Interreg North Sea

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WaterWarmth

WORKPACKAGE 6
Governance of collective energy systems

6.3 Barriers and opportunities to AE system development: insights from WaterWarmth pilots

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ACCELERATING THE TRANSITION TOWARDS SUSTAINABLE HEATING AND COOLING BASED ON COLLECTIVE SURFACE WATER HEAT PUMP SYSTEM

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Project WaterWarmth
20 partners from 6 countries: Sweden, Denmark, Germany, The Netherlands, Belgium, France
Lead partner Province of Fryslân
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A GREEN TRANSITION

WATER = WARMTH

Report Summary

The main research question that guides the analysis for this Work Package 6 Deliverable 6.3 report is: What are the barriers and opportunities that govern niche development and scaling of aqua thermal energy (AE) systems? In answering this research question, we map and analyze the enabling policy and opportunities that support AE system niche development, as well as policy that can also play a role in up-scaling and out-scaling of AE systems and practices through demonstration pilots. The report also identifies barriers that (could potentially) hinder AE system niche development. The focus of the report is on the AE pilots of the Interreg North Sea WaterWarmth Project and is therefore primarily based on interviews and pilot text documents. We compiled a set of key questions that were designed to explore issues related to governance and implementation of renewable energy systems. For this report we particularly explored issues about the tensions and challenges faced by the pilots as well as enabling factors that lead to successes in the implementation and scaling of their projects. We studied nine pilot projects using an exploratory multi-case study approach. The first questions for mapping the AE projects were asked to the pilots in an on-line online survey April 2024. A workshop was then held in Caen May 2024 and in the next step semi-structured interviews were carried out with key respondents involved in the nine pilots during the Fall of 2024. The results are first analyzed case-by-case, and then a multi-case synthesis is presented followed by conclusions and policy recommendations.

Results show that all the nine pilot projects have experienced several barriers that hinder AE niche development but also referred to important enablers. *Policy and regulation* barriers were observed in all cases. Lack of clear policy and regulations included complex regulations and inconsistent policies for AE systems. *Working closely with policy and governance stakeholders* was regarded as an enabling factor in developing the projects, especially at the early phases. Having no *internal vision* was considered a barrier as it leads to difficulty in formulating a business plan that in turn may hinder securing funding. Lack of *financial support* is in turn one of the key barriers for the projects having challenges in securing bank guarantees for equipment and operation costs as well as permitting costs. The novelty of the technology in some countries also created barriers in convincing permitting authorities and finance stakeholders about project viability. Further, lack of *expertise* was seen as something that could be overcome through *sharing experiences* with similar projects in the same regions or in other countries. Exchange of lessons lead to strengthening of the project and peer-to-peer feedback. S*upport of fossil fuels* by governments reduces subsidies for innovations such as AE systems and leads to lack of incentives for adapting AE or large-scale collective energy systems and is therefore regarded as unfair competition for renewable energy alternatives. Reluctance and *lack of acceptance of AE* technology due to skepticism about renewable energy technologies is also a hindrance to AE development. Finally, lack of *public awareness* is a related barrier which can partly be attributed to key stakeholders withholding information that could benefit the projects through information exchange. Regarding enablers, *networks and stakeholder collaboration* were regarded as fundamental in the implementation and success of projects. Good communication with these stakeholders was also seen as a key success and an enabling factor to ensure a full understanding of the project details and expectations.

Through this analysis of barriers and enablers a solid basis is created for mapping and developing insights into how to resolve such hurdles, which is also a key component of the coming WP6 report D6.4., which will present a key vision, strategy and transition policy pathways. This may include developing and implementing specific policy instruments or policy mixes, or by using networking and participatory arrangements.

1. Introduction

1.1 Interreg North Sea WaterWarmth project and WP6

Interreg North Sea WaterWarmth is a project funded by the European Union (EU). The project aims to raise awareness about the potential of aquathermal energy (AE) so that more energy cooperatives and other actors can utilize this sustainable energy source. The movement to greater AE system use has the benefits of reducing carbon dioxide (CO_2) emissions, decreasing air pollution, contributing to energy system diversification and localisation, and the more efficient use of energy and resources. WaterWarmth achieves this through collaboration with over 20 project partners in six EU countries: Sweden, Denmark, Germany, The Netherlands, Belgium, and France, across six work packages, ultimately aiming to provide the knowledge necessary for collective energy initiatives. These work packages include researching how to intelligently utilize the local energy system, scaling, and facilitating regulations and permits. The project lasts from June 2023 to September 2026 and has a total budget of roughly €8 million.

This report presents work from **Work Package 6: Innovation and Governance** (WP6). The objective of WP6 is to develop a framework for the analysis of current governance (arrangements), policies and stakeholder involvement in AE developments. This is done through conducting a literature study, collecting empirical insights from real-world use cases, data analysis (reflecting on case material using an analytical framework), mapping and assessment of governance arrangements and enabling policies, identification of barriers that can hinder AE system niche development, and co-designing AE “visions” with regional authorities and related stakeholders. The work presented in this report addresses an empirical study on *barriers and opportunities* regarding governance and innovation observed in WaterWarmth pilots **(Deliverable 6.3**).

1.2 Background

AE systems refer to the extraction, storage and distribution of thermal energy from different sources. They can include drinking water sources (TED), surface water (TEO), and wastewater systems (TEA); they are used to cool and heat homes and other buildings (Benning, 2023; Goossens et al. 2021; STOWA, 2023). According to the ‘Netwerk Aquathermie’ in The Netherlands (NAT), *aquathermia* refers to the sustainable way of using water for thermal heating and cooling needs while simultaneously contributing to climate neutrality goals by lowering carbon emissions and dependence on fossil fuels such as gas, coal, and oil.

AE systems are an under-explored technology in many parts of Europe. They can be viewed as an important part of deploying a heat pump technology transition in the EU as they are key in amplifying the energy from water sources to the high-quality energy for warming and cooling purposes in buildings. In countries where there is experimentation with AE systems using different surface and wastewater sources, there is also a consideration for policy and governance systems that will allow further implementation of these systems

(Benning, 2023). According to NAT (2023), countries such as Norway, Sweden and Finland have ample experience with the implementation of AE systems; however, there are few projects because of low technology *up-take* influenced by the availability of other energy sources such as hydropower, biomass, and ground-based geothermia as well as high costs associated with the implementation of AE projects. The countries with the most AE systems projects include Switzerland and the Netherlands (Benning, 2023).
In the Netherlands, several stakeholders including government, regional water boards, commercial and investment groups have signed a 'Green Deal Aquathermie', to work together in finding solutions for governance, large scale investment and implementation of AE projects (Green Deals, 2019).

Barriers to AE system development from a governance and innovation perspective highlight contradictions between traditional practices and new, more sustainable technologies. The current reliance on fossil-fuel-based systems creates considerable economic, technological, and regulatory barriers to AE adoption (Ramdan, 2025).
On the other hand, stakeholders and network formation can facilitate the removal of such barriers to some extent and provide good practice lessons and an enabling environment for implementation of AE projects.

