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QHeat Coaxial Reversible Medium-Deep Geothermal Heat Well Technology

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ABSTRACT

Heating systems are major contributors to carbon emissions, particularly in Northern Europe, where they account for up to 30% of CO_2 emissions. This paper presents QHeat's patented coaxial medium-deep geothermal heat well (MDGHW) technology, designed for depths of 1,000 to 3,000 meters. Unlike traditional shallow wells that suffer from heat loss during fluid ascent, this technology utilizes a closed-loop coaxial flow design with an isolated inner pipe to maximize conductive heat transfer from the surrounding rock. This methodology relies solely on conductive heat transport within rock, which is globally scalable and predictable. This methodology enables a versatile energy system capable of simultaneous heating, cooling, and underground thermal energy storage (UTES) to balance seasonal and daily demand fluctuations. Simultaneity is achieved through 5th Generation District Heating and Cooling (5GDHC) nodes where the well acts as a storage or source unit. Results from successful pilot implementations in Finland demonstrate that a single 1.5 km well can provide heating for up to 15,000 m^2 of commercial real estate. Field measurements show that a single 1.5 km MDGHW typically produces 0.3–0.4 MW of continuous thermal output, with peak seasonal capacities reaching approximately 1.0 MWth. Furthermore, quantitative analysis reveals that the system achieves a Coefficient of Performance (COP) exceeding 5.0, reduces CO_2 emissions by approximately 60%, and decreases operational costs by 40%. Crucially, the technology requires 97% less land area than traditional geothermal fields, making it highly suitable for densely built urban environments.

1 INTRODUCTION

As climate change intensifies, the demand for sustainable energy solutions becomes increasingly critical. Heating systems, especially those relying on fossil fuels, represent a major contributor to greenhouse gas emissions globally. In Northern Europe, heating systems account for approximately 30% of CO_2 emissions, underscoring the urgency for innovative technologies (International Energy Agency, 2021).

Medium-deep geothermal heat wells (MDGHWs) offer a promising alternative by tapping into stable resources at depths of 1,000 to 3,000 meters (Geothermal Energy Association, 2020). Integration of industrial-scale heat pumps with these reliable heat sources allows for high-efficiency operation. These systems can supply heat in winter, cooling in summer, and recharge wells during off-peak times. A major advantage is the ability to store excess or waste heat underground, improving system efficiency and reducing energy loss. This extended abstract explores the design and benefits of coaxial reversible geothermal technology, emphasizing its potential in low-temperature heating networks.

2 TECHNOLOGY OVERVIEW

2.1 Company Overview

Quantitative Heat Oy, commonly referred to as QHeat, is a company specialized in geothermal energy. The company has developed a new co-axial geothermal heating and cooling system. QHeat was founded in 2018 and its technology has been patented and tested in cooperation with Finnish experts and universities. QHeat has successfully delivered Finland's 5 first co-axial deep geothermal heating projects. Currently focusing on new market entries with first projects in Estonia and Sweden, also negotiations in the Nordic countries.

2.2 Coaxial Reversible Medium-Deep Geothermal Heat Wells

MDGHWs utilize a coaxial configuration that allows for simultaneous heating and cooling, maximizing thermal exchange and minimizing energy losses at the network level. The system operates at depths where temperature gradients are significantly higher, making it possible to extract thermal energy efficiently.

QHeat geothermal wells are based on coaxial flow technology, which helps to keep the temperature difference between the cool and warm flow. Typical well is about 1000 – 2000 m deep, has a coaxial current and an isolated inner pipe. One 1.5 km well can provide heating to 15 000 square meters of commercial real estate so QHeat is not targeting single-family houses.

2.3 Operational Principles

The operational principles of MDGHWs hinge on conductive heat transfer, which enables the system to achieve higher efficiencies than convective systems. The inner insulated pipe is designed to extract thermal energy from the Earth, while the outer pipe returns cooler fluid, creating a continuous loop of heat exchange. This design minimizes thermal losses and enhances the overall Coefficient of Performance (COP), a critical metric for assessing the efficiency of heating systems. COP rates for MDGHWs have been reported to exceed 5.0 in optimal conditions, making them highly efficient compared to conventional systems.

The QHeat concept relies solely on conductive heat transport within rock, a property that shows minimal variation in populated areas. Traditional geothermal methods, by contrast, often rely on convective systems, where high-temperature fluid convection occurs. However, this convection is rare and challenging to predict before a project begins. The global heat flux in the Earth's crust serves as a reliable proxy for heat wells at depths of around 2 km. Conductive geothermal solutions are also globally scalable.

