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SAPHEA

INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

D 6.1 Summary report on early-stage stakeholder interaction (TUM, month 14): This report will summarize the performed activities and conclusions drawn on user requirements and needs related to knowledge gaps. The report will also contain recommendations for the design of the Market Uptake Hub (contribution to milestone M3) and will be complemented by an electronic repository on the documentation and materials used for the stakeholder interaction.

D 6.1 Summary report on early-stage stakeholder interaction

Participant and stakeholder questionnaire on geothermal energy use in heating and cooling networks

Survey Evaluation

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List of Abbreviations

5GDHC	5th-generation district heating and cooling networks
ASHP	air source heat pump
ATES	aquifer thermal energy storage
CHP	combined heat and power
DHC	district heating and cooling
geoHC	geothermal heating and cooling
HP	heat pump
HT	high-temperature
LT	low-temperature
NIMBY	„not-in-my-backyard“
RES	renewable energy sources
UTES	underground thermal energy storage

Participant and stakeholder questionnaire on geothermal energy use in heating and cooling networks

Survey Evaluation

1 INTRODUCTION

For an early stakeholder interaction in the framework of the SAPHEA-Project two questionnaire surveys were jointly designed within the consortium and conducted in two events.

The surveys aim to evaluate perceived and identified or unidentified needs associated with knowledge gaps in various stakeholder groups, and to gather data on the existing knowledge and awareness of geoHC networks, their potential effects, and obstacles to their advancement.

The results will be used for the fact-finding for the Market Uptake HUB, for instance as FAQs, to design it and transfer the gathered knowledge to different interest groups.

The evaluation is part of SAPHEA's Work Package *WP6 Capacity building and stakeholder interaction to support future uptakes of geoHC networks in European regions* and its deliverable *D6.1 Summary report on early-stage stakeholder interaction* which will summarize the performed activities and conclusions drawn on user requirements and needs related to knowledge gaps. The report will also contain recommendations for the design of the Market Uptake Hub and will be complemented by an electronic repository on the documentation and materials used for the stakeholder interaction.

The results will feed a deeper focus group where the requirements and knowledge gaps will be analysed towards the design of the Market Uptake Hub and its contents, created in SAPHEA's thematic work packages WP3 to WP5.

The present evaluation aims to assess the stakeholder needs in the context of geoHC networks. The conducted surveys focus on challenges and barriers regarding the integration of geothermal energy into a new or an existing DHC grid. They further asked for the key points and recommendations for successful integration and about how to deal with redundancies and peak load supply.

In general, a geoHC network can be regarded as a thermal distribution grid network that operates at a scale from local communities to cities, with temperatures ranging from below 30 °C to around 120 °C and peak load capacities between 500 kW to hundreds of MW. It uses geothermal energy as either a primary or seasonal heat source, integrates on-site fluctuating heat sources, prioritizes local, low-enthalpy inputs for resilience, and serves both new and existing infrastructures with a focus on reducing fossil fuel use and energy imports.

In the first section (Chapter 2), the report describes the structure and conduction of the two surveys, including a short comparison of the validity of the results. It further gives an overview of the participants of the two surveys. The following sections (Chapters 3 and 4) present the evaluation of the topic's challenges and barriers and possible solutions. Chapter 5 summarises the main aspects of the evaluation and draws first conclusions.

2 CONDUCTION OF THE SURVEYS

In 2023, SAPHEA conducted two surveys on the use of geothermal energy in heating and cooling networks in Europe: a live survey at the Geothermal District Heating and Cooling Days in Aarhus, Denmark and a questionnaire written in the framework of COST Action 18219.

2.1 Structure of the two surveys

Both surveys used the same set of questions but were conducted differently. The questions were composed of two parts, i.e. general information and technical questions.

- General questions
    - Name, surname, affiliation (COST Action only, Aarhus survey was anonymous)
    - Country, email-address
    - Background: Which group are you representing? Choose from operator/service provider, research, financial/investor, planner, Other
    - Experience: In how many case studies were you involved concerning the implementation of
        a) Low-temperature grids integrating geothermal energy sources
        b) High-temperature grids integrating geothermal energy (deep geothermal)
        c) The design and implementation of heating (and/or cooling) grids in general?

        Choose from none / 1 / 2-5 / >5.
    - Experience: Do you have (practical) experience in the implementation of geothermal energy into Cooling Grids? Choose between yes/no.
- Technical questions to be answered by text (Cost Action questionnaire) or by keywords (Aarhus survey)
    - What are the main challenges and barriers on designing and implementing a new construction of a district heating or cooling grid with the integration of geothermal energy?
    - What are the main challenges and barriers on integrating geothermal energy in an existing district heating or cooling grid?
    - How do you deal with redundancy and peak load supply?
    - What are the key points from your experience or perspective for a successful integration of geothermal energy into heating (and/or cooling) grids?

See Annex 1 for a copy of the full questionnaires, a template of the COST Action questionnaire and slides from the presentation of the survey at the conference in Aarhus.

2.2 Live-survey Aarhus, Denmark

The survey in Aarhus was conducted during the Geothermal District Heating and Cooling Days which took place 19th-21st of September 2023 in Aarhus, Denmark. The Geothermal District Heating and Cooling days were organized by the European Geothermal Energy Council (EGEC), the university college VIA of Denmark, the EU COST Action 18219 Geothermal-DHC and SAPHEA. The conference consisted of an international workshop on "Business and Financing Models for Geothermal Energy-Supplied Heating (and Cooling) Networks in Europe.", sessions for discussions and knowledge-sharing opportunities on various aspects of geothermal energy-supplied heating and cooling networks in Europe and a field trip, offering the opportunity to visit practical applications of geothermal technologies

For further information, visit https://www.egec.org/events/geothermal-district-heating-and-cooling-days-2023/.

On the first day of the conference, the EU-Horizon project "SAPHEA" (www.saphea.eu), the EU COST Action 18219 "Geothermal-DHC" (www.geothermal-dhc.eu) and VIA University College (Aarhus, DK) jointly organized a workshop on "Business and Financing Models for Geothermal Energy-Supplied Heating (and Cooling) Networks in Europe". It addressed the key questions related on making investments into geothermal energy solutions in heating (and cooling) networks more attractive, such as:

- How to address legislation and policymakers? "The hen or the egg" type of problem
- How to construct the right value proposition?
- How to secure consistent financing for geothermal DHC?

The workshop aimed to learn from good practices across Europe and transfer ideas and solutions between the industry, municipalities and research in different European regions. Therefore, it especially addressed the following target groups:

- R&D representatives focusing on geothermal, district heating/cooling and the heating and cooling sector in general
- Energy suppliers, energy contractors, district heating operators
- Representatives from municipalities
- Energy planners and energy agencies
- Interest groups and NGOs.

75 participants attended the session. During the workshop, SAPHEA had the opportunity to conduct a live survey in a forum. The participants used their mobile phones to vote on questions and to contribute information. The survey therefore emphasized fast and short answers to the survey questions. For some questions, especially the technical ones, several answers were allowed.

2.3 Questionnaire in COST Action 18219 Geothermal DHC

The questionnaire in the framework of the COST Action 18219 Geothermal DHC was conducted in September/October 2023 via email.

EU COST Action 18219, "Research Network for Including Geothermal Technologies into Decarbonized Heating and Cooling Grids (Geothermal-DHC)", is part of COST (European

Cooperation in Science and Technology), which is a funding organization for research and innovation networks. COST itself is funded by the EU. The Actions help connect research initiatives across Europe and beyond and enable researchers and innovators to grow their ideas in any science and technology field by sharing them with their peers. COST Actions are bottom-up networks lasting four years that boost research, innovation, and careers.

EU COST Action 18219 addresses the inclusion of geothermal technologies into district heating and cooling systems in Europe to foster the de-carbonization of the heating and cooling market. Regarding technological solutions, the Action follows a strong bottom-up approach. Shallow, intermediate as well as deep geothermal technologies are considered in monovalent or multivalent grids. Geothermal may act as a heating source, sink or storage and may be combined with other renewables (e.g. solar thermal), waste heat and other technologies like carbon capture and utilization. The Action covers networking, knowledge exchange and transfer, training and stakeholder interaction activities based on real-life case studies to investigate and promote solutions and roadmaps for raising the RES share in public heating and cooling grids to at least 30 % in 2030 and at least 50 % in 2050.

For further information, visit https://www.cost.eu/actions/CA18219/ and the website of the Action at https://www.geothermal-dhc.eu/.

18 questionnaires were returned by the COST Action members. Though fewer in number, the returned questionnaires provide detailed answers to the questions.

2.4 Remarks on the evaluation of the two surveys

As the two surveys are quite different from each other in format, they were evaluated separately. In general, due to the limited number of answers, it is rather a compilation of examples and possibilities than a statistical evaluation. The Cost Action questionnaire consists of only a small though detailed sample (18), answers from the Aarhus survey are often open to interpretation as replies consist of buzzwords only.

- Remarks for the General questions
  - It cannot be excluded, that individuals participated in both surveys.
  - If appropriate, the answer “none” and questions without an answer were grouped.
- Technical questions
  - The technical questions were answered mostly in detailed texts by the participants of the Cost Action questionnaire, while the participants of the Aarhus conference answered with one or several keywords.
  - Descriptive text as well as keywords allow one to express multiple views on a single issue. For each technical question, the number of participants that answered the question, as well as the number of answers given in total, is shown in the corresponding figure below.

2.5 Comparison of general information from the surveys

18 **75**

Number of questionnaires returned.

Cost Action Questionnaire Aarhus Survey

Question 1: Which country are you from?

The answers to the question of the origin of the participants differ depending on the survey:

- For Cost Action 18219 only member countries were included and only a few members per participating country were consulted.
- For the Aarhus survey, the participants were composed of conference participants. As the conference took place in Denmark, obviously Denmark and its neighbouring countries (Sweden, Norway, Iceland) make up the larger part of the participants.

