Geothermal
Power Plants
Power grows when we all work together.

There is a strong demand for energy decarbonization in the world today. One in ten people is forced to live without reliable access to electricity, while global demand for power continues to grow. Mitsubishi Power, Ltd. addresses such needs by providing stable, highly reliable, and clean energy solutions.

Mitsubishi Power, a core subsidiary of Mitsubishi Heavy Industries Group based on a long history of product development and supply for more than a century, has been dedicated to designing, manufacturing, verifying, engineering, installing and providing services for a wide range of proprietary power generation systems.

One of our products is gas turbine combined cycle (GTCC) power plants, which provides incredibly efficient electric power while reducing CO2 emissions.

We also provide next-generation power systems, such as integrated coal gasification combined cycle (IGCC) power plants, steam power plants, geothermal power plants, air quality control systems (AGCS) and digital solutions MHPS-TOMONi. Mitsubishi Power is creating a future that works for people and the planet by developing innovative power generation technology and solutions to enable the decarbonization of energy and deliver reliable power everywhere.
Geothermal Power Plants

Mitsubishi Power’s geothermal power plants extract heat energy from the ground to produce environmentally-friendly electric power of high efficiency with the latest power generation technology.

High performance and reliability

Mitsubishi Power became the first in the world to introduce the two-phase flow transportation system and the double flash cycle as technologies for geothermal power generation. We have been striving to develop new geothermal power generation technologies. Based on research findings accumulated over a long period of time, our geothermal power plants have been verified to produce high performance and high availability all over the world. For example, the Los Azules III phase I geothermal power plant in Mexico, which came into operation in 2015, achieved an availability of 99.4% during the one year from the commencement of operation. Mitsubishi Power will continue to supply reliable electric power on the basis of our superior geothermal power generation technologies.

<table>
<thead>
<tr>
<th>Life cycle CO₂ emissions (p-CO₂/kWh) from power generation technologies</th>
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<tbody>
<tr>
<td>Coal/Fired</td>
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<tr>
<td>Oil/Fired</td>
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<tr>
<td>LNG (GTT)</td>
</tr>
<tr>
<td>Nuclear</td>
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<tr>
<td>Onshore Wind</td>
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<tr>
<td>Offshore Wind</td>
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<tr>
<td>Hydro (Run-of-River)</td>
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<tr>
<td>Hydro (Turbine)</td>
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<tr>
<td>Geothermal</td>
</tr>
<tr>
<td>Biomass</td>
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<td><em>Source: CREDI Report (Report No. 135)</em></td>
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Environmentally-friendly

Geothermal power generation involves no combustion on the ground because it uses magma heat energy from inside the earth. Therefore, it emits very little carbon dioxide to the atmosphere and is effective against global warming. While it is a natural energy source, heat energy that exists in large quantities inside the earth is not affected by weather conditions. This gives geothermal power generation the advantage of a high availability, comparable with that of thermal power generation.

Engineering, procurement and construction (EPC) services

Mitsubishi Power is not merely a manufacturer that designs and manufactures the equipment and devices required for geothermal power plants. We also provide EPC services, including plant construction, in a consistent manner.

We delivered over 100 geothermal power plants since 1950 and we supplied EPC service for more than 70% of them. Accordingly, we have offered engineering, procurement and construction services.

Our strength is the optimization and integration of power plants, including design, manufacturing and construction to ensure maximum output from limited geothermal energy and atmospheric properties which vary from region to region.

Supply units for geothermal power plant

What is geothermal power?

Geothermal power comes from the Earth. Deep inside the planet, arteries flowing with molten hot magma create extremely hot water and highly pressurized steam. The steam and hot water are extracted from the ground through production wells. The steam separated by the separator rotates a turbine that activates a generator, which produces electricity. The hot water separated by the separator is re-injected into the underground, providing a sustainable resource.

Geothermal power plants are a highly capable and reliable supply of permanent electricity. Otake Geothermal Power Plant, Japan’s first water-dominated geothermal power plant, was commissioned in 1967 and has been delivering reliable power for over 50 years.
Contribution to Kenya’s expansion of environmentally-friendly energy sources

In Kenya, hydroelectric power has been the mainstay of the country’s power generation industry for several decades. However, in recent years, poor rainfall has limited hydropower production, resulting in serious power shortages and a growing reliance on thermal energy sources to make up the shortfall.

To stabilize the electricity supply and meet projections for a sharp increase in energy demand, the government’s Kenya Vision 2030 national development policy set targets to significantly expand energy generation capacity by 2030. As part of the policy, it has made increasing geothermal power generation, harnessing the country’s ample geothermal resources, a top priority.