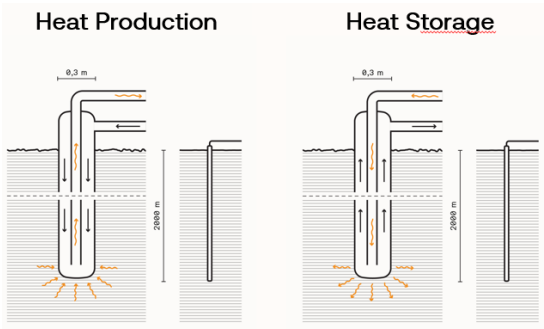


Figure 1. Two-Mode Operation of the Coaxial Well: Heat Production and Heat Storage

As illustrated in Figure 1, the coaxial design allows the well to be used for two distinct purposes:

Heat Production: The inner insulated pipe extracts thermal energy from the Earth while the outer pipe returns cooler fluid, creating a continuous loop.

Heat Storage: The process can be reversed to store excess thermal energy (e.g., industrial waste heat or summer solar gain) back into the rock.

2.4 Challenges in Current Geothermal Applications

Despite the potential of geothermal energy, several challenges persist:

- Geological Variability: The effectiveness of geothermal systems heavily depends on local geological conditions. Not all regions are suitable for deep geothermal installations, which limits widespread adoption.
- High Initial Costs: The capital investment required for drilling and infrastructure can be prohibitive, particularly in urban settings where space is limited. The cost of drilling deep wells can vary significantly based on geological conditions, depth, and technology used.
- Technical Limitations: Conventional geothermal systems often face operational inefficiencies, including heat loss during transport. Additionally, issues related to groundwater contamination and induced seismicity must be addressed to ensure public acceptance.

The coaxial design of MDGHWs addresses these limitations by optimizing heat transfer, enhancing scalability, and reducing land use, making it a viable solution for densely populated areas.

2.5 Advantages Over Conventional Systems

1. Higher Thermal Exchange Rates: The coaxial design significantly improves thermal exchange capabilities, enabling MDGHWs to generate heat equivalent to approximately 40 traditional geothermal wells.

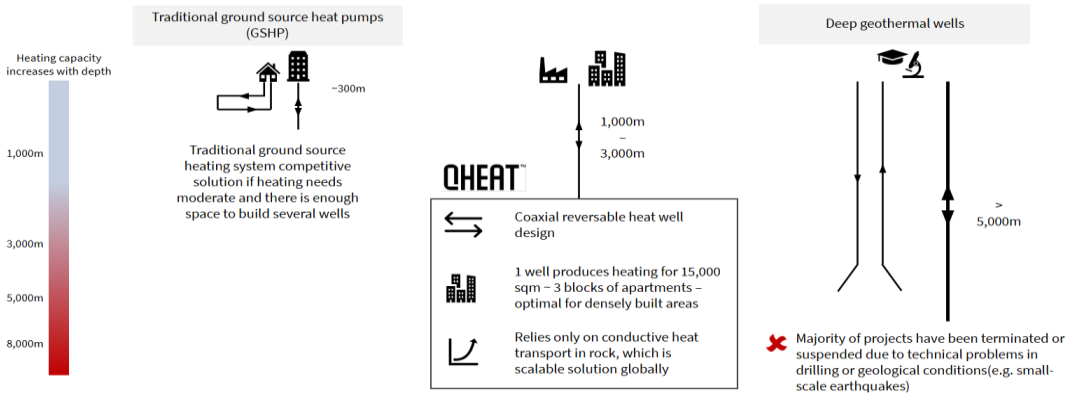


Figure 2. Heating Capacity of Coaxial Wells vs. Traditional Systems

2. Reduced Land Use: By utilizing a compact coaxial design, MDGHWs can be installed in urban areas with limited land availability, reducing the overall land footprint required for geothermal installations by up to 97%. This is particularly beneficial in densely populated cities where land scarcity is a significant concern. A conceptual comparison is given in Figure 2.

3. Improved Efficiency: The coaxial flow technology enhances the COP of heat pumps by allowing for lower temperature differentials. This not only extends the lifespan of the systems but also reduces maintenance costs. Lower temperature differentials also enable the use of lower-cost materials and components, further decreasing overall project costs.

3 CASE STUDIES

3.1 Successful Implementations in Finland

QHeat has successfully delivered large-scale geothermal heating and cooling solutions in several Finnish municipalities, demonstrating the technology's effectiveness in real-world applications.