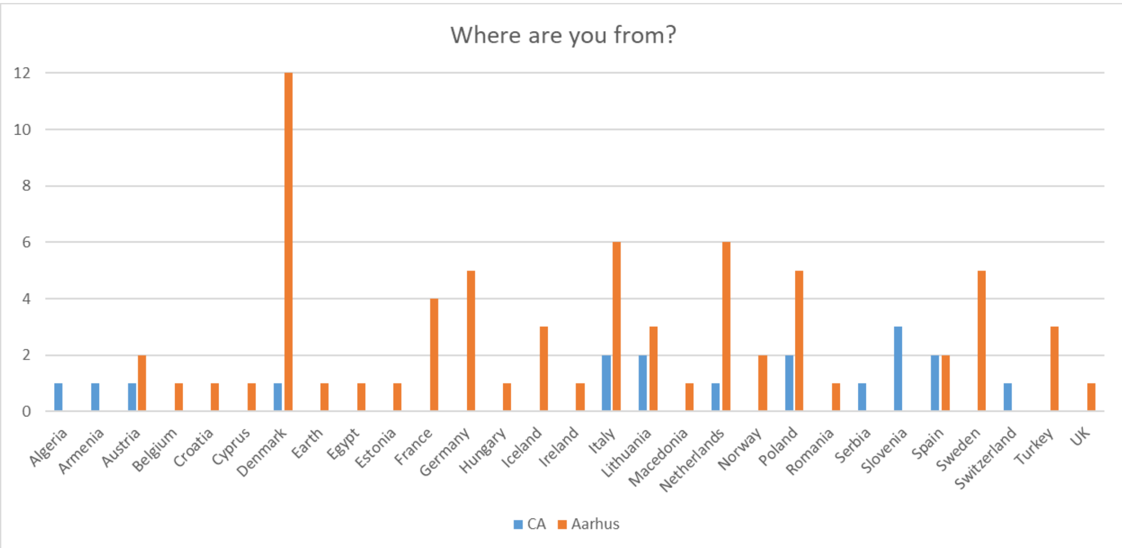


Figure 2.1: Countries of origin of the participants of the Aarhus survey

Question 2: Which group are you representing?

The given options for the question of group representation in the two surveys differ slightly from each other. The Aarhus survey offered seven groups to choose from, while the Cost Action questionnaire offered only four.

Differences between the groups were evaluated by comparing the answers of research-oriented participants (Group: research) and implementation-oriented participants (Groups: financial/investor, operator, service providers and planners) for the Aarhus survey using only the first of multiple answers. Due to the small number of participants in the Cost Action questionnaire, a more detailed evaluation was omitted.

# participants	18
# answers	20

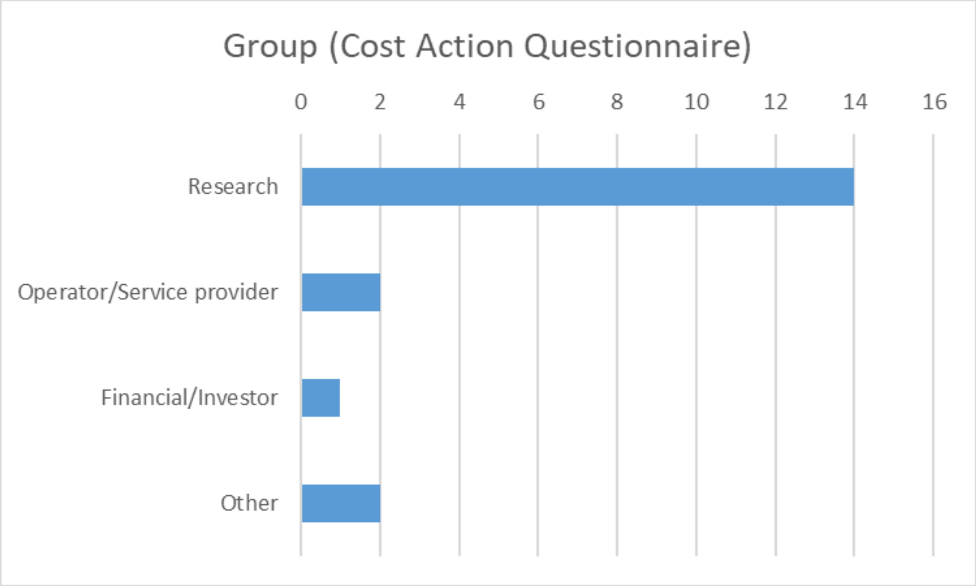


Figure 2.2: Number and distribution regarding the target groups of the Cost Action questionnaire

# participants	71
# answers	95

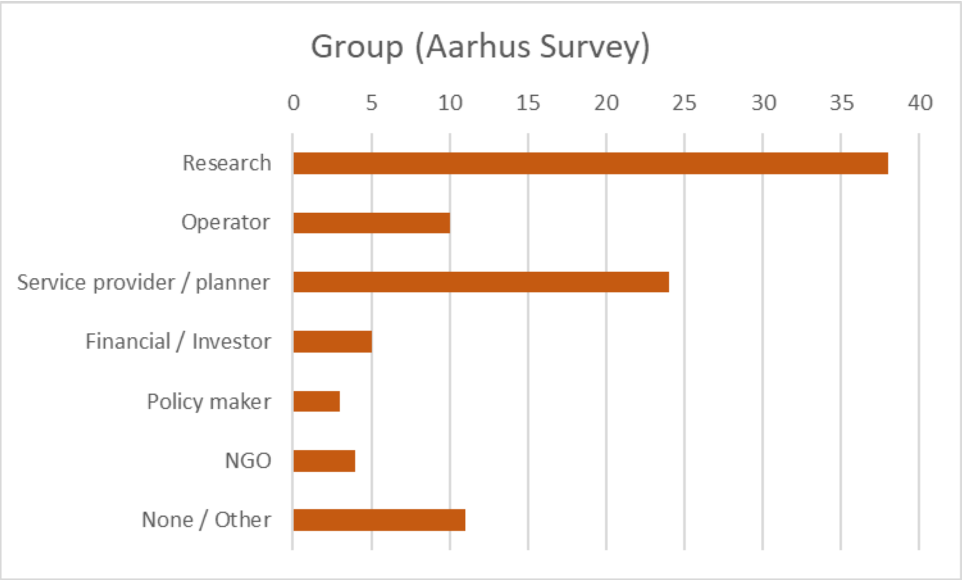


Figure 2.3: Number and distribution regarding the target groups of the Aarhus survey

In the Aarhus survey, 15 participants represented 2 or even 3 groups, and “no answer” was merged with *None/Other*.

Question 3: Expertise in Geothermal Projects

Questions about the participants' experience in the integration of geothermal energy in networks also differ slightly between the two surveys and are compared to each other in the table below. Both surveys asked for the involvement in the implementation of low/high-temperature grids and the involvement in the design/implementation of heating (and/or cooling) grids in general. The Aarhus participants were also asked about their experience in the implementation of geothermal energy into DHC grids and to give a self-assessment on how confident they feel about Geothermal DHC, while participants from the Cost Action questionnaire were asked about their experience in the implementation of geothermal Energy into specifically cooling grids.

Table 2.1: Comparism of the questions concerning the participants' experience in the integration of geothermal energy in networks between the Cost Action questionnaire and the Aarhus survey

Cost Action questionnaire	Aarhus survey
	q0 - Confidence level in geothermal DHC
	q1 - Have you been involved in the design/planning/implementation of heating and or cooling grids in general? (how many):
	q2 - Do you have any (practical) experience in the implementation of Geothermal into district heating (and cooling) grids?
Q2a - In how many Case studies were you involved concerning the implementation of Low-temperature grids integrating geothermal energy sources?	q3 - In how many projects have you been involved concerning the implementation of ***Low temperature*** grids integrating geothermal energy sources?
Q2b - In how many Case studies were you involved concerning the implementation of High-temperature grids integrating geothermal energy (deep geothermal)?	q4 - In how many projects have you been involved concerning the implementation of ***High temperature*** grids integrating geothermal energy sources?
Q2c - Have you been involved in the design and implementation of heating (and/or cooling) grids in general?	
Q3 - Do you have (practical) experience in the implementation of Geothermal into cooling grids?	
	q5 - Self-assessment: How confident do you feel about geothermal district heating and cooling?: Expert level

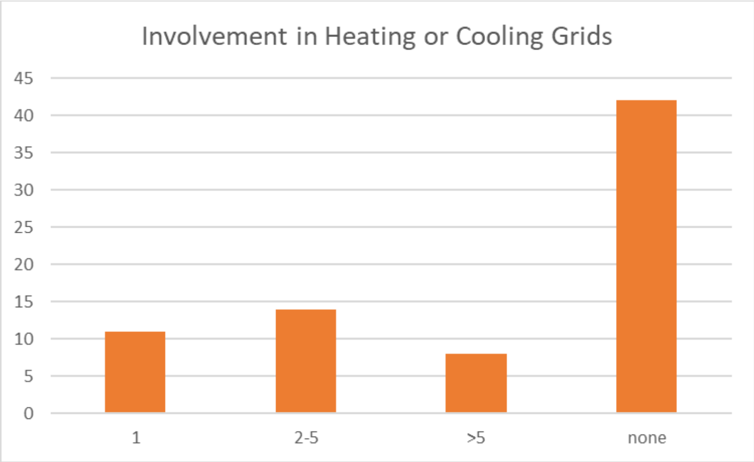


Figure 2.4: Aarhus survey and Cost Action questionnaire participants' involvement regarding the design of heating and/or cooling grids

Figure 2.5: Self-assessment on the confidence level - low (1) to high (5) - of the Aarhus survey participants regarding geothermal DHC

Participants of both surveys were asked about their experience in the implementation of geothermal into grids, though the Cost Action questionnaire asked specifically about Cooling Grids, while the Aarhus survey asked for District Heating and Cooling Grids

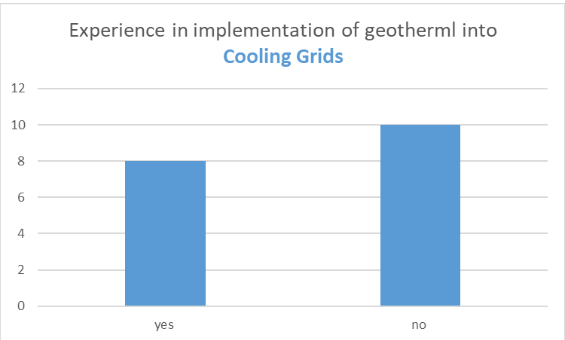


Figure 2.7: Experience of the Cost Action questionnaire participants regarding the implementation of geothermal energy into cooling grids

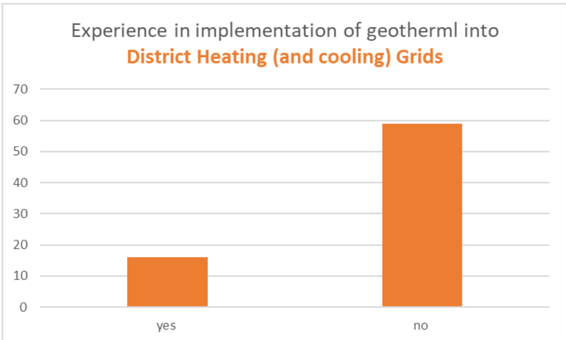


Figure 2.6: Experience of the Aarhus survey participants regarding the implementation of geothermal energy into district heating and cooling grids

More specifically, both surveys asked for the involvement of the participants in integrating geothermal in low and high-temperature grids

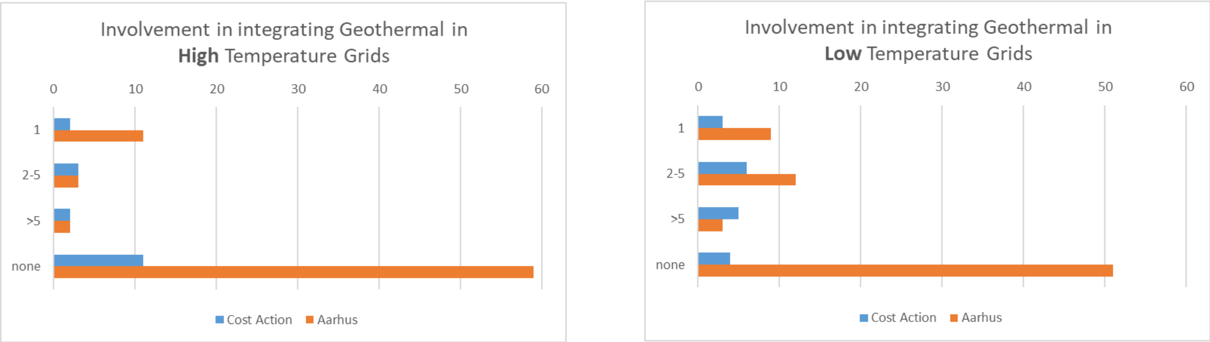


Figure 2.8: Involvement of the Aarhus survey and Cost Action questionnaire participants regarding the integration of geothermal energy in high and low temperature grids

Finally, an additional question in the Cost Action questionnaire for those participants that answered neither of the previous ones (see Figure 2.8) was asked in general about the involvement in design planning or implementation of heating and cooling grids. Only two participants answered LT and HT with none, one of them indicating general experience in one case in heating and cooling grids.

