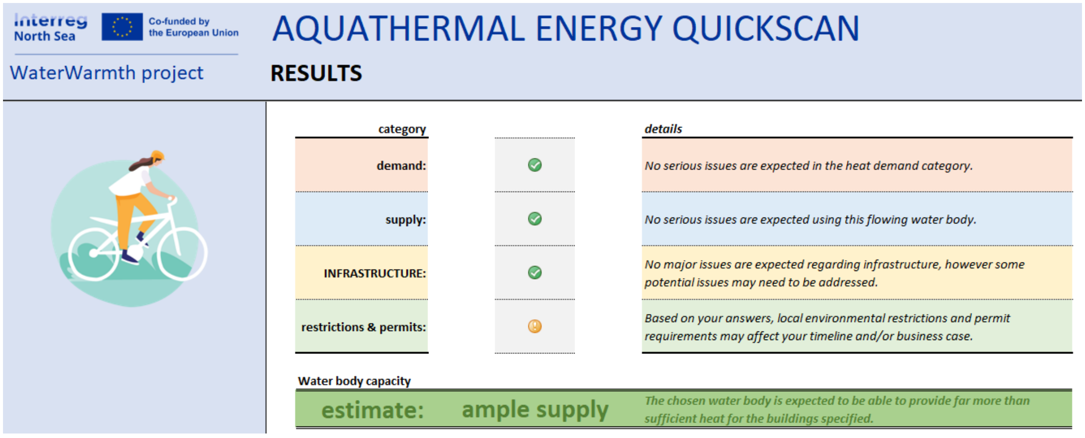

Figure 8 - Results Feasability Quickscan Interreg NorthSea (2023)

2.2.2 Connection with societal actors

Although the technological aspects of the smart heat grid are crucial, they must be combined with social considerations in the design. Consideration of the heat consumption patterns of consumers is essential to optimise the development and operation of the network. In addition, the use of existing infrastructure can minimise problems and gain public support. According to Pengwei et al. (2019) this covers mainly factors such as the time of use, the performance, the ease of use, the grid design, the integration of other renewable sources, accessibility and more.

A first factor to keep in mind is grid design and optimization. According to Best et al. (2020) new approaches in district heating and cooling networks would improve the overall performance. In the research Best et al. (2020) describe that data analysis from consumption patterns and building insulation types is important to consider before installing a system. This data can inform decisions on factors such as pipe sizing, network topology and placement of thermal storage. In addition, advanced modelling and simulation tools can be used to predict heat demand patterns and optimise network operation for maximum efficiency and minimum energy losses. By analysing the data the heat producer (in this case aqua thermal energy) can be scaled up to the perfect temperature in the system or can provided detailed information to which buildings need further insulation incentives by the city or own means (Pengwei et al., 2019).

This leads to the second technological consideration which is the working temperature, the technical standards and the promise of renewables. In the book of Pengwei et al. (2019) there is stated that demand management for renewable sources is still a challenge due to unexpected external factors such as weather forecast, biophysical conditions and more that may occur. If there is a promise of green energy this should not change the working temperature, and the connected installation.

A third technological but also social consideration is the ease of use and maintenance of a system that is put in place. Romanovs et al. (2021) state in a paper about cyber security education in smart heat grids that people mainly are connected to be de-maintained for themselves and made ready for other providing enough heat when this is demanded to satisfy the customers. A cost-benefit is also coupled herewith.

Research into the economic viability and incentive of smart heat networks highlights the need to address the concerns of both residents and energy providers for successful project implementation (Novelli et al., 2021). Affordability is a high concern for residents as stated in most of the reviewed reports. Community engagement makes people feel like they own the project and lets them take part in it. Wolsink (2012) highlight the success of participatory approaches in Denmark, where residents were involved in decision-making processes. This makes people feel like they own the project and increases public acceptance. Also, having ways for people to talk about their concerns and give feedback throughout the project helps the project respond to what the community needs.

In countries where there is experimentation with aqua thermal systems using different water sources, consideration is being given to policy and governance systems that will enable further implementation of these systems (Ellaban, 2016). According to NAT (2023), countries such as Norway, Sweden and Finland have an established practice of using AE systems, but there are very few such projects due to low uptake, which is influenced by the availability of other energy sources such as hydropower and biomass, as well as the high costs associated with implementing aqua thermal energy projects.

2.3 SPECIFIC NEEDS AND PRIORITIES STAKEHOLDER GROUPS FOR IMPLEMENTATION

2.3.1 Public perceptions

Aqua thermal energy faces several challenges (Interreg NorthSea, 2023) which are that energy from fossil fuels is cheaper to operate (at the moment), that infrastructure investments are needed to implement the technology and that high initial investments are integrated. In the paper from Van Der Schoor et al (2023) community aqua thermal energy and other emerging technologies that require community involvement are key elements facing the energy transition.

Public awareness of new emerging heating technologies tends to be low. A recent survey carried out by a Becker et al. (2023) found that when air-source and ground-source heat pumps were considered together, only 4% said they knew a lot about both, 20% knew something about one type, and 76% had never heard of or knew nothing about either. In another study carried out in the UK 42% of survey respondents had never heard of heat or new heating technologies (Becker et al., 2023).

Lund et al. (2012) found that clear communication about the benefits and potential drawbacks of smart grids increased public acceptance. Building trust and making sure that a project meets community needs is important, but acceptance takes ongoing effort. Studies by Becker et al. (2023) and Piselli et al. (2022) show that it is important to address public concerns at every stage of a project. People need to know how the smart heat grid will affect them, including costs, energy efficiency and data privacy. Lund et al. (2012) says residents should be able to control their incoming temperature and their self-allowed use in the smart grid. This makes residents feel more in control and involved.

For aqua thermal energy innovations, it is also important to make sure that this technology meets social needs (Haji Bashi et al., 2021), they bring social innovation to technology to make sure that these innovations meet social goals. Van Den Hove (2016) found that people are worried about how data is collected and used in smart grids. To build trust, data security and privacy policies must be strong and clear. People need to know their personal information is safe.

2.3.2 Social acceptance and stakeholder needs/priorities

Social Acceptance is a term which refers to the acceptance and participation for specific product and service by the public. Social acceptance is increasingly used in connection with new technologies. Stakeholder's needs and priorities align with social acceptance in that in knowing the needs, solutions can be sought, transparency and trust can be built and community values can be respected. In broader view, the social acceptance and stakeholder needs/priorities are related to Social Concern, Social Information and actual usage of the new product or service (Wolsink, 2012). Based on the topic of this research which is related to renewable energy in the heating sector using river water, there are different elements that need to be taken into account. These are the public perceptions, technology, economics, the environment and the overall public needs.

The environmental benefits of a smart heat grid represent a significant selling point in terms of public acceptance. According to Wolsink (2012), if it is possible to quantify the projected reduction in the carbon footprint of the project it should be clearly communicated with the positive environmental impact, which will persuade environmentally conscious residents and provide a good city image. A key aspect of sustainability is the integration of renewable energy sources to reduce dependence on fossil fuels (Wolsink, 2012), thus aqua thermal energy fits in with these statements.

A second environmental benefit is the reduction of heat in the water in summer periods. The 'Vlaamse Waterweg' which is the Belgian waterways stated in recent reports that due to the effects of climate change, the temperature of water rises and its quality is affected. The surface temperature of the water should not exceed 28°C to avoid possible mortality and biodiversity loss due to possible migration of organisms/fish (Life-Sparc, n.d.). By using aquathermy, heat is captured from the Lys in summer to reheat the geothermal field (winterisation) and thus for this project, can cool the river by up to 0.25°C, resulting in environmental benefits (Interreg NorthSea, 2024).

While research on geothermal energy, including aqua thermal systems, has increased, specific studies focusing on stakeholder perspectives remain limited. A few studies have examined stakeholder engagement in geothermal projects related to aqua thermal energy, as it is a renewable energy source (Howes and Hoskin, 2024; Shortall et al., 2015). These studies generally show that local communities, policy makers and industry representatives have different concerns and expectations.

Local communities often prioritise environmental impacts, potential risks and community benefits (Shortall et al., 2015). They seek transparent communication, opportunities for participation, and assurances about project safety and sustainability. Policymakers, on the other hand, emphasise energy security, climate change mitigation, economic development, and regulatory frameworks (Baria et al., 2023). Industry stakeholders focus primarily on project feasibility, economic returns, technological advances and a supportive policy environment (Howes and Hoskin, 2024).