Executing every phase of the geothermal power generation process

Mitsubishi Power has been involved in geothermal development by the national electric utility, Kenya Electricity Generating Company Ltd. (KenGen), in the Olkaria steam field in the Great Rift Valley since the early 1990s. Beginning with the installation of a 15 MW power plant at Olkaria I-#1 1981. It was followed by two additional 15 MW power plants at I-#2, 3. In 2003, at Olkaria I-#1, 2 combined to provide 70 MW (35 MW x 2). Then in 2010, Olkaria II-#3 provided an additional 35 MW of power capacity.

Next, the 140MW Olkaria V-#2 geothermal power plant was constructed under a full turnkey contract and started operations in 2019. Mitsubishi Power designed the plant’s geothermal facility and supplied the steam turbines, generators, condensers, and other auxiliary equipment. Making use of our extensive expertise and experience in EPC (engineering, procurement, construction), we also dispatched our technical advisors on-site to assist with installation and commissioning trials running.

Mitsubishi Power’s superior reliability and technology

Mitsubishi Power’s performance on this project was highly evaluated for its excellent record of equipment delivery, technological strength and EPC execution capabilities. Today, the project is helping to achieve Kenyan government energy generation targets, while at the same time reducing greenhouse gas emissions and preserving our environment. Thanks to this investment, in recent years geothermal power is positioned to overtake hydropower as the country’s main source of power generation.

Geothermal energy is not only securing Kenya’s energy future, it is also an important source of employment. By contributing to this sector, which is indispensable for stimulating industrial development and improving living standards, Mitsubishi Power aims to stimulate economic growth and environmental sustainability, while providing reliable and cost-effective electricity to the people of Kenya with our highly efficient and environmentally friendly technologies.

Mitsubishi Power has supplied more than 100 units supplying more than 3,000 MW of geothermal steam turbines to 13 countries worldwide.

REYKJAVIK

Country: Iceland
Owner: Reykjavik Energy
Plant: Hellisheidi - Geothermal Power Plant #1-6
Mitsubishi Power: EPC
Scope: 1-#1: 65 MW, 1-#4: 46 MW

GÜMÜŞTAT (Germencik)

Country: Turkey
Owner: GÜMÜŞTAT ELECTRICITY GENERATION CO. LTD
Plant: Germencik Geothermal Power Plant #1, 2
Mitsubishi Power: STG
Scope: 1-#1: 30 MW x 2

GRODESA

Country: Mexico
Owner: Geotermia para el Desarrollo S.A.P.I.: de C.V.
Plant: Ojo de San Pedro - Geothermal Power Plant
Mitsubishi Power: EPC
Scope: 20.5 MW
Commercial Operation: 2014

KYUSU ELECTRIC POWER

Country: Japan
Owner: Kyushu Electric Power Co., Inc.
Plant: Hatchobaru #1, 2
Mitsubishi Power: EPC
Scope: #1: 55 MW x 2

ST Star Energy

Country: Indonesia
Owner: Star Energy
Plant: Darajat #2, 3
Mitsubishi Power: ST
Scope: #2: 81.3 MW, #3: 110 MW

DARAJAT

Country: Indonesia
Owner: Star Energy
Plant: Darajat #2, 3
Mitsubishi Power: ST
Scope: #2: 81.3 MW, #3: 110 MW
Steam Turbines

Over the years Mitsubishi Power has supplied more than 100 steam turbines for geothermal plants generating more than 3,000 MW of electricity and satisfying a wide range of output levels to meet various operational requirements.

Wide Output Range: 100 kW to 151 MW

Providing a flexible range of exhaust directions and characteristics

Mitsubishi Power offers a lineup of steam turbines with upward, downward and axial exhaust designs to suit different turbine-generator (TG) building and condenser layouts. The different exhaust directions and turbine building layouts are shown below.

<table>
<thead>
<tr>
<th>Exhaust direction</th>
<th>Downward exhaust</th>
<th>Upward exhaust</th>
<th>Axial exhaust</th>
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<tbody>
<tr>
<td>Turbine frame</td>
<td>SCIF</td>
<td>SCIF</td>
<td>STCF</td>
</tr>
<tr>
<td>Output</td>
<td>~100 MW</td>
<td>~30 MW</td>
<td>~40 MW</td>
</tr>
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</table>

Meeting demand with single flash and double flash cycles

Mitsubishi Power can offer single and double flash cycle to meet the varied demands of different geothermal steam conditions.
Mitsubishi Power technologies in turbines for geothermal power plants

As geothermal steam contains corrosive gases and impurities such as silica, salt, and solid particles, steam turbine design for geothermal plants has to be not only highly efficient, but also highly corrosive-resistant. Hence, the following technologies are applied in all our turbines for geothermal power plants.

