Proceedings World Geothermal Congress 2020+1
Reykjavik, Iceland, April - October 2021

Applications of Geothermal Energy in the Food Supply Chain: State-of-the-art and Future Perspectives

Guglielmetti L.[1,4,5], Brommer M.[2], Mattéo S.[3,4], Moscariello A.[1],

[1]Department of Earth Sciences, University of Geneva. Rue des Maraichers 13, 1205 Genève (Switzerland)

[2]International Geothermal Association IGA. Charles-de-Gaulle-Str. 5 D-53113 Bonn, (Germany)

[3]Wise&Wizard. https://www.wiseandwizard.ch/ (Switzerland)

[4] #Geothermal.Pills

[5] #Geo.Fork

luca.guglielmetti@unige.ch

Keywords: geothermal food, food sustainability, food security, Farm-to-Fork, geothermal energy, geothermal applications

ABSTRACT

Geothermal energy is known to have the potential to supply power and heating and cooling (H&C) solutions all over the world. However, power production is limited to very few regions characterized by favourable geologic conditions and well-established H&C shallow applications are mostly installed for individual uses. At present, the cases where geothermal energy is applied to food production and processing cover a rather large variety of applications, including horticulture, brewery, dairy, fish farming, even caviar, and cooking directly in fumaroles and hot springs and more. New energy policies are developing worldwide (e.g. the Green Deal at the European level) to support the decarbonization of the food sector and geothermal energy can play a major role in the near future.

With this study, we wish to present a global map of the known applications of geothermal energy into food production and attract awarness to the opportunities that can be implemented in the future worldwide to contribute to local economic growth, food security, and improved sustainability.

INTRODUCTION

The international community is becoming increasingly concerned about the high dependence of the global food sector on fossil fuels as supported by FAO projections indicating that by 2050 a 70 percent increase in current food production is forecast and to meet the expanding demand for food, yield increases will be necessary. The use of fossil fuels by agriculture has made a significant contribution to feeding the world over the last few decades boosting farm mechanization, fertilizer production and improved food processing and transportation. The food sector currently accounts for around 30 percent of the world's total energy consumption and contributes to over 20 percent of total GHGs emissions (FAO, 2015). The biggest challenge the world has to face now is the development of a resilient, sustainable and energy efficient food systems that emit fewer GHG emissions, enjoy a secure energy supply and can respond to fluctuating energy prices while at the same time support food security and sustainable development.

Geothermal energy is demonstrating its large flexibility in energy supply to the food sector but at present, geothermal contributes just in a small part to the transformation of the food chain that according to the guidelines published by FAO (2015), involves:

- phasing-out fossil fuels by relying more on efficient low-carbon energy systems
- strengthening the role of renewable energy, including geothermal, within the food system for decentralized generation of heat and electricity
- providing greater access to geothermal energy development, and at the same time supporting the achievement of national food security and sustainable development goals.

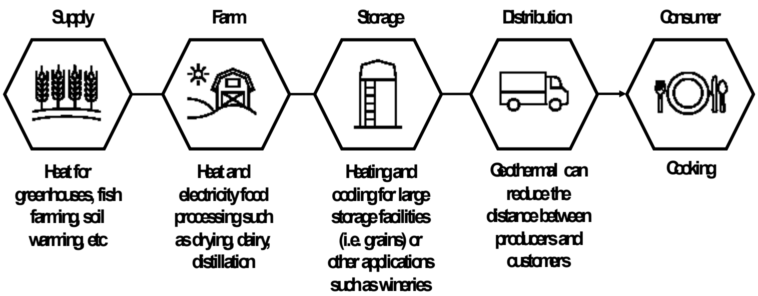

Figure 1 Examples of integration of geothermal energy in the food supply chain

The energy-food nexus is addressed in the 2030 Agenda for Sustainable Development (2015) that sets the objective by 2030 to end hunger, achieve food security and promote sustainable agriculture as well as to ensure access to affordable, reliable, sustainable and modern energy for all. Therefore, geothermal energy, coupled to other renewable energies can contribute to enhance the sustainability of the entire food sector as they can be applied across the entire food supply chain (IRENA, 2019).