The literature identifies several challenges and barriers to aqua thermal development. Technical challenges, such as site development and heat extraction, are cited (Piselli et al., 2022). Economic factors, including high upfront costs, uncertain returns on investment and financial risks, are also significant barriers (Alsaleh et al., 2023). In addition, regulatory and permitting processes can be complex and time-consuming, creating bureaucratic hurdles (Shortall et al., 2015).

Environmental concerns, particularly related to water resource management and pollution of water, have emerged as issues. Public perception and acceptance of aqua thermal energy varies depending on factors such as project scale, location and perceived benefits. A lack of public awareness and understanding often contributes to resistance and opposition to new energy projects (TU Delft, n.d.).

2.4 MOST EFFECTIVE PERSUATION STRATEGIES

How the public sees smart grid projects affects how well they succeed. Ellabban (2016) argues it is important to work with stakeholders throughout the design process. This helps the public to trust the grid and makes sure it meets local needs and preferences. Becker et al. (2023) show that participatory design leads to more socially sustainable smart grid projects. Thus leading to a persuasion by communication (visual, oral and textual), transparency and inclusivity in the design phase to address public concerns (Lund et al., 2012).

Transparency and education are described as the main strategies in persuading. Clearly communicating the benefits of a smart heat grid, such as cost savings and environmental benefits, can effectively address public concerns (Biao et al., 2023). This can be achieved through campaigns, forums and materials that explain the technology and its advantages in a way that it is easy to understand.

Money can also persuade people. Subsidies or rebates most of the times encourage people to adopt the technology early (Biao et al., 2023). These incentives can make the technology more attractive to a wider range of consumers by offsetting the initial costs. People are in Belgium more convinced through a continuous subsidy instead of a one-time subsidy (Flanders, 2023)

A third plausible method that is widely used in research for persuasion is through demonstrations and pilot project. Showcasing the benefits of a smart heat grid through demonstrations and pilot projects helps residents see the technology in action and feel more at ease (Li et al., 2021). Media coverage and community presentations can help spread the word and get people on board.

Lastly, fostering community engagement by actively involving residents and stakeholders in the planning process lets them raise concerns and have these addressed (Mazzotta et al., 2009). This approach builds trust and fosters a sense of ownership in the project, which leads to more support.

2.5 FACILITATION OF THE ENERGY TRANSITION

By using aqua thermal energy there may occur a temperature difference in the water body thus heating or cooling the water which may result in fatal failures of the ecosystem. The Flemish waterway currently has set a maximum allowed temperature difference of 3°C on the water extraction and discharge (De Vlaamse Waterweg, n.d.)

2.5.1 Feasibility and future proofing

Economic feasibility is something that is taken into account in the thesis during the stakeholder's needs and expectations and is asked for during the interviews. Yang et al. (2020) state that for stakeholder engagement a techno-economic analysis is crucial for determining the economic viability of aqua thermal projects especially for energy corporations that will emerge. Side note as this study was done in the USA.

Financial models such as subsidies, are crucial to ensure accessibility for all income levels (Rossi et al., 2010). However, the long-term economic benefits for residents should also be highlighted. Smart heat networks can lead to lower energy bills through increased efficiency and potentially lower gas/fuel costs (Sarma et al., 2023). Before a project gets deployed, clear projections of cost savings can encourage participation and improve project acceptance (Rossi et al., 2010).

From the perspective of energy companies, a clear path to financial viability is needed (Rossi et al., 2010). This includes regulatory frameworks that support the economic viability of the project as is the exploration of revenue models that benefit from potential cost savings through reduced grid losses and improved operational efficiency (Sarma et al., 2023). Clancy (2024) emphasizes the importance of understanding public perceptions regarding costs.

2.5.2 Energy transition

The transition to renewable energy requires intelligent management systems to optimise energy use and grid integration. Energy management systems (EMS) have emerged as a key tool, providing real-time data collection, analysis and control capabilities. Energy management systems enable proactive decision making, reduces energy consumption and facilitates the integration of intermittent renewable sources (Wyrwicka et al., 2023; Hoppe et al., 2024).

Wyrwicka et al. (2023) also state that while there has been research into EMSs for various renewable energy sources, their application to aqua thermal energy (AE) is a specific area with promising potential. An EMS coupled with AE systems could optimise extraction and use based on real-time demand and grid conditions. This integrated approach could increase the efficiency and overall contribution of AE to the clean energy transition.

3 RESEARCH DESIGN

In chapter 3, the research design is presented using the methods presented Sohna McCombes (2021) which is described as 'A research design is a strategy for answering your research question using empirical data'. Therefore this section will explain the process to adopt the research methodology.

3.1 RESEARCH FRAMEWORK

The first step in designing the research includes the defining of the research goals and choosing a research design and objective which is categorised. This is done in chapter 2.3 (Theoretical Model)

For developing the research framework related to this project the objective (described in chapter 1.5) is taken into account and further defined. Secondly the research object is defined which is the region of Kortrijk and the related stakeholders.

3.1.1 Scope and sample selection

The research object/unit in this study is the Lys River and its potential for aqua thermal energy to the Kortrijk Weide, Buda and Havenkaai region. This is related to the Interreg project WaterWarmth, with or without the implementation of the existing heat grid. The stakeholders involved in the project, other than the integration companies and the Interreg project, are mainly Belgian and further explained in the stakeholder analysis chapter.

Figure 9 – Project Kortrijk Buda TIP (vlaamsebouwmeester, 2024)

Figure 10 - Project Kortrijk Havenkaai / Weide (caaap, 2024)

The implementation case of Kortrijk consists of two projects: Kortrijk Buda Tip (Figure 9) and Kortrijk Havenkaai/Weide (Figure 10) with two different approaches. In Kortrijk Havenkaai/Weide, a residential building with integrated school facilities will initially be supplied with aquathermy, followed with the supply of the energy into an existing heat grid from the Weide site. In Kortrijk Buda TIP, the entire island will be equipped with a heating network with aquathermy (Interreg NorthSea, 2024). This project is still in the approval phase, which means that the city of Kortrijk is not allowed to communicate with its citizens until the end of October 2024. This means that only Kortrijk Havenkaai/Weide has been taken into account in this thesis. In Table 2, a comparison is made in between the two sites and their statistics (Kortrijk, 2024).

Table 2 - Comparison two sites (Kortrijk, 2024)

FEATURE	KORTRIJK WEIDE/HAVENKAAI	KORTRIJK BUDA TIP
URBAN LAY-OUT	School buildings, industry buildings, swimming pool, event building, public apartment/houses	City buildings, public apartment/houses, school
PRESENCE OF EXISTING HEAT GIRD	YES (only Kortrijk Weide)	NO
(COMMUNITY) OWNERSHIP	90% private buildings (public organisations & residents)	50% Of island owned by the city, other by residents
MEDIATE BUILDING AGE	12 years	70 years
AVAILABILITY HEAT & RENEWABLES	CHP's, gas boilers and 4 heat pumps Installed solar panels on most buildings	Mainly gas heated Solar panels rarely on roofs
WATER INFRASTRUCTURE	20 meters apart to the Lys river	Island on the Lys river
PROJECT DEVELOPEMENT START DATE	End of 2023	Beginning of 2025
ESTIMATED PROJECT FINISHING DATE	2026	2027
AQUA THERMAL PROJECT'S COMMUNICATION	December 2023	October 2024

3.1.2 Research perspective

This research aims to identify stakeholders and analyse their needs and priorities to support the energy transition and adopt heating (and cooling) using the new aqua thermal/electrical energy. This research uses the energy initiatives conceptual framework from Van Der Schoor et al. (2023) to determine the possible impact of emerging technologies on stakeholder attitudes towards sociotechnical transitions. The research covers public and private actors in Kortrijk. Public by the (heat grid connected) public buildings (swimming pool, university, city building) and private by the future residents of buildings to be connected in the Kortrijk Weide and Havenkaai region.

The research design is a case study for three reasons. First, a case study allows for in-depth insights with interviews and a focus group. Second, it allows for the collection of data from multiple sources (described later). Third, interviews and desk research allow for the comparison of similar cases that differ in terms of independent variables such as the implementation case in Norway (Verschuren & Doorewaard, 2010). The overarching dependent variable in this project is the social acceptance and stakeholders' needs and priorities for the aqua thermal heating project.

