Sugawara Binary Power Station

Kyuden Mirai Energy Company, Incorporated

1 What is Geothermal Power Generation ?

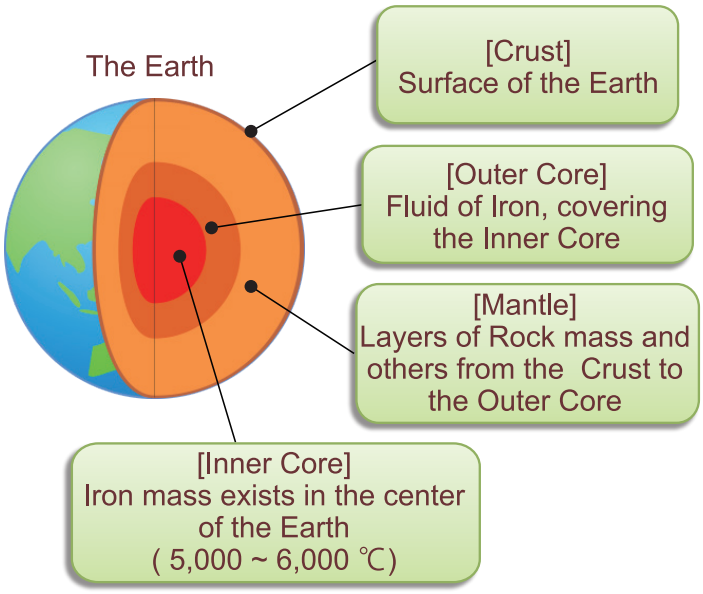
A Geothermal Power Generation is to generate electric power by driving the turbine with steam directly, that is taken out of the geothermal reservoir in the underground.

A thermal power station generates steam by burning coal or petroleum, while Geothermal Power Generation lets the Earth itself work as a kind of boiler. Temperature at the center part of the Earth is said to be more than 5,000 ℃.

Partially molten rock mass of Mantle by the heat becomes Magma of high temperature, and when they reach the ground surface an eruption occurs, then a volcano is formed.

Magma chamber of approximately 1,000 ℃ is produced underneath Volcano, and the chamber heats up the surrounding rocks and waters, often forming [geothermal reservoir].

Geothermal Power Generation utilizes geothermal fluids (steam and hot water) of this geothermal reservoir.



Features of Geothermal Power Generation

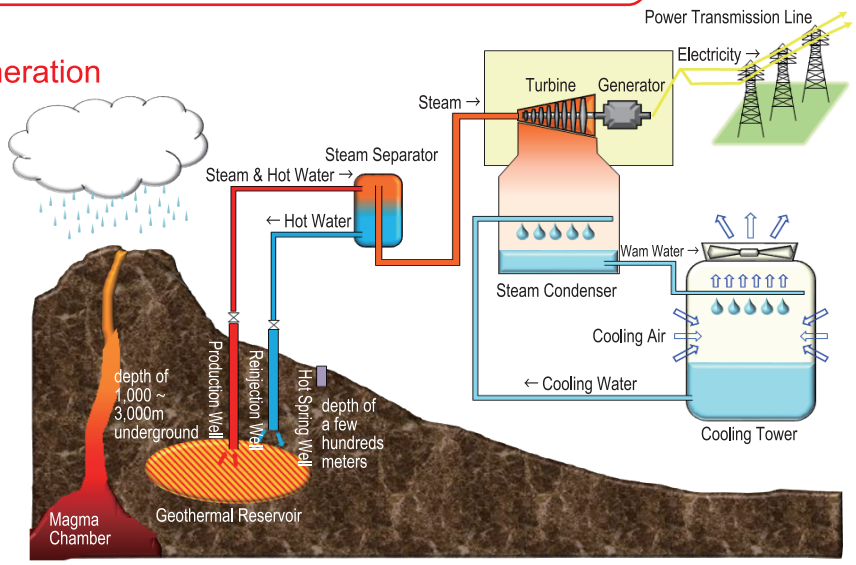
- ○**Renewable energy** that is semi-permanently used.
- ○**Clean energy,** because no fuel is burned and lesser emission of CO_2.
- ○**Pure nationally produced energy** because of utilizing geothermal resources which are sleeping underground.
- ○**Energy can be used, as a stable power source,** regardless of weather and days and nights.