- Project A

As illustrated in Figure 3, the project was located in a densely populated urban area utilizing MDGHWs to provide heating for a residential complex covering over 15,000 square meters. The project achieved a COP of 5.0, resulting in substantial reductions in energy costs and greenhouse gas emissions. The project also demonstrated the capability of MDGHWs to adapt to seasonal energy demands, effectively providing both heating and cooling. In this configuration, heat pumps at each building produce domestic hot water and cooling simultaneously by utilizing the shared network.

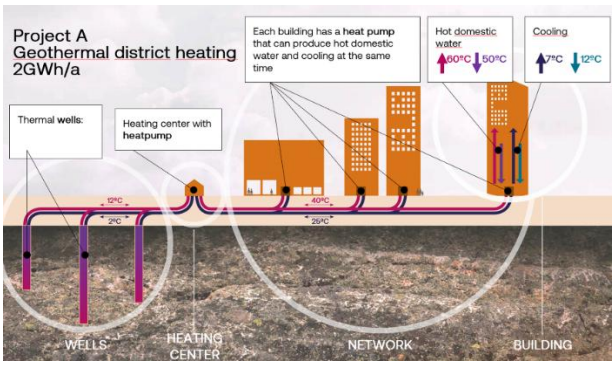


Figure 3. Project in a Densely Populated Area to Provide Heating for a Residential Complex

- Project B

This project integrated MDGHWs with industrial applications. The coaxial wells integrate heat storage technology into waste-to-energy plant, emphasizing the potential of QHeat's technology to store excess heat and use it during peak demand. The purpose of this storage is to increase efficiency, reduce reliance on fossil fuels, and optimize economic and environmental outcomes.

During warmer months, the waste-to-energy plant produces excess heat, which is stored in geothermal heat wells. These wells retain the heat until it's needed during colder periods. When demand for heating spikes in colder months, the stored heat is released, providing additional capacity to the heating network without relying on additional power sources.

As a result, enhanced efficiency and lower emissions by storing heat rather than wasting it, the plant operates more efficiently, which translates into lower emissions overall. Also reduced fossil fuel or electricity dependence with the stored heat available during peak hours, the plant can avoid using fossil fuel or electricity-based peak power plants, which are typically used to meet sudden spikes in demand.

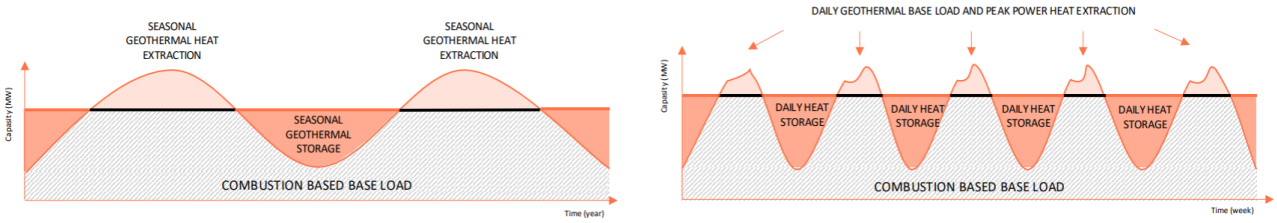


Figure 4. Seasonal and Short-Term Heat Storage and Extraction of Waste-To-Energy Plant

- Seasonal excess heat storage and extraction

As illustrated in figure 4 with seasonal heat storage, the boreholes are charged during the summer months utilizing the excess heat generated by the combustion-based facility.

This stored heat is extracted during the winter months to enhance the heating capacity during high demand season. The geothermal wells are therefore displacing peak production capacity, which is often based on fossil fuels.

- Daily excess heat storage and extraction

District heating system designed for baseload production enables the storage and peak hours utilization of excess heat. The additional heat and peak capacity are provided by the geothermal boreholes.

Once the highest demand drops the boreholes are switched to storage mode, storing the excess heat generated by the energy plant.

3.2 Quantitative Analysis

The performance metrics collected from these projects highlight the advantages of MDGHWs (Medium-Deep Geothermal Heat Wells):

- Field measurements show that a single 1.5 km MDGHW typically produces 0.3–0.4 MW of continuous thermal output, confirming its high baseline efficiency. Furthermore, during seasonal heat-release periods, peak capacities can reach approximately 1.0 MWth, depending on charging conditions and heat-exchange duration.

- Operational Performance: Integration of MDGHWs resulted in a coefficient of performance (COP) exceeding 5.0, approximately 60% reduction in CO_2 emissions, and around 40% lower operational costs—clearly demonstrating the financial and environmental viability of geothermal solutions.