3.1.3 Research boundaries

The integration of a smart heat grid is done by focussing on household, community and public level. During the research, only the closest related stakeholders to the project are taken into account as for the fact that installing a heat grid is costly and will not be covered by the city in the near future. The current heat grid is visible in Figure 11. The specific households/apartments that are connected to the heat grid are taken into account based on a random sample of residents that are willing to be part of an interview/ focus group.

Figure 11 - Current Heat Grid Kortrijk Weide (lines)

3.2 STAKEHOLDER ANALYSIS

Based on the project description and the research objective, the relevant stakeholders involved in or impacted by the development and installation of the aqua thermal energy project Kortrijk Havenkaai such as the regulatory actors and the project developers are described below. The related stakeholders are selected based on the Interreg NorthSea (2024) project implementation.

According to Mahajan et al. (2023) a stakeholder in a niche market is any individual or group who can be affected by the actions of an emerging project, company, or organization, or conversely, who can influence its success. After identifying the stakeholders their engagement needs to be entailed as well as the local willingness to connect to the project in order to save energy and time.

Eguiarte et al. (2020) highlight the diverse range of stakeholders involved in the heating/cooling energy sector and adoption of emerging energy technologies from prosumers, to consumers, transmission body's and much more. One crucial stakeholder group are the heat consumers, including both residential and commercial customers. They can benefit from the potential cost savings and environmental advantages offered by emerging systems such as the aqua thermal energy. Other related stakeholders are investors, regulatory bodies and related integration companies, they all play a significant influence in the feasibility and adoption of aqua thermal systems through their energy policy and environmental regulations.

Research by Wustenhagen et al. (2005) suggests that corporations can effectively engage stakeholders by employing various strategies. According to Wustenhagen et al. (2005), open communication is crucial. Transparency in communication such as public forums, workshops and targeted information dissemination can address stakeholder concerns and build trust.

Firstly, as the project is driven by the European Union Interreg NorthSea the central project has most of the control of how funding is allocated. Governmental bodies such as the country and city are responsible for establishing legislation aimed at monitoring the used water from the river in this case and permitting, as well as enhancing its quality, to guide the country towards achieving EU renewables and CO2 reduction goals ensuring the well-being of citizens. Similarly, the water authorities (who are seen as governmental bodies) oversee the enforcement and efficacy of these regulations and ask a sum for the usage of the water (Interreg NorthSea, 2024).

Secondly, as the aqua thermal energy will be used as a 'primary' source for Havenkaai (Kortrijk) in the Caaap building from 2026, there are research agencies and project experts involved in the research and implementation of the project to further develop it to an actual use case (Figure 8). Before implementation, they have to adapt to the regulations, quality requirements and testing standards (Kaaicity, n.d.).

On the demand side as the project gets to a finishing state there are the future and current residents that will connect to the heat infrastructure or are already connected to a heat grid and the heat grid exploiter which would be In the case of Kortrijk an energy corporation lead by the city.

The stakeholder analysis was done on a Water Warmth project meeting in Caen, France (27 and 28'Th of May) where all partners met and thus related program accompanies could be made. Table 3 presents an overview of identified stakeholders directly associated with the Aqua thermal project in Kortrijk. A preliminary analysis was conducted to determine their main objective considering the Water Warmth project, their potential impact on the situation and defined problem, and how they might be influenced this research case. This evaluation was conducted during the data collection based on the earlier mentioned partner meeting.

Table 3 - Stakeholder analysis based on the Interreg NorthSea (2024) project

STAKEHOLDER	MAIN OBJECTIVE	IMPACT ON PROJECT	IMPACT ON RESEARCH CASE
CENTRAL PROJECT CONTROL (INTERREG NORTH SEA)	Successful implementation of pilots with aqua thermal energy in the North Sea region	Funds and oversees project	Helping pilot sites to develop project success, efficient allocation of persuading funds
CENTRAL (WATER) GOVERNMENTAL BODIES	Foster adoption of sustainable energy solutions through policy and regulation to meet the EU heating goals	Stands in for approval of the project. May need to adjust regulations, policies	Project results and public opinion. Water quality needs to maintain and new non-polluting technologies should arise
RESEARCH AGENCIES	Advance research and understanding of aqua thermal energy in heating and cooling cases in the North Sea region based on 6 work packages	Gather data, contribute to knowledge on aqua thermal energy and the 6 work packages that are put up by the Interreg NorthSea	Provided knowledge on how pilots can be further rolled out. Helps to research viable cases for implementation.
PROJECT EXPERTS	Develop practical examples and pilots for aqua thermal energy	Provide technical knowledge and expertise to the realisation of Interreg the project	Provide technical, social and financial information for persuading residents
CURRENT & FUTURE RESIDENTS	Access to sustainable and affordable heating/cooling solutions that are non-polluting	Benefit from reliable, potentially cheaper heating/cooling	Social acceptance on new technology where the heat is brought in to your home
HEAT GRID EXPLOITER (ENERGY CORPORATION)	Explore and potentially develop aqua thermal energy as a business opportunity as a provider	Potential new market for aqua thermal energy, green portfolio and a contract of delivering	Regulations, public acceptance and provider of heat who can bet he city, a 'normal' provider, a resident or other

Following the project's scope of focusing on the city of Kortrijk and more specifically the sites Havenkaai and Weide, three main categories of actors could be identified and approached the engagement phase of the project to obtain primary data regarding operational processes. These actors are distinguished by type of existing knowledge and place of life. The actors are placed in a category and the categories chosen are a sample based on social acceptance and how the new emerging technology is viewed upon. In the designing phase of a project different stakeholders are involved then in the connection and contribution phase which leads to a selection of the current timeline in the project which is still in development. After a project search a stakeholder diagram was made (Figure 12) that was used to develop Table 4 which distinguishes the main stakeholders for the project, followed up by an interview/focus group

Table 5 which describes in detail the interviewed persons. The potential benefits that stakeholders could obtain from a connection or a participation in the project can be defined based on the interactions with the stakeholders and stakeholder groups that is done in interviews and focus group based on the energy initiatives research framework.

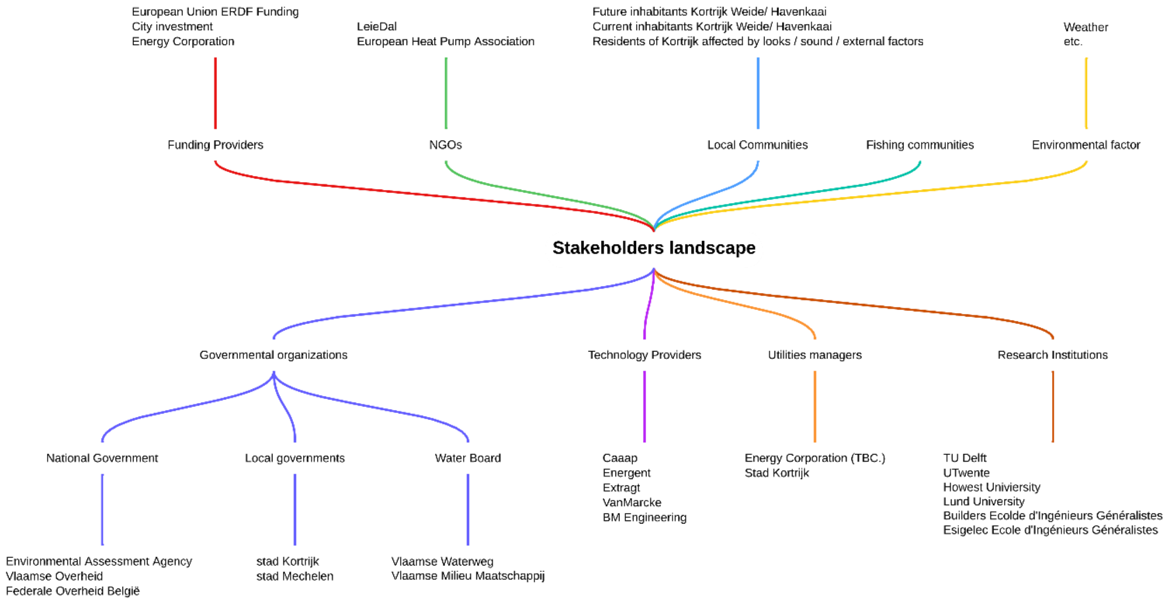

Figure 12 - Stakeholders Landscape Interreg Waterwarmth Kortrijk Havenkaai/Weide (Kortrijk, 2023)

