

# Geothermal Development Status in Japan



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*#Matsukawa: Japanese first geothermal power plant from 1966*

# Introduction (1)

*Profile of speaker:*

Geochemist for geothermal, EGS system

**Tracer test:** Hijiori EGS, Cooper-basin EGS,  
Nagano GHP

**Scale analysis:** Kakkonda geothermal field, Hijiori  
EGS, Hot spring binary system

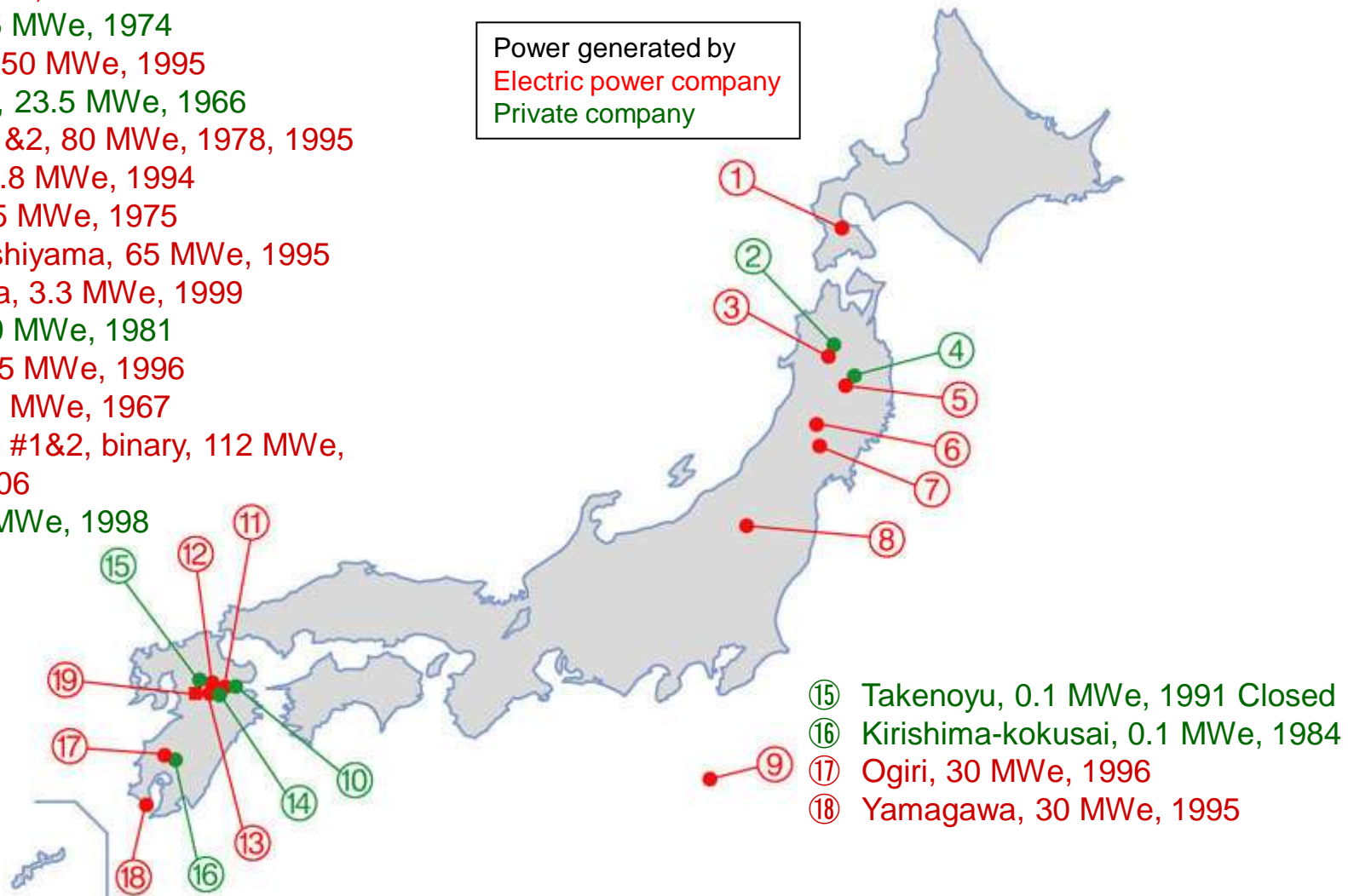
# Introduction (2)

- Japan has many geothermal energy potential and high technology of power plant, drilling etc.
- However, total capacity of geothermal power plant is only 0.2 % of national electricity generation and only 2.7% of the estimated potential.

# Geothermal power plants in Japan

- ① Mori, 50 MWe, 1982
- ② Onuma, 9.5 MWe, 1974
- ③ Sumikawa, 50 MWe, 1995
- ④ Matsukawa, 23.5 MWe, 1966
- ⑤ Kakkonda 1&2, 80 MWe, 1978, 1995
- ⑥ Uenotai, 28.8 MWe, 1994
- ⑦ Onikobe, 15 MWe, 1975
- ⑧ Yanaizu-Nishiyama, 65 MWe, 1995
- ⑨ Hachijo-jima, 3.3 MWe, 1999
- ⑩ Suginoi, 1.9 MWe, 1981
- ⑪ Takigami, 25 MWe, 1996
- ⑫ Otake, 12.5 MWe, 1967
- ⑬ Hatchobaru #1&2, binary, 112 MWe, 1977, 1990, 2006
- ⑭ Kuju, 0.99 MWe, 1998

Power generated by  
Electric power company  
Private company



- ⑮ Takenoyu, 0.1 MWe, 1991 Closed
- ⑯ Kirishima-kokusai, 0.1 MWe, 1984
- ⑰ Ogiri, 30 MWe, 1996
- ⑱ Yamagawa, 30 MWe, 1995