3 CHALLENGES AND BARRIERS

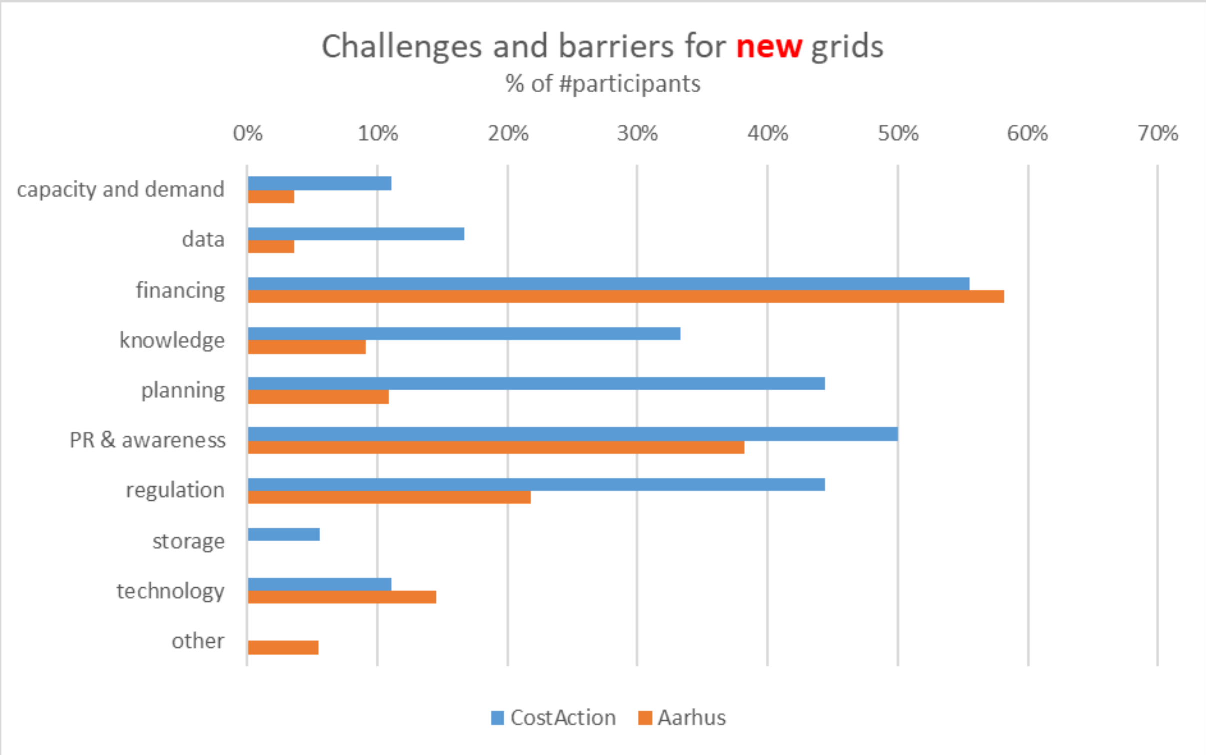
Whether designing and implementing a new construction of a district heating or cooling grid with integration of geothermal energy or integrating geothermal energy into an existing grid, both come with various challenges and barriers across different categories. While new site planning offers the advantage of starting from scratch and optimizing the entire system, integration into an existing grid requires careful consideration of current infrastructure, limited options and challenges concerning retrofitting, effective management of the transition process, as well as economic challenges including increased end-user prices Both approaches require thorough geothermal resource assessments, compliance with regulations, and community engagement for successful implementation.

The answers of participants from both surveys were grouped into categories and evaluated regarding new as well as existing grids. Deduced categories are capacity and demand, data, financing, knowledge, planning, PR and awareness, regulation, storage, technology and others.

The detailed answers from the Cost Action questionnaire showed that challenges and barriers cannot be uniquely grouped into single categories. Often answers were assigned to several categories. For example, technical challenges are a technological issue but can be expensive and will, therefore, also be a financial issue.

3.1 What are the main challenges and barriers on designing and implementing a new construction of a district heating or cooling grid with the integration of geothermal energy?

The design and implementation of a new construction of DHC grids face several challenges and barriers. Both surveys see financing as a major challenge, followed by PR & awareness. Knowledge, planning and regulation are seen as important by both, but with different emphases. Other issues are data, technology and capacity/demand.



# participants	18	55
# answers	56	91

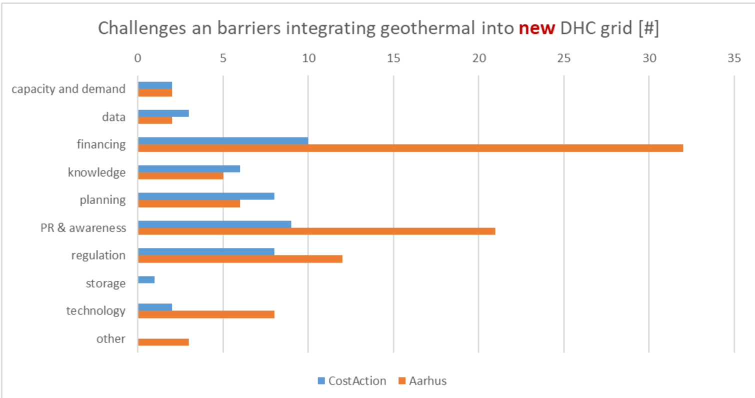


Figure 3.1: Overview on the assessment concerning the challenges and barriers on integrating geothermal energy into new DHC grids

Though fewer experts participated in the Cost Action questionnaire, they addressed more topics in detailed answers.

Regarding differences between research- and implementation-oriented participants, both groups express more or less the same opinion with only insignificant variations.

Financing

Securing financing for constructing new DHC grids, especially with integrated geothermal energy, can be challenging due to high upfront costs *such as drilling wells and setting up heat exchange systems* and uncertainties associated with geothermal exploration.

This is expressed in both surveys with several keywords (*financing, funds, investment, interest, money, upfront costs*), but also described in the Cost Action questionnaire in more detail. More than half of the participants (CA 56 %, Aarhus 58 %) in each survey see financing, investment, and costs as a challenge or barrier to implementing DHC grids integrating geothermal energy.

The high initial investment can especially be *a barrier to entry for smaller communities or private companies,* while *in rural areas, low population density may make it difficult to justify the investment.* Further, the comparison with traditional fossil-based DHC networks adds *uncertainty to CAPEX.* Renewable energy sources need to be able to compete with conventional ones. Thus, the non-inclusion of externalities in the *economic assessment of conventional sources such as gas* is also seen as a barrier. For Austria, it was specified that *no risk mitigation scheme is available* and that the *available public funding only covers around 10 % of total investments.*

PR and Awareness

Awareness and marketing issues are relevant to both survey groups: 50 % of the Cost Action questionnaires and 38 % of the participants in Aarhus see challenges and barriers here. A major barrier is the general lack of awareness of stakeholders that geothermal can be the solution, e.g. *The problems are due to the mentality of people who do not know how to look into the future and energy savings, but mainly focus on the investment costs and deal primarily with how much subsidy they will receive, not what they will gain.* Once awareness is established, there might still be a *lack of willingness to change*, e.g. *mental barriers to shift from individual boilers to shared.*

The lack of awareness will concern *local authorities as well as citizens.* A reason given is the *lack of demonstration facilities* and *established and well-known solutions linked to 5G networks* to *demonstrate benefits to end users.*

Also mentioned here is the importance of engaging *with the public early in the planning process to ensure that there is support for the project. This can be a challenge in areas where there is a lack of awareness of district heating and cooling or where there are concerns about environmental impact.*

The Aarhus survey describes the range of awareness issues with further keywords such as (*public*) *acceptance, cultural expectations, cultural barriers, habits, NIMBY, off-takers, prejudice, risk aversion, paradigm shift, socio-political, SH perception, and understanding the value prop*.

Regulation

Regulation issues play an important role in all questions of the surveys. For constructing new grids, Cost Action participants gave them more weight (44 %) than Aarhus participants (22 %). The latter points to challenges and barriers concerning regulation with keywords such as *regulation, ownership, permitting, policies, legislation, legal or government*.

Cost Action questionnaires agree and describe in more detail: regulation can be too much, in that *permit/authorization procedure can be complicated/unclear* and that *obtaining the necessary*

permits for drilling and utilizing geothermal resources can be a lengthy and bureaucratic process. Compliance with environmental regulations is crucial but can also slow down the implementation. Regulation can also be not enough (*lack of specific normative*) as *specific regulations help to design and realize new construction of DHC networks*.
An example from Austria shows that regulation frameworks are often not truly fit for geothermal use, as permitting regulations such as *concessions, claims, and first-come-first-serve procedures* can hinder the integration of geothermal and make *it hard to plan long-term investments (e.g. 3D seismic) without having the security of investments*. Further, for shallow geothermal, *ownership of geothermal installation; is connected with the land/property and leads to hurdles for contracting models (e.g. geothermal installation leasing)*.

Planning

While planning issues are important to the Cost Action participants (44 %) they are only mentioned in a general way in the Aarhus survey (11 %) with terms such as *business model, existing long-term plans* or *lack of concept*.

