Geothermal Greenhouses

A more sustainable and cost-effective approach to heating greenhouses

HEATNET GLOBAL

Geothermal Energy Advancement Association

Executive Summary

April 2023

Heatnet Global Executive Summary– 2023-04

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A more sustainable and cost-effective approach to heating greenhouses

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/ The Challenge

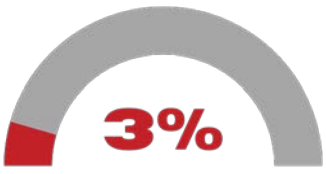
Agricultural production is rapidly increasing to meet the demands of a growing global population. By 2050, the world will need to produce approximately 70% more food than it does today to feed a projected population of 9.8 billion people. Greenhouse agriculture, which creates a controlled environment to enable year-round production of crops regardless of outside temperatures, will be instrumental in meeting this growing global food demand. In many countries greenhouse agriculture is already responsible for over 50% of crop production and this share is expected to grow in the coming decades.

During colder seasons and in colder climates, greenhouses often require additional heating to maintain optimal growing conditions. This requires a substantial amount of energy, most commonly produced by fossil fuel combustion which has significant financial and environmental costs.

In Focus:

In the Netherlands, a world leader in greenhouse agriculture, it is estimated that 2.8 million metric tonnes of CO_2 are emitted each year from heating greenhouses and that 40-45% of the country's total natural gas consumption is used for greenhouse heating.

For most greenhouse operations, heating represents the third largest cost. And as energy prices across Europe continue to rise, the financial burden of heating greenhouses will only grow. An estimated 3% of agricultural emissions come from heating greenhouses alone. Considering that agriculture itself is responsible for a sizable portion of global emissions (~9%), greenhouse decarbonisation is increasingly recognized as important to reaching net zero. The pressure to find and adopt more economically and environmentally friendly heat sources is growing.



Share of Global Agricultural Emissions From Greenhouse Heating

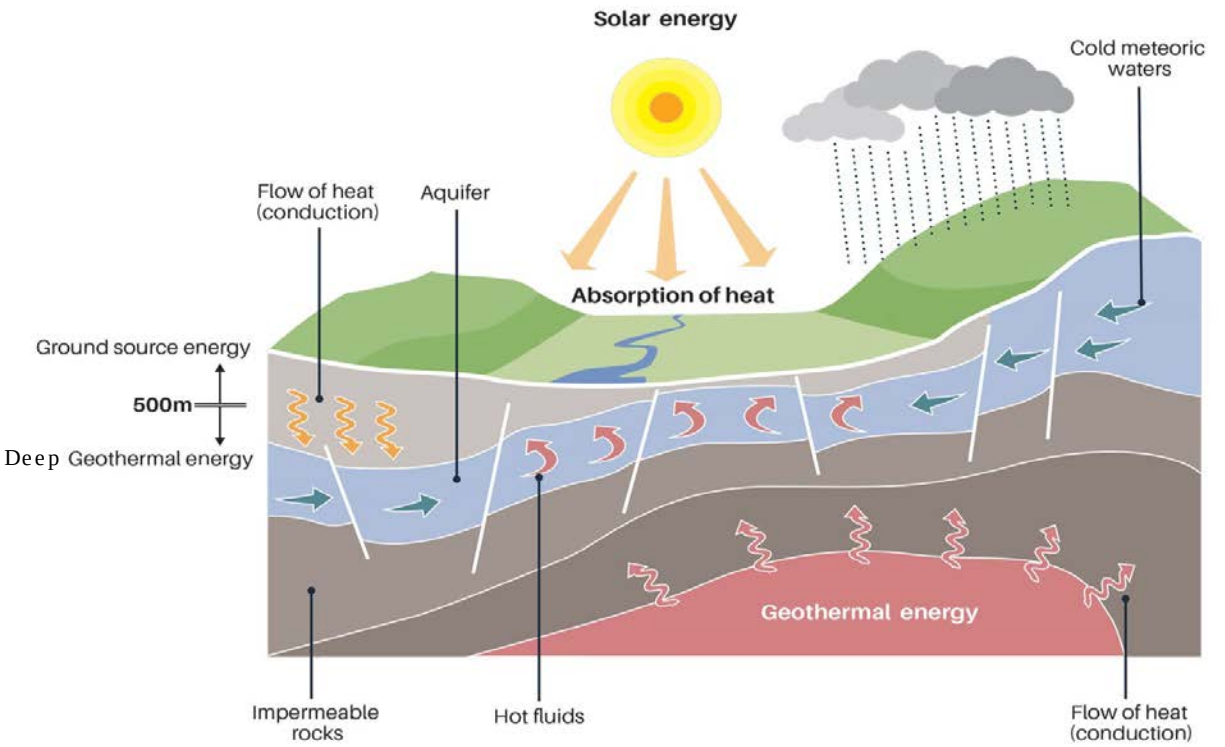
Projected growth in global food demand by 2050.

