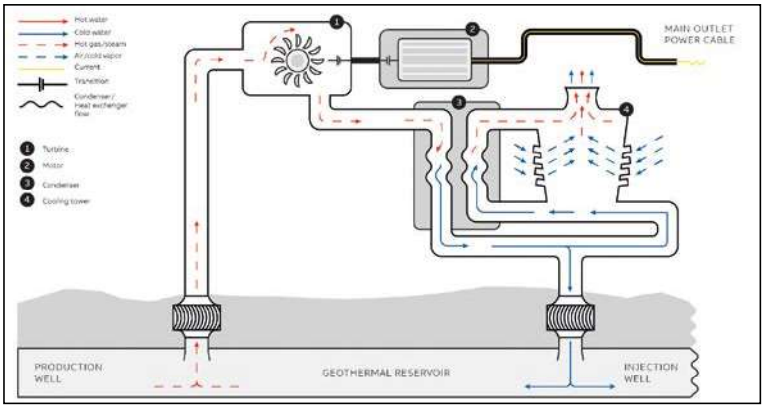
Why now is the time to harness the energy deep inside our planet

Luca Rizzo provides *GDI* with an insight into geothermal energy and the four main technologies for generating power from geothermal energy



An illustration of a dry steam power plant

Geothermal energy – heat that has been generated beneath the Earth's crust – comprises a small but rapidly growing share of the global energy mix.

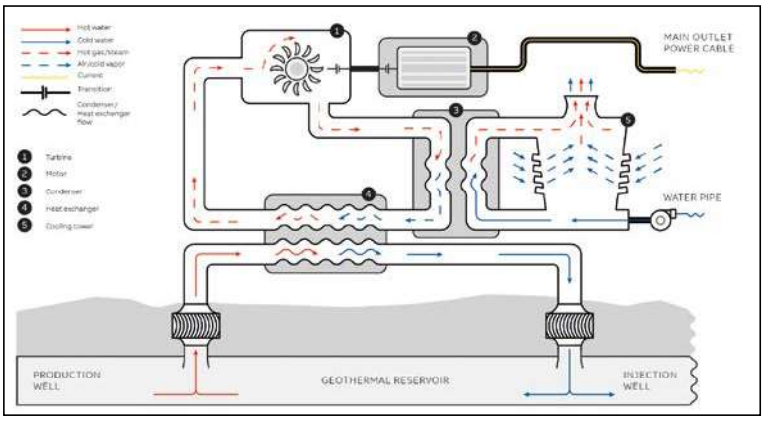
Combining energy that originates from friction created during the Earth's formation over four billion years ago and radioactive decay, it is a renewable source radiating continuously from the planet's core and reaching temperatures between 2700-4000C.

Extracting and using this heat energy is most viable within regions that experience high temperatures at relatively shallow depths, with drilling costs typically accounting for half of a power plant's total expense. These hotspots are often associated with volcanic and seismic activity around tectonic plate boundaries like the Pacific Ring of Fire.

While geothermal is still a fairly underutilised form of energy, there are 26 countries that generate power from geothermal sources, with Asia-Pacific – especially Indonesia – leading the way. And the signs are that it is growing globally, with an annual capacity increase of 7% expected year-on-year to 2030.

So how exactly is geothermal energy utilised and what form do geothermal power plants take? In some cases, geothermal heat is in the form of steam or hot water and can be utilised directly. However, "enhancing" techniques like pumping water into heat pockets to produce steam are most common.

There are four main technologies for generating power from geothermal energy: dry steam, flash steam, binary cycle, and combined flash/binary cycle plants. Each approach is suited to different resource characteristics.



An illustration of a flash steam power plant

DRY STEAM PLANTS

The oldest and simplest process, dry steam plants utilise steam piped directly from a geothermal reservoir (over 150C) to drive a turbine. The steam is then condensed to water and re-injected into the reservoir. While efficient, few dry steam plants remain in operation.

FLASH STEAM PLANTS

Highly pressurised water at a temperature of 180C or more flows into a low-pressure vessel, causing a portion to "flash" into steam, which then powers a turbine. Remaining hot water and condensate are cooled and re-injected.

BINARY CYCLE PLANTS

With the advantage of being able to use lower temperature fluids down to around 57C, binary cycle plants pump hot water from the geothermal reservoir through a heat exchanger to vaporize a secondary working fluid like isobutane, which has a lower boiling point. The vapor produced drives the turbine before condensing and returning to the heat exchanger loop.

COMBINED FLASH/BINARY

High-temperature, high-pressure water is flashed into steam in a separator to power a first turbine stage. The remaining hot water preheats the working fluid for a binary cycle, further vaporized by the spent steam to drive a second turbine stage.