Planning issues span from design to economic cost calculation: *district heating and cooling grids with geothermal energy integration are complex systems that require careful planning and design.* Besides the primary challenge of *finding suitable geological formations for geothermal energy extraction*, several technical challenges *must be addressed, such as heat loss in the distribution pipes, corrosion, and water quality. Long planning and construction timelines, usually several years, can be a challenge in fast-growing communities or areas with complex permitting requirements.*

Knowledge

Just as with regulations and planning issues, more Cost Action participants (44 %) than Aarhus participants (9 %) name knowledge issues as challenges and barriers to the implementation of new grids. These can be summarized as a *lack of competencies, a lack of engineering experience, a lack of demonstration facilities and best practices and a knowledge gap*. Aarhus participants add general keywords such as *knowledge, lack of understanding, and guidelines*.

Technology

Technology issues are only seen by 11 % (Cost Action) respectively 15 % (Aarhus) of the participants of the two surveys as problematic. In general, the integration of *geothermal energy into a district heating or cooling grid requires careful planning to ensure compatibility with existing infrastructure and technologies*. A few issues such as *heat loss in the distribution pipes, corrosion, and water quality* or *in urban areas, it may be difficult to retrofit existing buildings to connect to the grid*, are named explicitly. Aarhus participants also used the following keywords: *adapting surface equipment, ASHP, buildings, old buildings, poor constructors, smart controls, technology, and upscaling.*

Capacity and demand

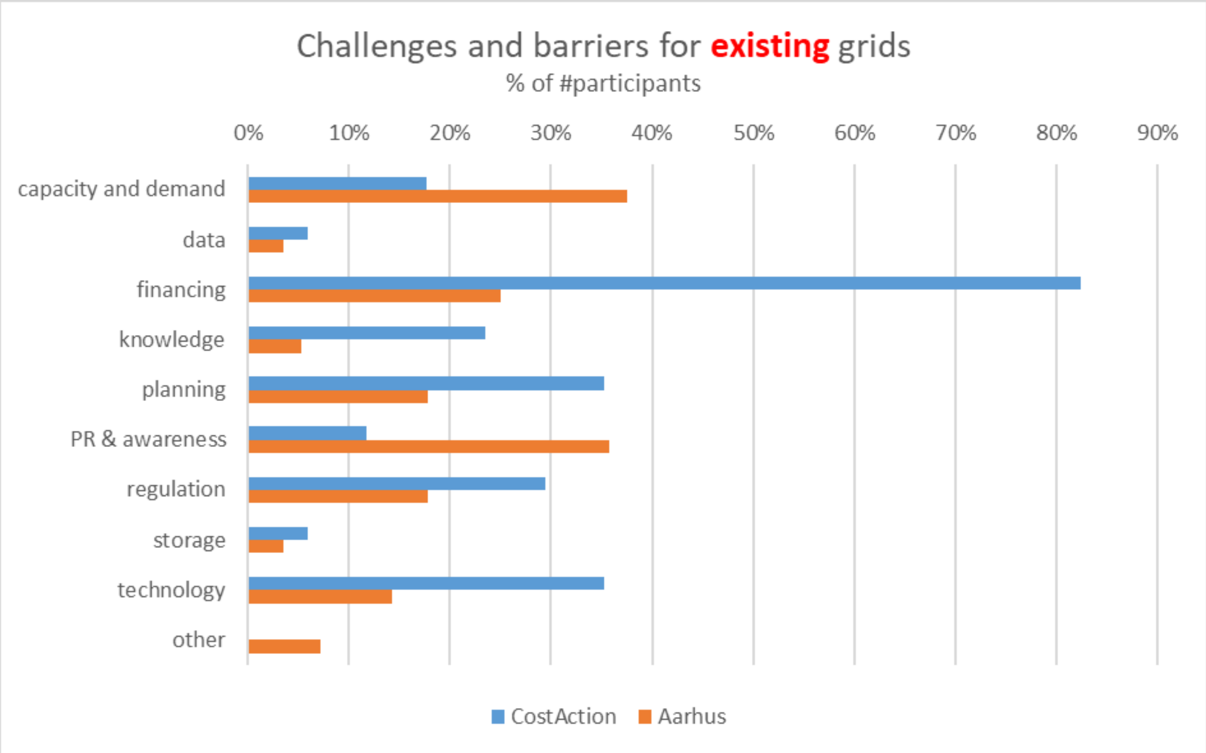
Only a few participants see capacity and demand issues as relevant for the construction of new grids, these include the geological risk, i.e. *finding suitable geological formations for geothermal energy extraction as not all regions have accessible geothermal resources, and the quality and depth of these resources can vary significantly* as well as *matching temperature levels*. Further, *the sustainable utilization of geothermal energy is essential. Over-extraction can lead to resource depletion and a decrease in energy output over time*.

Data

Finally, data issues are mentioned by only a few participants (3 for Cost Action and 2 for Aarhus respectively) referring to a *lack in the availability of stratigraphic logs/data publicly accessible, with geological, hydrogeological, and/or thermo-physical information of the underground soils* as well as a lack of data *from energy demand of final users (buildings, facilities, …).* Aarhus participants also named *spatial plans* and *subsurface data.*

3.2 What are the main challenges and barriers on integrating Geothermal energy in an existing district heating or cooling grid?

The integration of geothermal into an existing grid faces a lot of similar challenges and barriers as the construction of a new grid but additionally has to deal with more technical issues such as compatibility, matching temperatures or maintaining the service running during the installation.



# participants	17	56
# answers	36	94

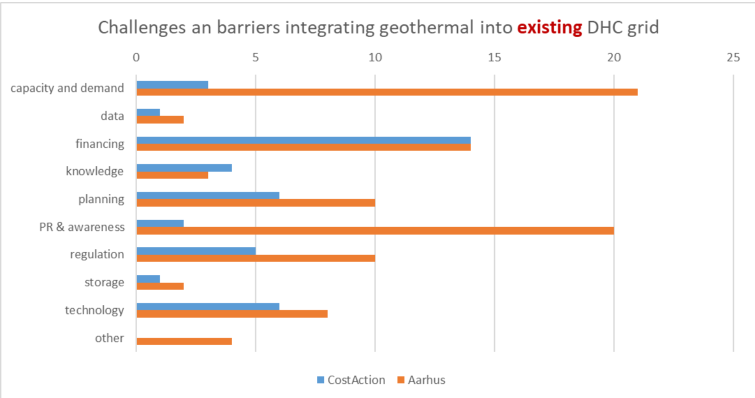


Figure 3.2: Overview on the assessment concerning the challenges and barriers on integrating geothermal energy into existing DHC grids

While financing and PR & awareness issues are again important, with existing grids researchers focus also strongly on capacity/demand topics, while financing and regulation issues are more important to the focus on implementation.

Financing

Challenges and barriers in the category of finances are a major issue for Cost Action participants (82 %). This is even more than the answers for the construction of new grids implementing geothermal (56 %). On the other side, only 25 % of the Aarhus participants see financing as an issue which is only about half of the answers for new constructions (58 %).

Though financing is a major issue most answers only refer to it in general as *financing, (high) investment* or *extra costs for thermal response tests*, additional necessary equipment and *urgent maintenance*.

In addition to the challenges of financing new construction, investments in existing grids are even more difficult as *convincing people to lend existing grids is a very painstaking job, more so than the implementation of the project. People do not think about investments for the future and that by investing in new technologies, you will improve the standard and comfort in the future.*

Furthermore, new excess heat sources can require new networks, and thus new financial incentives and specific norms. Boosting technology (for increasing temperature from a supply source and for increasing temperature at certain places in the grid in cold seasons) can become relevant and expensive, and thus need to be incentivized.

Aarhus participants add keywords such as *capital, cost, price cost of retrofitting, long-term investment, and money*. Financial incentives or subsidies are not explicitly mentioned but might be included in *funding*.

Planning

The importance of planning issues is similar to the construction of new grids: 38 % of Cost Action and 18 % of Aarhus participants see challenges and barriers in the planning phase. Successfully integrating geothermal into an existing grid involves several additional considerations besides those already listed for the construction of new grids.

Especially managing a *prolonged planning phase* to ensure compatibility with the current layout, capacity, and operational requirements. Also, coordinating the integration of geothermal energy while maintaining uninterrupted service to customers is a critical challenge.

Further, urban areas often face space limitations, making the installation of geothermal equipment *such as heat exchangers and pumps,* challenging. Therefore, *finding solutions for space constraints in urban areas* must be addressed.

Another aspect is that the *non-inclusion of externalities in economic assessments of conventional sources such as gas* can create a skewed competitive landscape. *In areas with high geothermal resource potential, there may be competition for the resource from other users, such as power plants or direct-use applications.*

Additional keywords mentioned are the *absence of cooling grids*, *business model, feasibility, competitiveness, long-term contracts, making network complex, implementation period, management, cost compared to other e, time, risk and benefit allocation.*

Technology

Participants of the two surveys see challenges and barriers in technological issues. With 35 % for Cost Action and 14 % for Aarhus participants, this is even more than for the construction of new grids, additionally, the above arguments such as *heat loss in the distribution pipes, corrosion, and water quality* also apply to the integration into existing grids.

The largest part of concerns refers to adapting the existing grid and retrofitting the buildings to the new grid. *Integrating geothermal energy into an existing district heating or cooling grid can be complex and technically challenging*. For the existing grids, *matching temperature levels* might be problematic as *geothermal energy systems typically operate at lower temperatures than traditional fossil fuel-based systems*. The existing *grid might* therefore *not be scaled for low-temperature districting heating*, and modifications and upgrades or additional *heat exchangers and controls* are necessary to ensure *operation compatibility for heat supply*.

Adding to the planning issue of limited space in urban areas, *poorly insulated buildings* may result in heat losses, reducing the overall system efficiency. *Retrofitting existing buildings to connect to the geothermal system* can also be challenging due to structural limitations *as the current equipment might not be scaled for low-temperature district heating*. There might be *physical improvements to buildings required*.

The Aarhus participants point to the same issues using keywords such as *adapt equipment, maintenance, existing assets, gas, infrastructure, bad engineering, phasing out old equipment, and technical technological barriers.*

Capacity and demand

Issues of capacity and demand are strongly related to planning and technology as matching the temperature levels of the geothermal and the existing grid is a challenge. Therefore, these issues are mentioned by 18 % / 38 % of the participants of the Cost Action / Aarhus survey.

Further, *geothermal energy is often a stable and continuous source. Developing strategies to balance supply and demand effectively is essential as it may not always align with the varying demand on the grid*.

Participants from the Aarhus survey also mention the following points: *achieving set temperature, pressure temperature, full load hours, baseload, high temperature, existing sources, available resources, capacity, changes in the grid, and thermal interferences.*

Regulation

Regulation issues are slightly less mentioned in the answers concerning existing grids than new grids. Only 29 % and 18 % of the Cost Action and Aarhus participants see challenges in regulation issues.