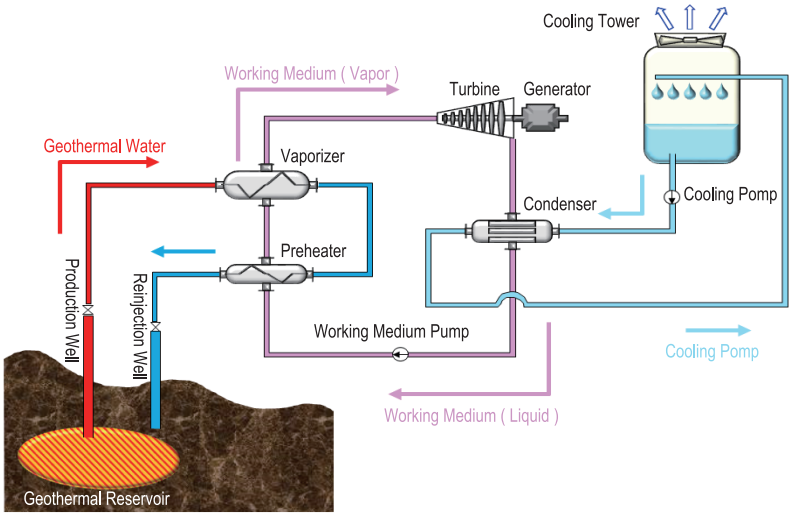
Mechanism of Geothermal Power Generation

Geothermal Power Generation produces electricity by driving the turbine with steam which is taken out of geothermal reservoir.

Drilling a well (production well) so called " Geothermal Well ", geothermal fluids are taken out of geothermal reservoir and are separated by the steam separator into steam and hot water.

Steam drives the turbine to generate electricity, and hot water is returned to deep formation of underground through reinjection well. The steam used to drive the turbine is cooled down through steam condenser and cooling tower.





Mechanism of Binary Power Generation

In the case of geothermal fluids being medium to low temperatures below 200 ℃, the separated steam is unable to drive the turbine efficiently.

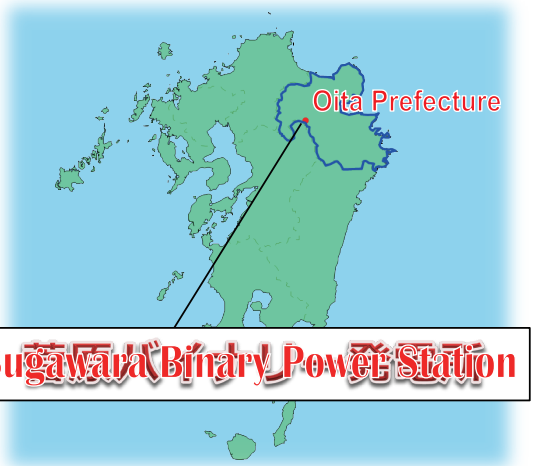
In such a case, another power generation method called Binary Power Generation would be used, which exchanges the heat of the geothermal fluids with that of another fluids (e.g. Normal Pentane, etc.) boiling at lower temperature than water and rotates turbines using steam coming out as a result.

This method greatly expands possibilities of Geothermal Power Generation, and has been increasing year by year.

2 Characteristics and Outline of Sugawara Binary Power Station

Three Characteristics of Sugawara Binary Power Station

1. Output capacity of 5,000 kW that is the largest scale in Japan, as the binary type geothermal power Generation.
2. Development of utilizing the existing geothermal wells. (no need of drilling a geothermal well)
3. Japan' s first geothermal power generation business that is based on collaboration with local government and private enterprise.



Location	Sugawara, Kokonoe Town, Kusu County, Oita Prefecture
Output	5,000kW (output at generator terminal)
Business Operators	Owner of the Geothermal Well : Kokonoe Town (2 Production wells, 2 Reinjection well) Owner of the Power Station : Kyuden Mirai Energy Company, Inc.
Type of Power Generation	Air-cooling Binary Power Generation
Amount of Power Generation (July,2015 to June,2016)	Approx. 40 millions kWh/year (equivalent to annual power consumption of approx. 11,000 households) [for reference] Estimated amount of power generation was approx. 30 millions kWh/year (15 years average) that is equivalent to annual power consumption of approx. 8,000 households.
Commercial Operation Date	June 29,2015

3 Development History of Sugawara Binary Power Station

The timeframe from the planning to the commencement of commercial operation was shortened, because there was no need of digging new wells and the development was conducted based on collaboration between the local government and private enterprises (see the above).