The applications of geothermal energy in the food value chain are broad and can be summarized as follows (IRENA, 2019; Lund & Toth 2021):

- Greenhouse heating (25°C-100°C) is the largest application of geothermal in food, reported in 31 countries worldwide. Greenhouse heating is employed to grow crops such as vegetables and fruit in addition to flowers, houseplants and tree seedlings.
- Aquaculture (20°C-40°C) Geothermal waters can be used to heat freshwater in heat exchangers or mixed with freshwater to obtain suitable temperatures for fish farming. This application has been reported in 30 countries worldwide and it is mainly used for aquaculture pond and raceway heating.
- Cultivation of algae – mainly spirulina – is another growing use, which requires temperatures of 35°C-37°C.
- Soil heating (20°C-40°C) for example, to grow carrots and cabbages. The constant soil temperature increases the yields and makes it possible to extend the growing season.
- Irrigation (40°C-75°C) Geothermal energy at this temperature range can be employed to heat winter crops in open field agriculture and in greenhouses.
- Food/crop drying (around 40°C up to 100°C) which consists of removing water contained in the product, thus reducing moisture quantity to below 20%. Low to medium temperature geothermal resources can reduce energy consumption in the drying process and preserves the nutritional factors of the food which areusually partially lost during standard drying processes at higher temperature.
- Milk pasteurisation (around 70°C up to 100°C) Geothermal hot water can be used for milk pasteurisation, while geothermal steam can be used for milk drying and ultra-heat treatment (UHT) processes.
- Evaporation and distillation (around 80°C up to 120°C) This is commonly employed to separate mixtures and/or to increase the concentration of some components of the product. Examples include milk evaporation, sugar and liquor processing (beer, gin, vodka)
- Sterilisation (>105°C) Geothermal heat is used to achieve a temperature of 121°C for food sterilisation in the meat and fish industry, which is a standard temperature for food sterilisation. Besides, geothermal water can also be used at 105°C-120°C to sterilise food processing equipment.
- Refrigeration (>120°C) Geothermal energy can be used for refrigeration by absorption technology, using an ammonia/water cycle for applications below 0°C. So far, there has been very limited use of this geothermal application.

RESULTS

The map in Figure 2 report all the worldwide applications of geothermal energy in the food sector

