菅原バイナリー発電所

Sugawara Binary Power Station

九電みらいエナジー

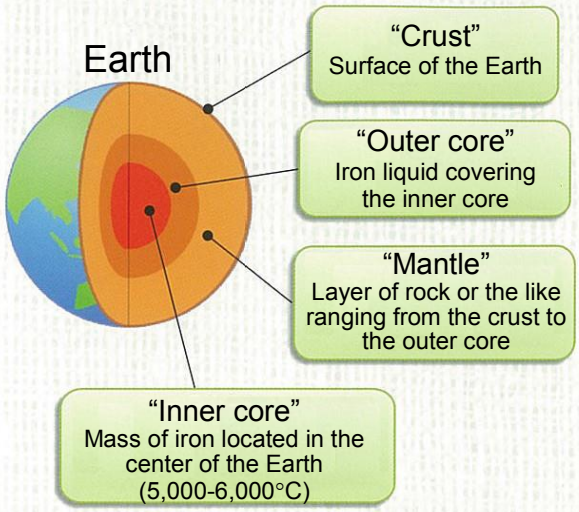
Kyuden Mirai Energy

1. What is Geothermal Power Generation?

Structure of the inside of the Earth and geothermal power generation

The earth has a three-layer structure consisting of the core, the mantle, and the crust.

The central part of the Earth is said to have a temperature of over 5,000°C and is assumed to be a mass of iron, and rocks of mantle melted by the temperature turn into a high temperature liquid called “magma.” When magma reaches Earth’s surface, it erupts and forms a volcano. Below a volcano, there is a “magma chamber” which has a high temperature of around 1,000°C regardless of its depth, and it heats surrounding rocks and water and in some cases may form a “geothermal reservoir.” Geothermal power generation makes use of geothermal fluid (steam and hot water) of a geothermal reservoir.



Characteristics of geothermal power generation

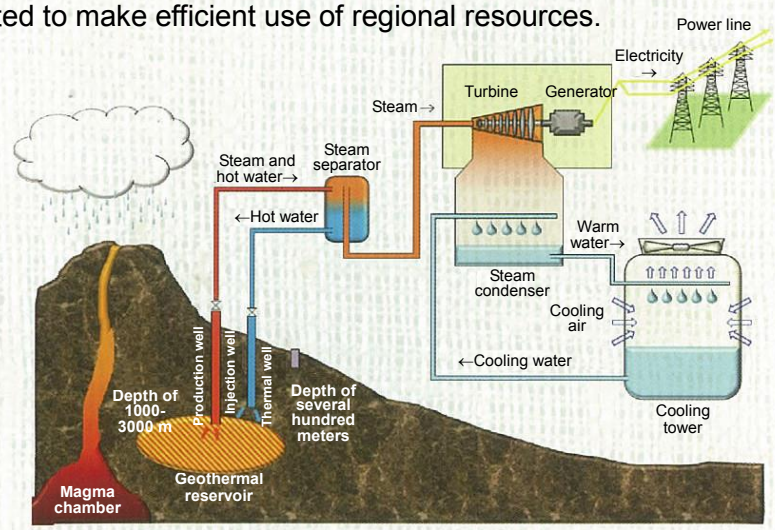
Compared with finite resources (petroleum, coal, etc.), geothermal heat is recyclable energy which can be used permanently if we use it systematically, and it can supply power steadily regardless of weather, time of day, or season. Also, it is characteristic in that CO_2 emissions are less than in the case of power generation using petroleum, coal, natural gas, or the like.

For Japan, which relies on imports for most of its energy resources, promoting geothermal power generation leads to saving of fossil fuels, as geothermal resources are abundant in Japan, a country rich in volcanoes, and geothermal power generation is highly expected to make efficient use of regional resources.