Table 4- Stakeholder distinction

STAKEHOLDER	TRAITS	KEY DISTINGUISHING TRAIT
AQUA THERMAL EXPERT	Technical knowledge and expertise in aqua thermal energy	Combines Technical knowledge of aqua thermal energy and some understanding of public perception
GOVERNMENTAL / CITY EXPERT	Expertise in policy and regulation related to energy solutions	Focuses on shaping public perception and addressing community anxieties
WATER BODIES	Hydrology, ecology, and potential environmental impact of aqua thermal use	Provides expertise on the usage of the water body and sustainability for life under water based on the aqua thermal energy
CURRENT RESIDENT	Current user of heating/cooling systems, potentially impacted by project	Highlights existing user experiences and openness to new solutions
FUTURE RESIDENT	Potential future user of aqua thermal heating/cooling	Focuses on potential user opinions and anxieties

Table 5 - Overview of interviews and focus group

NR.	ORGANISATION	ROLE	SCOPE	ACRONYM
1	City of Kortrijk	Energy manager	City/ Governmental	KEM
2	City of Kortrijk	Financial advisor and energy manager	City/ Governmental	KFE
3	*City of Mechelen*	*Legal expert and energy manager*	*Aqua thermal Expert*	*MLE*

4	EnerGent	Head Grid and social acceptation expert	Aqua thermal Expert	EHS
5	VanMarcke	Aqua thermal expert	Aqua thermal Expert	VMA
6	*Howest*	*Lecturer Internet Of Things*	*Current Resident*	*HL*
7	Advisory Company	Administrative clerk	Current Resident	ACA
8	TrikThom	Energy management system developer	Future Resident	TTE
9	Vives	Student healthcare technology	Future Resident	VSH
10	Howest	Student Energy Management	Future Resident	HSE
11	*UGent*	*Student Product design*	*Future Resident*	*GSP*
12	*KULeuven*	*Student Business Administration*	*Future Resident*	*LSB*

3.3 DATA COLLECTION

To address the main research question on "*the key stakeholder needs, priorities, and concerns when implementing a smart heat grid utilizing aqua thermal energy in Kortrijk, Belgium, to support the energy transition and achieve EU 2030 sustainable heating goals*" and its sub-questions, an outlook on the data collection methods is presented in Table 6.

Table 6 - Overview of data collection and analysis methods (* P. = Primary- & S. = Secondary- data requirements)

Research question (RQ)	Accessing method	Sources and data collection methods	Desired (key) information*	Data analysis method (3.4)
Sub RQ 1 What are the current and past lessons upon how to connect the technical design process of a smart heat grid with stakeholders in the region of North Europe?	Content analysis (Scientific & Grey literature) and an Expert interviews	Scopus, Web of Science, Governmental publications, newspapers, publications of organisations/institutes /universities and semi-structured expert interviews with key figures in the smart heat grid integration	**P. Process design** for integrating societal needs into the technical design of smart heat grids **P. Expert insights** on lessons out of previous/ongoing smart heating projects **S.** regarding stakeholder engagement	An analysis of literature to identify key themes and patterns in stakeholder integration combined with a thematic analysis of transcribed interview data to categorize expert experiences and report from the interviews. The focus mainly lays on a combination of the external network and internal network with a focus on the material dimension of the research framework with the technology.
Sub RQ 2 What are the specific needs and priorities of stakeholder groups regarding the implementation of a smart heat grid in Kortrijk?	Semi-structured interviews and Content analysis (Scientific & Grey literature)	Scopus, Web of Science, governmental publications, newspapers, city publications and semi-structured open ended interviews of stakeholders groups	**P. Specific needs and priorities** of different stakeholder groups regarding the implementation of a smart heat grid with a focus on aqua thermal energy **S. Perspectives** on the inclusion of new and emerging heat sources	a Thematic analysis of the transcribed interview data to categorize stakeholder needs and priorities related to aqua thermal energy and new heat sources combined with a content analysis to identify existing knowledge on stakeholder needs in smart heat grid implementation and lastly a comparative analysis to compare interview findings with the literature. This question mainly focusses on a combination of the external network and material dimension part of the research framework.

Sub RQ 3 What are the most effective strategies for persuading residents and stakeholders in Kortrijk to connect to a smart heat grid, considering their consumption patterns and overall performance?	Focus group and Content analysis (Scientific & Grey literature)	Scopus, Web of Science, governmental publications, newspapers, city publications and semi structured to unstructured focus group brainstorm	**P. Most effective persuasive strategies** for residents and stakeholders to connect a heat grid or new emerging technology **S. Comparison of (visual) data** to gather the most appealing items	A thematic analysis of focus group data to identify preferences regarding persuasion strategies according to a mood board will be held combined with a content analysis of literature to identify existing knowledge on effective persuasion strategies for new technologies. Lastly there will be a comparative analysis to compare focus group findings with the literature. This question mainly focusses on the internal network of the research framework.
Sub RQ 4 What technical, infrastructural, social, and educational elements should be included in the aqua thermal design to further facilitate the energy transition in Kortrijk, Flanders, based on the needs and priorities of local stakeholders?	Content analysis (Scientific & Grey literature) and an Expert interviews	Scopus, Web of Science, governmental publications, newspapers, city publications and semi-structured interviews of key figures with expertise in smart heat grids	**P. Future-proofing elements and niches** in the heating market based on the stakeholder needs and priorities **P. Expert insights** on future-proof installations and technologies S. **Stakeholder awareness** of future proofing	A thematic analysis of the transcribed interview data to identify key points to future-proofing needs and priorities of stakeholders (and residents) combined with a Content analysis to identify existing knowledge on future-proofing elements, social acceptance and niches for smart heat grids and lastly a comparative analysis to compare interview findings with the literature. This question focusses mainly on the external network combined with the internal network part of the research framework.

The sub research questions are exploratory research questions since the project still has to be implemented. The project is exploratory due to the fact that there research is still scarce to test existing knowledge on its correctness, there are new techniques covered which is unfamiliar territory by which limited data is available. Lastly the research will help implementation of the heat grid and try to involve the stakeholders from the start.

To find the best fitting strategies a focus group was held with 4 external persons, 1 aqua thermal expert, a current resident and two future residents. In the focus group conducted a layout of persuading strategies was made together with recommendations. The structure of the focus group conducted can be found in Appendix 3 of the thesis. It consisted of two groups of two people each who, based on their beliefs, set about creating a mood board with good and bad elements that they considered a possible persuasive factor. The focus group produced two completely different mood boards, which the team then merged into one mood board with the key elements, guided by a discussion of the different beliefs.

3.4 DATA ANALYSIS

The collected data is mostly of qualitative nature. As presented in Table 6, the research uses three types of research methods, a content analysis where the found literature is analysed, a thematic analysis where patterns are analysed to identify and extract meaning from the data, interviews and the focus group combined with a heuristic stakeholder analysis which reports the data transparently to limit bias. Lastly a comparative analysis to compare the interview/focus group results with the thematic/content analysis.

Once the interviews, the focus group and the literature analysis were conducted, the responses were analysed and separated to identify the three key factors (external network, material dimension and internal network) outlined in the framework that shape each stakeholders perception. This is presented in the results and findings section.

The total of 9 transcripts created in this study together consist of 62.917 words, totalling 131 pages of text and an average transcript length of 6400 words. To analyse these transcripts, a thematic analysis is employed, guided by the theoretical framework. A combination of inductive and deductive coding is used. For the deductive coding, the three preliminary codes based on the theoretical framework are used: the external network, internal network and material dimension. Additionally, inductive coding is used to generate new codes for themes and insights that emerged during the coding process.

4 RESULTS AND DISCUSSION

As one of the aims of this research is to investigate the perception by current and future inhabitants and also other important stakeholders and/or professionals, three complementary approaches have been used: a literature review (Qualitative), an Interview (Qualitative), and a focus group (Qualitative) approaches. In this chapter, the data and analysis based on these three methods will be presented. With the conducted interviews, the results are split up into different sections based on the type of stakeholder where the interview is conducted from and the research energy initiatives framework.

