Geothermal Power Generation Continues to Advance and Offers a Clean-Energy Future

An inside look at turbomachinery in a geothermal plant, how these plants are designed, recent advancements, and how geothermal can help decarbonize the energy landscape.

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Turbomachinery International hosted Joseph Bonafin—Sales and Business Development Manager at Turboden, a part of Mitsubishi Heavy Industries Group—on the TurboTime Podcast to discuss geothermal power generation. Bonafin dives into the history of geothermal power, how it's grown over the past 20 - 25 years, its place in the decarbonization journey, and more.

Q What role does turbomachinery play in a geothermal plant?

Bonafin: The turbomachinery is the rotating part that converts pressure in the organic fluid into work and electricity by spinning a generator. Pressure in the organic fluid is created by a heat exchanger transferred from a geothermal source, so no geothermal fluids are used. A closed-and-tight circuit generates emissions-free power.

Turbomachinery is key to having an efficient and reliable baseload generation with low maintenance costs.

Q What goes into designing, manufacturing, and constructing a geothermal plant?

Bonafin: Turboden is involved in the main steps of a geothermal project—from front-end engineering and design to the procurement and construction of the power plant, and remote monitoring and operation.

A geothermal project requires a multi-discipline approach: geochemistry, reservoir engineering, thermodynamics, turbomachinery design, electrical engineering, and metallurgy. We embrace all these disciplines, starting from our core know-how: power plant and turbomachinery design and control philosophy. Not only is engineering required but also financial skills are needed to implement a

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project. Being part of a multinational group such as Mitsubishi Heavy Industries, we can leverage many instruments to facilitate the export of our equipment, such as export credit financing or grant mechanisms for CO_2 reduction.

How has demand for geothermal power plants grown over the past 25 years?

Bonafin: As of today, there are roughly 16 GWs of geothermal plants installed worldwide. The organic Rankine cycle (ORC) is the fastest-growing technology in the geothermal power generation market. ORC has doubled its share among all types of geothermal generation systems in the last five years, adding about 2 GWs of new plants. Exploiting the full range of resources—from low to high temperatures, liquid to steam, and remote locations such as high-elevation deserts or islands—and installing ORC power plants close to inhabited areas show the benefits of this trending technology.

Turboden has experience with power plants delivering both electricity and heat to the district heating networks, and I see more and more of these projects, especially in Europe. A new trend that is quickly expanding is higher-temperature and larger-capacity ORC plants. There is a natural synergy between ORC and enhanced geothermal systems— new drilling technologies allow the fluid to be fully injected by mining the heat and exploiting the thermal energy from the ground, giving back the fluids at a lower temperature. This synergy between power-plant technology and new drilling technologies is the only way to scale up geothermal applications among other renewables.

How is geothermal power generation a pathway to decarbonization? What are its limitations, and what recent advancements have been made to further geothermal new-builds?

Bonafin: Geothermal generates power year-round and can replace coal- or gas-fired power stations as a baseload power with low production costs. It's also dispatchable and supports grid stability in combination with intermittent sources. It's also easily integrated into most locations with a small footprint and CO_2 lifecycle compared to other renewables such as solar and wind. Plus, geothermal provides not only electrical power but inexpensive thermal power for a district heating network—not to mention that geothermal projects create temporary and permanent jobs that are important in developing a local supply chain.

It does have limitations, too. Regulatory barriers, such as long licensing and permitting procedures similar to mining and oil and gas, can limit new builds. Financial barriers come into play with the initial exploration and drilling activities. Geothermal also suffers from misconceptions. It is much less known compared to conventional renewables such as photovoltaics or wind. Geothermal is even incorrectly compared to shale gas technology in the case of enhanced systems. Issues can also arise from induced seismicity or underground water pollution, for example.

There is, however, an overall positive acceptance of geothermal among the various energy sources to decarbonize the power generation sector. This is reflected in supporting schemes and international programs to facilitate the implementation of new projects at a large scale. I also believe that the oil and gas industry is more interested in investing in geothermal compared to a few years ago.

What's next for Turboden with geothermal?

Bonafin: Integrating ORC technology with other innovative geothermal technologies, such as enhanced geothermal systems, closed-loop geothermal systems, and lithium extraction from geothermal brine, can improve efficiency, sustainability, and economic viability.

Enhanced geothermal systems generate electricity from hot dry rock locations, enhancing the heat exchange by circulating clean water through artificially engineered fractures. This efficiently converts moderate temperature into electricity, expanding the geographic applicability of ORC projects to previously inaccessible heat sources, especially for large-scale projects.

Closed-loop geothermal systems provide environmentally friendly alternatives by creating a thermosyphon effect by drilling multiple lateral wells underground. Integrating ORC with closed-loop systems minimizes the environmental impact and reduces water consumption.

Lithium extraction from geothermal brine, crucial for electric batteries, is a sustainable source. ORC technology works as a cooler for the lithium extraction process in the shared infrastructure, contributing to a more economically viable and environmentally friendly process. Sale of electricity is added on top of the additional revenue stream coming from lithium extraction, promoting a cleaner and more profitable energy supply chain.

In summary, amalgamating ORC technology with enhanced geothermal systems, closed-loop systems, and lithium extraction from geothermal brine creates a holistic approach to geothermal energy production. This synergy enhances diverse resource utilization, promotes environmental sustainability, and contributes to the production of rare materials required for emerging technologies. This integrated approach underscores geothermal energy's potential in a sustainable and diversified global energy portfolio. ■

To hear the full interview, visit turbomachinerymag.com/podcast.