**Large potential (23GW), but small development (535MWe)**

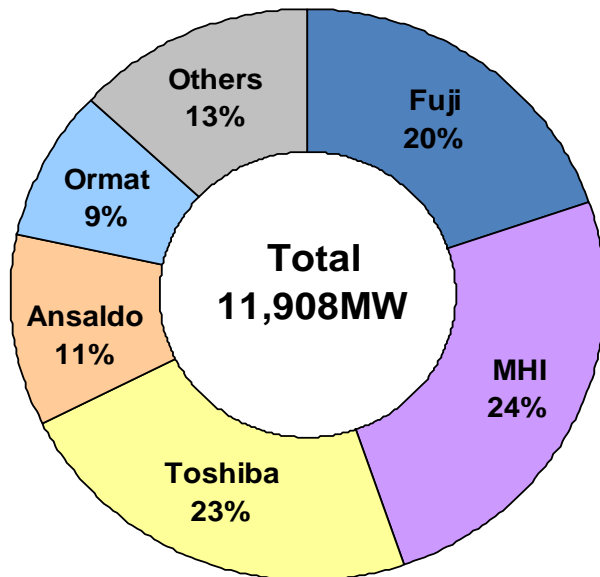
# High potential of geothermal technology of Japan (1)



日本初の地熱発電

## High share of geothermal turbine by Japanese company

About 70 % of world geothermal power is generated by geothermal turbine of Japanese company, Fuji electric (20%), Mitsubishi Heavy Industry (24%) and Toshiba (23%)



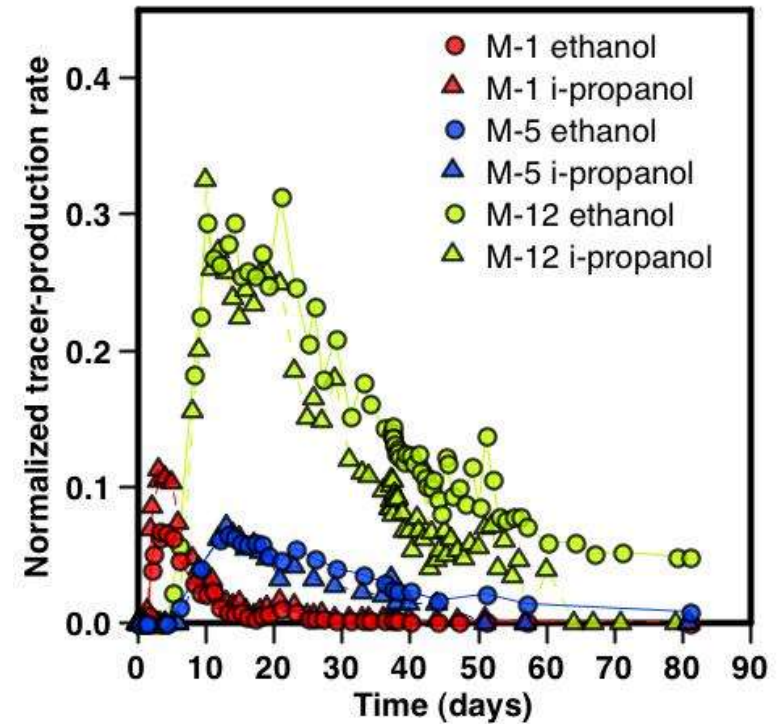
Geothermal Power Plant



Kawerau, New Zealand (140MW)  
Fuji Electric Company

# High potential of geothermal technology of Japan (2)

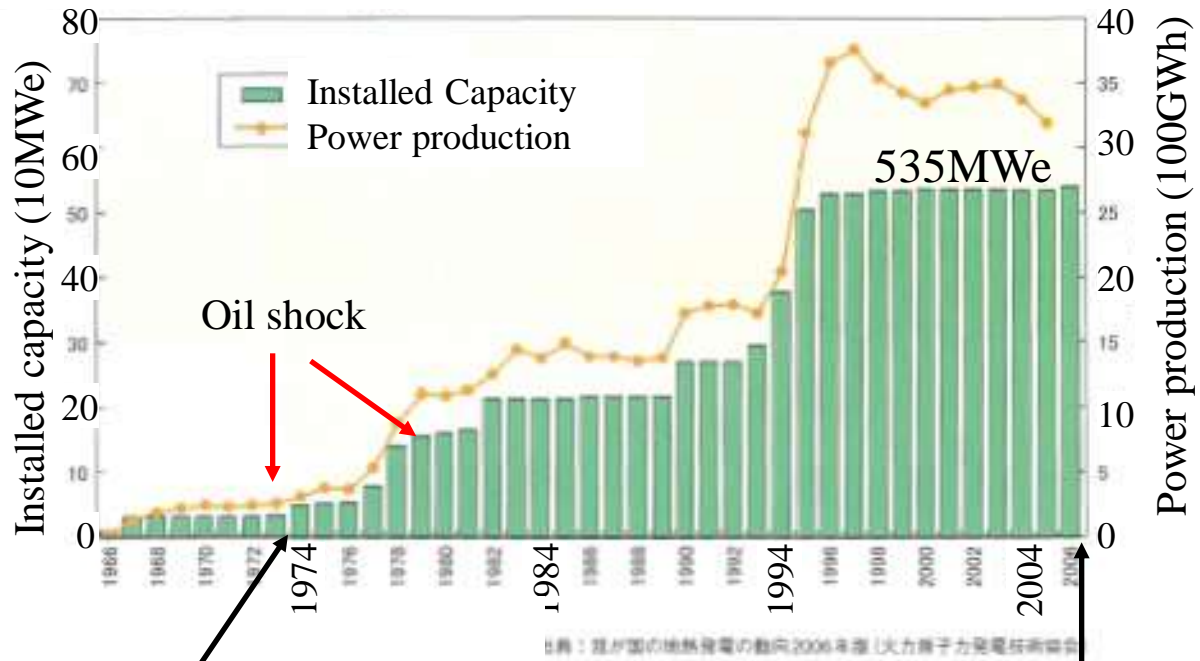
**Kakkanda WD-1a reached 500 degree at  
3,729 meter depth**