1988 New Energy and Industrial Technology Development Organization, Incorporated Administrative Agency (NEDO*1) conducted drilling of geothermal wells for verification and demonstration test in Kokonoe Town.

2003 NEDO made gratuitous transfer of the wells to Kokonoe Town.

2010 Kokonoe Town consulted Kyushu Electric Power Co., Inc. as to the development of geothermal, in studying efficient use of the geothermal wells the Town owns.

2012 Started well discharge test (for about three months), Carried out the environmental assesment for hot springs in the surrounding area.

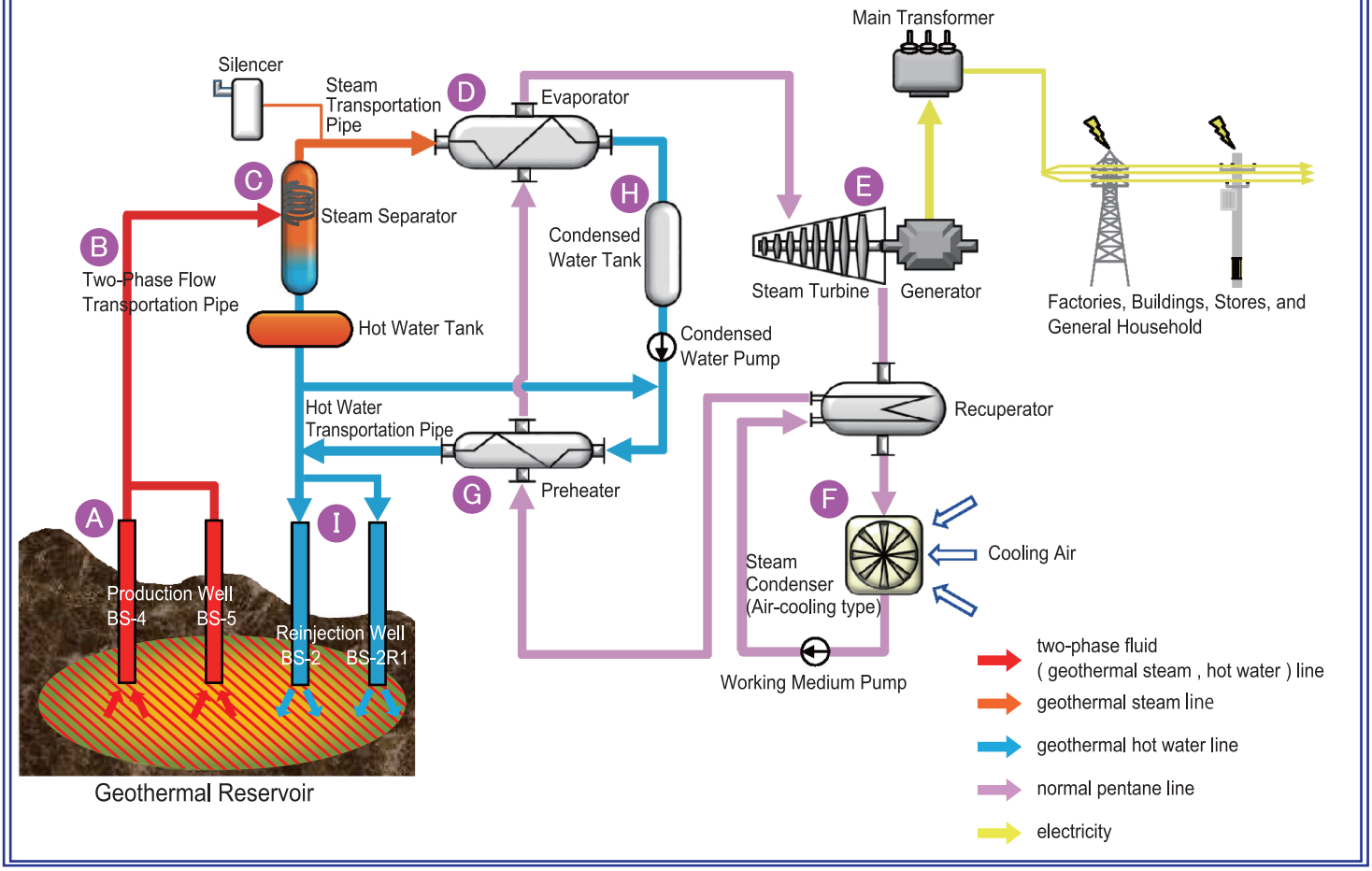
2013 "The Basic Agreement of Geothermal Power Generation Business in the District of Sugawara" was signed among Kokonoe Town, Kyushu Electric Power and Nishinippon Environmental Energy Co., Ltd., in attendance of the Governor of Oita Prefecture.