Interreg North Sea WaterWarmth Work Package 5 (WP5) has conducted an analysis of key barriers to district heating adoption with a focus on integrating AE sources as well as an examination of the interplay between economic, technical, regulatory, and social factors in shaping these barriers (Behrendt, 2025). This desk study was based on documented case studies, academic and grey literature. The report outlined the current state of district heating in the EU noting the demand of the systems whereby over 60 million homes across the EU utilize such systems. The report stated that 'heat pumps play a crucial role in harnessing AE for district heating' (Behrendt, 2025). The WP5 study highlighted several barriers to district heating using AE. These include economic barriers such as high capital costs which deter take up of district heating systems by low-income households and municipalities with limited budgets. The high costs were also mentioned by the pilot project teams interviewed for the present WP6 study, whereby interviewees mentioned that investments in innovations such as AE systems are difficult to secure. Moreover, there is limited access to finance for municipalities and energy cooperatives who are considering developing local AE systems.

1.3 Research questions

This report focuses on the analysis of pilot projects for the WaterWarmth Project. The research question that guides the analysis on barriers and enabling factors is **'What are the barriers and opportunities that govern niche development and scaling of AE systems?**' To answer this question, we analyse and map the enabling policy and opportunities that support AE system niche development, as well as policy that can also play a role in scaling of AE systems and practices. The report also identifies barriers that (could potentially) hinder AE system niche development. We will map and develop insights into how to resolve these barriers, for example, by developing and implementing specific policy instruments or policy mixes, or by using networking and participatory arrangements. This will involve collecting insights and emerging theoretical insights from project partners, empirical project cases as well as conducting expert interviews, and a desk study.

1.4 Research methods

1.4.1 Exploratory multi-case study design

An exploratory case study research design is a qualitative approach aimed at investigating complex phenomena within real-life contexts. This research is especially useful when exploring a theme with limited prior understanding, which is the case regarding our projects. By employing various data collection methods, researchers can collect rich, detailed insights that drive deeper understanding.

Multiple case studies use information from different studies. Multiple cases are selected so that individual case studies either: a) predict similar results or b) predict contrasting results but for anticipatable reasons. When the purpose of the study is to compare and replicate the findings, the multiple-case study produces more compelling evidence so that the study is considered more robust than the single-case study (Yin, 2017). To analyse a multiple-case study, a summary of individual cases should be reported, and researchers need to draw cross-case conclusions and form a cross-case report (Yin, 2017). With evidence from multiple cases, researchers may have generalizable findings and develop theory (Bryman 2016).

1.4.2 Data collection

The data was collected from the pilots that are partners in the Interreg North Sea WaterWarmth project. In total, there are nine pilot projects that have been initiated as part of the project to assess the implementation and viability of AE projects.
For some of the partner countries one pilot is presented (Denmark, France) while in the Netherlands and Belgium four pilots are included. We also conducted an interview with an energy cooperative that has partnered with one of the pilots to explore possibilities of using AE to generate electricity for its own local community.

The data collection process was set up in different steps to progressively gain deeper insights into socio-technical aspects of each of the pilots. The process (WaterWarmth Report 6.1; Hoppe et al. 2024) began with a survey of different analytical frameworks where the Multi-Level Perspective (MLP) (Geels, 2002) and Strategic Niche Management (SNM) (Kemp et al. 1998) were deemed as particularly useful for AE governance system analyses. The Governance Arrangements framework (GA) (Termeer et al. 2017) framework was also deemed useful due to its ability to help structure complex and messy sustainability challenges such as AE system development. The first broad questions for mapping the AE projects from these frameworks were asked to the pilots in an on-line survey April 2024. Building on these responses, a workshop was then held during the meeting in Caen May 2024 where additional dimensions of the pilots were focused on. Responses were integrated and in the next step interviews were carried out with a key respondent for all pilots during Fall 2024.

For the interviews, a semi-structured approach was used, combining a predetermined set of open-ended questions with additional questions posed to more deeply explore certain themes and responses. We compiled a set of key questions that were designed to explore issues related to governance and implementation of renewable energy systems, in this case AE, among the project pilots. The questions were designed to align with the governance analytical frameworks that the research team is using for the work package.

All the respondents were asked the same questions. We formulated questions as per SNM, the MLP and GA frameworks. Using these frameworks, we compiled questions that explore issues of project visioning, how learning is organized within the pilots, network formation and regulatory frameworks that are important for the pilots. We also explored issues about the tensions and challenges faced by the pilots as they implement their projects. This data will lead to a revelation of current governance arrangements in the different countries where the pilot projects are implemented and hopefully provide insights on how such projects can be scaled and become part of the renewable energy solutions in the sustainable and inclusive energy transition.

Each interview was conducted by a minimum of two members of the WP6 research team. All the researchers documented the interviews with written notes; these were then compiled into a single document after the interview. This ensured that all the information was cross-checked by the research team and safeguarded against data omissions that may occur if only one person documented the interview session. Even though we collected qualitative data, all the interview notes were transferred onto a spreadsheet for ease of documenting all the interviews in a single file. The responses were captured and organized according to the key themes raised in the interviews. This provided the team with an in-depth overview of how each question was answered and the ability to compare all responses from the different pilots to each question. The research questions asked to all the pilots and the energy cooperative are as follows:

1. What are the most significant challenges and tensions your pilot encountered, and how did you (and/or other stakeholders) cope with them?
2. What are the good practice lessons that you can share with us and those that would like to replicate your work?

1.4.3 Data analysis

The data on the spreadsheet were analysed by observing the responses to each question from the different pilots. Based on combining the transcripts from pilot interviews with our first phase of work in the on-line survey April 2024 and following the project workshop, we built up the innovation story per pilot.
We then in the next step could observe the differences and similarities in the given responses, and where key themes were captured in the comparative table in section 3.2. Data treatment used an abductive coding approach. Annex 1 shows comparative analysis of barriers and enabling factors among the pilots.

1.4.4 Data ethics and data management

The WP6 research team comprises academic researchers that conduct qualitative research through interviews with relevant stakeholders. Since Delft University of Technology is the WP6 lead, the research team followed the ethical guidelines established by Delft's Human Research Ethics Committee (HREC). Prior to completing and submitting the research ethics application form, the team had to work with the faculty's

Data Steward in completing a Data Management Plan (DMP). Through the DMP, the researchers provide information on the type of data they will be collecting, how the data will be processed, the purpose of processing and the organisations that will have access to the data. In the DMP, we supplied information on how we will safely store the collected data, and most importantly, how this data will be shared among the research institutions that are part of the Waterwarmth research project consortium. Once the DMP was completed, we applied for ethics approval from the HREC.
On the ethics application form we provided risk assessment and mitigation plans concerning data protection. This included information on the type of data we will be collecting, collaborating partners, location of research participants and how they would be recruited.