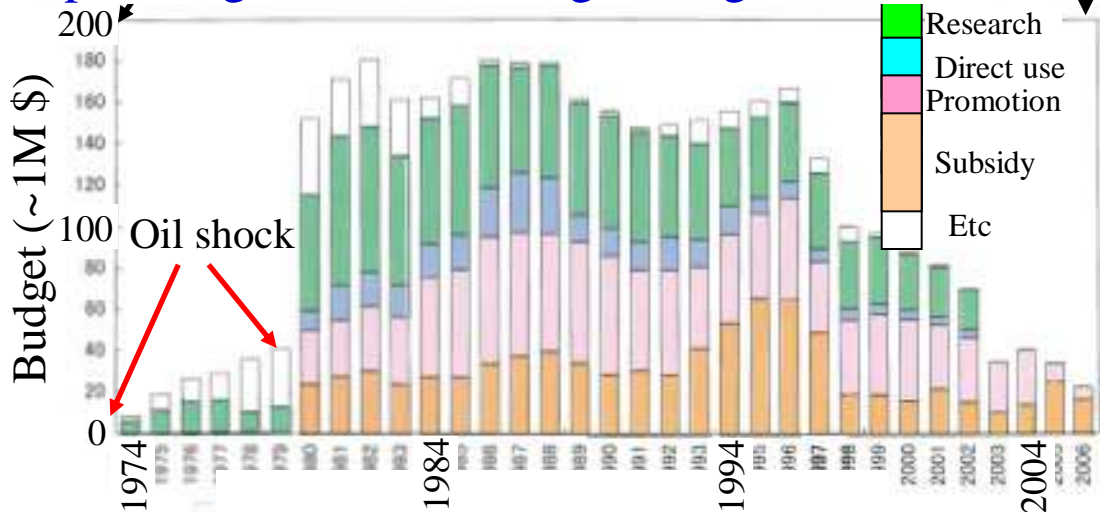
Two phase tracer test

(Fukuda et al.)

# Geothermal power plants and electricity production



## Japanese government budget for geothermal



# Problems for geothermal development in Japan

After accident of nuclear power plant by earthquake on this March, geothermal development will be very important. To progress geothermal, we have to solve several social problems,

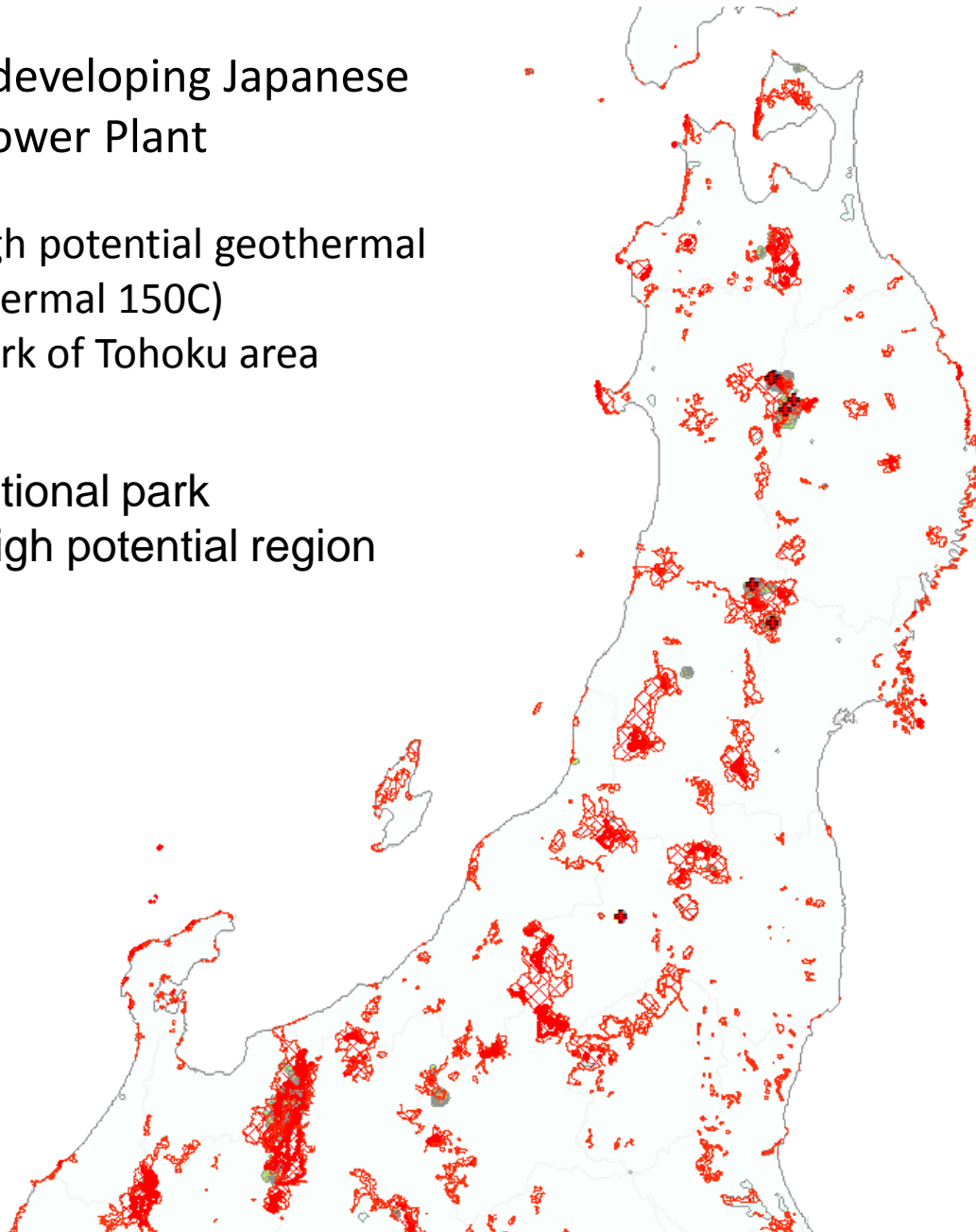
- 1) high potential region exists inside of nation park, over 80% of national potential
- 2) several hot spring owner resist to build geothermal power plants
- 3) long lead time (over 10 years) for geothermal power plant due to several lows and assessment
- 4) high cost due to long lead time and government did not support for initial development cost.

