This report explores the governance and innovation of Aquathermal Energy (AE) systems as a sustainable alternative for heating and cooling in Europe. AE systems, which utilize surface water, sewage water, and drinking water for thermal energy, offer promising environmental and economic benefits in the transition away from fossil fuels.

To analyze AE system development and implementation, the report introduces several theoretical frameworks **Multi-Level Perspective (MLP)**, **Strategic Niche Management (SNM)**, and **Contextual Interaction Theory (CIT)**.

These frameworks are applied to two case studies: household-level AE development in Sweden and regional AE governance in Fryslân, the Netherlands. The analysis focuses on factors influencing AE adoption, including policy, regulation, actor dynamics, infrastructure, and community involvement.
Key research questions addressed include:

1. How can AE transitions in the EU be understood through broader sustainability and governance frameworks?
2. Which theoretical approaches are effective for analyzing transformative change in AE systems?
3. How can these frameworks be applied to real-world AE cases?

Findings:

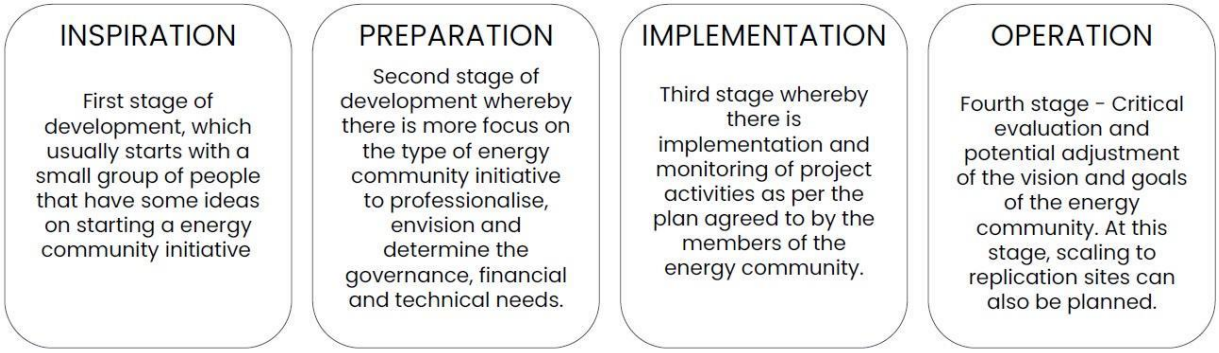
- **MLP** helps explain how macro-level pressures (e.g., climate goals, energy security) and niche innovations interact with existing regimes, highlighting the resistance and enablers of systemic change.
- **SNM** emphasizes the importance of expectation shaping, network formation, and learning processes in supporting niche AE innovations.
- **CIT** provides insights into how motivation, power dynamics, and actor interactions shape policy implementation and governance outcomes.

In Sweden, AE adoption at the household level is influenced by established heating technologies (e.g., district heating, geothermal, and air-based heat pumps), despite favorable policy contexts. In contrast, the Dutch case shows more institutional engagement, with multi-actor governance initiatives like the **Green Deal Aquathermie** and the **Netwerk Aquathermie** promoting AE uptake, although regulatory and financial barriers persist.

The report also explores the growing role of **community energy initiatives** and **Integrated Community Energy Systems (ICES)**, which combine decentralized energy management, smart technologies, and local participation to enhance resilience and sustainability.

Conclusion:
The report demonstrates the utility of combining theoretical frameworks to understand and guide AE system transitions. It offers valuable insights for academics, policymakers, and practitioners aiming to foster sustainable heating solutions. Future research should expand the number of case studies and include primary data to deepen understanding of AE system dynamics and governance across diverse contexts.

Monitoring frameworks and methodologies aid in assessing the progress and performance of energy collectives and support organizational decision-making.



Factors influencing AE development in Fryslân. High energy prices, commitment to the Paris Agreement, and community energy initiatives have spurred AE exploration.