It is important to note that no interviews were conducted prior to the research team's receipt of provision ethics approval from the HREC. Part of ensuring that due ethical procedure is followed includes requesting the research participants to give their consent for the information they are providing to be used for specified research uses. Participants were therefore properly informed about the purpose of the study and how their data would be used during data collection and they had to confirm their consent by signing the forms and handing them to the research team.
To ensure extra measures in protecting data, for the WaterWamth project it was decided by the Data and Privacy Department for the key data collecting institutions to have a formal 'Joint Controllership Agreement'. This agreement enables the WP6 research institutions to freely share the research data among each other while ensuring data protection measures.

2. Results

In this chapter the results of the analysis are presented. Prior to presenting the results of the comparative case analysis case-by-case basis information is presented, indicating barriers and opportunities observed in the Interreg North Sea WaterWarmth pilots. The sections below present the results from the qualitative analysis of the responses provided by the pilot leads and other stakeholders on questions that focus on the barriers and opportunities experienced during activities related to setting up, exploring, developing or implementing their demonstration pilots.

2.1 Individual cases (barriers and opportunities)

Prior to presenting the analytical items on barriers and opportunities attention is paid to the general introduction of the pilots.

2.1.1 Fryslân region; Terherne, Baard, Heeg (The Netherlands)

The Fryslân region hosts three of the Waterwarmth project pilots, namely the village of Terherne village in the municipality of De Fryske Marren, the village of Baard in the municipality of Leeuwarden, and the Heeg village . They also have an alliance with the Warm Heeg energy cooperative in the Heeg village under the Súdwest Fryslân municipality.

The village of *Terherne* is a popular tourist destination located on an isle and there is an abundance of water around and within the village itself. In the old part of the village, there are 120 homes and several large

buildings (e.g., a school, hotel and restaurants) that can potentially be heated by a small collective heating network. The other homes in the town which almost all directly face a waterfront can be heated by individual AE systems that can use the water flowing through the town as a network. The goal of the Interreg North Sea WaterWarmth project for the Terherne pilot is to determine whether heating using the AE system is plausible in the 'small' scale of 120 homes, as this is not done elsewhere in the Netherlands.
The plan is to implement an AE system in around 100 homes by using systems that fit the houses and the layout of the village while keeping in mind that the noise from heat pumps is not appreciated by the locals. The pilot is organized in collaboration between a citizen-led energy cooperation and the municipality De Fryske Marren.
Status: Exploratory, with a focus on exploratory studies, feasibility studies, and business case development.

The village of *Baard* pilot is about a small 'source-district' heating net which connects five to nine privately owned homes and a primary-school in the village. Each building connected to the network will have its own heat pump. The source of the net is a combined 'closed' heat exchange system, like MEFA (heat pump system), sufficient for all the buildings. There is also a plan to have geothermal storage connected to the system, for buffering summer heat for winter use. The pilot entails development of a closed system AE project, by extracting heat out of the Baarder Feart river, bordering on the six homes and a school building. The pilot is organized (governance) via multiple stakeholder ownership, which is expected to turn into an energy community at a later stage. The focus of the project is on setting up a workable organisation and attracting upfront investment.
Status: The pilot is under development, with construction of the technical project attributes and setting-up the ownership rules and legal affairs.

The village of *Heeg,* located in the municipality of Súdwest Fryslân, aspires to be energy neutral by 2025. First of all, that means saving as much energy as possible, including through good home insulation. But it also means becoming independent of natural gas. Work is being done to create a collective heat supply for the entire village. The heat will be extracted from the surface water of the Hegermeer (lake).

The intention is that all residents of Heeg will soon be connected to this. It is important that the heat network is accessible and affordable for all residents of Heeg. In the pilot the energy cooperative Warm Heeg has a central role because it entails a community-driven project. The process leading to the pilot already set-off in 2012 and has already surpassed the exploratory and development stages.
Status: Preparations for project implementation are ongoing. Currently, Warm Heeg is carrying out excavation work for its AE project to install infrastructure, such as heat exchangers and piping that will connect the surface water source to the heating network. This infrastructure is crucial for extracting thermal energy from the water and then distributing it to homes and other buildings in the village (Warmheeg, 2024).

Barriers, Challenges and Tensions

For the *Terherne* pilot, the greatest challenge was starting the AE pilot project without a framework. Due to a desire to get involved in the Waterwarmth project, the municipality was added as an afterthought with no proper implementation plan and what their role would be. The other challenge is the difficulty in evaluating the economic and social feasibility of the project, especially when partnering with an energy cooperative or an energy community that does not have formal and legal structures. Another challenge is the lack of control in timing the project activities, which leads to lack of communication in fear of raising the expectations of stakeholders such as the community.

For the *Baard* pilot team, the main challenge is the competition with cheap fossil fuels due to subsidies. This becomes unfair competition for renewable energy alternatives that they would like to implement. This is also linked to the natural gas system which makes it difficult for new and renewable energy installations. Another challenge is the lack of bank protection and technical guarantees for AE installations. Since this is considered a new innovation, financial organizations do not have much information and trust in new technologies. The high installation costs of AE are also another barrier to full scale implementation. Social housing stakeholders are also reluctant to collaborate on AE implementation because of high capital costs and the need for renovations if this technology is implemented. The communication issue has also led to some minor struggles whereby the community finds it difficult to understand information about this new technology, and therefore difficult to get buy-in from them.

For the *Heeg* pilot team the main challenge is the funding for the development phase of the project whereby they are unable to secure subsidies. The initial funding needed for the AE implementation they want to undertake was estimated at 11 million euros and has now increased to €33 million due to high costs. Another challenge is the instability of subsidies and the frequent change of rules that govern the attainment of energy subsidies. The difficulty in finding the right companies for the project due to its small size and higher prices in the Netherlands is also another challenge that Warm Heeg is facing. Municipalities are making slow progress with approval of the project plans due to the novelty of such projects and risk aversion. This is due to lack of knowledge and fear of making decisions.

Opportunities and Good practice

The *Terherne* pilot's good practice lesson that was expressed as important is that, for an AE project at any scale, it is better to use the first year to get everything in place. This means the project team members have to familiarise themselves with the project needs and ensure that they understand what is needed, such as permits and the tests that need to be performed before the installation of the system. Another good practice observed is to ensure that stakeholders such as energy cooperatives fully understand the project details in order to discourage unrealistic expectations.

For the *Baard* pilot, the good practice was to communicate extensively and clearly about project progress to their stakeholders because they realized that sometimes households misinterpret and misunderstand information, especially about a technology that people are not familiar with.

In the *Heeg* pilot, the Warm Heeg energy cooperative mentioned that their important good practice lesson was to engage in local campaigns promoting their work and its benefits to the households as well as to build community support. Another good practice lesson was to ensure transparent energy pricing with a price calculator that they have developed and is on their website for easy access for their customers and community members. Another good practice lesson they've experienced is that of inviting residents to bring their energy bills to the Warm Heeg office for personalized cost comparisons, in an event that customers want to change energy providers.