While some of the arguments from the new grid constructions such as the need for a *legal framework*, *no uniform regulation* or *too much political interference*, still apply, participants also mention that *new excess heat sources can require new networks, and thus new financial incentives and specific normative*. Further, *a model of using public space or shared probes is required* as well as a general need for policies *to account for the benefits of geothermal.*

A few additional keywords are given by the Aarhus participants: *ownership and responsibility, law proceedings, legislation, regulation, permitting, and policies.*

Knowledge

While still 24 % of the Cost Action participants see knowledge as a challenge or barrier, only a few (5%) of the Aarhus participants add a keyword. Both groups remain quite general in their answers referring to *lack of knowledge, poorly known technology, lack of specialists, staff, skills and no experience*.

PR & awareness

While PR & awareness still seems important to Aarhus participants as 36 % of them contributed keywords to these issues (in comparison to 38 % for new construction of grids), it hardly remains an issue for the Cost Action participants. Only 2 (12 %) of them mention them at all.

Keywords from the Aarhus participants include *culture, desire to gain money fast, lobby, lack of awareness, lack of political courage, perceived complexity, lack of trust in DHC, social acceptance, perceived risk, mindset, offtake, off-taker willingness, political willingness, lack of goodwill, consumer expectations, social acceptance, unawareness*.

Data

Data is a minor issue for the participants of both surveys. Only a few comments on data problems, i.e. 6 % resp. 4 % for Cost Action and Aarhus participants.

Challenges mentioned are the *lack of publicly accessible stratigraphic logs (data), for deep and shallow geothermal* and keywords *data* and *subsurface data*.

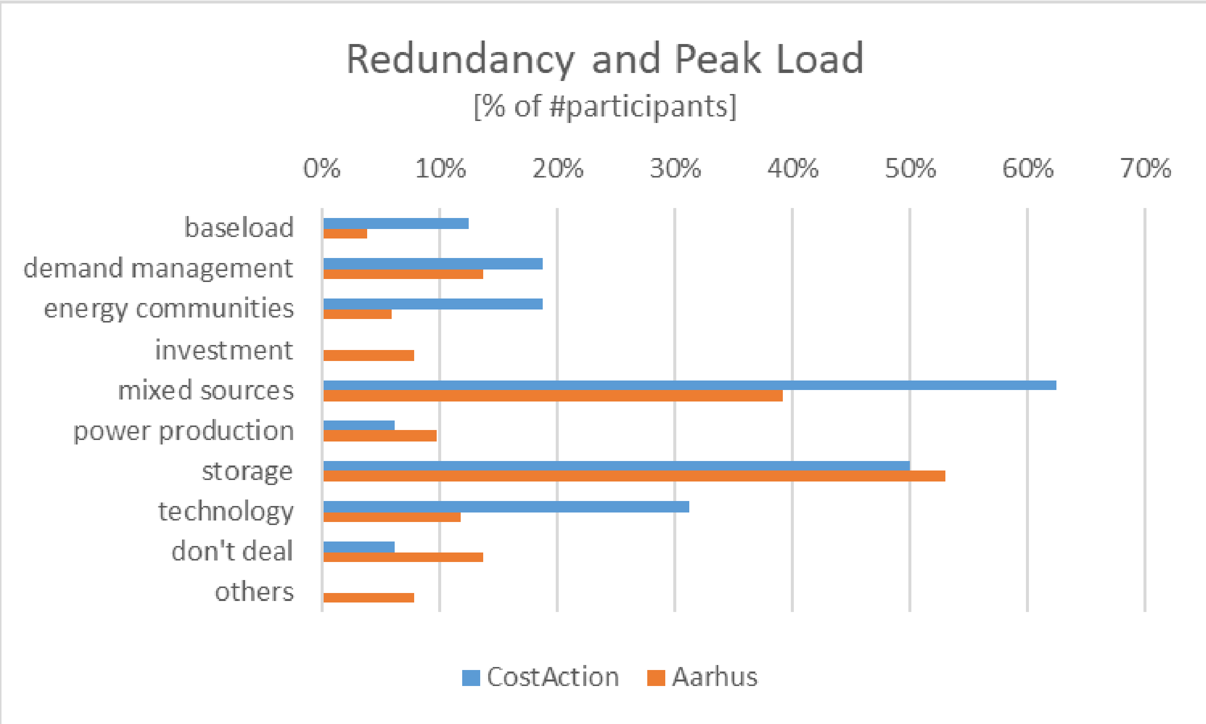
Storage

Similarly, storage issues are only mentioned with *storage* and *seasonal storage* by a few participants. Again, only 6 % resp. 4 % for Cost Action and Aarhus participants.

4 SOLUTIONS

4.1 How do you deal with redundancy and peak load supply?

The question addresses two main problems of the integration of geothermal energy supply in district heating and cooling networks: redundancy is crucial for ensuring uninterrupted service while managing peak loads is essential for grid stability.



# participants	16	51
# answers	36	85

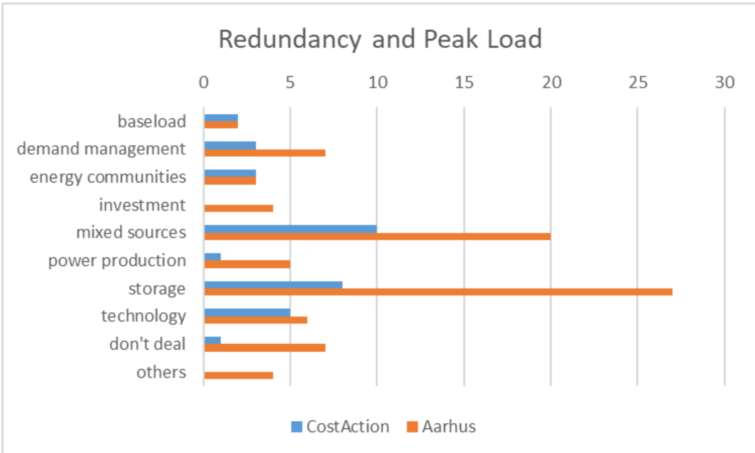


Figure 4.1: Overview on the assessment concerning redundancy and peak load on integrating geothermal energy into DHC grids

Redundancy and peak load can be met with two main strategies: storage or additional energy, and control of the demand side. *Diversifying energy sources, including renewable and conventional, can help ensure a consistent energy supply, especially during extreme weather conditions*.

In both surveys, the most important measures to deal with redundancy and peak load are *storage* and the combination of geothermal with other energy sources. Also, comparing research and implementation-oriented participants, both groups see storage issues and the combination of geothermal with other energy sources as important topics.

Storage solutions

Answers including storage solutions are given by 50 % of the Cost Action and 53 % of the Aarhus participants. Cost Action participants suggest incorporating energy storage solutions, such as *thermal storage*, to address fluctuations in geothermal resource availability. Storage helps ensure a stable and reliable energy supply, especially during periods of low geothermal heat production.

Storage systems for backup *mitigate the risk of supply interruptions from geothermal sources or other energy inputs*. Excess heat or cooling energy generated during off-peak hours can later be discharged into the system. This can help to meet peak demand at other times, to reduce the need to build additional heat production capacity and to improve the efficiency of the grid. The high number of answers for storage possibilities shows its importance and is ultimately even seen as *the only choice* (e.g. answer from Spain). *Thermal energy storage can be used to store excess heat or cooling energy generated during off-peak hours, and then discharge it to meet peak demand. This can help to reduce the need to build additional generation capacity and improve the efficiency of the grid.*

Especially *deep geothermal and high-temperature grids provide the base load and a supply of seasonal storages (e.g. ATES) to maximize the operational hours at constant load* (e.g. answer from Austria).

Storage can also be in the form of *energy accumulation in buildings*, especially in combination with *solar-thermal gains and passive buildings. Cold and cloudy winter days can be met with accumulation in all available masses: concrete, soil, and heat accumulators* (e.g. answer from Slovenia).

The answers for storage solutions from the Aarhus participants include *storage, UTES, underground storage, heat storage, and energy storage*.

Combinations of geothermal with other energy sources

Similarly, many responses see additional energy sources as a way to deal with redundancy and peak load issues. About two-thirds of the Cost Action participants (63 %) see combinations of geothermal and other energy sources as a solution as well as 39 % of the Aarhus participants. Other renewable or fossil sources are listed as well as more general terms such as *power production*, indicating specifically a single additional source or a diversity of sources to cover peak load and redundancy cases. Examples here are: *District heating and cooling grids can be designed with multiple heat sources, such as boilers, combined heat and power (CHP) plants, and geothermal energy systems. This can help to improve the reliability and resilience of the grid, as well as to reduce its carbon footprint*; *flexible energy carriers provide additional load*. The main additional source mentioned is gas, followed by biomass and solar/PV.

Further, redundancy and peak load are met with *electricity*, i.e. a non-specified production of power. Aarhus participants add keywords such as *electricity, integration with power, power production, and energy production*. Answers for the use of different sources of additional energy from Aarhus participants include in a more general form *mixed sources, aux_heater, multiple sources, portfolio of sources, diversity of supply, cogeneration, thermal, hybrid, diverse power source, diversity in power source, diversification, and more specifically solar, boiler, fossil, gas*.

Beyond that, other possibilities are technological solutions that mainly use additional installations of heat pumps such as *min. 2 multifunctional heat pumps with each 60% of total power* or *ground-source reversible heat pumps* to *fractionate the reversible heat pump size and to keep the existing heating and cooling generation system to cover peak demand or failure of the geothermal system. Smart grid technologies can be used to monitor and control the operation of district heating and cooling grids in real time. This can help to improve the efficiency and reliability of the grid.*

The Aarhus survey supports solutions with additional installations. *Closed loop, EAVOR loop, implementing 5GDHC, several wells, smart grid, and heat pumps* are mentioned by the participants.

Solutions that build on the demand side

Solutions that act on the demand side are mentioned by 19 % resp. 14 % of the Cost Action and Aarhus participants. The solutions can be divided into more active or passive approaches.

Active solutions include

- *Load forecasting: utilizing advanced load forecasting techniques helps anticipate peak demand periods, allowing for proactive adjustments in energy supply and distribution.* Using weather predictions for load forecasting and combining it with short-term storage applications.
- *Demand response programs can be used to incentivize consumers to reduce their energy consumption during peak periods. This can help to reduce the load on the grid and avoid the need to build additional generation capacity.*
- The demand can be limited by a *partial shutdown for some network sections to be sure that demand will not exceed production and avoid a blackout.*

The Aarhus participants indicated active management of the demand side with keywords such as *demand (side) management, limiting heat demand, flexible consumption, heat demand, user awareness, and balance*.

A passive solution is, *given that a redundancy or peak load supply is not expected* to use geothermal also for baseload supply.

Further solutions

- Energy communities and thermonets: *We do thermonets, where we connect primarily household geothermal heat pumps with pipes. In terms of redundancy, all the heat pumps have built-in auxiliary heaters based solely on electricity. The heat pumps should be sized so they can handle the peak load without the auxiliary heater, but in extreme cases, they can be used to supplement the heat pumps.*
- Financial solutions are only mentioned by the Aarhus participants, including keywords such as *funds, grant, investment or public investment.*

- Finally, though not really a strategy but mentioned in both surveys, a solution is to simply ignore the problem and not deal with it at all.