To solve these problems, we have to change laws and technical development and we need social support.

# Problems for developing Japanese geothermal Power Plant

Overlapping high potential geothermal region (hydrothermal 150C) and national park of Tohoku area

Red zone: National park  
Dark zone : high potential region

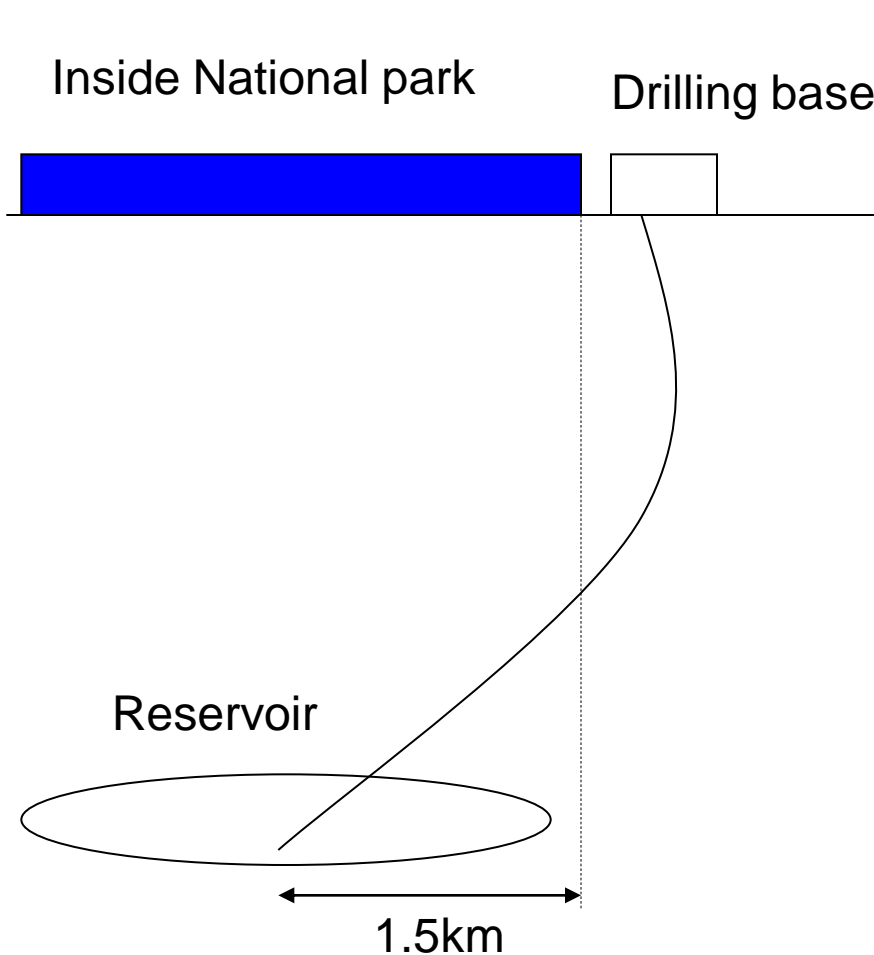


Geothermal power Potential in Japan  
23.4GW

Inside 19.7 GW  
Outside 3.7 GW

Economically  
(lower 25 cent/kW)  
2.2 GW  
(lower 12.5 cent/kW)  
1.1GW  
*(including existing  
0.53 GW plant)*