Landscape event	**Regime factor**	**Regime aspect**	**Enabling or Inhibiting?**
Climate change – COP21 Paris Agreement 2015			Enabling – COP21 transposed in national Climate Agreement supporting adoption of renewable energy – also indirectly via the 'Green Deal Aquathermie' which was part of the Climate Agreement's 'Green Deals' package – and similarly via the Regional Energy Strategies (RES) empowering regional governance of energy transitions
Earthquakes in the Groningen region – since 1986 but a serious issue since 2012			Enabling – raised attention phase out natural gas use. Heat transition has been on the agenda since 2018 with enabling (national) programs on experimentation with neighbourhood approaches ('PAW'), heat pump adoption and thermal insulation adoption. Moreover, key to the heat transition policy is decentralised control via municipalities getting a coordination role, formulating TVHs (heat visions) and local heat tr. implementation plans
Culture of citizens wanting green energy systems themselves Energy cooperatives?			Enabling – Over years citizens have become more knowledgeable, aware and capable of mobilising resources to green (local) energy systems themselves. This is in part also a response to government and market failure to successfully encourage green energy transitions – momentum for the rise of community energy (per 2010)
Russian invasion in the Ukraine in 2022 – ongoing war			Enabling – surging gas prices are creating a window of opportunity for heat pump and thermal insulation adoption (which led to surging market demand and long waiting lists in supply).
	Partial reimbursement for surging gas prices (following Russian invasion)	(Sectoral) policy	Inhibiting – (partial) reimbursement works as a disincentive for households and other end users to invest in heat pumps and AE, because the price difference is made smaller
	Restrictive legislation	Sectoral policy	Inhibiting - restrictive legislation and regulations that cause hindrance when permits are required to apply AE. What makes things even more difficult is dependence on permit systems in different sectoral policy silos

Key takeaways from using the CIT and MLP frameworks

The report explores how theoretical frameworks like CIT and MLP can be used to analyze AE project implementation. Table 5 summarizes key insights from these frameworks, linking their elements to factors influencing AE implementation in various contexts

Key CIT and MLP takeaways

#	CIT key takeaways	MLP key takeaways
1	Analyses the key actor characteristics that influence the interaction process	The MLP emphasises dynamic, co-evolutionary interactions between the niche, regime, and landscape levels. Changes in one level can influence and be influenced by changes in other levels.
2	The key motivations for the different actors include meeting national climate change obligations, lowering dependence on fossil fuels, innovation advancement in renewable energy production and ensuring access to clean energy for local communities.	Transitions are directly and indirectly influenced by factors in the broader landscape; these can include societal values, economic conditions, and policy changes. The external pressures create opportunities for niche innovations such as AE to gain traction or force change within the regime.
3	In terms of cognitions, information and knowledge generation about AE systems is important for all actors to enable suitable decision-making, influence policy decisions, and contribute to good governance.	Regime level actors respond to developments and changes at the landscape level. Regime actions can either impede niche level innovation developments such as AE systems, or support the innovations through the creation of new policies, markets, etc.
4	Resources and power are essential elements in the actor interaction and implementation of AE projects. Such projects are implementable only with the willingness of actors that have resources. In this regard, how each actor's power is perceived and used is also essential in implementing AE projects.	Transitions and the MLP allow practitioners to understand change processes over a longer-term perspective. Recognizing the historical development of regimes and understanding the trajectories of niche innovations allows for a deeper analysis of transition dynamics.
5	The specific context is important in assessing the feasibility of implementing AE projects. In this case, it is about assessing the appropriateness of the local conditions and how these match the needs for such implementation.	Managing transitions such as AE energy system development requires active intervention and governance. Policy measures, regulations, and supportive frameworks can facilitate the emergence and diffusion of these niche innovations.
6	The structural context provides a lens to assess the structures in place for implementation to take place. In the case of AE, stakeholder networks and multi-level governance systems are essential in the successful implementation of AE projects.	Formal and informal networks are key to driving niche innovation processes. AE system development will require robust constellations of actors including citizens, local government, interest organisations, and market players.
7	The wider context assesses the influence of geopolitics in the development and implementation of new innovations. The motivation to encourage AE innovations is partly based on the fragile global politics that have a strong influence on energy security, production and supply.	