Warm Heeg has also learned to hold biannual information sessions in the village to keep the community informed, which also emphasizes the importance of communication, with a focus on customer engagement.

2.1.2 TU/Delft; Firma van Buiten (The Netherlands)

The aim of the Firma van Buiten pilot is to augment the current air-sourced heat pump (ASHP) based heating system with an aqua thermal one (while the air-sourced heat pump remains as backup and peak 'boiler') and using this as a test bed for shallow water AE systems. **Status**: Exploratory. Technical studies prepared and performed.

Barriers, Challenges and Tensions

This pilot experienced some challenges and tensions. There were delays in proposal approval by the TU Delft Campus Innovation Committee (CIC), followed by delays in finding project management capacity and a prolonged permit procedure. As costs for equipment and services have risen since the budget was approved (partially because of geopolitical influences), the 15% of the budget set aside for unexpected costs is already expected to be mostly used up. Therefore, the budget is currently tight, and as the project is unlikely to receive additional funds from the university campus development departments, this leads to a possible need for new project funds if the pilot runs over budget. This is anticipated to be difficult and may cause further delays in project implementation. On the other hand, there has been a generally positive attitude from all stakeholders and supporting parties of the project, but some resistance from a project that is implementing similar pilot technology on campus.

Opportunities and Good practice

The importance of temperature measurements to record baseline temperatures a year before project start for permit requests was the most important good practice lesson for this pilot. This led to early discussions with Water Boards about plans and permits to understand and address their reservations about the implementation of the project. It is assumed that changes to the permitting system will be implemented when AE systems become more common. Sharing positive experiences with other project pilots within the Interreg North Sea WaterWarmth project was considered a good experience for this pilot. Another lesson that can be drawn from the pilot was to get effective project management due to complex university administration that may make it difficult to smoothly implement the project.

2.1.3 Kortrijk; Buda Island, Kortrijk; Weide, Kortrijk; Havenkaai (Belgium)

The City of Kortrijk sees opportunities for the successful application of AE and has three experimental AE projects: Buda Island, Kortrijk Weide, and Kortrijk Havenkaau (i.e. Howest University of Applied Sciences). The three pilots are geographically close, all on the Leie river. These three locations represent the large-scale implementation of the WaterWarmth project - i.e. AE technology demonstration pilots - in Kortrijk. Research was conducted into how much energy can be extracted from water courses with the aim to contribute to making the City of Kortrijk energy-neutral.
The ultimate goal is to complete all necessary research, calculations, and designs within the project which will be followed by implementation.

The investment for Buda Island is 50% by the energy cooperation and 50% by the City of Kortrijk. Additional funding opportunities will be explored by the project team together with the Interreg North Sea WaterWarmth consortium project partners.
Status: Development stage.

Barriers, Challenges and Tensions

Currently, the Kortrijk Spatial Planning department (municipality) subsidies do not include energy planning, making coordinated planning difficult especially for budget-constrained neighborhoods. This makes planning impactful energy interventions challenging and spatial planning activities are also important for energy supply planning, especially for laying heating pipes underground. Another challenge was that colleagues within the Kortrijk municipality and Flemish provincial government took time to get convinced about the viability of AE systems and to align that with the city budgets.

Lack of public knowledge about AE is not a big challenge even though it is a new technology and has not earned much trust from the public. The public's focus is on ensuring the heat comes from a sustainable source. With the production and delivery of renewable energy, the city is currently debating and assessing the advantages and disadvantages of having different energy cooperatives/companies or one big energy company as an energy provider.

Opportunities and Good practice

Good practice and other lessons shared by other cities and networks were considered helpful for the City of Kortrijk. Similar to the Firma van Buiten pilot, the Kortrijk pilot team found that conducting the feasibility study quickly at the beginning of the project helped determine investment needs and project scale. Having concrete numbers was crucial for stakeholder communication and securing commitments. Part of the lessons the Kortrijk pilot team still wants to learn is to visit large-scale AE systems in Denmark or Sweden and engage with engineers and managers to build knowledge for the City of Kortrijk.

2.1.4 Kortrijk; Howest University of Applied Sciences (Belgium)

The pilot site with which Howest participates in WP2 of Interreg North Sea WaterWarmth, is part of a larger investment project. The complete investment project features student accommodation buildings, university buildings, apartment units and office spaces with a total area of 18,000 m^2. For the duration of the Interreg North Sea WaterWarmth project the student accommodation (127 rooms) and possibly a few of the residential apartment units nearby will be operational, as the whole site is currently being built. Therefore it can be considered that Howest's pilot site will be the student accommodation building. On the pilot site AE will be used in combination with geothermal energy. Since the demand is expected to be high, there are high fees for extraction and discharge of Leie (river) water for heating, and the site will be expanded, it was decided that the techno-economic optimum was to use the AE for regenerating the geothermal borehole field. Simply put, the heat extracted from the river will be stored in the soil around the boreholes in order to extend the lifetime of the field.

Status: The Howest student building is expected to be completed and operational by fall 2025. The first tests and commissioning of the AE and geothermal systems should begin in June 2025 and be put in operation for the beginning of the heating season 2025-2026.

Barriers, Challenges and Tensions

The challenges for Howest include high cost of permits that had to be obtained from the water authorities, and the technical matter of defining the water temperature difference pre and post AE system intervention. This was an expensive exercise for the pilot. Please note that only a maximum 3°C temperature difference is allowed. Furthermore, the pilot team found it difficult for the pilot to define the production-consumption ratio of energy for the new development. The initial energy charges / costs by the energy service company (Esco) were considered too high, leading to revisions and discussions. This led to a conclusion that the student housing unit charges are acceptably priced, but the charges for energy that will be used by the school are overestimated. Moreover, having six stakeholders actively busy with the site has been challenging to navigate. Keeping everyone updated on the developments of oneself, getting the approval of everyone and bringing everyone on the same page is a lengthy and time-consuming process. Negotiations and discussions with stakeholders are held on a regular basis.

Opportunities and Good practice

The pilot team learned that it would have been beneficial for them to be involved from the beginning of the project. Due to some circumstances, the project staff has changed, and this has led to a lack of knowledge regarding initial project plans for implementation. Good documentation of activities was considered as essential by the pilot, especially for learning processes and sharing with stakeholders. Signing a working agreement between all involved parties from the beginning of the project was also considered essential, especially to ensure that all partners contribute to the research and project activities. In the Howest pilot's case it is essential for all partners to contribute their inputs, including data, to the research in order to gain knowledge about the project's impact. The pilot team also learned that it is essential to explain the concept of niche innovations in detail especially to stakeholders, as they found that AE technology is not well understood.