4.1 CURRENT AND PAST LESSONS UPON THE TECHNICAL SMART HEAT GRID CONNECTION

The first sub question of the thesis is 'What are the current and past lessons upon how to connect the technical design process of a smart heat grid with stakeholders in the region of North Europe?' To connect the technical design with the societal actors in Kortrijk the three elements from the energy initiatives framework can be combined which are the internal network, external network and material dimension (specifically technology).

The literature review offers the first insights in the connection between technical design and the societal actors. The crucial factors that need to be considered during the design phase when integrating societal needs were highlighted and are further evaluated during the interviews. Due to the fact that North European aqua thermal systems are not that commonly researched, a connection between technical and social aspects is carried out with expert interviews.

4.1.1 Internal network

The internal network deals with the inner workings of the heating initiative (Van der Schoor et al., 2023). According to the experts interviewed, social acceptance is the most critical factor for the uptake of this new technology, where concerns about potential environmental impacts, affordability and appearance need to be addressed as soon as possible through substantiated publications (EHS). The city expert highlights the importance of residents' priorities such as ease of use, cost and noise levels to show that these systems are still clearly in the development phase.

In order to link technical design and new technologies with 'ordinary people', the experts stress the importance of communication with residents (VMA & KEM). According to the city expert (KEM), this can be achieved by involving resident groups in the decision-making process.

The literature review is consistent with Van Der Schoor et al. (2023) in emphasising the importance of a core group with access to resources for project success. Although this isn't explicitly mentioned in the interview findings, the emphasis on resident involvement and communication by the experts (VMA & KEM) suggests an emerging understanding of the importance of the internal network. Cultivating a core group that encourages resident participation and bridges the gap between residents and technical experts will be critical to project buy-in and long-term sustainability.

4.1.2 External network

The external network includes the relationships between the local heating initiative and external organisations, both public and private, such as development plans (Van der Schoor et al., 2023). According to the interviewees, financial incentives are crucial for the participation of residents (EHS, KFE) in local heating initiatives. Here one of the experts (KEM) points out that in Nordic countries such as Denmark and Sweden a start-up grant of 40% of the project costs can be given to the project and to the people who join the project and keep their share in it. This shows that offering investment opportunities in renewable energy projects can create a sense of ownership and economic benefits. One of the experts working in Mechelen, Flanders (MLE) states that "the optimal ownership model for heat networks (public, private or municipal) has yet to be determined, but transparency and credibility are essential", with the intention of making a possible financial model manageable.

The interviews cite failed projects such as the Bruges underwater heat network and successful projects such as the Kuurne, Flanders waste incinerator (KFE, VMA). They also highlight the potential of Positive Energy Neighbourhoods to connect aqua-heating with actors, where renewable energy production exceeds residents' needs and can then be sold to wholesale consumers further afield. This can address residents' concerns about affordability, and a just transition for those on lower incomes should be addressed (KFE).

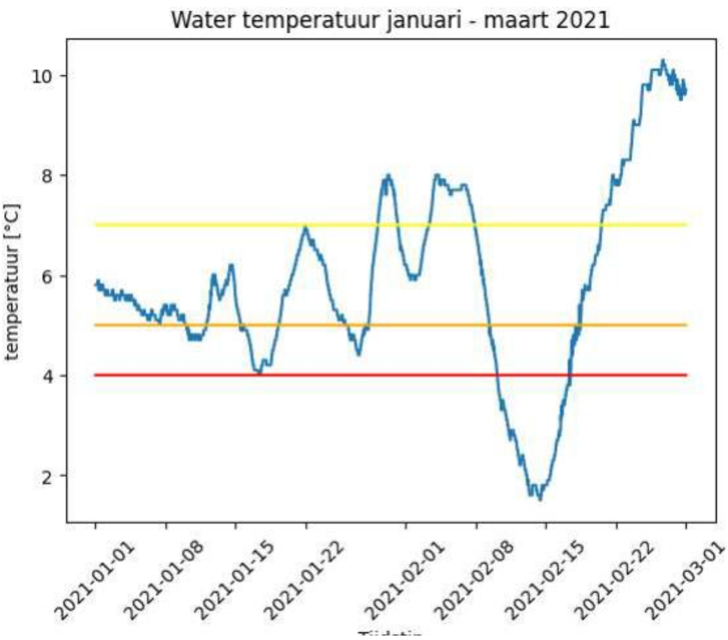

Figure 13 - Lys Water Temperature between January and March (City Expert Interview)

One of the city experts (KEM) mentioned the water temperature graph (Figure 13). Aquathermy is only interesting above 7°C. In the period between January and March, when people need heat the most, aquathermy can produce the least heat. For this reason, it is always necessary to work together with other renewable technologies, such as geothermal energy, which extracts heat from the earth's layers.

The city experts (KEM, KFE) would also like to own and operate the heat network themselves, which is connected to the various stakeholders, so that there is a good first impression for future projects and a benchmark can be set. However, this is not really feasible as it would require a new team member (KEM).

The literature review is in line with the framework by highlighting the role of public actors (municipalities) in granting permits, subsidies and spatial planning (Van Der Schoor et al., 2023). The interview results reinforce this notion, with city experts (KEM, KFE) expressing a desire to own and operate the heat network. This suggests a proactive role for the city within the external network. In addition, the mention of financial incentives in Denmark and Sweden (by EHS) points to the potential involvement of external financial institutions, underlining the need for a well-developed external network to navigate different stakeholders and secure funding.

4.1.3 Material dimension

The material dimension refers to the physical aspects and technological capabilities required for the project (Van der Schoor et al., 2023). The literature review found that technical aspects such as network design and heat consumption patterns need to be considered alongside the implementation of a heat network (Novelli et al., 2021). This is combined with the analysis of consumption patterns and building insulation types, which can be used to understand user needs and thus design the aqua thermal system accordingly (Pengwei et al., 2019).

According to the experts, the technical feasibility of linking the smart heat grids with aqua thermal and geothermal is certainly there (VMA). However, this comes with the necessary economic uncertainties about the overall lifecycle and water conditions of the river to be captured, which may affect the heat exchangers in the system (EHS).

The literature review follows Van Der Schoor et al. (2023) in emphasising existing infrastructure, technical feasibility and the importance of sustainable technologies. The critical role of data analysis on consumption patterns and building insulation for network optimisation is also highlighted. The interview results complement this by acknowledging technical feasibility (VMA) but raising concerns about economic uncertainties and water quality. The experts (KFE, VMA) who mention river temperature limitations and the use of geothermal energy as a back-up underline the importance of considering the complexity of the material dimension. Furthermore, the failed and successful projects discussed in the external network (by KFE, VMA) provide valuable lessons from past experience with this technology.

4.2 SPECIFIC NEEDS AND PRIORITIES STAKEHOLDER GROUPS FOR IMPLEMENTATION

The second sub question of the thesis is 'What are the specific needs and priorities of stakeholder groups regarding the implementation of a smart heat grid in Kortrijk?' Considering the specific needs and priorities of the stakeholder groups regarding the implementation of aqua thermal energy and heat grids for Kortrijk connects the material dimension and external network part of the research framework.

There are different stakeholder groups present in the Kotrijk Weide / Havenkaai area with each their needs and priorities consisting of public buildings, a private swimming pool, houses (with future inhabitants) and school buildings. Therefore there is a distinction made in between the types of stakeholders described under the external and material dimension of the research framework by Van Der Schoor et al. (2023).

4.2.1 External network

The external network includes the relationships between the local heating initiative and external organisations, both public and private, such as development plans (Van der Schoor et al., 2023). Based on the different building types each of the stakeholders have varying needs and priorities for the implementation of an aqua thermal smart heat grid The resident housing, public city buildings, school buildings and businesses relate the most to the external network and are described in Table 7.