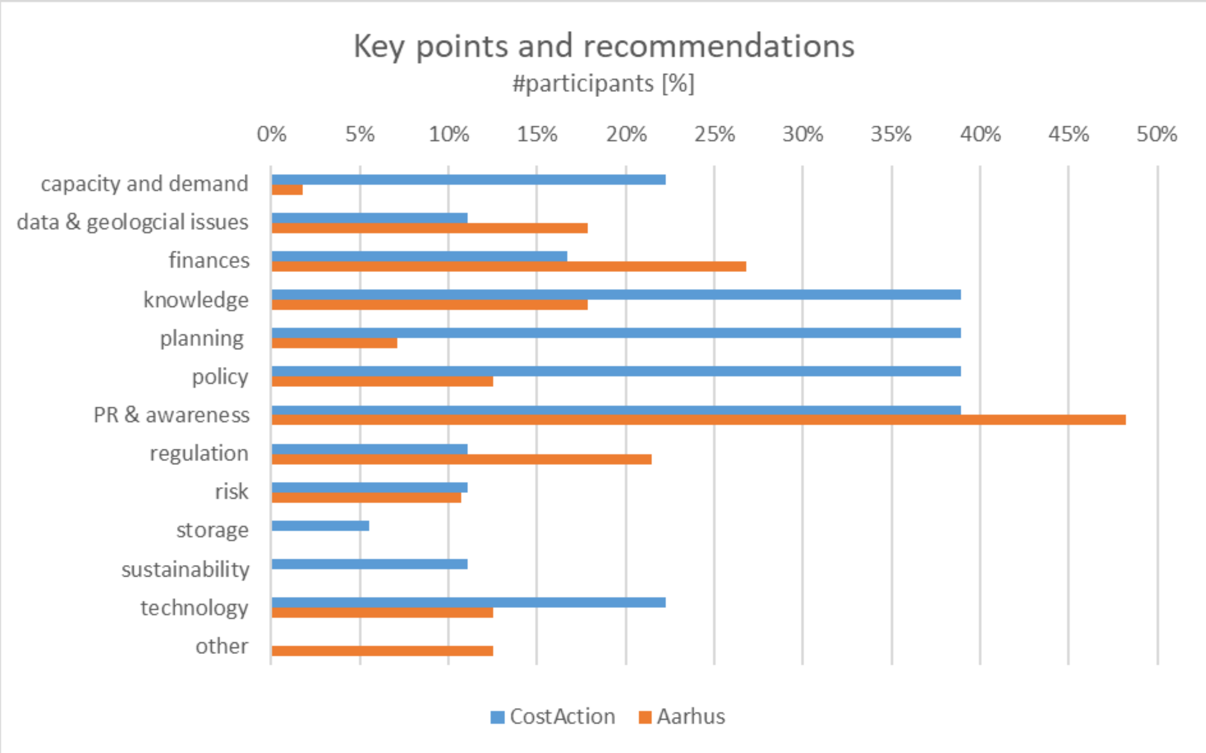
4.2 What are the key points from your experience or perspective for a successful integration of geothermal energy into heating (and/or cooling) grids?

Integrating geothermal energy into heating and cooling grids can be a sustainable and efficient way to meet energy needs. The final question summarizes the key points and recommendations of the participants for a successful integration.

The most important topic in the section on key points and recommendations in both surveys is “PR & awareness” followed by answers referring to finances, knowledge, planning, and policy. Answers concerning capacity, storage and sustainability are mostly or only mentioned by participants of the Cost Action questionnaire.

Comparing again research and implementation-oriented participants, PR & Awareness and data issues play a more important role in research, while the implementation group focuses more on planning and regulation issues. Other topics are answered similarly.

Awareness plays a pivotal role in the success of geothermal integration into district heating and cooling networks. 39 % of the Cost Action participants, and even more (48 %) of those at Aarhus see awareness and active lobbying as a key point. Engaging the local population, educating customers and the public, building awareness, promoting transparency, showcasing successful examples, involving the community and stakeholders, and working diligently with authorities



# participants	18	56
# answers	48	104

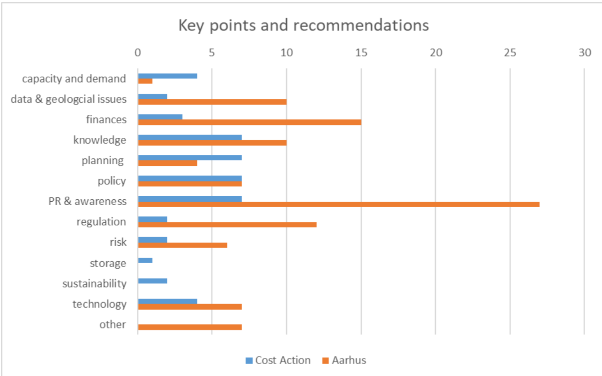


Figure 4.2: Overview on the assessment concerning key points and recommendations on integrating geothermal energy into DHC grids

collectively contribute to creating a favourable environment for the implementation and sustainability of geothermal projects.

Building awareness is the main solution mentioned by participants from the Aarhus survey. Involving *the local community and stakeholders in the project to garner support and address concerns* as well as *scrupulous and tenacious work with municipal authorities and other stakeholders* is crucial for navigating regulatory processes and addressing any challenges that may arise. Transparency and public awareness can contribute to project success.

Further along that line, not only awareness in the different stakeholder groups but active marketing and lobbying is needed to foster geothermal. A few participants of the two surveys suggest a more demanding demeanour towards investors and decision-makers and *lobby like OG and Tabac*.

Demonstrating good examples such as an *off-the-shelf-prod* and successful geothermal integration projects to potential investors (*people with money; long communication with them to make them see the benefits*) and decision-makers can be influential.

Knowledge

To successfully navigate the complexities of designing, implementing, and maintaining efficient and sustainable district heating and cooling systems, a diverse range of knowledge and skills is essential. The following points highlight key aspects mentioned in the two surveys. 39 % of the Cost Action participants and 18 % of those from Aarhus see knowledge as a key issue.

The key point is to develop a *mature supply chain* or even an *off-the-shelf product*, so there is an easy answer for every possible question a customer might ask. Currently, *for the customer, it can feel like every question requires a new multiyear research project, and that does not give the customer the confidence needed to make the right decision.*

Collaboration with academic institutions and research organizations can help tap into cutting-edge research and knowledge and provide insights into new technologies, efficiency improvements, and sustainable practices relevant to DHC systems.

Policy

According to the results of the surveys, with 39 % resp. 13 % of the Cost Action and Aarhus participants answering in that direction, governmental and EU support as well as greater involvement of public administrations are needed to create a friendly environment for implementation of geothermal and other renewable energy projects. Participants of the surveys also ask for more policies directed to support geothermal projects, ranging from the implementation of a national strategy to incentive programs and subsidies helping investors, local authorities and private citizens to integrate geothermal energy and promoting the realization of new networks.

Policy frameworks with specific regulations for geothermal installations ensure safety, environmental compliance, and technical standards. Clear guidelines help in the planning phase, allowing for the development of technically sound and environmentally responsible geothermal DHC projects.

Regulation

Regulations can significantly facilitate or hinder the implementation of geothermal energy into district heating and cooling networks by creating a conducive environment for investing and planning. The following issues were pointed out in the surveys by 11 % resp. 21 % of the participants of the Cost Action and Aarhus survey.

The establishment of clear and consistent legal frameworks and EU-wide regulations is necessary to provide a standardized environment, reducing uncertainties for investors and project developers. This clarity can reduce uncertainties for investors and project developers. The simplification of regulations and permitting makes it more attractive for investors, as it reduces administrative burdens and accelerates project development.

A proactive engagement with regulatory authorities from the early stages of a geothermal DHC project helps in understanding and addressing regulatory requirements, preventing potential delays, and ensuring that the project aligns with environmental and safety standards. *Engage with regulatory authorities early in the project to navigate permitting processes smoothly. Compliance with environmental and safety regulations is critical.*

Finances, risk and planning

For the implementation of geothermal into DHC policy and regulation play a crucial role for financing and planning. While the participants of the Cost Action questionnaire (17 %) focused on the planning and cost part, participants of the Aarhus survey (27 %) tended to financial issues more generally. Here, *financing* and *funding* are the main keywords.

Risk is mentioned only a few times in the surveys, but is closely related to finances as *reducing investment risks for geothermal exploration and development* is crucial for investment decisions. One possibility in high-risk investments is to search for partnerships and create risk mitigation portfolios, saving time, money and reputation.

Planning district heating and cooling (DHC) networks involves addressing several important issues to ensure the success and efficiency of the system. Comprehensive planning involves a thorough and detailed preparation of the project. Employing an excellent technical approach accompanied by the involvement of public authorities in charge of giving permits/authorization, from the very beginning ensures that the system is well-engineered, reliable, and optimized for efficiency.

Implementing a robust monitoring system is essential for continuous performance evaluation and optimization. *Monitoring helps continuously assess the performance of geothermal components. Regular maintenance and servicing are essential for system longevity.*

Advanced load forecasting techniques help *to anticipate and respond to changes in heating or cooling demand, optimizing the use of geothermal energy.* By analyzing historical data and considering factors such as weather patterns and population growth, load forecasting ensures that the DHC network is designed to meet current and future demand efficiently.

Further key points and recommendations:

- Geology: on the geological side, the participants of the Aarhus survey mostly see a need for sufficient available data. Participants in the Cost Action questionnaire specify the necessity to conduct a thorough geological survey and assessment of the geothermal resource to determine its quality, temperature, and sustainability as the foundation for a successful project. In general, data is seen rather as a prerequisite than a problem.
- Capacity and demand: key words mentioned are *capacity building*, *high demand for heat, mature supply chain, scaling up direct use of geothermal heat, design the grid to accommodate fluctuations in geothermal energy production* and *scalable solutions*
- Storage: storage as a key point is only mentioned once for this question by a participant of the Cost Action questionnaire, recommending to *utilisation of heat storage systems to store excess geothermal heat during periods of low demand and release it during peak load times, improving grid stability.*
- Sustainability: to ensure sustainability for the grid participants recommend improving *DHC networks through energy efficiency measures* and *adopting sustainable practices in geothermal resource management to prevent resource depletion and maintain long-term energy production.* Also, sustainability in terms of environmental impact is addressed: *the integration of geothermal energy into a heating and/or cooling grid should have minimal environmental impact: noise pollution, water use* and compostable as well as non-compostable gases, especially green house gases.
- Technology: participants of the surveys recommend a number of measures to ensure an optimal use of technology: *evaluate the technical compatibility of geothermal energy with the*

grid infrastructure; ensure that heat exchange systems, pipes, and distribution networks can handle geothermal fluid efficiently; *design the grid to accommodate fluctuations in geothermal energy production;* ensure technical feasibility by *integrating into the existing heating and/or cooling grid (This includes considering the temperature requirements of the grid, the availability of geothermal resources, and the physical constraints of the site); incorporating backup systems or alternative heat sources to ensure uninterrupted service; HP in smart grid mode, energy communities (PV, PVT panels), improve DHC networks through energy efficiency measures, integrate low temperature technologies (solar thermal, geothermal, waste water, others…)* Participants of the Aarhus survey also add key words such as *closed loop, cooling, grids upgrading, infrastructure, resource assessment, resource geothermal, thermonet.*

5 CONCLUSIONS

General remarks

- The differences in the structure of the two surveys need to be considered for the evaluation. The Cost Action questionnaire has fewer responses but gives detailed feedback, while the Aarhus survey provides a larger overview but only keywords subject to interpretation.
- Most of the participants in both surveys represent the field of research. For the Aarhus survey, implementation-oriented participants (financial/investor, operator, service providers and planners) are about as large as the research group.