# Drilling to inside park



Drilling target: Reservoir at inside of national park

Drilling base : outside park

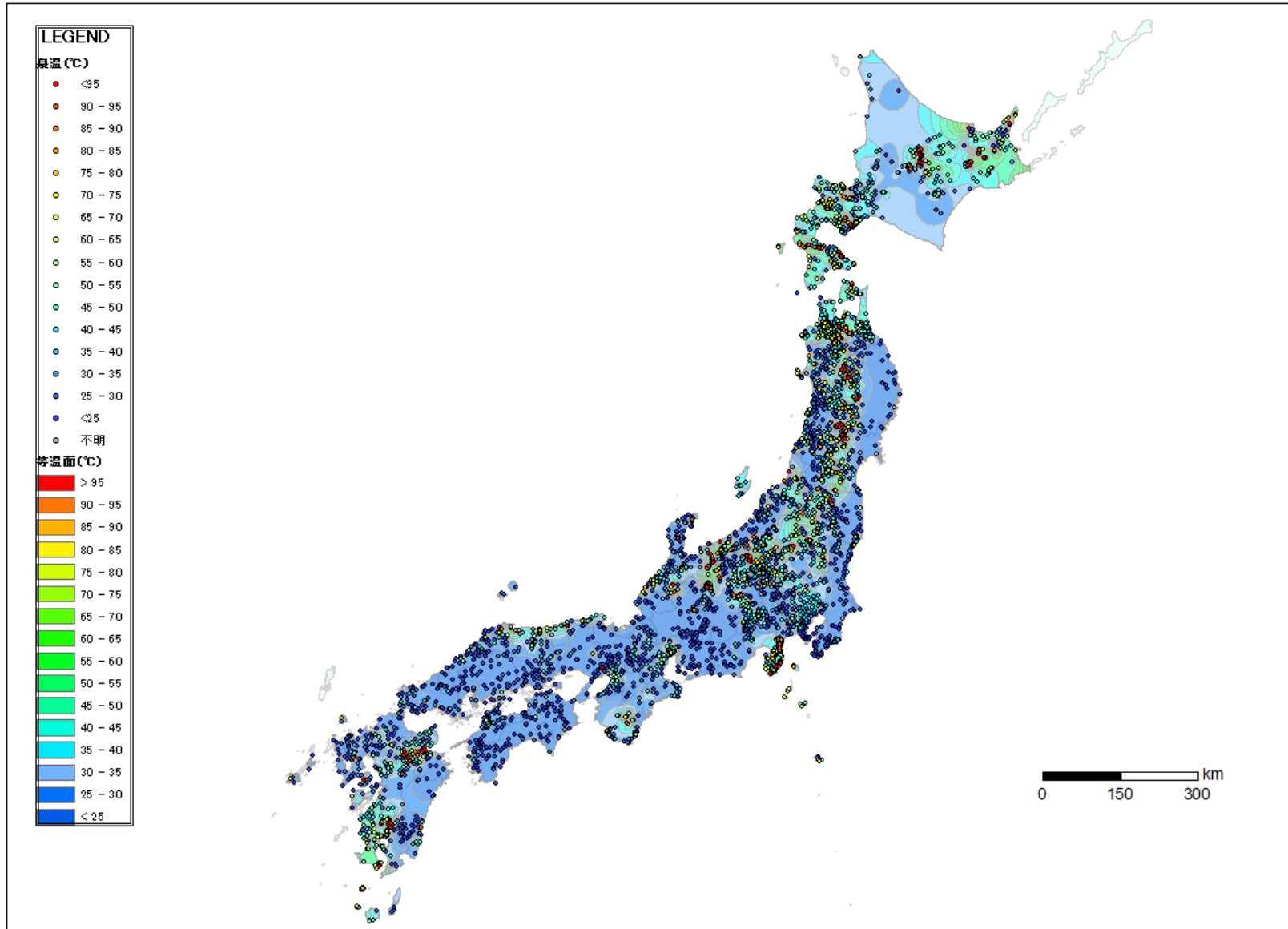
Geothermal potential increase  
(lower 25 cent/kW)

Only outside	2.2 GW
Inside 1.5km	6.3 GW
3km	10.2GW
Inside all	23.4GW

#need government support such as FIT

*Based on Study of Potential for the Introduction of Renewable Energy (FY 2010) by the Minister of the Environment*

# Many hot springs: Temperature of hot springs in Japan



# Hot spring

- There are about 28,000 hot springs in Japan
- Many Japanese like hot spring (Onsen)
- Several hot spring resorts resisted to R&D geothermal power plant
- Recently, CO<sub>2</sub> decreasing is serious problem and we have to R&D renewable energy
- In Japan, many high temperature (about 100 C) hot spring and this heat release to air
- We try to use this heat for power generation

# Concept of hot-spring power generation



Estimated Potential 723MW

Source of spa (70~120°C)

Heat of high temperature spa water was released to Air. We try to use this heat for power generation

Bathing (45-50 °C)



Spa *Spa water*

Ammonia-water

Local energy

Electric power



Turbine

Separator

Hotel Spa resort

Heated cooling water (24~27°C)

Condenser

Pump

*Cooling water*

Power generation instead of [Yumomi]