Table 7 - Needs and priorities stakeholder groups External network

STAKEHOLDER GROUP	NEEDS AND PRIORITIES IMPLEMENTATION AQUA THERMAL HEAT GRID
RESIDENT HOUSING	The needs and priorities with the current and future residents of the Kortrijk Havenkaai area encompass different elements which are related to the items found in the literature review. The main concerns thus needs and priorities for residents based on the interviews are: • **Cost:** Affordability is a primary concern. Residents are more likely to participate if the heating network is cheaper than their current systems. (ACA, MLE) • **Efficiency:** Residents want a system that offers good value for money and reduces energy consumption. (TTE)

	• **Comfort:** Easy to use with minimal maintenance and reliable heat supply. (ACA, EHS) • **Information:** Clear and accessible information about the system's operation, subsidies, and benefits. (VSH) • **Transparency:** Residents want to be aware of the annual maintenance costs and how they are distributed. (ACA, TTE) • **Ownership:** Preference for a public institution like the city to own the network due to concerns about profit-driven pricing by energy companies. (TTE, ACA, HSE) An interesting quote from one of the residents that stood out was "More education and awareness is needed about the benefits of smart heat grid energy corporations" by which he meant that he did not hear from it in the past even though he lives close by. By the public there is also a "Scepticism about reliability of large energy companies" in providing their so called green energy which has to be further communicated.
PUBLIC CITY BUILDINGS	According to the interviews conducted with the city experts, the public city buildings require a different set of variables by which they try to enhance their image, their performance upon the regulations, their role model of being an enforcer and their CO_2 emissions reduction incentives. The City expert (KEM) also stated the following: "There is a strong consensus among stakeholders that there is a need for green solutions for heating and cooling in Kortrijk" which further entails the main needs and priorities of city buildings are: • **Sustainability:** The city prioritizes reducing CO_2 emissions and achieving climate goals through a sustainable energy supply in their own buildings. (KEM) • **Policy Framework:** The city made a renovation service where people can go to let them be advised of plausible (cheap) energy savings to reach the CO_2 emissions goal which also encourages and simplifies investments in green energy projects. (KFE) • **Financial incentives:** The main need for the city is that the government needs to provide subsidies, interest-free loans, and guarantee funds to facilitate the transition for residents. (KFE)
SCHOOL BUILDINGS	Technical schools care about how systems work and how their own system can be implemented in their lectures, stated by one of the residents. Others may just need the cheapest heat to make as much profit as possible which leads to the two most important needs: • **Cost-effectiveness:** Similar to residents, schools would likely prioritize a system that is affordable and reduces their energy consumption. (HL) • **Efficiency and Comfort:** A reliable and easy-to-use system that ensures a comfortable learning environment with minimal maintenance burden. (VMA)
BUSINESSES	The majority of small to medium scaled (and even large scaled) businesses are concerned about their product sales and thus lays their main need in cost effectiveness.

- **Cost-effectiveness:** Businesses want a system that helps them manage energy costs and reduce their carbon footprint. (VMA)

The interviews show that residents prefer the involvement of the city, which indicates the importance of trust and public ownership (KEM, KFE). This is in line with the literature review, which emphasises the role of public actors such as municipalities in granting permits, providing subsidies and influencing project development through spatial planning (Van Der Schoor et al., 2023). Financial incentives from government agencies are also seen as crucial by residents (ACA, MLE, TTE, VSH, HSE), underscoring the need for collaboration between public and private actors to secure funding and ensure project viability.

The expertise and resources required for project development and operation require the involvement of a wider external network. The literature review highlights the role of private actors such as consultants, contractors and financial institutions in providing expertise and management solutions (Van Der Schoor et al., 2023).

4.2.2 Material dimension

The material dimension focuses on the technological aspects and the physical infrastructure required for the aqua thermal system. The interviews highlight the residents' desire for a user-friendly system with minimal maintenance requirements (KFE, VMA). This suggests a focus on user-centred design principles and readily available technical support.

The literature review highlights the environmental benefits of aqua thermal energy, including reducing dependence on fossil fuels and cooling rivers threatened by rising temperatures (Life-Sparc, n.d.; Wolsink, 2012). When selecting and implementing the technology, it is important to consider its adaptability to future advances to ensure the long-term viability of the project (VMA, MLE).

The energy supplier or energy corporation is responsible for the supply of heat in a heat network to the customers, who are all the above-mentioned actors in the external network. Their main needs, according to the aqua-thermal experts (VMA, EHS), are network efficiency and low maintenance costs. They see an opportunity to manage their network more efficiently and potentially offer new services to customers (VMA). The lower the maintenance, the higher the potential revenues and the lower the costs for the stakeholders involved (EHS). An interesting quote on the city expert interview stated: "People want a heating system that is easy to use and requires little maintenance" meaning that systems may not be complex and just need to operate by which the energy supplier can succeed.

The long-term financial viability of the project is essential (EHS) and can only be achieved through cooperation between all stakeholders, including residents, government agencies, heating companies and developers (VMA). In addition, the technology must be adaptable to future developments (TTE). An important external factor is the environmental impact, including water consumption and potential disturbance caused by the aqua thermal energy, for which stakeholders stated that "cost is an important factor for all stakeholders", but "financial incentives are crucial to convince residents to participate in green solutions" that needed to be trusted.

4.3 MOST EFFECTIVE PERSUATION STRATEGIES

The third research question of the thesis is 'What are the most effective strategies for persuading residents and stakeholders in Kortrijk to connect to a smart heat grid, considering their consumption patterns and overall performance?' To connect to a smart heat grid where most of the actors/ residents never heard from will only be adopted by the so called early adopters who try to be in touch with the latest technologies and developments. Therefore there is a need of persuading strategies. These entail the basis of people connections and cover the internal network in of the research framework which deals with the inner workings of the initiative and the people that run the project and are closely connected to it (Van der Schoor et al., 2023).

During the focus group, conducted with MLE, HL, GSP and LSB, it became clear that effective persuasion for green technologies is needed combined straightforward communication that avoids overpromising. The importance of demonstrating the benefits, such as emissions and pollutant reductions, to justify the transition were also emphasized.

Financial factors were also crucial as there was found that affordability, reliability and comfort were the most important factors. A consensus emerged from the focus group: "As long as you have heat in your home when you want it, that it is not expensive and that it is reliable, we are happy". If a green system is significantly more expensive than a gas system, people are not interested in switching.

Figure 14 - Result Focus Group conducted on 19-06-2024

Communication wise the focus group came up that it is needed to convince people by simple posters, stickers and campaigns to make it clear to residents and passers-by that the new technology is attractive to invest time and money in.

A final factor was the importance of interconnection: "TV has been telling us for years that everything can be connected, and a heat network that provides us with heat should be a big step forward" (LSB). The foursome felt that interconnection was important because it would make life easier. However, it was also mentioned that the noise level is the deciding factor for many. It should be quiet".

The results of the focus group are reflected in Figure 14. Combining the data from the focus group with the expectations from the literature review, it can be concluded that the environmental aspect, reliability, efficiency, possible economic benefits, transparent and clear communication all play a role in the implementation of a project and in the involvement of current and possibly new residents in the new project. It is therefore a collection of different elements.

In the focus group, additional elements such as interconnection and CO2 rates versus costs were mentioned. Based on the literature review, one factor that was not mentioned in the focus group was efficiency and local impact (Li et al., 2021). If the consumption patterns of residents and stakeholders in Kortrijk are considered the most effective strategies for persuading can be placed in the internal network of the framework outline in order to provide a sufficient answer.

The findings from the focus groups are consistent with the established literature on public persuasion for smart grid initiatives. Both emphasise the importance of transparent communication (Ellabban, 2016; Biao et al., 2023). The focus group highlighted the need for clear and straightforward messaging that does not make unrealistic promises. This is consistent with the literature's call for the benefits of technology to be explained in an understandable way (Biao et al., 2023).

In addition, both the focus group and the literature review identified cost as a critical factor (Becker et al., 2023; Flanders, 2023). Focus group participants highlighted affordability as a key concern, which is consistent with the literature's suggestion of financial incentives such as subsidies or rebates (Biao et al., 2023).

The focus group's emphasis on clear communication is consistent with fostering trust and transparency within the surrounding network. The framework also emphasises community involvement, which can address concerns raised in the focus group, such as noise levels. By actively involving residents in the planning process, these concerns can be mitigated, fostering a sense of ownership and support for the project (Mazzotta et al., 2009). The focus group discussion did not explicitly mention efficiency or local impact, which are highlighted in the literature review and framework.

In addition, the focus group highlighted the importance of aesthetics and connectivity, suggesting that residents prefer visually appealing and well-integrated systems. These aspects can be considered at the design stage to increase project acceptability.

