Baker Hughes

CENetic geothermal pumping systems

Clean geothermal energy is an increasingly important part of the world's energy mix

Unlike fossil fuels, geothermal energy is a long-term, environmentally sustainable energy source for power generation, direct use, or ground-source heat pumps. Geothermal energy is less affected by fuel-cost fluctuations and, because the energy is produced locally, supports local economies and eliminates costs associated with fuel transport.

A growing number of countries are relying on geothermal to diversify the energy mix. Twenty-four countries are producing electricity while geothermal heating is used in 70 countries developing geothermal projects to supply energy is growing. According to 2018 statistics from the International Energy Agency, a growth of 3,600 to 4,500 MW of geothermal electrical capacity is expected within the next 5 years, which equates to an annual growth rate of 4.7%.

But, sustainable geothermal energy development is dependent on reliability standards that make projects economically viable.

The return on investment from geothermal energy projects is much longer than fossil fuels production and, consequently, profitability is dependent on the uninterrupted flow of hot water from the Earth. That means the entire operation is reliant on the dependability of the machinery driving power generation.

To meet economic thresholds, geothermal projects require an average run life of approximately 3 to 5 years from the pumping systems used to lift hot water from the Earth. But, the extreme conditions associated with geothermal energy sources are challenging for mechanical downhole equipment, and environmental concerns can limit options to deal with issues that negatively impact reliability.

New technology development to meet the distinct challenges of geothermal energy production is important. But, technology is not enough.

To improve reliability standards and the economics of geothermal energy projects takes integrated solutions that go beyond the pumping equipment. These solutions combine:

Pumping technology innovations that address not only the technical challenges of geothermal wells but also the economic realities

Customer support throughout the life of a well to ensure the technical and economic sustainability of each pumping system

Commercial models that meet the specific needs of geothermal energy projects

A HISTORY OF SUCCESS

In the late 1980s, Baker Hughes installed electrical submersible pumping (ESP) systems in Europe's first permanent geothermal heat-producing projects in France and Switzerland—projects that continue to produce today. Today, Baker Hughes has geothermal pumps operating in France, Germany, The Netherlands, Switzerland, Hungary, the United States, and Turkey, continuously pushing the temperature, flow rate, and lifting capabilities of ESP technology while achieving substantial run-life targets. As of 2019, Baker Hughes ESPs were responsible for 980 MW of both thermal and heat capacity globally. That amount of energy is equivalent to not burning over 5 million barrels of oil a year.

Projects in the United States further pushed the temperature requirements for geothermal pumping systems to 182°C (360°F), and Baker Hughes successfully met the challenge.

When multiple geothermal district heating projects got underway in Germany in 2000, Baker Hughes worked with the project operators to perform well tests and then provide pumping systems. At the Unterschleissheim project, Baker Hughes installed an 80-L/s (1,268-gal/min) system in 2004, which is still running, and has produced an estimated 630 gigawatt-hours (GWh), or 42 GWh/a, of power currently.

In 2008, the geothermal industry again challenged Baker Hughes with requirements that far exceeded the current technology capabilities. Baker Hughes developed its extreme-horsepower 880 Series motor for subsea, which was then modified for geothermal use, providing 2,240 hp (1,670 kW) to increase production rates to more than 140 L/s (2,219 gal/min). Several extreme-horsepower geothermal pumping systems are now operating at production rates up to 200 L/s (3,170 gal/min). We have ESPs installed in 35 different geothermal projects in Germany. Six of them are running the 880 extreme-horsepower ESP. The 880 is still the largest ESP in the market today.