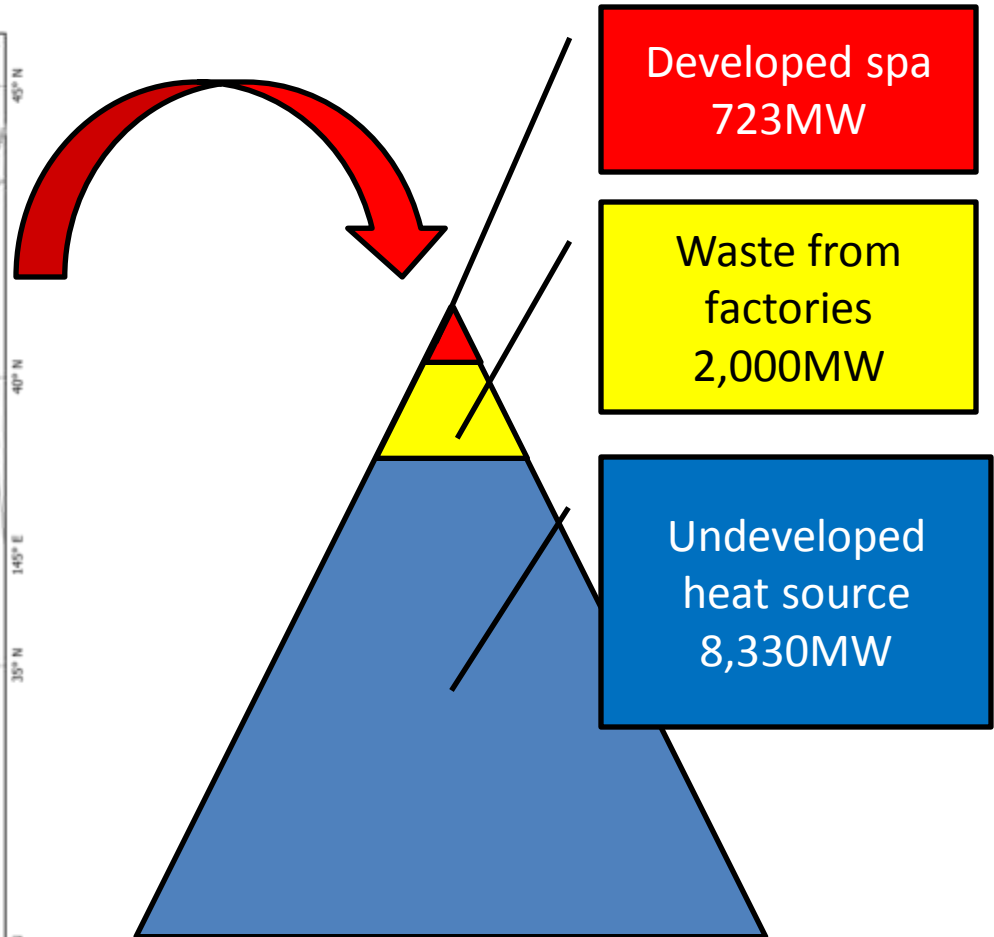
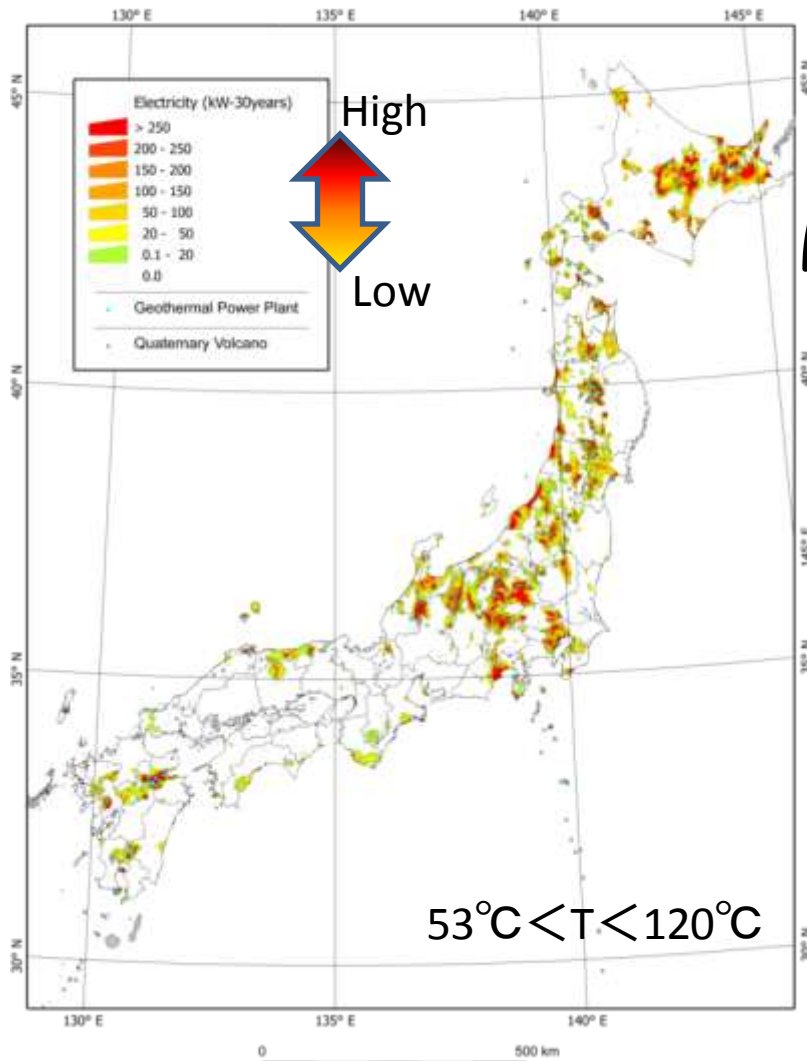


Kusatsu



# Power Generation potential using hot spa (Muraoka, 2008)

Electricity (kW-30years)  
[T<sub>ref</sub>=53°C, 53°C<=Reservoir Temperature<120°C]



# Market and Merit

- Market
  - Hot spring owner and user
  - High temperature wells ( Gas, Oil field etc)
  - Factories (For example, Kashima Steel company)
- Merit
  - Using waste hot spring water
  - Supply bathing water with power generation
  - CO2 decreasing
  - Local symbol
  - New guest to hot spring

# Problems

- System
  - Long term stability and safety
  - Connection to Electric Line
  - Scale and Corrosion of system
  - Automated generation
  - Cost down
- Laws
  - Change Laws (Electric, Boiler man, Environment etc)
  - Communication with hot spa region

Funded by Ministry of the Environment  
「Development of hot spa generation system」 (FY2010-2012)

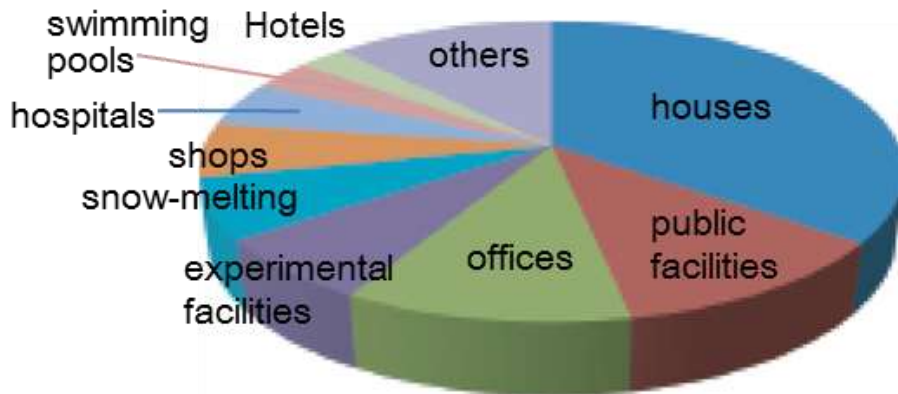
Matsuno-Yama, Niigata

- GERD, AIST, Hirosaki Univ.
- Using Takano-yu No.3 spring
  - ✓ Temp 97.2°C
  - ✓ Production 624L/min (Using now 260L/min)
  - ✓ Release to river 130L/min
  - ✓ Generator 50kW
- Field test
  - ✓ Power generation (Nov. of 2011 to 2012)
  - ✓ Monitoring of neighbor springs
  - ✓ Prevent Scaling
  - ✓ Potential estimation