/ The Solution: Geothermal

Geothermal energy offers an efficient, reliable, and entirely renewable source of heat. Beneath the surface of the Earth exist vast reserves of thermal energy stored in the Earth's complex geology and thermal water systems. Thermal energy temperatures increase with depth and hold significant heating potential. However, even at shallower depths and locations without extraordinary geology, there is potential to harness thermal energy for heat. Geothermal reserves are typically classified by depth, the two most common categories being "shallow" and "deep" geothermal.

Shallow: Shallow geothermal otherwise known as "ground source energy" typically refers to heat stored <200m underground and is mostly generated from solar radiation. Starting at just 5 feet below the earth's surface, temperatures become stable and relatively unaffected by immediate changes in outside air temperatures. Temperatures at shallow depths typically range from 10°C - 20°C, assuming an average annual air temperature of 12°C.

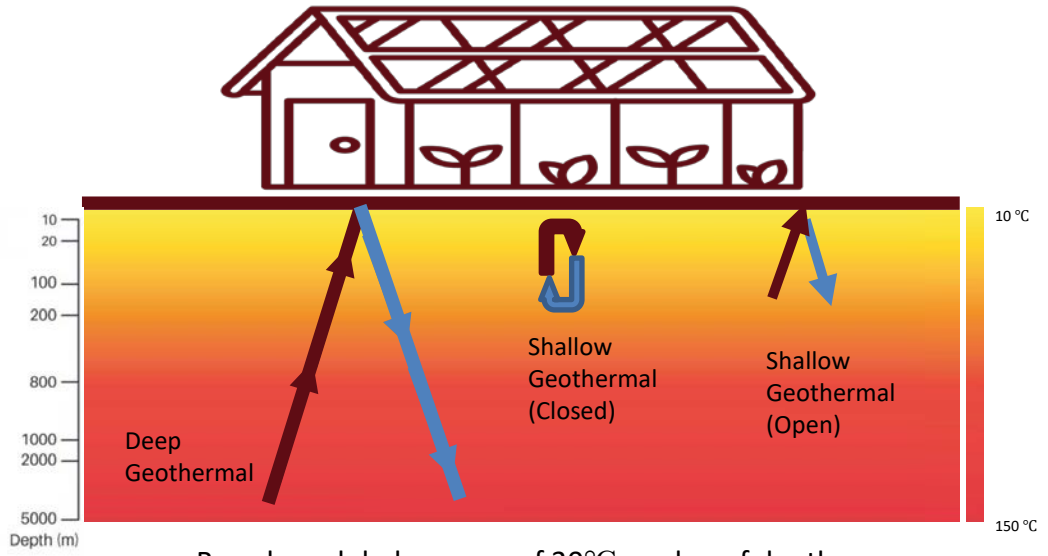
Deep: Although there is no single definition of Deep geothermal, it is commonly associated with heat derived from depths >500m. This heat is derived from the Earth's formation and the decay of mildly radioactive elements within the Earth's crust. To put things into perspective, temperatures at depths of 1000m, 3000m, and 5000m are around 39°C, 89°C, and 139°C, respectively, assuming an average annual air temperature of 12°C.



Geothermal heating systems make use of these otherwise untapped reserves of thermal energy and supply heat to buildings. Greenhouses, which typically rely on the burning of fossil fuels for heating, are ideal candidates for geothermal energy. Many countries around the world have committed to growing crops greener and more affordably, and have already connected greenhouses to geothermal heating systems. Globally, roughly 1330 hectares of greenhouses are heated by geothermal energy. These systems are most common in Turkey, Russia, Hungary, China and the Netherlands. Both shallow and deep geothermal can be utilized to heat greenhouses; however, the systems and technologies needed to harness the heat are different.