2014
- JOGMEC (Japan Oil, Gas and Metals National Corporation) adopted The Sugawara project as the first project of liabilities-guaranteed geothermal resource development. Two projects adopted (Sugawara, Kokonoe Town and Tsuchiyu Hot Spring in Fukushima Prefecture).
- Groundbreaking ceremony was done on April 10.
- Nishinippon Environmental Energy Co., Ltd. started construction on April 21.
- Kyuden Mirai Energy Company, Incorporated was established on July 1, and the construction of the project was transferred to the Company.

2015
- Trial Operation : April 1 (Power Receiving, back-feed) to June 29.
- Commercial Operation Date : June 29
- Completion Ceremony : August 5

*1: The name of the organization as of the year of 1988. Now, it is called New Energy and Industrial Technology Development Organization, National Research and Development Agency.

4 Mechanism of Sugawara Binary Power Station



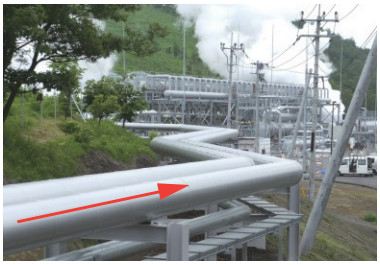
At Sugawara Binary Power Station, the liquid (working medium: normal pentane) of which boiling point is lower than that of water is heated and vaporized by geothermal fluid supplied from the production well, and its steam of working medium drives the turbine. This is the Binary cycle system.
And, geothermal fluid used as the heat source is supplied via the well owned by Kokonoe Town, while air-cooling system is adopted to cooling and liquefaction of normal pentane.

A Production Well

This well takes out high temperature steam and hot water from geothermal reservoir which is located at deep in the ground.

B Two-Phase Flow Transportation Pipe

The steam and hot water taken out at production well are sent to steam separator, while their mixture status (two-phase status) remains unchanged.
The steam is not separated near the well head, so that, each well head outputs the steam and hot water, and they are transported as the two-phase fluid as are, thus efficiency of the fluid transportation is achieved.



C Steam Separator

This facility divides two-phase fluid consisting of steam and hot water mixed taken out at production well into steam and hot water.
Steam after separation is sent to evaporator, and the remaining hot water is heat-exchanged with preheater, then hot water are returned to the underground by reinjection well.

D Evaporator

This facility is to heat up normal pentane with geothermal steam, and evaporates it. Vaporized normal pentane is sent to the turbine and it drives the generator, generating electlicity.
On the other hand, geothermal steam is back to fluid and goes to condensed water tank.

E Turbine・Generator

Normal pentane (gas) of high temperature and high pressure transported via evaporator drives the turbine at approx. 3,000 revolutions per minute. The turbine drives the generator by which connected to reduction gears, generating electricity.
The normal pentane used for turbine is sent to the steam condenser.

F Steam Condenser (Air- Cooling Type)

The normal pentane (gas) used for the turbine is cooled down and liquefied by air taken from outside at this facility.
The liquefied normal pentane is again heated by preheater and evaporator and changed to high temperature gas, and it is sent to the turbine, again.

G Preheater

With hot water and condensed water, this facility preheats the normal pentane which was cooled down at the steam condenser, before it is passed through the evaporator. On the other hand, the hot water and condensed water cooled down after passing through the preheater are sent to the reinjection well.