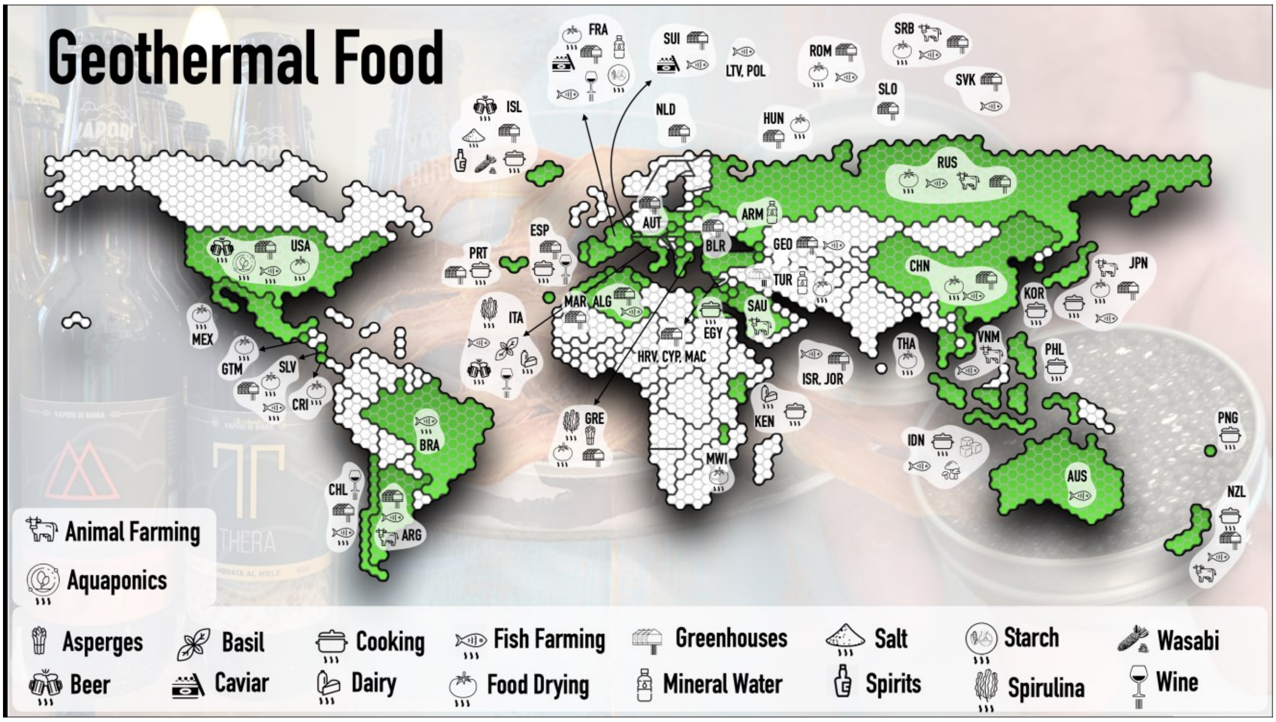

Figure 2 Global map of the Geothermal food (Sources: FAO 2015, IRENA 2019, Lund & Toth 2021)

CONCLUSION

Decoupling increase in food production from fossil fuel use will require fundamental changes in global food systems. More analysis is required on how a shift to a less fossil fuel dependent food sector would affect food security, food prices, energy access, climate change resilience, technology uptake and capacity building.

Reducing energy demand is a key element of success to increase the sustainability of the food sector. If energy prices continue to rise, the global food sector will face increased risks and lower profits. However, achieving increases in productivity and efficiencies in both small and large-scale food systems may be hindered by high energy costs. Lowering the energy inputs in essential areas, such as (but not limited to) heating and cooling, electricity supply can help the food sector to improve its reliance. Geothermal energy is demonstrating how it can support such development in many applications worldwide in production and processing practices so that they become less energy intensive in terms of energy consumption per unit of food produced, and at the same time deliver food in a safe and environmentally sustainable manner. Methods for improving energy efficiency are reasonably well understood. However, these methods should be applied only when they do not lower productivity, do not restrict energy access and do not threaten rural livelihoods. A simple 10 percent reduction in food losses and a change to diets for example to include the use of more fresh and local foods would help reduce overall demands for energy, water and land. However, implementing these changes would take time as they involve significant behavioural changes and present formidable social challenges.

Enabling policies. Strong and long-term supporting policies and innovative multi-stakeholder institutional arrangements are required if the food sector is to become energy-smart for both households and large corporations. Financial mechanisms to support the deployment of energy efficiency and renewable energy will also be necessary to facilitate the development of energy-smart food systems. Examples exist of cost-effective policy instruments and inclusive business schemes that have successfully supported the development of the food sector. These exemplary policy instruments will need to be significantly scaled up if a cross-sectoral landscape approach is to be achieved at the international level. Implementing these policies will require:

- investments in applied research development;
- the deployment of appropriate technologies;
- the introduction, sharing and adaptation of energy-smart technologies;
- fiscal support mechanisms
- capacity building, support services, and education and training.

A supporting policy environment without the appropriate allocation of financial and human resources is unlikely to succeed in establishing energy-smart food systems.

REFERENCES

General Assembly Resolution A/RES/70/1 adopted on 25 September (2015). *Transforming our World: The 2030 Agenda for Sustainable Development*"

IRENA (2019). *Accelerating geothermal heat adoption in the agri-food secto*r, International Renewable Energy Agency, Abu Dhabi.

Lund, J.W., Toth, A.N. (2021). *Direct utilization of geothermal energy 2020 worldwide review*. Geothermics 90

Van Nguyen, M., Arason, S., Gissurarson M. and Pálsson, P.G. (2015). *Uses of geothermal energy in food and agriculture – Opportunities for developing countries*. Rome, FAO.