Demand a higher reliability benchmark for geothermal pumping systems

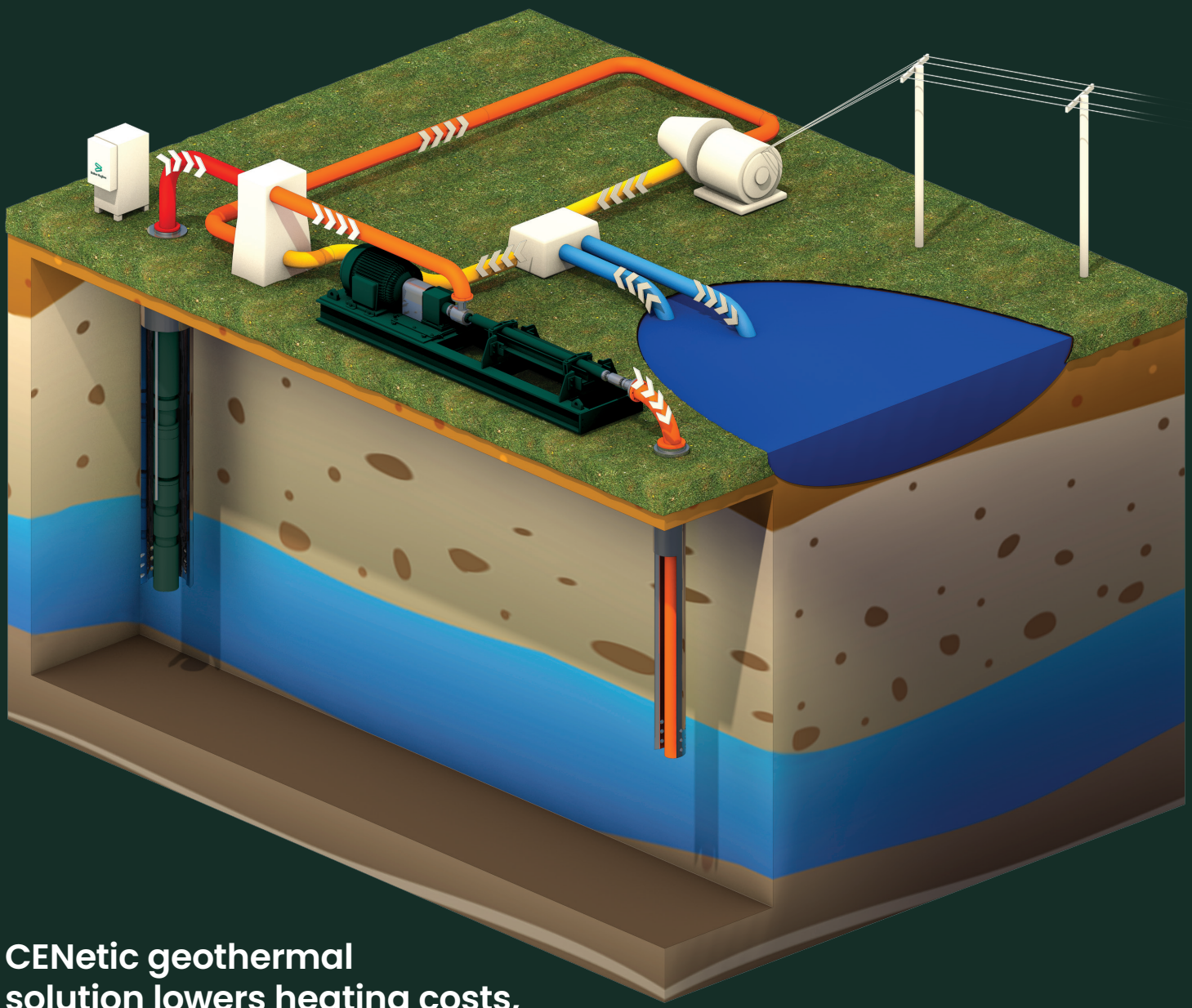
The combination of focused technology innovation and customer service from a business partner serious about achieving a step-change in reliability with nontraditional commercial models is essential to the profitability of geothermal energy development projects.

Focused technology innovation

Pumping systems customized for the specific challenges of geothermal energy production are imperative to achieve the reliability standards operators' demand. Baker Hughes has been dedicated to advancing geothermal energy pumping technology since the advent of the resource in the 1980s. A single source for the design, manufacture, and delivery of geothermal systems eliminates potential equipment compatibility issues, improving quality control. Technology based on more than 50 years of oilfield pumping experience provides geothermal operators the ability to produce high volumes of water from smaller diameter wells—dramatically reducing well construction costs. For 30 years, the company has worked side by side with operators to push the capabilities of the high-temperature, high-horsepower systems needed for geothermal applications.