Structure of a geothermal plant

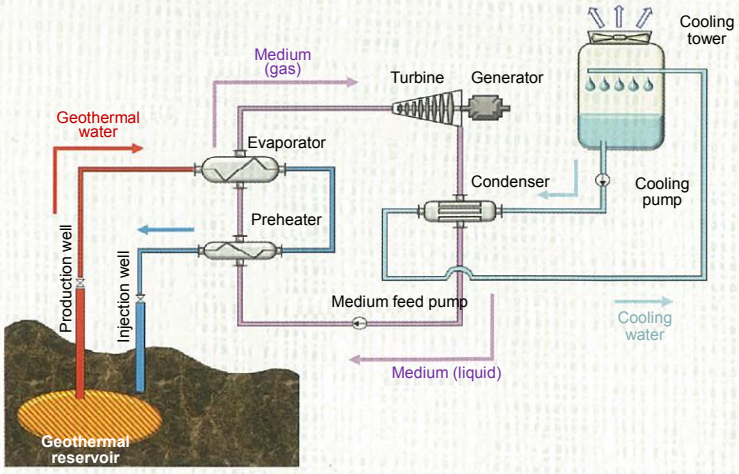
Geothermal power plant generates electric power by rotating a turbine with steam extracted from a geothermal reservoir.

A well (production well) called a “winze” is dug, and geothermal fluid is taken out from a geothermal reservoir and separated into steam and hot water with a steam separator. The steam rotates a turbine to generate power, and the hot water is returned deep in the ground through an injection well. The steam which has finished its job is cooled with a steam condenser or a cooling tower.



Structure of binary power generation

When a geothermal fluid has a medium to low temperature, a method called binary power generation is employed: heat of a geothermal fluid is exchanged with that of a medium whose boiling point is lower than water (N pentane, etc.), and a turbine is rotated with steam of the medium. This method very much increases possibilities of geothermal power generation and it is employed in more and more instances year by year.

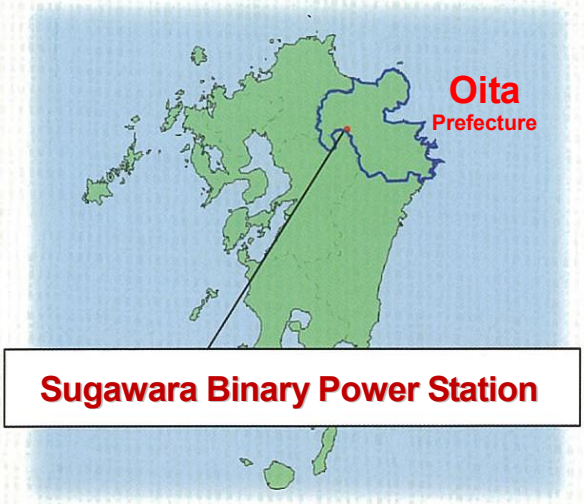


2. Outline of Sugawara Binary Power Station

Sugawara Binary Power Station is one of the geothermal binary power stations with the largest output in the country and it is the third in the country to employ a geothermal binary power generation method over the MW class (as of June 2015).