# Geothermal Heat Pump (GHP)

- In Japan, GHP can be used for space heating and cooling in most parts of the country. It can also supply hot water to domestic systems, public spas and indoor swimming pools. Although GHP market is still small in Japan, they are applied to a variety of buildings, such as public facilities (museum, schools, etc.), offices, hotels and individual houses.



GHP utilization in Japan

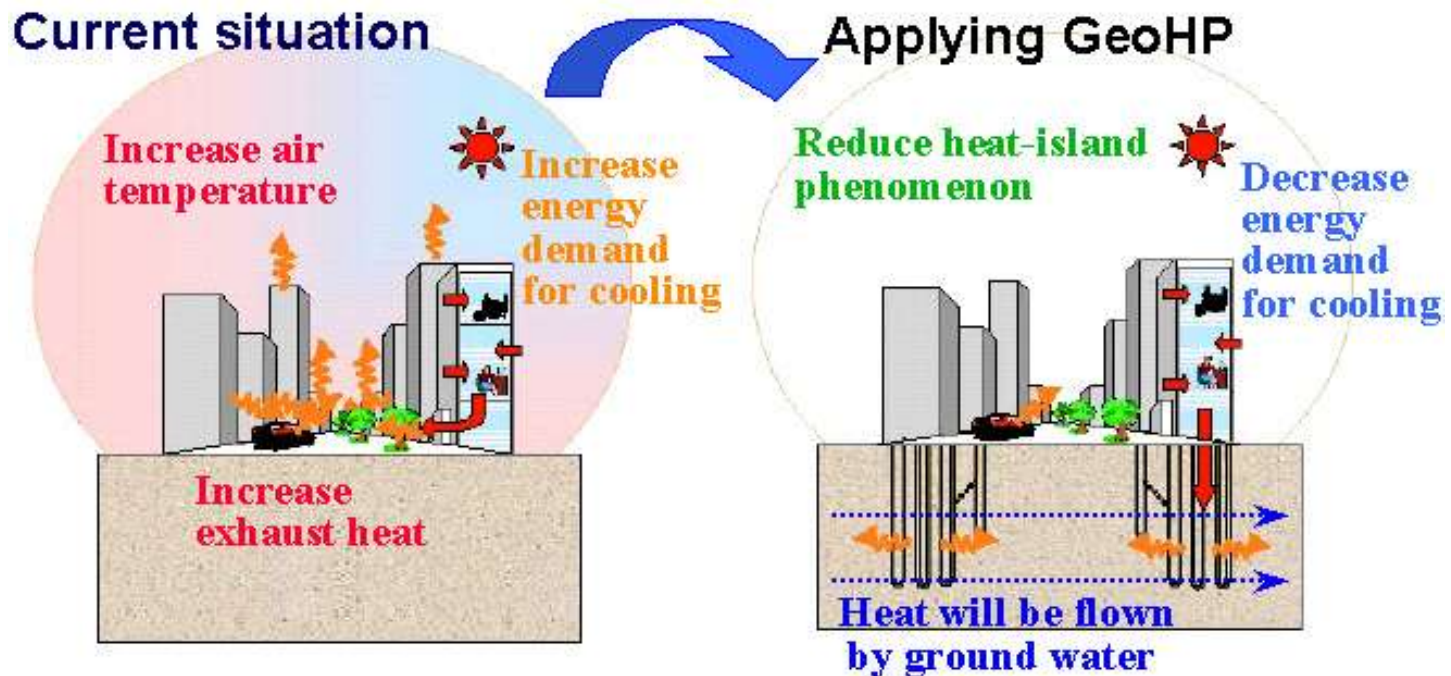
Total number: 275. The data is based on 2007 statistics.

(Geo Heat Promotion Association of Japan)

	Annual Energy GWh/yr	Installed power MWt	Installed Number
USA	13,200	12,000	1,000,000
Sweden	12,580	4,460	371,700
China	8,060	5,210	434,000
Norway	7,000	3,300	275,000
Netherlands	2,890	1,394	116,200
Germany	2,880	2,230	185,800
France	2,800	1,000	83,300
Canada	2,360	1,111	92,600
Switzerland	1,017	1,830	84,800
Japan	19	13	275

# Save energy using GHP at urban area

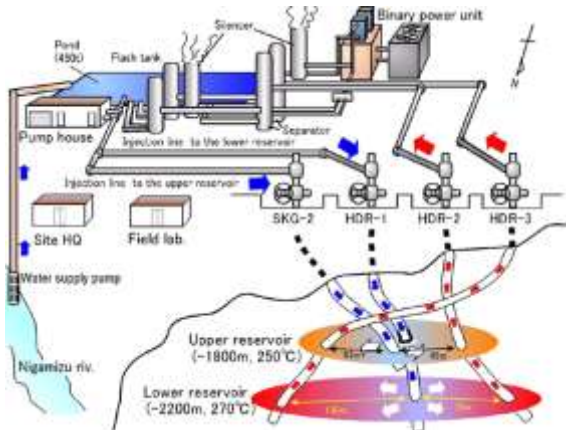
- If all conventional air conditioners in Tokyo area are changed to GHP system, about 5GW save energy at highest temperature time of summer.
- *(based on the simulation by Geothermal Research Society of Japan)*
- We have to promote GHP system