2.1.5 Gent; Energent (Belgium)

The Energent pilot focuses on new residential buildings (mainly new apartments) with 1 MW peak power (thermal energy). Energent, a citizen-led energy cooperative, will develop a concept plan to use AE as a heat source for heating homes and apartments in the Muide city district within the city of Ghent (Flanders region, Belgium). The Muide is situated next to a large canal, which has sufficient potential to heat a large number of homes using heat pump technology. Energent wants to investigate the role of energy cooperatives in the roll-out of local heating networks, where aqua thermy (i.e. AE) is present as a sustainable and fossil-free energy source. At the end of the Interreg North Sea WaterWarmth project, the aim is to have knowledge of which technical development is required, what the profitability is and which legal framework applies to heating networks using AE.

Status: Studies are conducted and activities conducted to develop a project concept, project plan and business case.

Barriers, Challenges and Tensions

The challenges and tensions for Energent include the difficulty to estimate the capital expenditures which involve significant, long-term investments in tangible assets, as well as operational expenditures. With the progress of the business plan of the pilot presently developed, further clarity will be gained.
Another concrete challenge has been the lack of access to underground pipe maps which was a problem in the beginning of the project. However, since then, the city has provided the necessary access to the plans.

Amongst the partners in Energent there originally existed a Non-Disclosure Agreement. This however has now been resolved, allowing access to all necessary information from stakeholders. Finally, there are some tasks in Energent where an expert is needed and the hiring process is not yet completed.

Opportunities and Good practice

Structured communication with well-defined project expectations has been a good practice lesson for Energent. The pilot team also learned that positive communication and expert knowledge are highly valued by stakeholders. Securing financial support is considered a good practice lesson because it encourages other stakeholders to get involved when they don't have to invest money. Covering costs during the development phase, as WaterWarmth does, can be a significant motivator for others to get involved in the project. Regarding the politicians and their impacts on the project no significant changes are expected as the same parties still rule and are part of the city government.

2.1.6 Mechelen; Ragheno (Belgium)

The City of Mechelen is located in the region Rivierenland in the Flanders region with a population of 87,000 inhabitants. The city as a frontrunner in local sustainable heating has mapped the potential of renewable heat sources including geothermal and AE and is planning a local policy framework to support the development of heat projects with AE. The present project involves using AE energy (in combination with geothermal borehole thermal energy storage - BTES - systems) from the canal Leuven-Dijle for fossil-free heating of a new development on the Ragheno site - to become a new, sustainable and attractive city district - next to the canal.
Status: the pilot feasibility study is drafted, and a next step would be that the study's results will be presented to a project developer.

Barriers, Challenges and Tensions

The City of Mechelen does not have property rights in Ragheno and there are several challenges and tensions arising from this. Below are some of the challenges mentioned by the pilot.
Initially there was skepticism from the municipality and decision-makers about the AE project. District heating is generally seen as insecure and financially unviable. A feasibility study showed heat networks were not viable in this context, while the City of Mechelen still saw potential and continued to advocate for the project. However there is currently minimal financial support or policy support for heat networks.

Another barrier concerns the fact that local authorities are by-passed in Flemish energy regulation. This means that energy performance reports or feasibility studies have to be filed directly with the Flemish Energy and Climate Agency, without any advice requests to local authorities, despite that a municipal heat plan may exist.

Further, energy regulation lacks integration with spatial, water, and environmental policies. Therefore there is no incentive in energy regulation to consider AE energy nor large-scale collective energy systems. Although there is a ban on gas since 2021, this in fact often results in individual air-sourced heat pumps per dwelling unit being installed, although there is enough heat demand for heating and cooling for collective energy systems

There are also concerns that communication activities on Ragheno disregard energy development and that 'sustainability' rather is used in the context of greenwashing.

Opportunities and Good practice
The pilot team considered it beneficial to have a policy working group due to the lack of regulatory framework they could follow. In this case, the co-creative approach was best.

2.1.7 Ouistreham; Le CANO (France)

The pilot is located at ‘Le CANO’, which is the Water Sports Centre of the city of Ouistreham, Normandy, France. Located at the outlet of the River Orne, the Caen Canal, the maritime entrance to the urban community of Caen-la-Mer and the setting of the Bay of Sallenelles, the Centre brings together associations and the public in a sporting, educational and cultural centre focused on the sea and water sports. In the framework of the Interreg North Sea WaterWarmth project, a heat pump will be installed to supply Le CANO facilities, particularly the bathrooms and shower. The key actors are the users of Le CANO facilities (such as the sailing club, Société Nationale de Sauvetage en Mer) and the company that is central to the pilot and installing the AE system. The pilot envisages using sea water because the Normandy region has a lot of coastlines which could be used to provide heating and cooling. It is an important resource of the region, with around 600 km of coastline. The key stakeholders and local authorities of the pilot consist of the City of Ouistreham, Ports de Normandie (Normandy Ports), DDTM14 (Calvados Departmental Directorate for Territories and the Sea), the Harbour master's office (Capitainerie), Normandy Region, and Caen-la-Mer. The pilot is owned by the city and the works are under the supervision of Ports de Normandie (Normandy Ports) which is the local authority approving the modification of the area.
Status: Implementation phase. The pilot site is currently under construction.

Barriers, Challenges and Tensions
One of the key challenges were corrosion issues which demanded budget adjustments requiring an extra €100,000 for equipment. Staff costs were principally reduced, this way the project remained within the overall budget. Regarding the overall budgetary issues, the project aims to produce a functioning pilot.

Opportunities and Good practice
Support from the Mayor of Ouistreham was considered crucial for the initiation of the project as this convinced other stakeholders to be part of the project. Another key lesson from the projects concerns who to talk to regarding different obstacles for the system. Also identifying an engaged energy company as the to work

with, has been essential for the pilot developments. The Elairgie company had already carried out work on the pilot site before and that has its own motivations. Support from the lead partner of WaterWarmth has also been useful for solving overriding issues such as financial matters.

2.1.8 Middelfart (Denmark)

The municipality of Middelfart is located on the west coast of the island of Funen in southern Denmark. The municipality with about 40,000 inhabitants is committed to replace fossil fuels heating and cooling systems with sustainable alternatives. The key stakeholders are the citizens, local business enterprises, the municipality and basically everyone with an address in the municipality. The main competences in the municipality are planning, permissions and implementing renewable energy for space heating.

On the initiative: Several neighbours in the villages Fjelsted and Harndrup got interested and over time 300 neighbours in a rural community decided to phase out their oil/gas boilers for cheaper, cleaner heating solutions. From a citizens' perspective the energy source should be renewable and if it was therefore not the key perspective if it was AE, geothermal, air-air or another technology. Due to local geographical characteristics AE was considered a natural part of a solution. The pilot started as an inclusive community driven project based on the legal entity of a cooperative that was formed. Nobody was turned away, and over time the size of the project became overwhelming. It was a community initiative, to be driven by a legal entity, a cooperative, that was established. However, the project grew out of its 'comfort zone' partly related to the fact that a loan of 40 Million Dkk became necessary for the project.