Main trends from the surveys and recommendations for considering them in the Market Uptake HUB fact-finding

Generally, it turned out, already during the joint design of the surveys, that it is crucial to distinguish specific tasks and open questions regarding the development status of considered grids. This means mainly the difference between challenges for implementing geothermal energy in new grids or by renovating existing grids. Besides the challenge of providing climate-friendly redundancy and peak load covering by geothermal energy, the results showed also that PR and awareness are still key points for the implementation of geothermal energy.

Below the main results of the surveys are summarized:

- Constructing new grids, including geothermal: For both survey groups, financing is the main issue in constructing new grids due to high upfront costs and uncertainties in geothermal exploration. Also important to them are PR and awareness topics, especially the lack of awareness of stakeholders to realize that geothermal can be the solution. Therefore, the public, as well as authorities, need to be engaged in the planning and implementation process from early on. Regulation, i.e. too much (e.g. number of permits) and too little (e.g. lack of specific normative), can hinder the construction of new grids. Planning and lack of knowledge are further issues concerning the participants of both surveys but are described in more detail in the answers to the Cost Action questionnaire. The lack of data is only mentioned a few times.

- Integrating geothermal into existing grids: Financing is also the main issue for integrating geothermal in existing grids but is more relevant to participants from the Cost Action questionnaire. In addition to the challenges of financing new constructions, it is even more difficult to convince investors of existing grids as their construction can be complicated. Planning and technology play more important roles for existing grids as the limited space, compatibility with the current layout and existing use of other energy sources require fitted solutions. Regulation and PR issues are less important for the implementation of existing grids.

- Redundancy and peak load: The most important issue for redundancy and peak load is storage solutions to mitigate supply interruption. Excess heat or cooling energy generated during off-peak hours can then be discharged into the system later. Further geothermal is combined with all kinds of other energy sources to cover peak load as well. Also, solutions to control redundancy and peak load from the demand side such as load forecasting and demand response programs are mentioned. Though not really a strategy but mentioned in both surveys, a solution is to simply ignore the problem and not deal with it at all.

- Recommendations and key points: Recommendations for future projects focus on PR and awareness. Engaging the local population, authorities, customers and other stakeholders as well as promoting transparency and showcasing successful examples, contribute to creating a favourable environment for the implementation and sustainability of geothermal projects. Often, not only building awareness but also active lobbying is demanded.

6 ACKNOWLEDGEMENT

The work summarized in this report was supported by the EU COST Action 18219 by an internal survey involving the COST Action members. For more information on COST Action 18219, please visit https://www.geothermal-dhc.eu.

7 ANNEX: MATERIAL USED FOR THE STAKEHOLDER INTERACTIONS AND DOCUMENTATION

7.1 Annex 1: COST Action Questionnaire

GEOTHERMAL DHC
Towards Decarbonized Heating and Cooling!

Participant and stakeholder questionnaire on geothermal energy use in heating and cooling networks

Please answer before 31 October and send the document to kai.zosseder@tum.de

General Information:

Name:

Surname:

Affiliation:

Country:

Contact e-mail:

Q1: Which Group are you representing?

☐ Operator/Service provider ☐ Research ☐ Financial/ Investor ☐ Planner

☐ Other: _________________

Q2: Your expertise in Geothermal Projects:

2a: In how many Case studies were you involved concerning the implementation of Low-temperature Grids integrating Geothermal Energy Sources?

☐ None ☐ 1 ☐ 2-5 ☐ >5

2b: In how many Case studies were you involved concerning the implementation of High-temperature Grids integrating Geothermal Energy (Deep Geothermal)?

☐ None ☐ 1 ☐ 2-5 ☐ >5

➔ If both answers are "None":

2c: Do you were involved in the design and implementation of heating (and/or cooling) Grids in general?

☐ None ☐ 1 ☐ 2-5 ☐ >5

Q3: Do you have (practical) experience in the implementation of geothermal energy into cooling grids?

☐ Yes

☐ No

Q4: What are the main challenges and barriers to designing and implementing a new construction of a district heating or cooling grid with the integration of geothermal energy?

Q5: What are the main challenges and barriers to integrating geothermal energy in an existing district heating or cooling grid?

Q6: How do you deal with redundancy and peak load supply?

Q7: What are the key points from your experience or perspective for a successful integration of geothermal energy into heating (and/or cooling) grids?

7.2 Annex 2: Aarhus survey

Audience Survey

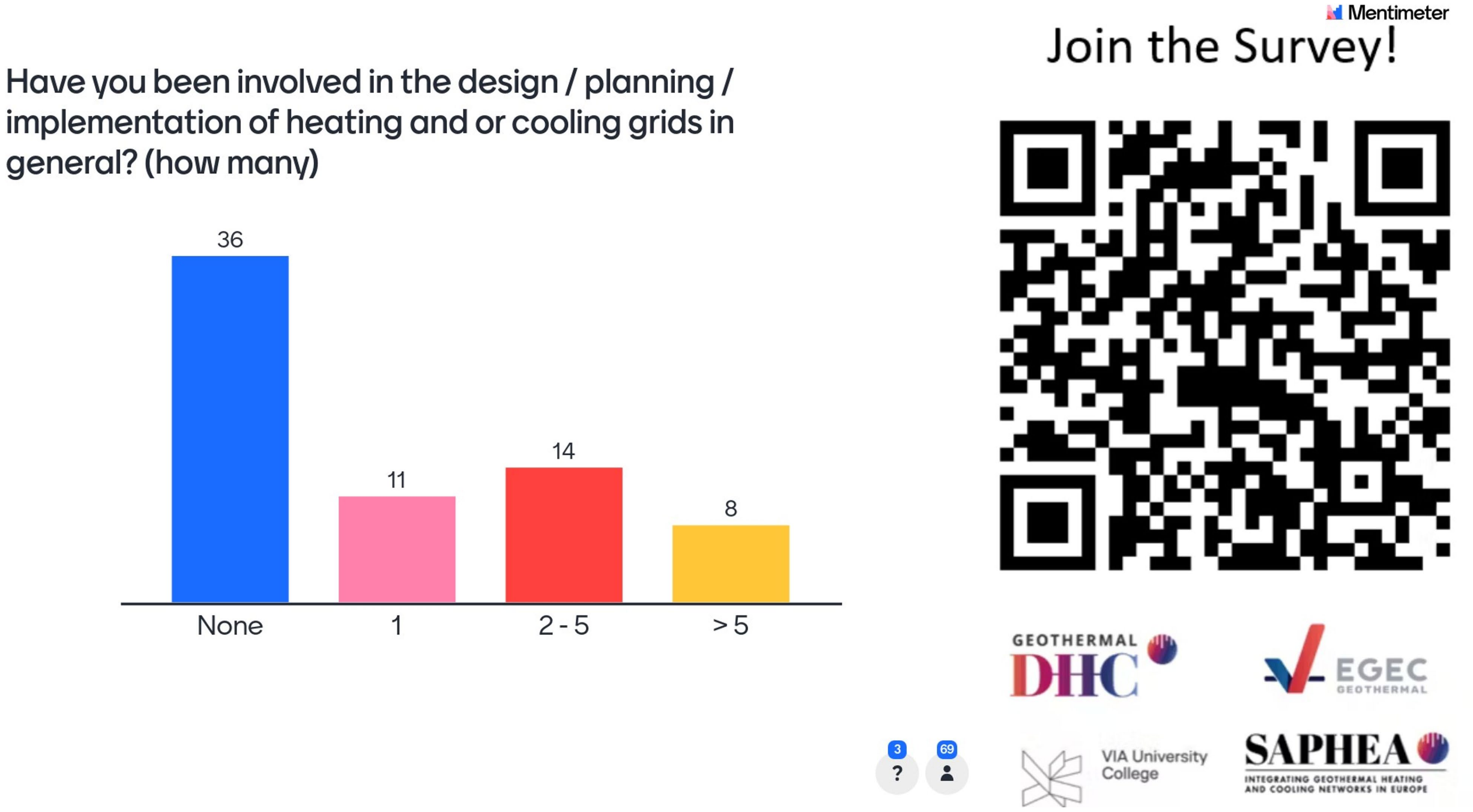
We want to collect your opinions and design a survey for a wider audience (stakeholders and citizens)

Mentimeter

Join the Survey!

44


Mentimeter
Join the Survey and help us fostering Geothermal!
50


Have you been involved in the design / planning / implementation of heating and or cooling grids in general? (how many)
36
11
14
8
None
1
2 - 5
> 5
Mentimeter
Join the Survey!
3
69
GEOTHERMAL DHC
EGEC GEOTHERMAL
VIA University College
SAPHEA
INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

SAPHEA
INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

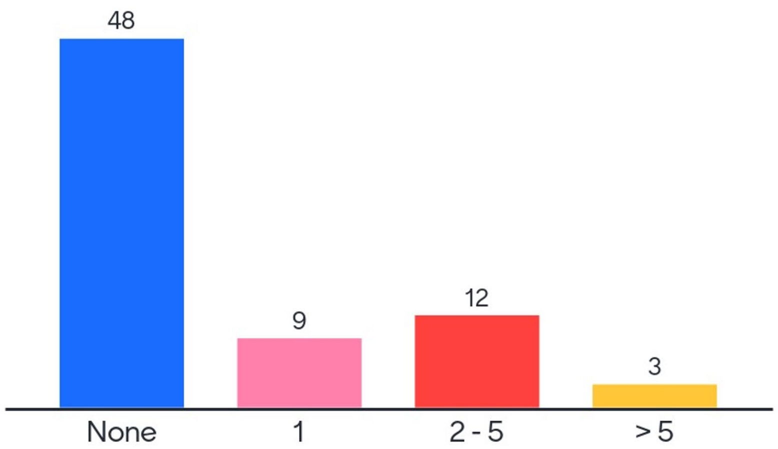
Mentimeter

Do you have any (practical) experience in implementation Geothermal into District Heating (and Cooling) Grids?