4 DISCUSSION

4.1 Implications for Urban Heating

The integration of MDGHWs into urban heating networks can significantly reduce reliance on fossil fuels and decrease overall carbon emissions. By tapping into deep geothermal resources, cities can transition towards a low-carbon heating future in line with international and regional policy trajectories (International Energy Agency,

2021; European Commission, 2021). Studies indicate that widespread adoption of geothermal heating could reduce urban emissions by up to 50% in the coming decades (Rybach, 2003).

4.2 5th Generation District Heating and Cooling (5GDHC)

The implementation of heat storage and low-temperature heating networks, referred to as 5th Generation District Heating and Cooling (5GDHC), involves the use of bidirectional and heat pump-assisted nodes. These systems necessitate at least one adjustable node, preferably a storage node, within the network area, such as the QHeat well. Over 100 such systems are currently operational across Europe, utilizing various primary energy sources. To achieve European Union targets, thousands of small-scale 5GDHC systems, each with a capacity of around 1 megawatt (MW), are set to be constructed. Notably, Europe is transitioning directly from the existing 3rd Generation District Heating (the current Nordic standard) to the more advanced 5th Generation systems.

4.3 Scalability and Future Applications

The potential for expanding MDGHW technology to regions with similar geological characteristics presents significant opportunities for widespread adoption. Future research should focus on optimizing drilling techniques, enhancing system integration, and developing innovative financing models to maximize the efficiency and scalability of geothermal heating systems.

Data centers produce significant amounts of excess heat, which can be utilized for heating purposes in alignment with the EU taxonomy and various local incentives. Connecting data centers to heating networks not only ensures the effective use of this surplus heat but also offers substantial economic benefits. While excess heat generation is continuous, the demand for heating can vary, making heat storage solutions essential for optimizing these economic advantages. By implementing storage systems, data centers can better match heat supply with demand fluctuations, enhancing overall efficiency. As the industry moves forward, the future of combined heat and power (CHP) systems may evolve into combined heat and district heating (CHD) systems.

4.4 Market Potential

The total addressable market for geothermal heating is substantial, with sector reports indicating rising interest across Europe and beyond. With a large share of heat still generated from fossil fuels, transitioning to geothermal solutions represents a significant market opportunity and supports policy goals for decarbonization (Renewable Energy World, 2023)

5 CONCLUSIONS

The Coaxial Reversible Medium-Deep Geothermal Heat Well (MDGHW) technology offers a robust and sustainable solution to the challenges posed by traditional heating systems. By effectively harnessing the Earth's geothermal resources, this innovative technology not only meets current energy demands but also aligns with future climate goals, helping to combat the pressing issue of global warming. This is consistent with the European Union's climate-neutrality trajectory (European Commission, 2021) and supports broader UNFCCC sustainable-development objectives (United Nations Framework Convention on Climate Change, 2022).

Moreover, as cities around the world strive to reduce their carbon footprints and transition to sustainable energy systems, MDGHWs emerge as a viable alternative that promises to reshape the future of heating and cooling in urban environments. The integration of this technology within existing heating networks can enhance energy efficiency and provide cost-effective solutions for both consumers and municipalities.

However, for MDGHWs to realize their full potential, continued research, development, and investment are imperative. Collaboration between governments, industry stakeholders, and researchers will be crucial in optimizing the technology and addressing any challenges related to implementation and scalability. Policymakers should also prioritize supportive regulations and incentives to encourage the adoption of MDGHWs in urban planning and energy strategy frameworks (International Energy Agency, 2021).

In conclusion, the advancement of Coaxial Reversible MDGHW technology represents a significant step towards sustainable energy solutions. As the transition moves forward, embracing such innovative approaches will be vital in achieving energy resilience and sustainability, ultimately contributing to a greener and more sustainable future for urban populations.

REFERENCES

European Commission. (2021). The European Climate Law: A legally binding framework for climate neutrality.

Geothermal Energy Association. (2020). Geothermal Technologies: State of the Market.

International Energy Agency (IEA). (2021). Heating and Cooling: Trends and Outlooks.

Renewable Energy World. (2023). The Future of Geothermal Energy in Europe.

Rybach, L. (2003). Geothermal energy: its role to play in the 21st century. Proceedings of the International Geothermal Conference, Reykjavik, Sept. 2003, pp. 10-18.

United Nations Framework Convention on Climate Change (UNFCCC). (2022). Sustainable Development Goals: A pathway for action.