The main reason why this initial project failed can be attributed to the national level. A change in the Danish Heat supply Act was ongoing and national policymakers were discussing if Thermonet should be included in the heating act. Thermonet is a technology that includes AE. If Thermonet was not to be included in the Danish Heat supply Act, access to loans via municipality guarantees would be more difficult to access. These national disputes made "the hand tremble" of the energy cooperative. Even if the legal dispute that was discussed in the national parliament was not settled, the citizen energy cooperative gave up. As the dispute was a national matter, many villages found themselves in a similar situation and the debate and the case reached many headlines. Several political and legal forces and experts supported Thermonet. After the cooperative "gave up" the discriminating change in the Heating Act was adopted by Parliament.

An alternative plan was brought to life due to the Interreg North Sea WaterWarmth project. It would be based upon the purchase of approx. 14 hectares of land and lakes and establish a Thermonet with AE that could support a smaller heating project for approx. 40% of the local villagers. The purchase of land, and thereby plan B, was not carried out mainly due to poor management at the municipality. Instead a smaller project was initiated as an alternative plan B within the Interreg North Sea WaterWarmth project. The new AE project would be located at a pond, initially used for firefighting, and protected by a 1992 law. The project has low projected energy demand <0.25 MW which means that it does not fall under the Danish Heating Act. However, currently, again rules and regulations are challenging the project (i.e., Environmental Law).
Status: measurements have started and sensors are installed.

Barriers, Challenges and Tensions

The project experienced challenges with legislature and some governmental actors and it became clear that legislative support is needed for energy communities to implement AE. In sum, the factors that led to the larger project not being implemented was a major setback.

In this type of community driven project many moving parts had to engage each other. These were not aligned at first which led to project delays and change of scope. The question arose when to engage with people? How to engage? What soft skills are needed? There were also time-constraints of the leaders and participants in the project and unexpected events. This led to a realisation that a one-stop-shop is needed providing certain skills, empathy and a co-leadership model needs to be in place. To keep things simple was one of the conclusions but under the given structures and actors not an option.

In the end things had grown too big to be handled by local residents in the neighborhood. In addition, fossil fuel prices had gone down which led to a decrease in motivation. Another challenge was that land needed to be purchased but the formed AE community got out-bidded.

The Danish Energy Agency did not fully understand the system and could not give financial guarantees as they thought it was too risky. No guaranteed funds for innovation possibly mean that heat networks could get locked into 3rd generation district heating. In summary, government adoption of new behaviours and technologies is challenging despite strong arguments.

Opportunities and Good practice

Involving different actors internally at the municipality as well as externally has been central to build up the project. The baseline temperature measurements in the water source have to be conducted prior to project implementation and this must be considered early in the project planning phase. Technical as well as legislative barriers require courage, stamina, curiosity, and imagination. When the founders have these qualities projects continue despite setbacks.

In short, the existing regime of rules, regulations and culture is not geared for the tasks of tomorrow. If you do business as usual you get the usual results. The task of today is to phase out fossil fuels fast, and factors to do this are not established.

2.2 Results of the comparative analysis

In this chapter the results of the multi-case analysis of the pilot cases are presented. This analysis enables one to map the hindering and enabling factors that affect AE system niche development, as well as policy that can also play a role in up-scaling and out-scaling of AE systems and practices. Through this analysis we also attempt to map and develop insights into how to resolve these barriers, for example by developing and implementing specific solutions, managerial, policy instruments or policy mixes, or by using networking and participatory arrangements. This analysis also intends to provide clarity about several issues that influence the governance and innovation of AE systems in pilot demonstrations in the EU North Sea Region.

2.3 Barriers

Policy and regulations barriers

For some of the pilot projects that are being implemented by the local government, one of the barriers experienced included being left out by regional and national levels in decision making processes concerning energy at the local level as reported by Mechelen.
Such exclusion of local government has led to difficulty in accessing important documentation such as city spatial plans or information on what the other local government departments are planning that could impact renewable energy projects such as the implementation of AE systems as reported by Energent and Mechelen. Some of the pilots reported not having the necessary property rights needed to local development projects that could benefit from AE systems. This led to a lack of collaboration with key stakeholders within the local level, and it reflects how energy regulation lacks integration with spatial, water, and environmental policies.

The lack of regulation and policy integration is partly caused by national policy making and also leads to lack of support from key government actors for AE project implementation, as it was partially experienced in the Middelfart pilot. In turn, local regulations are considered difficult to apply because of bureaucratic administrative systems that energy cooperatives or other pilot teams do not have full control of. The local government actors often lack the autonomy to act without support from upper government levels. Due to absence of clarity in various regulations that affect energy project implementation, it becomes difficult to evaluate the economic and social feasibility of such (AE) projects, especially when partnering with an energy cooperative or an energy community that does not have a formal and/or legal structure, such as experienced in the Terrherne pilot in De Fryske Marren municipality. This was also observed in the WP5 study (Behrendt 2025) whereby it was noted that inconsistent policies lead to loss of investor confidence.

Change of government due to elections and political climate, has also added to lack of clarity about the future of renewable energy technology as reported by the Belgium based pilot projects (i.e. Kortrijk, Mechelen, Energent). This has an impact, particularly on emerging innovations such as AE systems where support needs to be secured beyond a single mandate period.

No internal vision

The lack of internal vision and starting a project without a clear framework was a common theme observed in the Kortrijk, Energent and Terherne pilots. These aspects were mentioned as some of the key barriers that have led to difficulty in predicting project costs. This lack of vision leads to difficulty in formulating a business plan that will take projects forward.

Government support of fossil fuels

Even though many European governments are responding positively to calls regarding climate change mitigation and adaptation, there is still significant support for fossil fuels. This support is by means of subsidies for fossil fuel use, and in some cases, seen as necessary to mitigate energy poverty and high energy prices that many consumers cannot afford. On the other hand, this reduces subsidies for renewable energy innovations such as AE systems, and leads to lack of incentives for adapting AE or large scale collective energy systems as experienced by the Mechelen and Middlefart pilots. Cheap fossil fuels due to subsidies are therefore regarded as unfair competition for renewable energy alternatives that could be implemented if funding was available as observed in the Baard pilot.

AE technology reluctance
Due to various factors, such as unfavourable policy and continuous subsidies for fossil fuels, there is notable skepticism about AE projects from policy and decision makers. The Mechelen, Baard village and Kortrijk pilot teams noted that in some instances, the projects were not easily accepted because funding, policy decision-makers and social housing stakeholders were not familiar with AE system innovation. This led to reluctance in supporting the project and partnering in its implementation. Some potential stakeholders did not consider AE and related collective district heating as viable energy systems.

Withholding information – not sharing information
As mentioned above, due to the novelty of AE systems innovation in some countries, an extent of reluctance is displayed by some stakeholders. Some pilot projects such as Energent and Howest/Kortrijk experienced difficulties in ensuring a free flow of information among stakeholders due to strong conditions set by some actors on how information can be shared. These stakeholders were worried that important project information such as financial details, could be misused by others. This caused the inability to share information and knowledge with potential project partners and consumers due to such restrictions.