4.4 FACILITATION OF FURTHER ENERGY TRANSITION

The fourth exploratory research question is “What technical, infrastructural, social, and educational elements should be included in the aqua thermal design to further facilitate the energy transition in Kortrijk, Flanders, based on the needs and priorities of local stakeholders?” The future needs and priorities have different viewpoints based on the stakeholder groups and their background in life. To facilitate the energy transition the external network of the research framework is combined with the internal network and further entailed. In the facilitation of the future energy transition collaboration in between all stakeholders is keen (KEM). Each of the stakeholders groups profiles them in one of the two networks. The internal network which entails the inner workings of the initiative and the people that are closely connected to it (Van der Schoor et al., 2023) was mainly answered by the current and future residents. The external network of the framework mainly entailed answers of the experts.

4.4.1 Internal network

In order to facilitate the technical, infrastructural, social and educational future energy transition, the interviews with current residents highlighted the need for a cost-effective future with a high level of comfort. This can be achieved through financial support in the form of what the interviewees call subsidies or financial support programmes for early adopters and a good assessment of the reliability of the system in order to set up a combined maintenance plan (ACA, KFE).

Future inhabitants have a different view on the energy transition. For them, the most important factors are sustainability and flexibility. This means a sustainable heating solution, be it aqua thermal or something else that is reliable and can be integrated into future smart homes where all appliances are interconnected to ultimately save on energy and heating costs. These can also be hybrid systems (TTE, VSH, HSE).

Both the interviews and the literature review highlight the importance of cooperation between different stakeholders in the external network to facilitate the energy transition.

In the interviews, residents prioritise financial support (subsidies), which can be obtained through cooperation with the government (government/city expert). In addition, experts recognise the need for public-private partnerships to leverage expertise and resources (government/city expert).

Yang et al. (2020) highlight that techno-economic analysis, which requires collaboration between stakeholders, is crucial for successful aqua thermal projects, especially for attracting energy companies. Furthermore, studies by Rossi et al. (2010) and Sarma et al. (2023) highlight the importance of regulatory frameworks that support project viability, which can be achieved through collaboration between public actors and energy companies. Smart heat networks through collaboration between stakeholders can lead to lower energy bills through increased efficiency (Sarma et al., 2023).

4.4.2 External network

Studies by Wyrwicka et al. (2023) and Hoppe et al. (2024) show that EMS are key tools for optimising energy use and grid integration of renewable energy sources. In addition, Wyrwicka et al. (2023) show particular promise for EMS applications in aqua thermal energy systems. Financial models such as subsidies are essential to ensure accessibility of projects to different income levels (Rossi et al., 2010).

The literature review highlights the potential negative impact of aqua thermal energy on the ecosystem due to temperature fluctuations in water bodies (De Vlaamse Waterweg, n.d.). This aspect requires careful consideration during project development.

In order to facilitate the technical, infrastructural, social and educational future energy transition, the interviews with the aqua thermal experts highlighted that efficiency and integration are the two main focus areas for further energy transition. By improving system heat extraction from the water, exploring interconnection with other renewables and special techniques to mitigate temperature fluctuations, the system could be optimised and further developed into a viable business case (EHS, VMA).

Based on the city interviews, the policy and implementation part is the main element for this stakeholder group to focus on. This involves the establishment of new regulations (to further develop smart heat networks), a template for easy application to other projects, a public-private partnership fund to finance the initial higher installation costs and an investment in feasibility studies combined with further infrastructure development (KFE).

Both the interviews and the literature review recognised the role of smart technologies in facilitating the energy transition. Experts highlighted the potential of energy management systems (EMS) to optimise the use of aqua thermal energy (aqua thermal expert). Residents prioritise cost-effectiveness and financial support programmes (ACA).

Based on the results of the interviews, two niches stand out and are considered to be emerging by the experts, namely energy management systems and the Finnish heating system, which according to the expert combines a heat pump, wood stove/boiler and geothermal drilling. The need for energy management systems has been studied for a long time (TrikThom, 2024), where dynamic peak shaving, efficiency and diurnal balance, heat production when renewable energy is available and controlled storage are central. However, these techniques are still in their niche phase and not yet significant enough to be integrated into current large-scale projects. The literature describes that over 400 new technologies are emerging and that proof of concept will ultimately win the renewables race (IPCC, 2020).

5 CONCLUSION

This exploratory thesis describes the implementation of an intelligent heat network with aqua thermal and electric energy in Kortrijk, Belgium, taking into account the needs and requirements of stakeholders in the context of the energy transition and EU sustainable heating targets. Using a qualitative approach with a combination of literature review, interviews and a focus group with experts and (future) residents on stakeholder needs and priorities. The internal, external and material dimensions of Van Der Schoor et al. (2023) as a basis for the theoretical modelling research. The three main networks (internal, external and material dimensions) were used to collect and analyse all the data.

The research question of what are the key stakeholder needs and priorities for the implementation of a smart heat grid using aqua thermal energy in Kortrijk, Belgium, to support the energy transition and achieve the EU 2030 sustainable heating targets, can be answered based on the different stakeholder research. Before considering the needs and priorities for the implementation of a smart heat grid, it is important to identify the different stakeholder priorities and a research framework.

Based on the research framework, it can be concluded that the successful implementation of a smart heat grid using aqua thermal energy in Kortrijk requires a balanced approach that integrates technical design, social actors and external network elements. There is an emphasis on linking technical design and social actors with a combined approach that integrates internal network elements (resident involvement), external network elements (permits, subsidies) and the material dimension (technology) within the research framework (Van Der Schoor et al., 2023).

Internal network

In Kortrijk, the involvement of stakeholders and residents is a critical factor for the success of a smart heat network. Transparent communication and clear information dissemination are essential to build trust and gain stakeholder support. The results highlight the role of communication with residents and their involvement in decision-making processes to achieve acceptance of the technology and new technologies in general (Mazzotta et al., 2009). In addition, financial incentives were identified as an important factor in encouraging resident participation in the project (Biao et al., 20-23).

The study highlights the importance of using effective persuasion strategies to gain stakeholder buy-in. Transparent and straightforward communication that avoids unrealistic promises is essential for building trust (Ellabban, 2016; Biao et al., 2023). By visualising the environmental benefits of aqua thermal technology alongside the potential cost savings on energy bills, visual understanding can be gained (MLE, HL). Financial incentives such as subsidies or rebates can significantly influence residents' decisions (Biao et al., 2023). Open communication creates trust and transparency within the internal network, while involving residents in the planning process can allay concerns and foster a sense of ownership (Mazzotta et al., 2009). The study also suggests that residents have a preference for aesthetically pleasing and well-integrated systems.

External network

The research identified different needs and priorities for different stakeholder groups. Residents prioritise affordability, efficiency, comfort, clear information, transparency and public ownership of the heat network (ACA, MLE, TTE, VSH, HSE). Public buildings prioritise the inclusion of sustainable solutions, supportive policy frameworks and financial incentives (KEM, KFE). Schools require cost-effectiveness, efficiency and systems that provide a comfortable learning environment (HL, VMA).

Businesses prioritise cost-effectiveness in terms of managing energy costs and reducing their carbon footprint (VMA).

Collaboration between stakeholders is emerging to facilitate further energy transformation. Supportive government policies and regulations are needed to encourage the development and implementation of smart heat networks (Rossi et al., 2010; Sarma et al., 2023). Public-private partnerships can bring together the expertise and resources of different actors (Yang et al., 2020). By adopting a new project, support for early adopters can be gathered, according to the experts (EHS, VMA).

Material dimension

In the Kortrijk landscape, heat companies responsible for delivering heat to customers prioritise network efficiency and low maintenance costs for long-term viability (EHS, VMA). The environmental benefits of aqua thermal energy, such as reducing dependence on fossil fuels and cooling rivers threatened by rising temperatures (Life-Sparc, n.d.; Wolsink, 2012), are another need.

One forward-looking finding of the study is the potential of energy management systems (EMS) to optimise the use of aqua thermal energy and improve overall efficiency (Wyrwicka et al., 2023; Hoppe et al., 2024). From the 400 new technologies, the most economically viable solutions will become the leaders for future development (VMA). Thus, through cooperation between stakeholders, the energy transition can be addressed with new technologies such as aqua thermal energy. By combining the different ways of thinking of the different stakeholders in future-proofing the energy industry, smart heat grids can be successfully implemented. However, improving the efficiency of the system remains an important objective. It can also be concluded that this project has the potential to make a significant contribution to achieving the EU 2030 targets for sustainable heating in Kortrijk. However, careful consideration of stakeholder needs and continuous development are essential for long-term success.