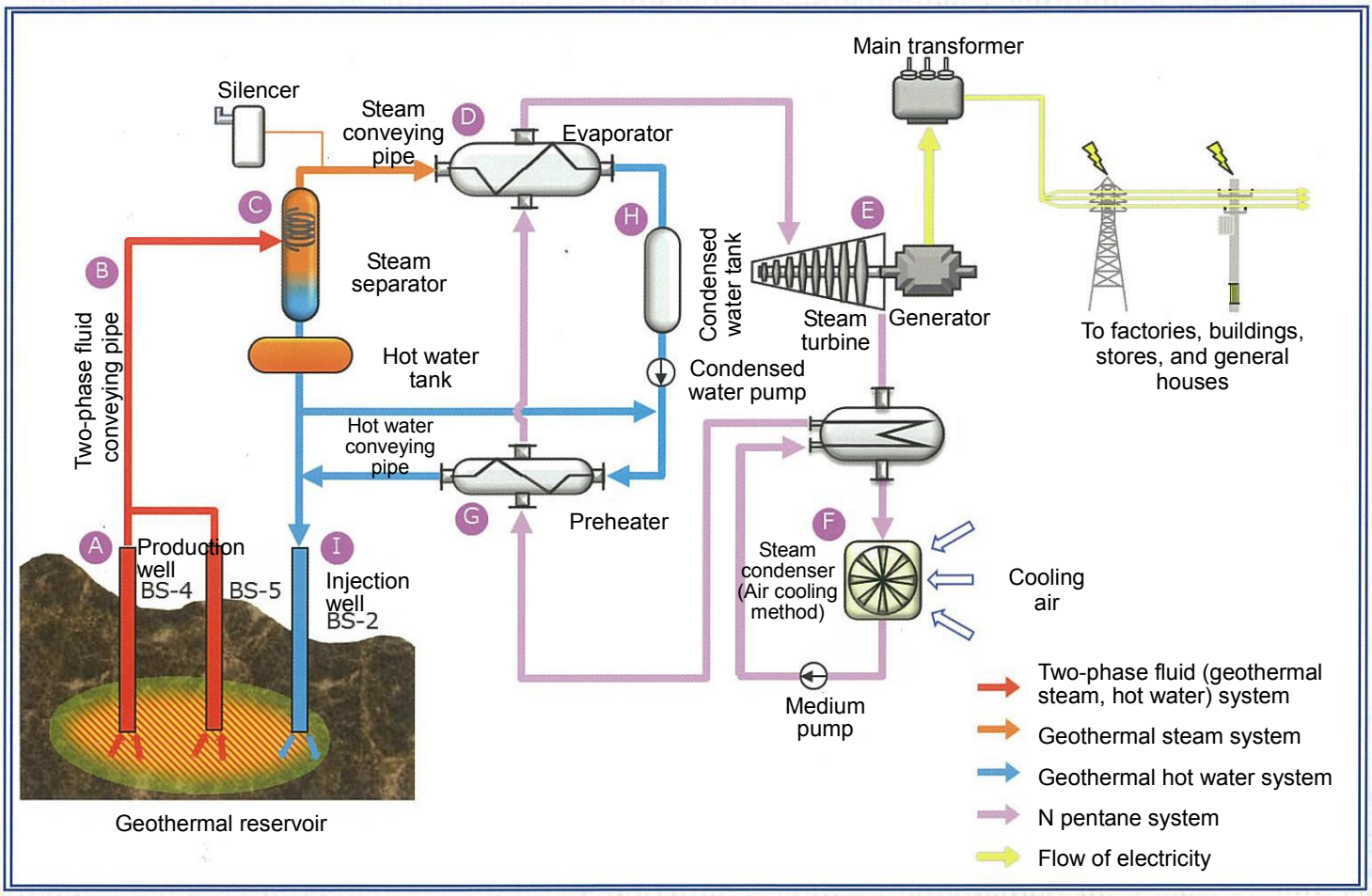
Among the geothermal binary power stations of the Kyushu Electric Power Company Group, it is the second facility, after Hatchobaru Binary Power Station, which is the first station in the country (Sugawara Binary Power Station is the sixth geothermal power station among the Kyushu Electric Power Company Group).

Also, it is the first geothermal power station operated by the cooperation of a local government and a private enterprise.



Outline of Sugawara Binary Power Station		
Address		554-13 Oaza Sugawara, Kokonoe-machi, Kusu-gun, Oita
Manufacturer of main machine		Mitsubishi Hitachi Power Systems (TURBODEN (Italy))
Rated output		Generation end 5,000 kW
Steam, hot water (outlet of steam separator)	Pressure/temperature	0.286MPaG/142.4℃
	Steam flow	40.1t/h
	Hot water flow	261.8t/h
Medium steam (inlet of turbine)	Pressure	0.953MPaG
	Temperature	137.5℃
	Flow	298t/h
	Working medium	N pentane (boiling point: 36°C)
Generator	Model	Horizontal cylindrical rotating field type synchronous generator
	Rotation speed	1,800min^{-1}
Steam separator	Type	Vertical cylinder cyclone separator
	Maximum working pressure/temperature	0.55MPaG/162℃
Steam condenser	Model	Mechanical-draft cooling method
	Number of fans	27 units (3 units x 9 rows)
	Inlet temperature of gas/inlet temperature of medium/outlet temperature	20℃/58.8℃/37℃
Heat exchangers	Evaporator	Horizontal straight tube method (1 unit)
	Preheater	Horizontal straight tube method (1 unit)
	Feed liquid heater	Horizontal U-shaped tube method (1 unit)
Production well	Temperature of steam, amount of steam, depth of excavation	BS-4 : 142℃、18.7t/h、811m BS-5 : 159℃、28.5t/h、870m
Injection well		BS-2 : 552m
Power generation facility main body installation area		Approx. 47 m x 74 m
Power line system		Approx. 20 km
Operation management of the power station	Method	As-needed monitoring method (remote monitoring is conducted in an on-site monitoring office)
Commercial operation started in		June 2015
Owner of the power station/owner of the geothermal well		Kyuden Mirai Energy Company, Incorporated / Local government of Kokonoe-machi