Lack of alignment among stakeholders on project activities as experienced by the Middlefart pilot in its inception phase has also resulted in difficulties to ensure a well-informed public about AE projects. This is mainly due to stakeholders not being sure whether all aspects of the projects will receive approval, and therefore, not wanting to raise false hope among the public.

Lack of public awareness
Insufficient public knowledge about AE systems is one of the key barriers mentioned by the projects. Concerns that sustainability and renewable energy technologies are merely used as a greenwashing excuse are among the barriers that make it difficult to get buy-in from the public and government actors. For some of the pilot projects such as Kortrijk, Middlefart and Mechelen, this has led to indecisiveness about key decisions to be taken in AE projects, not only among public sector decision makers, but also for the public who are engaged to support AE pilot experimentation. This lack of understanding has also led to lack of funding support and financial guarantees due to fear of risk in some instances.

Lack of financial support
As mentioned, the absence of knowledge about AE systems has multiple consequences, such as lack of bank and technical guarantees for AE installations as observed in the Baard pilot. AE projects are expensive to implement and large-scale projects require more funding and guarantees from various actors, including government and private investors. AE pilots often face insufficient access to funding at critical project stages such as the development phase as experienced by the energy cooperation Warm Heeg, which requires extensive financial support. The pilots also faced the barrier of frequent change of rules that govern the attainment of energy subsidies from the government. This was related to bureaucratic red-tape that is often experienced by projects when seeking legal approval and permits.

Technical and operational costs

High installation costs of AE are a barrier to full scale implementation as mentioned by several pilot team interviewees interviewed. Pilots such as Howest/Kortijk, Baard and Firma van Buiten considered high costs of permits from water authorities as a barrier to proceeding with their projects. These technical and operational costs also pertained to water temperature monitoring which is a prerequisite for receiving an operation licence. Unexpectedly, high costs of equipment as experienced in the Firma van Buiten and Ouistreham pilots hindered smooth project implementation for some of the pilot projects. This was due to underestimation of costs at the beginning of the project and the sharp rise of equipment and operations costs due to high energy costs as a result of macro level geopolitical development. Technical difficulties as experienced by the Ouistreham pilot have also been mentioned as barriers that have led to project- delays and restructuring. This caused unexpected financial inconveniences for the projects at different levels.

Lack of expertise

A barrier that was expressed by the Energent and Firma van Buiten pilots was the lack of expertise needed for project implementation at critical stages. This led to delays in the implementation and applying for permits needed for the project. The novelty of AE technology was considered a problem to several actors in the pilots as it became difficult for them to determine the energy production-consumption price ratio without overestimating the costs for the consumers as experienced by the Howest pilot project. This caused potential consumers becoming reluctant to opt for AE systems in the future.

Project delay

Another barrier observed in the projects concerned project delay. They were due to difficulties to control timing of the various project activities such as project proposal approval by public sector actors. Interviewees from the Firma van Buiten and the Terherne pilots expressed that such delays caused barriers in access and use of funding and time dependent resources.

2.4 Successes and enabling factors

This section presents results from the analysis of successes and enabling factors observed in several of the AE pilots.

Political, regulations and governance support

Working closely with policy and governance actors was considered one of the most important enabling factors to ensure implementation of AE systems projects in the Kortrijk and Mechelen pilots. They include the local politicians, water authorities and those in charge of local public service provision. For six of the nine pilots, this ensured an early understanding of pilots by policy makers as well as those having a leadership role. Being part of local, regional and in some cases even, national policy expert network or working groups ensured a level of policy influencing actions by AE project developers whereby the pilot experiences can be used to develop specific AE policy.

Through close cooperation with policy makers, several of the pilots were able to achieve some successes in their project planning as experienced by Ouistreham and Mechelen, such as being granted access to City planning documents that show development plans that could benefit from renewable energy such as AE systems. Close cooperation and support by the government also enabled other actors to recognise the benefits of AE, and by virtue of their influence, attract attention to the technology from the larger public.

Project preparation

Project preparation such as having a clear vision from the beginning of the project was considered a good practice lesson and an enabling factor to AE implementation. A clear vision helps to determine the different phases of the project and the needs for completion. Conducting feasibility studies early in the project helped to determine investment needs for each phase to know which stakeholders to approach as project partners, as witnessed in the Kortrijk and Firma van Buiten pilots. Feasibility studies were also regarded as important because they enable project developers to familiarize themselves with the AE technology, as observed by Terherne pilot, allowing for time to record baseline water temperature measurements, which can be presented to water authorities as part of the permits application process.

Network and stakeholders

One of the enabling factors to AE implementation is for all project stakeholders to take part in the project activities from the start. According to the Howest/Kortrijk pilot, this includes having formal agreements in place with such stakeholders to ensure accountability and sense of ownership. It is also crucial that the working agreements clearly state the stakeholder roles, investments and potential benefits, as experienced by the Ouistreham and Middlefart pilots. An enabling factor for project development is to include a variety of actors from different backgrounds in order to have different expertise and inputs.

Communication with stakeholders

Well-structured and positive communication with pilot partners and other actors involved in pilots is considered an important enabling factor because this helps to clarify information about AE technology and key concepts that may be difficult to grasp due to the technical language often used as experienced by the Energent pilot. It is important to ensure that all stakeholders such as potential investors, consumers and energy cooperatives, fully understand the project details through well-defined project expectations in order to discourage unrealistic project expectations. This was positively reported by the Howest, Energent, Terherne and Baard pilots. For energy cooperatives, engaging in local campaigns to promote their AE work and its benefits to the households builds community support, as mentioned by Warm Heeg.

Sharing experiences with similar stakeholders

The WaterWarmth project provides a platform for similar projects to collaborate and learn from each other's experiences. An enabling factor for the project pilots has been the opportunity to learn from other cities and projects within the consortium as mentioned by the Kortrijk, Energent, Firma van Buiten and Ouistreham pilots. This has also made it easier to access relevant expertise as the consortium members have a wide range of disciplines and networks.

Financial support and flexibility of funding
For the pilot projects, the key success at different stages has been the ability to secure financial support. Having financial support such as investments and bank guarantees was regarded as key in building stakeholder confidence as witnessed in the Energent pilot. Flexibility of funding was considered a key factor for the pilots as it allowed them to restructure their budgets as per their project needs, as experienced by the Ouistreham pilot.

3. Conclusion

3.1 Answering the research question

The research report started with the research question: 'What are the barriers and opportunities that govern niche development and scaling of aqua thermal energy (AE) systems?' Through analysis and mapping the barriers that could hinder AE system niche development and mapping the enabling policy and opportunities that support AE system niche development, the report provides balanced insights from the Interreg North Sea WaterWarmth pilots' experiences. Qualitative data were collected and analysed to narrate the cases' experiences of barriers and successes, as well as compiling the analysis using a multi-case approach that highlights the similarities and differences in the cases. The results show that all the WaterWarmth AE pilots experienced several barriers that hinder AE system niche development, and consequently, have posed challenges for the pilots. In addition, successes and good practice lessons from the AE pilots were reported, addressing potential enabling factors for AE niche development and project implementation.