H Condensed Water Tank

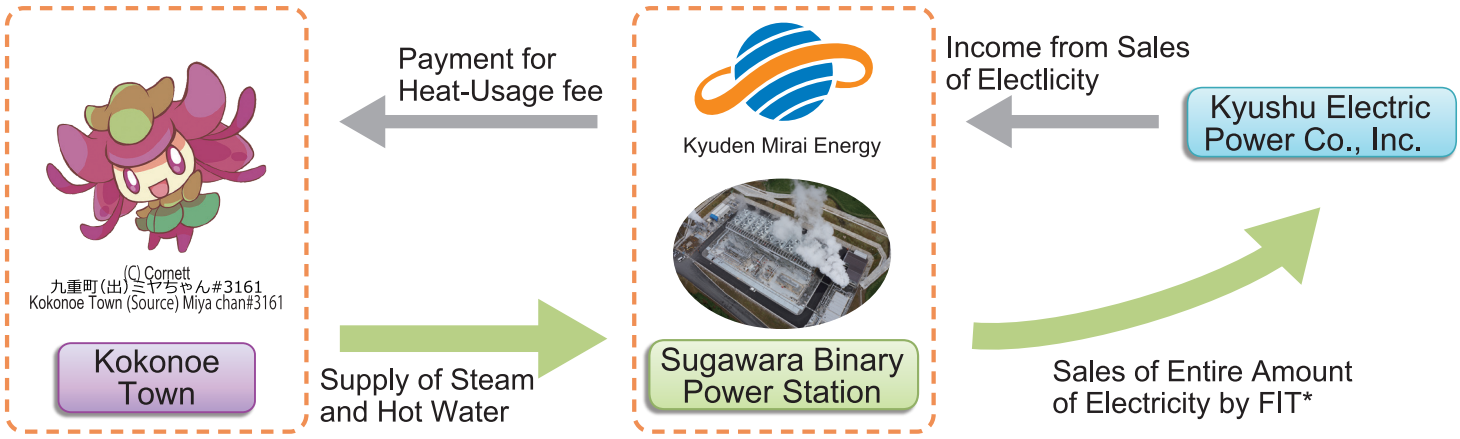
The tank preserves the condensed water that was changed back to the liquid from geothermal steam after its heat was removed by the evaporator. After this process, condensed water is sent to the preheater and preheats the normal pentane.

I Reinjection Well

This well reinjects hot water taken out of the production well and the condensed water which is changed to liquid after heat exchange process at the evaporator back into the underground. The entire amount of high temperature steam and hot water is returned to the underground, basically utilizing their heat only, therefore, this system can be called environmentally-friendly.

5 The first Geothermal Power Generation Business in Collaboration with Local Government in Japan

1. At Sugawara Binary Power Station, **we are doing geothermal power generation business in collaboration with the local government, Kokonoe Town.**
2. We receive steam and hot water from the geothermal wells owned by Kokonoe Town, and generate electricity through the binary power plant that we installed and operate.
3. The generated electricity is sold to Kyushu Electric Power Company, and we pay heat - usage fee to Kokonoe Town out of our income from the sales.
4. **While both our company and Kokonoe Town earn steady income, we will contribute to effective use of purely domestic energy resources and to prevention of global warming.**
5. Also, with the help of Kokonoe Town, we are proactively working on co - existing with local communities, by monitoring environmental impacts and explaining them to local residents and so on.



[Advantages of business collaboration between public and private sectors]

- Cooperation with local government helps form an agreement with local communities
- Locally - produced energy brings long-term and stable income to local communities
- Technologies and know-how accumulated in private sector enable stable power generation
- Local government' s initiatives promote its understanding of geothermal power, which helps utilize the power as a local resource and enhance people' s sense of preventing uncontrolled development

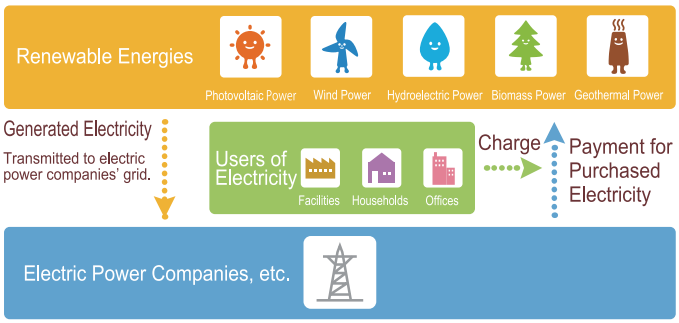
[Reference] About FIT (Feed-in Tariff)]

(Source: Homepage of Agency for Natural Resources and Energy in Ministry of Economy, Trade and Industry)

* "Feed-in tariff" is the scheme that government of Japan commits to the public, that electric power companies purchase electricity generated by renewable energies at fixed prices.