1
71

Mentimeter

In how many projects have you been involved concerning the implementation of *Low temperature* Grids integrating Geothermal Energy Sources?



2 ? 72

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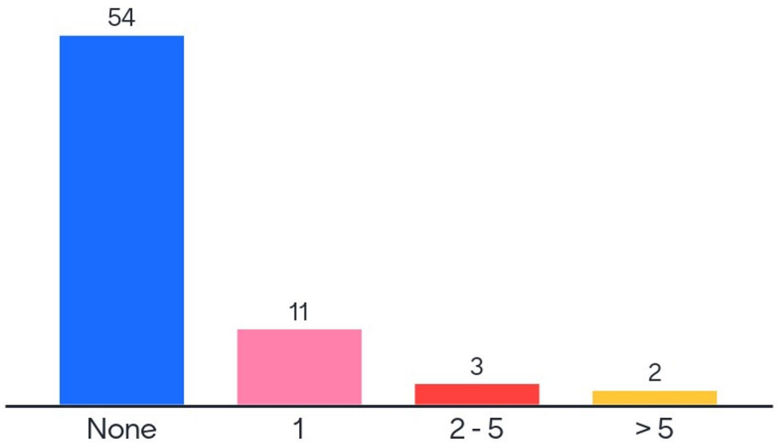
In how many projects have you been involved concerning the implementation of *High temperature* Grids integrating Geothermal Energy Sources?

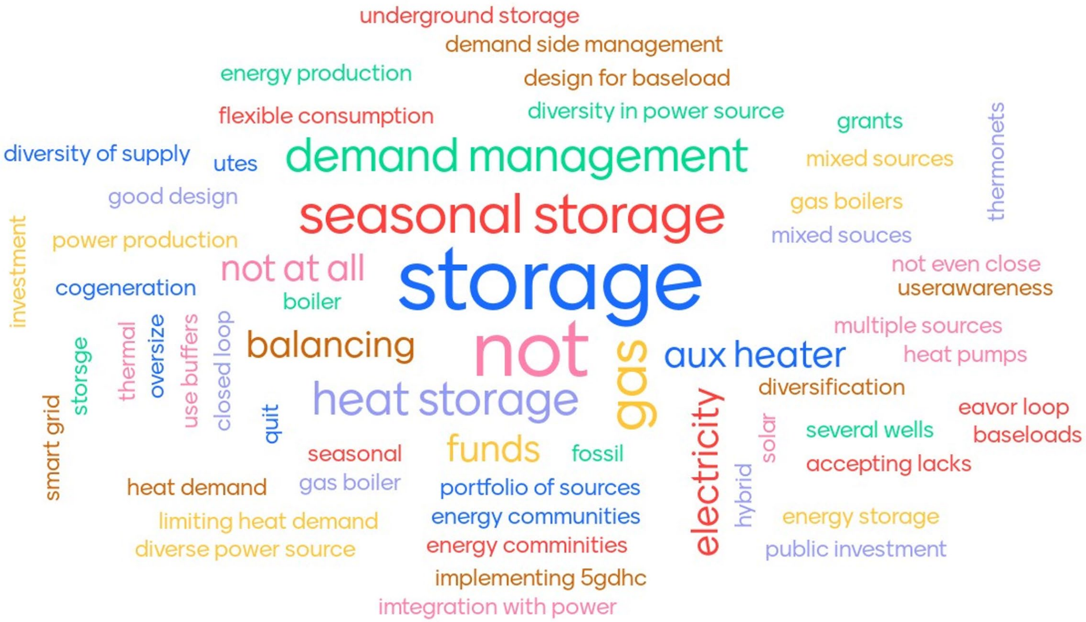


13 ? 70

Mentimeter

How do you deal with redundancy and peak load supply?

99 responses



4 ? 51

Mentimeter

What are the main challenges and barriers by designing and implementing a *new Construction* of a DHC Grid with implementation of Geothermal?

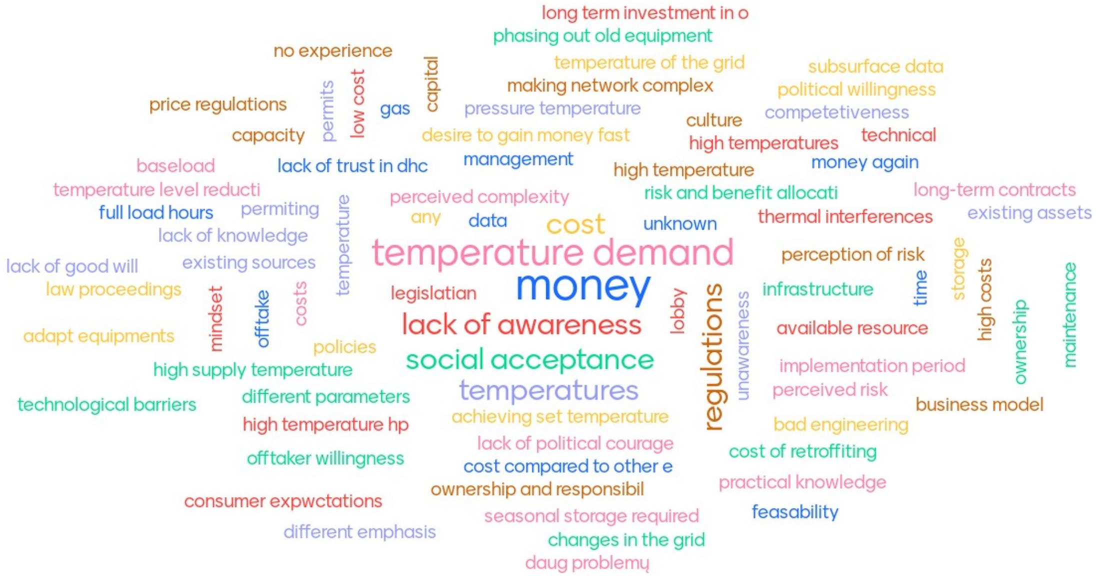
94 responses

? 55

Mentimeter

What are the main challenges and barriers by integrationg Geothermal into an *existing* DHC Grid?

94 responses



1 56

Mentimeter

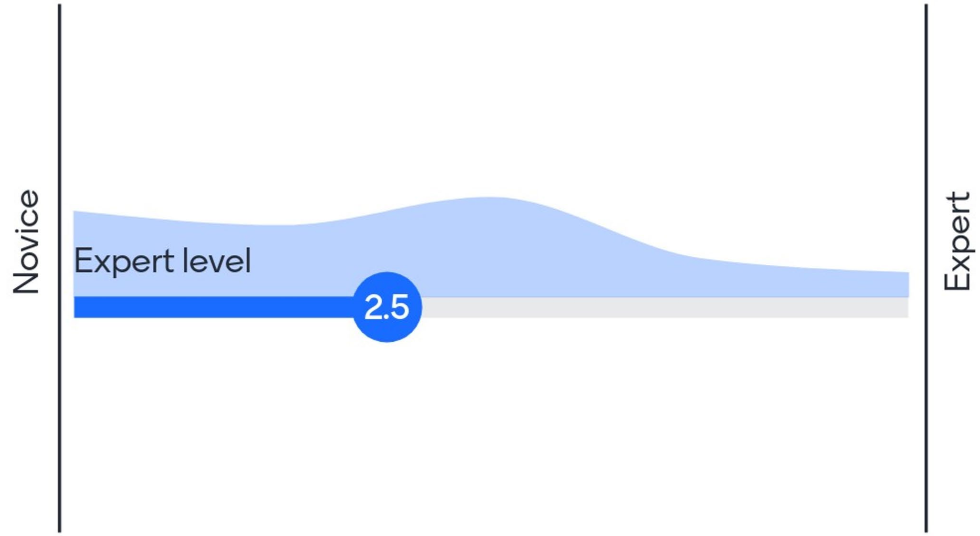
What are the priorities / recommendations for enabling geothermal in DHC?

108 responses

3 ? 57

Mentimeter

Self assessment: How confident do you feel about Geothermal district heating and cooling?



20 67


Mentimeter
Where are you from?
72 responses
denmark horsens planet
the netherlands
copenhagen denmark
catalonia
iceland
warsaw poland
turkey
france
ireland
estonia
egypt
belgium
macedonia
austria
netherlands
poland
denmark
italy
nl
lithuania
cyprus
denmark aarhus
romania
hungary
sweden
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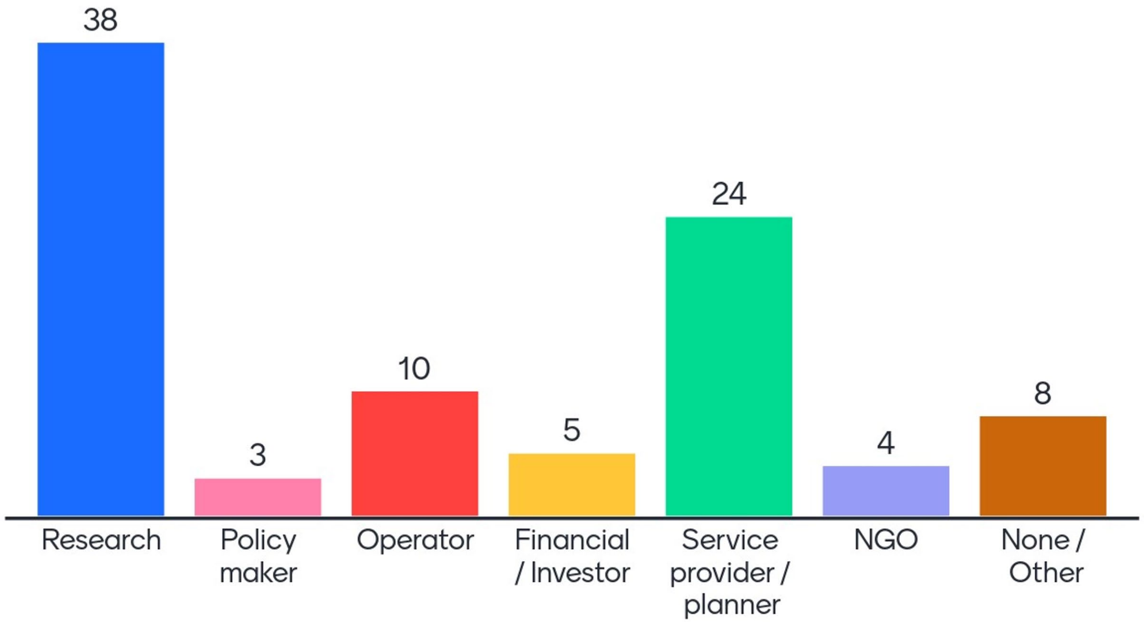
norway
cornwall
croatia
earth
10
69

Which Group are you representing?



Mentimeter

What would be an interisting topic for the next Geothermal District Heating and Cooling Days 2024

61 responses

7
61

Mentimeter

Do you have a final statement you would like to share?

61 responses

2 56