Policy and regulation barriers and enabling factors were observed in all nine pilot cases. Policy barriers included lack of clear policy and regulation where AE systems are concerned. This included difficult rules in the application of local and regional policy regulations, especially for under-capacitated municipalities. Inconsistent policy was also considered a hindrance to AE innovation as it demotivates investors and other actors in developing an interest in AE projects. Due to unclear policy, local government also felt left out of policy making processes, leading to difficulty in advocating for AE systems. On the other hand, *working closely with policy and governance stakeholders* was regarded as an enabling factor in developing and implementing the projects, especially at the early phases where feasibility is being determined. Part of project preparation ensures success in securing required permits from water authorities and other government bodies at an early stage.

Having no *internal vision* was also considered a barrier as it leads to difficulty in formulating a business plan that will take the project forward. Not having an internal vision also hinders funding security as stakeholders lose confidence in projects that do not have a clear and consistent plan. Lack of *financial support* is one of the key barriers for the projects as they have challenges in securing bank guarantees for equipment and operation costs as well as permitting costs. Due to the novelty of the technology in some countries, it is difficult to convince permitting authorities and finance stakeholders about project viability, especially when there is lack of expertise for project development and advancement. On the other hand, lack of *expertise* was seen as something that could be overcome through *sharing experiences* with similar projects in the same regions or in other countries. This exchange of lessons leads to strengthening of the project and peer-to-peer feedback.

Support of fossil fuels by the government reduces subsidies for innovations such as AE systems, and leads to lack of incentives for adapting AE or large scale collective energy systems. Cheap fossil fuels are therefore regarded as a hindrance to AE development and are seen as unfair competition for renewable energy alternatives that could be implemented if equal funding was available.

Lack of *awareness* is also a barrier to development of AE due to lack of knowledge about the systems. This is also a result of key stakeholders withholding information that could benefit the projects through information exchange. *Networks and stakeholders* were regarded as key in the implementation and success of projects and required formal commitment to ensure accountability and a sense of ownership. Good communication with these stakeholders was also seen as a key success and an enabling factor to ensure a full understanding of the project details and expectations.
Reluctance and *lack of acceptance* of AE technology due to scepticism about renewable energy technologies is also a hindrance to AE development. This reluctance was reported to be a result of high capital costs for such projects as well as lack of political backing which leads to lessened public acceptance.

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Annex 1: Challenges and Successes (Opportunities & Good Practice):

Pilot / Country	**Challenges**	**Opportunities / Successes / Good Practice**
BE- Mechelen (Ragheno)	- City has no property rights in the Ragheno development. - Skepticism about the project from decision-makers. - District heating not seen as viable. - Minimal financial support for heat networks. - Lack of policy frameworks for heat networks. - Local authorities are by-passed in (Flemish) energy regulation. - Energy regulation lacks integration with spatial, water, and environmental policies. - No incentive for adapting AE or large scale collective energy systems. - Concerns that sustainability is used as greenwashing.	- Beneficial to have a policy working group.
BE - Kortrijk (Howest)	- NDA hinders capturing and documentation of the learning process. Information can't be shared freely. - High costs of permits from water authorities.	- Good for all stakeholders to be part of the project from inception. - Documentation of activities is essential. - Signing a working agreement from inception

	- Water temperature monitoring is costly. - Production-consumption price ratio difficult to determine and seem overestimated. - Difficult to keep all stakeholders informed when there in an NDA.	with all stakeholders is essential. - Explaining project concepts to all stakeholders is important.
BE - Kortrijk (Buda Island)	- Pilot's activities not well documented due to time constraints. - Spatial planning subsidies don't include energy planning. - Skepticism about AE systems from decision-makers. - Lack of public knowledge about AE. - The city undecisive about mode of RE provision.	- Currently working with regional government to develop policies based on pilot experiences. - Lesson from other cities and projects have been helpful. - Conducting feasibility studies early in the project helps to determine investment needs.
BE – Gent (Energent)	- Difficulty to predict project costs without a complete business plan. - At first, difficulty to access underground pipe network plans from the city. - They don't have all the experts needed for the project due to delays. - There was an NDA in place which made it difficult	- They now have underground pipe network plans from the city. - NDA issue has now been resolved, info can be freely shared with stakeholders. - Structured and positive communication with well-defined project expectations to stakeholders - Expert knowledge is valued by stakeholders.

	to keep all stakeholders informed. - Unclear about political impact on the project.	- Securing financial support builds confidence in stakeholders.
DNK - Middlefart	- Challenges with legislature and government actors in giving support for AE and the project. - Lack of alignment among stakeholders and project activities. - Lack of understanding by the Danish Energy Agency led to lack of funding and financial guarantees due to fear of risk. -Government adoption of new behaviors and technologies is challenging despite strong arguments.	- Involving different actors from different backgrounds has been central to project development. - Technical and legislative barriers require resilient leadership.
FR - Ouistreham	- Corrosion issues requiring costly budget adjustments for equipment. - Reduction of staff costs due to unexpected high equipment costs.	- Could easily adjust staff costs to remain within budget despite unexpected equipment costs. - Support from the mayor has been crucial and beneficial. - Engaging key stakeholders has removed project obstacles. - Support from Waterwarmth project partners seen as valuable.
NL - De Fryske Marren / Terhene village	- Starting the AE pilot project without a framework.	- For AE projects, it is best to use the first year for

	- The local regulations considered difficult to apply because of bureaucratic administrative systems. - Difficulty in evaluating the economic and social feasibility of the project, when partnering with an energy cooperative or an energy community that does not have formal and legal structures. - Lack of control in timing the project activities.	feasibility and familiarization of the project. - Ensure that stakeholders such as energy cooperatives fully understand the project details in order to discourage unrealistic expectations.
NL - Leeuwarden (Baard village)	- Cheap fossil fuels due to subsidies which is unfair competition for renewable energy alternatives that they would like to implement. - Lack of bank and technical guarantees for AE installations. - High installation costs of AE are also another barrier to full scale implementation. - reluctance of social housing stakeholders to be part of the project.	- Communicate extensively and clearly about project progress to their stakeholders.
NL - Heeg (warm Heeg)	- Lack of funding for the development phase - Instability of subsidies and the frequent change of rules that govern the attainment of energy subsidies	- Engage in local campaigns promoting their work and its benefits to the households as well as to build community support - Transparent energy pricing.
NL -Delft (Firma van Buiten)	- Delays in proposal approval by the university's innovation committee.	- Importance of temperature measurements to record

	- Delays in finding project management capacity and a prolonged permit procedure. - Unexpected high costs of equipment leading to a need for more funding.	baseline temperatures a year before project start. - Early discussions with the Waterboard. - Sharing experiences with other projects within WaterWarmth consortium. - Conducting feasibility studies early in the project helps to determine investment needs.