5.1 LIMITATIONS AND FUTURE RESEARCH

A limitation of this study is the lack of in-depth examination of the legal and regulatory framework due to the pilot nature of the study. Although not the primary focus, legal considerations are crucial for project development. Ongoing research by the Flemish government into the potential drawbacks of large-scale implementation of aqua-thermal heating highlights the need for a comprehensive legal framework to mitigate risks and encourage wider uptake (INBO, 2023).

Another limitation is that only one technology is considered, rather than combining several 'green' technologies in one system and examining their potential alongside other renewable energy sources, such as solar, which could provide a more holistic perspective. Research by Sultan et al. (2023) suggests that combining green thermal energy with green electricity creates a more robust and flexible renewable energy system. In addition, Huang et al. (2023) suggest exploring the potential for combined heating and cooling solutions, although such complexity may require careful communication to ensure public understanding.

In addition to the limitations identified within the research itself, several external factors also constrain research. The political landscape can have a significant impact on the implementation of aqua-thermal energy systems. Uncertainty remains around the next local election (October 2024) and the federal election, which was held in June 2024 but had not produced a result at the time of publication. This could affect policy decisions and financial support.

In addition, a more comprehensive cost-benefit analysis, combined with a calculation of CO2 emissions savings, would be required to convince potential customers. The research clearly shows that aqua-thermal energy offers long-term benefits, but the up-front costs may be a barrier to implementation. In addition, price fluctuations combined with the under-taxed Belgian gas prices make ATES less attractive. The environmental impact of aqua-thermal cooling also requires further research, as it may ultimately increase river temperatures.

Finally, it was not possible to make contact with the Flemish waterways to arrange an interview to find out their view on renewable heating systems using the water flow of the Lys or other waterways.

Despite these limitations, aqua-thermal energy remains a promising technology for sustainable heating and cooling, which is why it is currently being implemented in the large-scale project. Addressing the limitations, conducting further research on technological improvements, social acceptance, cost benefits and water aspects, together with the development of a supportive policy framework can pave the way for its successful implementation throughout Flanders.

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APPENDIX 1 – EXPERT SEMI STRUCTURED INTERVIEW

1. Age, Place of birth, home heating system, (Years lived in Kortrijk/Experience with Kortrijk: Belgium), level of education. Actual or given by selection.
2. Kortrijk: My thesis research focuses on understanding residents' awareness and perspectives on future-proofing their homes in Kortrijk, particularly with regard to heating systems, smart heat grid integration and .
3. If you are considering renovating or upgrading your home, how important is it to make your heating system energy efficient?
4. Views on green energy/renewable energy sources (for/against/neutral)
5. Do you see an energy community as a viable alternative?
6. How do you usually stay informed about local infrastructure projects?
    a. Think booklet city, ...
7. What is your priority in implementing the project with regard to heating/cooling and the smart heat grid (or other)?
    a. Looks, cost, operation, owner, noise
8. Are you appointed to own a plant or is having and being able to rent also an option?
9. What do you think needs to be done to future-proof to future energy targets?
    a. How do you see these needs and priorities evolving in the coming years, taking into account the energy transition objectives?
10. Looking at the new project that is o implementation, how does the cost of the technical installation with aquathermy compare to the cost?
    a. Is this a feasible initiative towards the future?
        i. Are there any specific technical challenges associated with integrating aqua thermal energy compared to other renewable energy sources?
11. Looking back on your experience in this project and previous projects, what key lessons have you learned about connecting technical design with stakeholder engagement for smart heat networks with aqua thermal heating?
    a. Follow-up based on answer:
        i. What recommendations do you have for the future to improve collaboration and ensure successful implementation?
        ii. Are there any emerging trends or technologies that you think will affect the future of integrating aqua thermal heating with smart heat networks?
12. From a financial point of view, how feasible is it to use aqua thermal energy as the primary heat source for the smart heat grid in Kortrijk?
13. Are there any other elements/technologies that the energy transition should include in the cooling/heating of homes/businesses that you personally care about
14. In your experience, what are the main needs and priorities of stakeholders (residents and businesses) in Kortrijk in terms of heating solutions?
    a. How do you see these needs and priorities evolving in the coming years, taking into account the energy transition objectives?
15. Are there aspects of WaterWarmth that could be adapted or expanded to better integrate with these emerging solutions?
16. Is there anything else you would like to add with regard to facilitating the energy transition in Kortrijk, especially with regard to niche markets and residents' needs?
17. End: Extra question; would you join a heat network if you did or did not have your own heating appliance?

Questions towards a person that is delved thru in heat pumps

18. Would it be best feasible to integrate a low temperature Heat grid? Or a high temperature heat grid
19. Based on your expertise in future-proof installations and technologies, I'd like to understand your perspective on niches within the heating market.
20. Do you think aquathermy is the solution/one of the solutions to go forward?

APPENDIX 2 – CURRENT AND FUTURE RESIDENTS SEMI STRUCTURED INTERVIEW

- Age, Location of birth, heating equipment at home, (Years of living in Kortrijk/Experience with Kortrijk: Belgium), educational background. Factual or given by selection.
- Shortly: My thesis research focuses on understanding resident awareness and perspectives on future-proofing their homes in Kortrijk, particularly regarding heating systems, smart heat grid integration and .
- Have you heard about any initiatives or projects in Kortrijk related to future-proofing homes or buildings for energy efficiency? (e.g., WaterWarmth)
- When considering potential renovations or upgrades to your home, how important is future-proofing your heating system for energy efficiency?

First I want to ask a couple of questions

- Stances towards green energy
- Stances towards Renewables
- What does your environmental management look like (Amount of insulation at home/ …)
- How do you typically stay informed about local infrastructure projects?
- How do you think as an out stander about taking water from Lys regarding the quality and temperature of the water and the possible solution to pollution
  - Should there be a cost involved
- What do you think about the renew of Kortrijk Havenkaai with green energy sources
- What do you think is your priority considering the project's implementation regarding heating/cooling and the smart heat grid (or other)
- Are you reluctant to own an installation or is having it and being able to rent it also an option?
- Do you have any needs and priorities regarding the implementation of a smart heat grid?
- Can there be more returning costs involved if a technology is green?

For people with a more technical standpoint that was given during the interview:

- From a technical standpoint, how feasible do you think is utilizing aqua thermal energy as a primary heat source for the smart heat grid in Kortrijk havenkaai/weide? (In combination with the current heat grid)
- Are there other technologies you would prefer to see in the implantation fo the smart heat grid?

END UP

- Last: Concerns and questions: Do you have any concerns or questions about the smart heat grid project, such as potential disruptions during construction, costs involved for residents, or long-term maintenance?

APPENDIX 3 – FOCUS GROUP

The focus group was planned based on a schedule. The interpretation was done during the day.

1. Introduction (2 minutes):

- Welcome
- Introduction to the project
- Explanation of the working methods of the focus group.

2. Icebreaker (5 minutes):

- Short question round about their heating habits and energy consumption.

3. Perceptions (5 minutes):

- What are your feelings about the smart heat grid concept in Kotrijk Havenkaai.

4. Mood Board Creation – 2 to 3 person teams (10 minutes):

- Instruction to start to draw an outline of their most convincing element to switch technologies and participate in the project an outlook is gathered
- With the instructions they can come up with "easiest way" to convince current and future to switch to the smart heat grid (considering the personality types)
- This can be on paper or on pc (canva or other program if they want to)

5. Group Discussion & Comparison (10 minutes):

- Discussion to compare and contrast the different approaches that is coordinated by me
- After the discussion it is important to identify together the common themes and key takeaways.
    - Factors like communication channels, incentives, and community engagement need to be concidered.

6. Wrap-up & Thank You (3 minutes):

- Thank you
- General information what will be done with the collected data

ETHICAL CONCIDERATIONS

During the research project and the thesis, the ethical standards provided by the University of Twente Research Ethics Policy (2022) are followed and respected to ensure as least problems are overcome as possible. To keep the bias to a minimum, the research makes use of scientific research, grey literature as well as interviews, to take multiple perspectives into account in making the considerations of the report.