Extra-low sulfur CrMoV rotor material

Compared to low-pressure rotors used in conventional (thermal) power plants, this rotor material has higher corrosion resistance, resistance against stress corrosion cracking, and higher corrosion fatigue strength. This is achieved by reducing the amount of sulfur and nickel composition and adjusting the rotor quenching temperatures.

12Cr/17-4PH material for blades

Usually 12% Cr stainless steel is used for the blades, but for long blades where stresses are higher, and for first-stage blades where scaling easily occurs, 17-4PH is used. Compared to 12% Cr stainless steel, 17-4PH steel has better corrosion resistance against elements, such as H2S in geothermal steam, better resistance against stress corrosion cracking, and higher corrosion fatigue strength and durability.

3D blades/nozzles

Full 3-dimensional design is used to optimize blade profile so as to minimize secondary losses and frictional losses, thus increasing efficiency.

ISB blades/fast stage blades

Integral Shroud Blades (ISB) are designed such that the root section, profile section and shroud form a single body. This eliminates the need for high accuracy assembly required for blades with sections manufactured separately. During operation, the ISB also connects with each other to increase vibration damping and reduce tip leakages, thus increasing reliability and efficiency.

Drain catchers

To reduce water droplet erosion, drain catchers are applied to remove condensed water droplets.

Titanium blades

Used for first-stage blades when chlorine ICII concentration is high in the geothermal steam.

Inconel thermal spraying/overlaying

Applied at the gland sections susceptible to corrosion, so as to increase corrosion resistance.

Casing/diaphragm horizontal flange surface stainless steel overlaying

Stainless steel overlaying is applied on the surface to increase corrosion resistance.

Mitsubishi Power size applies the following technologies, especially designed for corrosive steam conditions.

Maximizing Customers’ Asset Values

Due to their very nature, power plants have extremely long lifetimes, often in excess of several decades. To ensure stable power generation over such a long period, Mitsubishi Power offers a wide service menu, including facility inspections, maintenance, repair and equipment upgrades. Mitsubishi Power also strives to improve power plant availability and maximize customers’ asset values. State-of-the-art ICT technology complements Mitsubishi Power’s traditional tools and know-how to guarantee that customers’ needs and expectations are not only met, but regularly exceeded.

Services

Providing services tailored to diversifying customer needs.

Steam turbine retrofits through application of latest technologies

The occurrence of performance degradation and various other problems related to steam turbines as a result of progressing aged deterioration are caused by erosion, corrosion, and fatigue damage over long periods of operation. Mitsubishi Power proposals for large-scale retrofit projects, such as steam turbine replacement and parts supply, have been adopted and implemented by many customers worldwide.

Engineer training at Steam Turbine Technical Training Center

The Steam Turbine Technical Training Center was established in July 2014 with the aim of systematically training engineers to take on more difficult levels of field service jobs for steam turbines. Technical training for steam turbine and disassembly/assembly of steam turbine casing, main valve, etc. is conducted using actual machines and equipment that were installed inside the power plant. This training center aims to cultivate engineers who can provide reliable service to customers through excellent quality and high levels of engineering skill.

MHPs-TOMONI

Mitsubishi Power’s digital solutions service that optimizes the operation of power plants that play increasingly diverse roles in building a low or decarbonized society.

Tomoni, which means “together with” in Japanese, reflects the importance of collaborating with customers to solve challenges and seize opportunities. Mitsubishi Power’s objective is to harness and leverage big data to provide insights, solve complex problems and maximize overall power plant performance.

Features of MHPs-TOMONI

- MHPs-TOMONI is composed of three solution categories: O&M Optimization, Performance improvement, and Flexible Operation. The combination of these three categories allows us to deliver optimal solutions.
- From utility to industry power plant, MHPs-TOMONI is applicable to a wide variety of power plants.
- MHPs-TOMONI is able to customize for a variety of systems such as cvsd and edge computing as well as customers existing platform.
- Combining AI technology and Mitsubishi Power’s knowledges secured over the long history has enabled to develop solutions to optimize the operation of the power plant to meet customer demands.

Digital Solutions MHPs-TOMONI

Roadmap for MHPs-TOMONI

Autonomous Operation of Power Plants.