While Baker Hughes **CENetic™ geothermal pumping systems** have set the standard for run life in geothermal wells, dedicated research and development is necessary to meet the expanding pumping requirements of geothermal projects. These requirements include:

- Temperature capabilities as high as 250°C (482°F)
- Flow rates of up to 280 L/s (4,500 gal/min)
- Environmentally compliant scale prevention methods to ensure flow
- Up to 2800-hp systems
- Efficiency across the energy cycle
- Smaller diameter pumping capabilities to reduce drilling CAPEX



CENetic geothermal solution lowers heating costs, CO_2 emissions

The economics of a greenhouse operation in The Netherlands were threatened due to the high costs associated with the existing natural gas-powered heating system. The operator elected to transition to geothermal power, not only to lower costs but also to reduce CO_2 emissions, and engaged the Baker Hughes artificial lift team early to ensure the well construction plan did not limit water production.

After each well was drilled, a well test was conducted and Baker Hughes supplied the downhole electrical submersible pumping (ESP) system as well as a surface test module, including a variable speed drive and transformer, for the well tests. By monitoring the data during the well test, Baker Hughes applications engineers collected valuable information, allowing them to design the optimal ESP system.

Since geothermal wells have high salinity values in the fluid, Baker Hughes supplied rugged geothermal pumping systems with components specifically designed to handle corrosion and scale issues to extend the run life of the production equipment. The well depths varied from 1,600 to 2,900 m (5,249 to 9,514 ft).

With a flow rate of 55 to 111 L/s (881 to 1,761 gal/min) and water temperature between 80 to 100°C (176 to 212°F), the greenhouses were efficiently heated year round. The Baker Hughes geothermal ESP systems delivered enough heat for a total surface area of 226 acres, reducing gas consumption by 54 Mm^3/day—equivalent to the natural gas used by more than 33,800 homes in one year. Today we supply the heat to 28 greenhouse projects in The Netherlands.

Interdependent, life-of-well business partnership

Pumping system uptime over the life of the well is essential to the viability of geothermal power generation. That means customer support doesn't end when the system is installed. It takes constant customer support from preplanning through decommissioning. Partnering with a team of experts who understands your business drivers ensures that you get the most reliable solution faster—based on a holistic, rather than a piecemeal, approach. Our comprehensive support team includes:

- Experts who understand the impact of reservoir characteristics on the pumping system
- Applications engineers who get the pumping system design right the first time for the highest level of reliability and efficiency
- Experienced field technicians for fast-response installation and maintenance
- Optimization engineers who remotely monitor pumping system operations in real time to provide predictive operational analysis and early intervention, as well as troubleshooting capabilities
- Experts in productivity testing
- Dedicated testing and repair service centers

By working interdependently with a service partner, you can accelerate decision making and implementation. Plus, a life-of-well, holistic approach drives continuous learning about what works and what doesn't. Timely, meaningful adjustments can be made over time to improve both technical performance and the economic threshold.

Customized commercial models

Since the economics of geothermal energy projects are dependent on the reliability of the equipment used to produce the energy source, commercial models structured to share the risk of pumping system performance are ideal. Commercial terms can include:

- A lease-based model
- A maintenance fee-based model

Geothermal Center of Excellence

To continuously improve the operating range and reliability of its CENetic geothermal pumping systems to meet future industry needs, Baker Hughes has established the Global Geothermal Center of Excellence in Celle, Germany. The facility is home to an engineering group dedicated to developing technology innovations that drive a step-change in reliability for large-volume, high-temperature ESP systems and operations.

The Center features a high-temperature test loop designed to test and validate new technology in a controlled environment for the specific requirements of geothermal projects. Unlike any other testing facility in the world, the hot loop was commissioned in 2012 with support from the German government.

Test loop capabilities	
Maximum flow	200 L/s (3,170 gal/min)
System pressure	100 bar (1,450 psi)
Minimum/maximum differential pressure	25/100 bar (363/1,450 psi)
Maximum temperature	190°C (375°F)
ID of pressure vessel	15.6 in. (396.2 mm)
Maximum ESP dimensions	12-in. (304.8-mm) OD, 120-ft (36.58-m) length
Maximum electrical power	3,500 kVA
Maximum cooling capacity	2,500 kW

- A straight sale with a maintenance fee structure to drive high-reliability standards for the life of the well and to keep unanticipated costs to a minimum
- Guaranteed response
- Total project management

Baker Hughes can work with you to determine the most effective model for your specific business needs.

Only Baker Hughes can partner with you to drive technology advancements, to build an interdependent business relationship, and to establish the best commercial model to achieve greater reliability and quicker payout from your geothermal pumping operations.