Based on this scheme, electric power companies' expenditures on purchasing the electricity are charged on users of electricity, which promotes to introduce renewable energies that are still being traded at high-costs.

Structure of Feed-in Tariff



reference

Outline of Sugawara Binary Power Station' s Facilities

Outline of Sugawara Binary Power Station		
Location		554-13 Ohaza Sugawara, Kokonoe Town, Kusu County, Oita Prefecture
Primary Manufacturers		Mitsubishi Hitachi Power Systems (TURBODEN S.p.A, Italy)
Output		5,000 kW (output at generator terminal)
Steam / Hot Water (Outlet of Steam Separator)	Pressure/Temperature	0.286 MPaG / 142.4 ℃
	Steam Flow	40.1 t/h
	Hot Water Flow	268.1 t/h
Working Medium Steam (Inlet of Turbine)	Pressure	0.953 MPaG
	Temperature	137.5 ℃
	Flow	298 t/h
	Working Medium Fluid	normal pentane (boiling point : 36 ℃)
Generator	Type	Horizontal, cylindrical revolving field type synchronous generator
	Speed of Revolution	1,800 min^{-1}
Steam Separator	Type	Vertical, cyclone type
	Maximum working pressure/temperature	0.55 MPaG / 162 ℃
Condenser	Type	Air-cooling System with Mechanical
	Number of Fan	27 units (3 units by 9 rows)
	Temperatures at Air Inlet, Inlet and Outlet of Working Medium	20 ℃ / 58.8 ℃ / 37 ℃
Heat Exchange Facilities	Evaporator	Horizontal Straight tube type (1 unit)
	Preheater	Horizontal Straight tube type (1 unit)
	Recuperator	Horizontal U – shaped tube type (1 unit)
Production Well	Steam Temperature, Steam Flow Rate, Depth of Excavation	BS-4 : 142 ℃, 18.7 t/h, 881 m BS-5 : 159 ℃, 28.5 t/h, 870 m
Reinjection Well		BS-2 : 552 m BS-2R1 : 589 m
Width of Area where Main Facilities for Power Generation is constructed		Approx. 47 m x 74 m
Power Transmission Line System		Approx. 20 km
Administration in Operation of Power Station	System	Controlled and supervised-at-any-time system (Remote controlled and supervised from the on-site office)

(Remarks) We are sorry but our facilities are not open to the public.

Introduction of Kokonoe Town, Oita Prefecture

Kyushu Azalea

Sujiyu Hot Spring

Specialties

(Source : Home Page of Kokonoe Town)

Kokonoe Town is located in the south-west area of Oita Prefecture, and the Town is surrounded by Kuju Range of Mountains of Aso-Kuju National Park in the east and south sides, also by the mountains of Yaba-Hita-Hikosan Quasi-National Park in the west side.There are many hot springs in the Town, in particular, Sujiyu hot spring is the largest one.

Also, there are Japan' s largest Geothermal Power Station which is " Hatchobaru Power Station ", and " Takigami Power Station " of which power generation sector is operated by Kyuden Mirai Energy Company, Incorporated. and steam supply sector is operated by Idemitsu Oita Geothermal Co., Ltd.

Hatchobaru Power Station

Takigami Power Station

Kyuden Mirai Energy Company, Incorporated

Updated Information of
Kyuden Mirai Energy is here !

KMG Building 8F, 3-2-23 Yakuin, Chuo-ku, Fukuoka
810-0022 JAPAN

TEL : +81-92-981-0981 (9:00am to 5:00pm, excluding Saturdays, Sundays & National Holidays)
Website : https://www.q-mirai.co.jp/top.htm

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