GEOTHERMAL ADVANTAGES

Geothermal power plants provide consistent baseload power generation with a high-capacity factor. Globally, geothermal has a mean capacity factor of 0.74, compared favourably to other renewables like biomass (0.55), hydropower (0.43) and solar (0.11). Nuclear has a slightly higher factor of 0.79.

Geothermal facilities are also highly scalable yet require relatively little land area compared to other power sources. For example, producing 1 GWh of electricity needs only 1046sq.km of land for a geothermal plant, versus 9433sq.km for coal.

Moreover, geothermal is generally a clean energy source, with water vapour as the main emission.

In some cases, plants may release small amounts of greenhouse gases like hydrogen sulphide and carbon dioxide, as well as trace pollutants like sulphur dioxide, nitrous oxides and particulates. There are also potential risks of underground water contamination from elements like arsenic, mercury and selenium if reservoirs are not properly isolated.

But overall, the advantages of high-capacity factors, small footprints, scalability and relatively clean operations make geothermal power plants an attractive option for baseload renewable energy.

MOTORS AND GENERATORS

In geothermal plants, robust induction motors drive critical applications like condensate pumps, cooling tower fans, and gas compressors. Their high power density, efficiency, and configurable designs enable optimal performance matched to each plant's needs. Premium-efficiency motors, combined with variable speed drives (VSDs) or direct drive configurations, can further maximise system efficiency.

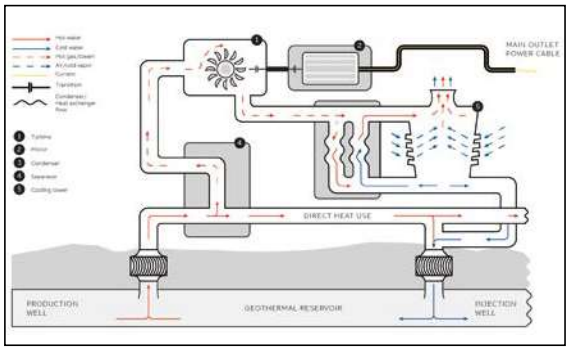
Generally, synchronous four-pole steam turbine generators are used in high-voltage supply solutions tailored to the specific installation requirements. Complete integrated packages are often specified, including cooling systems, terminal boxes, maintenance tools, VSDs, motors, control equipment, and monitoring/protection solutions.

Maximising efficiency is key, as even small improvements translate to lower losses, reduced operating costs, and greater power output from the same geothermal resource. High-efficiency motors and generators also help reduce CO_2 emissions.

Designing for cooler operating temperatures and low vibration enhances reliability and minimises unexpected downtime. And for plants with hydrogen sulphide gas present, special anti-corrosion measures are needed to protect motors, generators, and other metallic components through proper painting, coating, tinning or enclosure pressurisation.

KAISHAN'S GEOTHERMAL

ABB has an extensive track record supplying equipment for geothermal power generation, with around 500 MVA in generators at geothermal plants. A notable project showcasing ABB's high-efficiency generator technology is for Kaishan Group, a Chinese engineering firm pioneering modular geothermal power stations.



An illustration of a binary cycle power plant

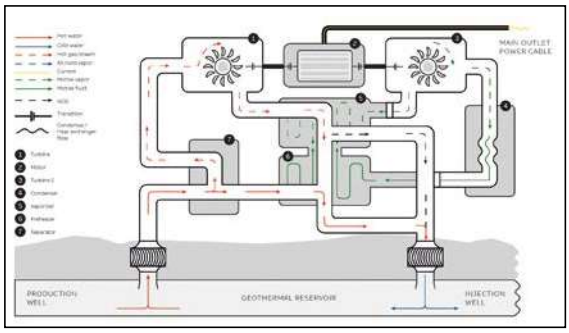
Kaishan constructed two plants in Indonesia – the 240MW Sorik Marapi facility in Sumatra and the 30MW Sokoria plant in East Nusa. For each, ABB provided 12 MVA synchronous steam turbine generators specified for 97% efficiency; in fact, they achieved 98.37% during type testing.

The two plants' combined use of these highly efficient ABB generators will reduce annual CO_2 emissions by approximately 1310t, the equivalent of powering 255 homes for a year.

A CLEAN RESOURCE

Geothermal energy stands as a clean, renewable resource with longevity measured in billions of years. Its ability to provide reliable baseload power makes it an excellent complement to intermittent sources like wind and solar. And as this abundant energy source continues advancing, it will play a pivotal role in the global transition to a greener future.

An illustration of a combined flash/binary plant



Luca Rizzo is the global power industry manager for Large Motors and Generators at ABB. With over 20 years of experience in various industry applications, he guides ABB's efforts in developing innovative motor and generator solutions to meet the evolving needs of the water and power sectors worldwide.