3. Structure of Sugawara Binary Power Generation



Sugawara Binary Power Station employs a “binary power generation” method which heats and evaporates a fluid whose boiling point is lower than that of water (medium: N pentane) with a geothermal fluid supplied from the production wells and rotates the turbine with medium steam. Also, a geothermal fluid serving as a heat source is supplied from a well owned by Kokonoe-machi, and N pentane is cooled and liquefied by the air cooling method.

A Production well

It is a well for extracting high-temperature steam and hot water from the geothermal reservoir located deep in the ground. Steam and hot water are sent to the steam separator via the two-phase fluid conveying pipe.

B Two-phase fluid conveying pipe

It is a pipe for sending to the steam separator steam and hot water extracted from the production wells in a mixed state (two-phase state).

Instead of conducting separation near the mine mouth, steam and hot water from the winzes are gathered and conveyed in the two-phase state. This improves the efficiency of fluid transportation.

C Steam separator

It is equipment for separating the two-phase fluid extracted from the production wells, which is a mixture of steam and hot water, into steam and hot water. After separation, steam is subjected to heat exchange in the evaporator while hot water is subjected to the same in the preheater, and then they are returned underground through the injection well.

D Evaporator

It is equipment for heating N pentane with geothermal steam to evaporate it. Evaporated N pentane is sent to the turbine to rotate the generator in order to generate electricity.

Meanwhile, geothermal steam turns back into liquid and is sent to the condensed water tank.

E Turbine, generator

High temperature and high pressure N pentane (gas) which has been sent from the evaporator rotates the turbine about 3,000 rotations per minute. The turbine rotates the generator, which is connected to the turbine, via a reducer to generate electricity. N pentane used in the turbine is sent to the steam condenser.

F Steam condenser (Air cooling method)

It is a facility to cool and liquefy N pentane (gas) used in the turbine with air from the outside. Liquefied N pentane is heated again with the preheater and evaporator, turns into a high temperature gas, and then, is sent to the turbine again.

G Preheater

It is equipment to preheat N pentane which has been cooled by the steam condenser with hot water and condensed water before it is sent through the evaporator. Meanwhile, hot water and condensed water which have been cooled by passing through the preheater are sent to the injection well.

H Condensed water tank

It is a tank for storing condensed water obtained by turning geothermal steam back into liquid by transferring heat with the evaporator. After that, the condensed water is sent to the preheater and used for preheating N pentane.

I Injection well

It is a well for returning condensed water which has been turned back into a liquid by exchanging heat with hot water extracted from the production wells and the evaporator to the underground. In principle, all high temperature steam and hot water extracted from the production wells is returned underground by using only their heat. The system is therefore environmentally friendly.

4. Background to Starting the Operation of Sugawara Binary Power Station

The period between the planning and the operation start was reduced because Sugawara Binary Power Station was of middle scale and did not require newly excavating a production well or the like, and the development was promoted by cooperation of the local government.

1. Ground surface investigation
2. Underground prospecting and evaluation

1988

New Energy and Industrial Technology Development Organization (NEDO) excavated three geothermal wells in Kokonoe-machi for demonstration experiment of geothermal study.

2003

NEDO transferred the wells to Kokonoe-machi free of charge.

2010

Kokonoe-machi conferred with Kyushu Electric Power Co., Inc. about geothermal development.
→ Effective utilization of the geothermal wells owned by the town was studied.

2012

End of May – December
Well discharge test started (about 3 months)
→ In addition, investigation on impacts on surrounding hot springs was carried out.

3. Discussion with the local community
4. Construction
5. Operation

2013

November 22
Kokonoe-machi, Kyushu Electric Power Co., Inc. and Nishinippon Environmental Energy Co., Inc. concluded the "Basic Agreement on Geothermal Power Generation Project in Sugawara Area" in the presence of the Governor of Oita Prefecture.