# EGS

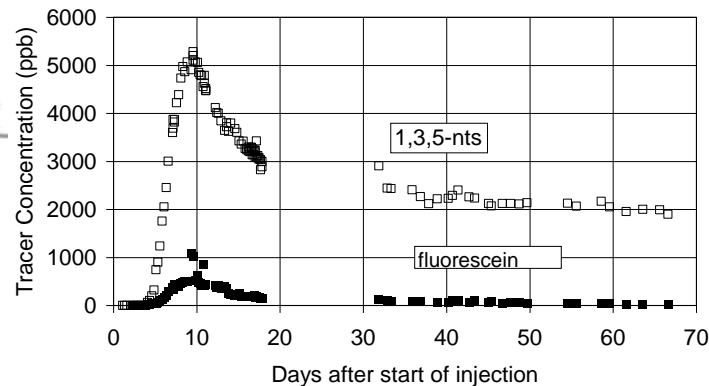
Until 2003, EGS projects were carried out at Hijiori and Ogachi in Japan. After that, several technology are used for other EGS project at several countries.

Hijiori site

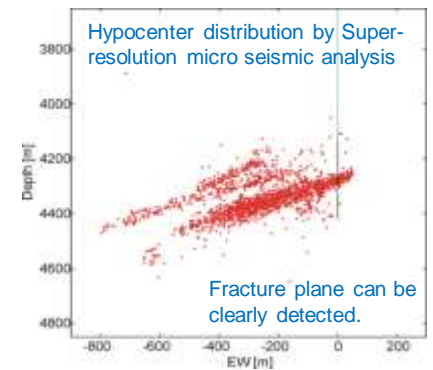


Technology used for cooper-basin

Tracer test

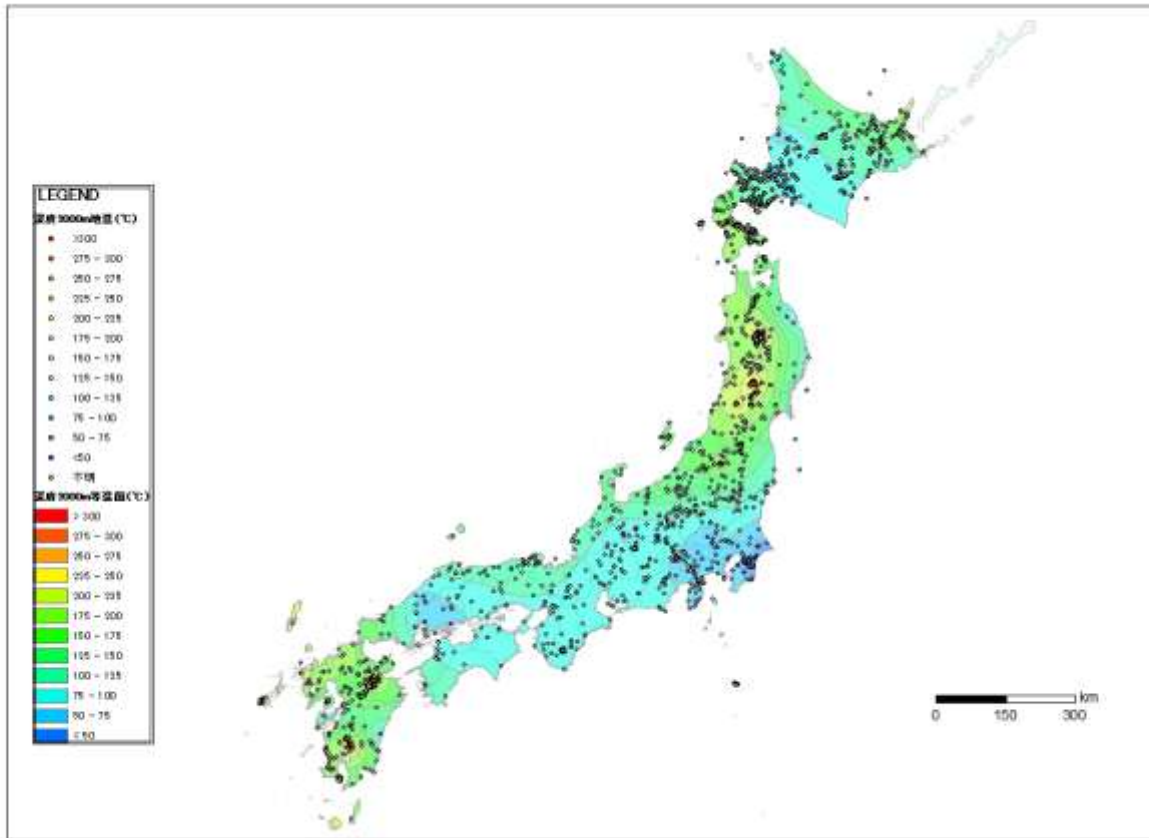


AE



# EGS potential

In Japan, deepest temperature profile is at 2km depth



If we can access to 5km depth, the potential reach about 50GW.

At several counties, 5km depth temperature profile exist.

We have to make 5km depth temperature profile and develop technology for EGS system.

# Summary

- Japan has many potential geothermal development in conventional plant, hot spring power generation, GHP and EGS.
- To promote geothermal system, we need understanding from citizen, support of government, more research and development and international corporation.

# Thank you for your attention.



Uenotai geothermal power plant near Ogachi.  
Next geothermal power plant will be built near Uenotai.