Shallow: There are several options for connecting greenhouses to shallow geothermal sources. At a high level, there are passive systems and active systems. Passive systems are simple and inexpensive solutions that gather heat through perforated plastic tubes laid just feet below a greenhouse. They do not require any external energy input to operate, as they rely solely on passive heat exchange from natural temperature differences. These are best for greenhouses with crops that do not require high temperatures. In some cases, when higher temperatures are required, a heat pump can be added to the system. Active systems on the other hand rely on mechanical heat pumps and heat exchangers to deliver the higher temperatures needed for some crops. Occasionally, however, hot water and steam are accessible at shallow depths, allowing for direct use. In the absence of these geological conditions, a closed loop or open loop will be required. Closed loop systems circulate an anti-freeze solution through a network of pipes that absorb heat from the ground and carry it to a heat exchanger which then extracts useable heat. These systems can be arranged vertically (boreholes), horizontally (trenches) or in a slinky formation (spirals). Open loop systems utilize ground water directly, pumping warm water from one well and returning cool water to another. These systems can also make use of nearby ponds and lakes. Due to lower temperatures, shallow geothermal systems often require additional energy efficiency improvements.

Deep: In deep geothermal systems, wells are drilled deep underground to access hot water or steam from aquifers and granite formations. These systems, much like open loop shallow systems, pump hot water from one well and inject residual cool water into another. In some circumstances, deep geothermal systems can provide direct heat without the need for additional heating equipment. However, in cases where extracted temperatures are too high or too low, additional heat transfer and temperature control mechanisms (such as heat exchangers or closed-loop systems) will be needed to achieve the ideal greenhouse climate. Overall, deep geothermal provides a larger, more consistent, and higher-temperature heat source for greenhouse agriculture. It is worth noting, however, that deep geothermal solutions require advanced planning, and their feasibility depends on location and geological characteristics.



Based on global average of 30℃ per km of depth.

/ The Commercial Case

Geothermal energy, whether shallow or deep, is commercially and financially viable for many greenhouse heating operations. Shallow geothermal systems are typically more cost-effective for smaller-scale greenhouse operations whereas deep geothermal systems are better suited for larger-scale greenhouses or those with high-temperature crop production, as they can provide a more consistent and higher-temperature heat source.

Shallow geothermal systems have moderate capital expenditure and relatively fast pay back compared to deep geothermal systems that require deep drilling and that face higher rates of pipe corrosion. However, deep geothermal offer some significant opportunities in terms of volumes and temperatures and should be explored wherever there is a potential.

Within the category of shallow geothermal there are massive differences in capital expenditure. Passive systems, which do not require external energy input, are far less expensive than active systems that use heat pumps (which can represent up to 60% of total cost) and heat exchangers to generate higher temperatures. While the CAPEX for deep geothermal systems might be higher, they can offer larger greenhouse operations a favorable return on investment (ROI) over the long term through massive energy savings. Indeed, the operational costs of both shallow and deep geothermal systems are lower than those of fossil fuel greenhouse heating systems, as they are no longer reliant on expensive and carbon intensive fossil fuels.

Although dependent on factors like local energy prices, greenhouse size, interest rates, system efficiency, and local geological characteristics, both shallow and deep geothermal systems offer potential for significant energy savings. These saving are likely to only increase in the coming years as fossil fuel prices continue to rise and technology advances further reduce prices.

/ Learn More

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Heatnet Global – Heat Academy

Capacity building services in Heating and Cooling

HEATNET GLOBAL is an international network of organisations and professionals all actively in involved in the practical delivery of affordable solutions to decarbonise heating and cooling at scale. The community offers a range of services to bridge capacity gaps, thereby accelerating the process of reaching net zero:

Activity Areas

- ADVISORY – advisory services
- RESOURCES – resource pool and recruitments
- SOLUTIONS – technologies and services
- INTEL & NEWS – market facts and news
- HUBS – local business centres and logistics
- MODULAR – bundled system solutions
- CITIES – collaboration and exchange
- FINANCE – access to project funding

Facilitating Networking and Match-making

Project Owners | Heat Customers | Broader Community | Industry Organisations

Delivery Services | Financial Services | Training Providers | Supply Chain

Capacity Building Services

Industry Knowhow and Resource Pool

Market Intel & Supply Chain Services

Training & Innovation Activities

Local, Business Hubs and Training Partners

THE HEAT ACADEMY is an international training and innovation platform offering a modular training concept on a broad range of topics related to decarbonisation of heating and cooling. Fully independent, the Heat Academy is based on a collaborative model involving partnerships with local colleges, universities, public institutions, energy operators, investors, and the wider supply chain. Following its mission to address the competence and capacity gaps in the sector, The Heat Academy facilitates collaboration through the sharing of best practice, technologies and reference cases.

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