* Provided by Oita Prefecture

2014

March 27
The project was one of the first two cases to be adopted as a case in which geothermal resources development debt is guaranteed by the Japan Oil, Gas and Metals National Corporation (JOGMEC). (Sugawara, Kokonoe-machi, and Tsuchiya Hot Spring, Fukushima)
April 10
Groundbreaking ceremony was conducted
April 21
Nishinippon Environmental Energy started the construction
July 1
The construction was transferred in association with the establishment of Kyuden Mirai Energy

2015

April 1 (reception of power) – **June 29**
Test operation

June 29
Operation started

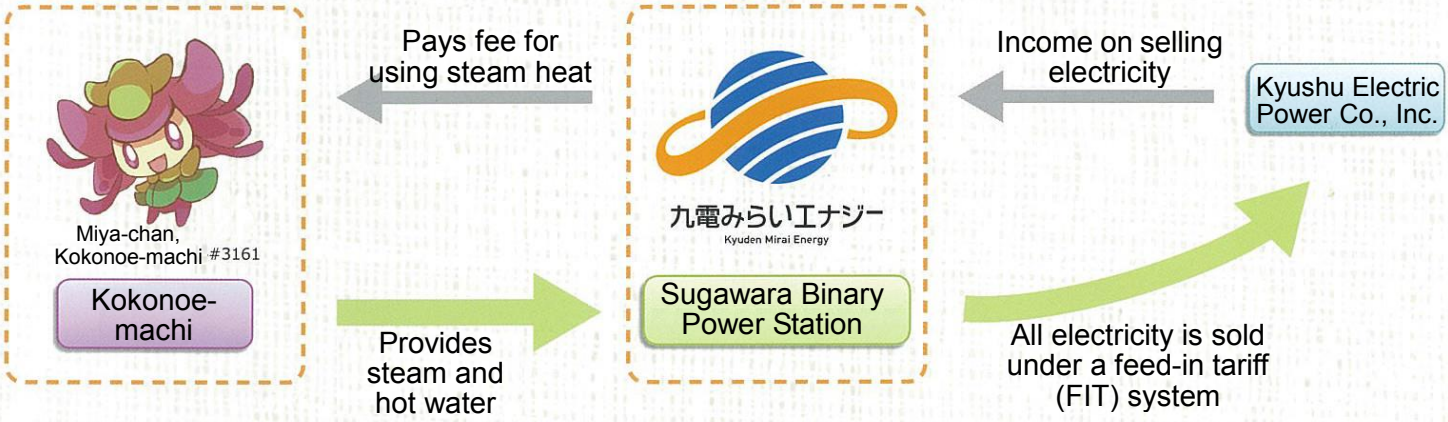
5. First Geothermal Power Generation Project in the Country Worked in Collaboration with a Local Government

The Sugawara Binary Power Generation Project is a geothermal power generation project on which we work together with Kokonoe-machi local government.

Kokonoe-machi provides us with steam and hot water from their geothermal wells and we generate electricity by using the geothermal binary power station established and operated by us.

We sell generated electricity to Kyushu Electric Power Co., Inc., and we pay heat usage fee to Kokonoe-machi with income obtained by selling electricity. Both we and Kokonoe-machi can make a steady income while simultaneously contributing to effective use of purely domestic energy and promotion of global warming prevention.

We also make efforts to coexist with the local communities by, for example, implementing a hot spring monitoring with the cooperation of Kokonoe-machi, giving explanations to the local communities, etc.



6. Corporate profile

Business lineup	Recyclable energy power generation service (geothermal, wind power, biomass, hydropower, solar power) Retail electricity service(*)
Business area	Inside and outside the country
Establishment	July 1, 2014
Capital	669.55 million yen
Representative	Yasuji Akiyama, President
Employees	120 (as of April 1, 2016)
Stockholder	Kyushu Electric Power Co., Inc. 100%
Affiliate company	Miyazaki Biomass Recycle Co., Inc., Nagashima Windhill Co., Inc., Kushima Windhill Co., Inc.

(*) Since April 2016, sales of electricity has been started in Kanto Area.

[Contact]

Kyuden Mirai Energy Company, Incorporated

3F Shogakukan Building, 2-4-8 Watanabe –dori, Chuo-ku, Fukuoka-shi, Fukuoka, 810-0004

[T E L] 092-738-4738 (9 am – 5 pm, excluding Saturdays, Sundays, and national holidays)

[U R L] http://www.q-miari.co.jp/

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