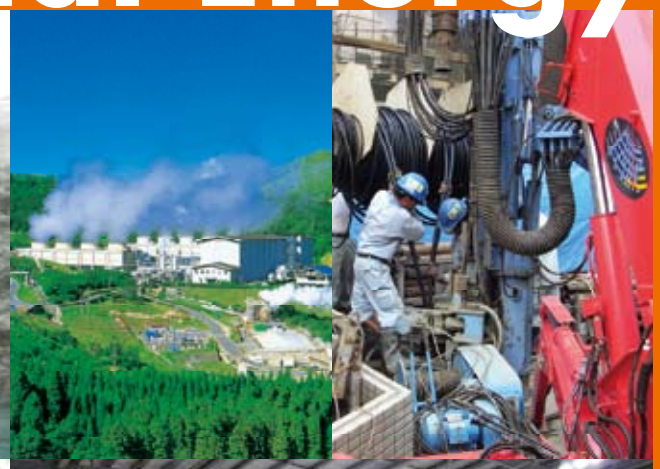
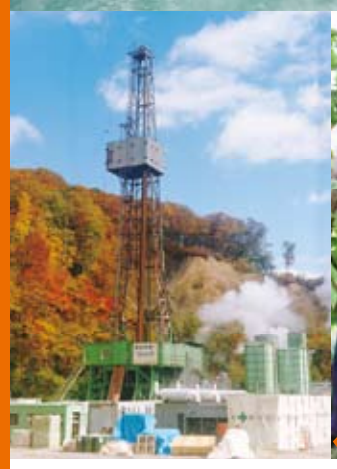
Geothermal Energy


Kusatsu, Japan (photo by M. Hamada)



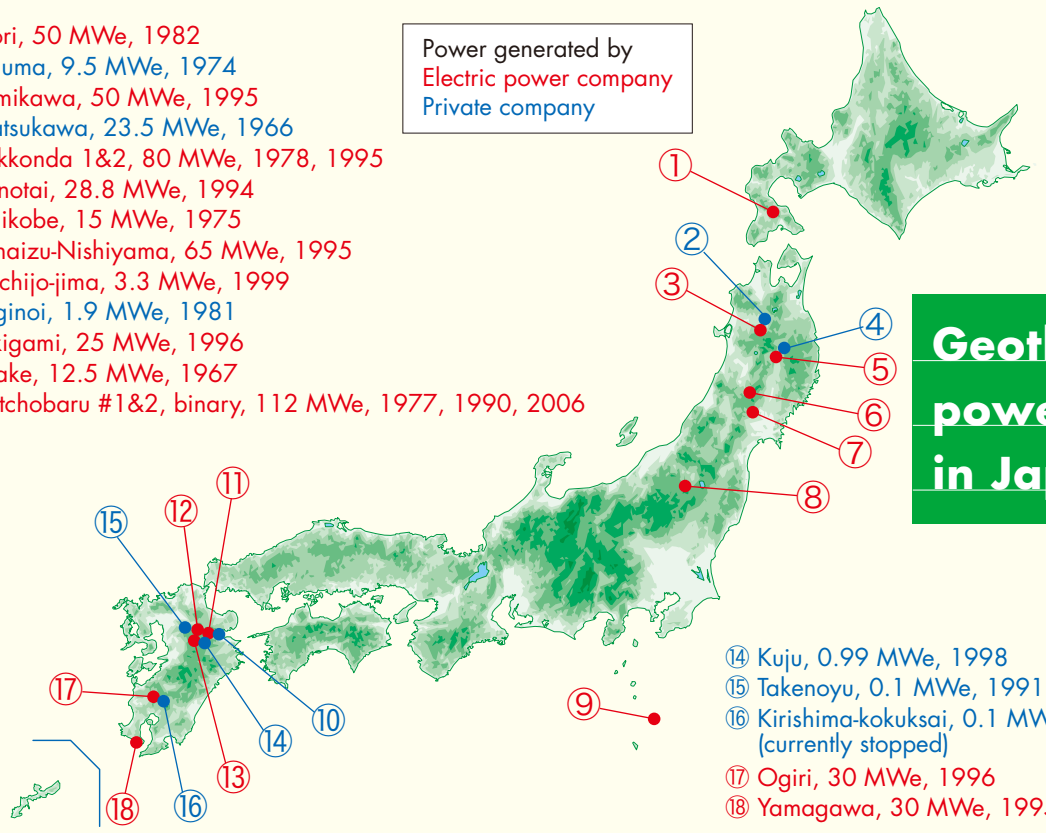


Japan

Resources and Technologies

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

Power generated by
Electric power company
Private company



Geothermal power plants in Japan

⑭ Kuju, 0.99 MWe, 1998
⑮ Takenoyu, 0.1 MWe, 1991 (closed)
⑯ Kirishima-kokuksai, 0.1 MWe, 1984 (currently stopped)
⑰ Ogiri, 30 MWe, 1996
⑱ Yamagawa, 30 MWe, 1995

POWER GENERATION

Hatchobaru geothermal power plant (Kyushu Electric Power Co., Inc.)

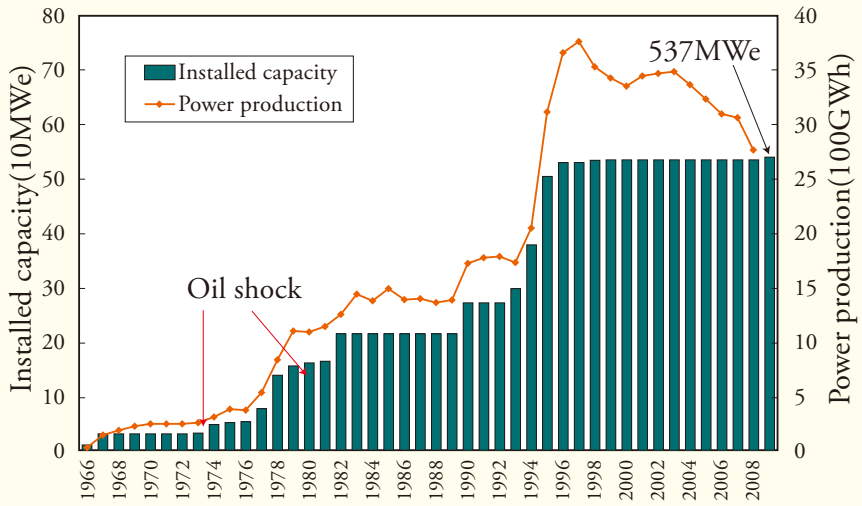
OUTLINE

Japan has about 120 active volcanoes. The estimated potential of geothermal power generation is 20,000 MWe or more from hydrothermal reservoirs to a depth of 3 km. Currently, twenty-one electric power units at eighteen geothermal sites, mainly located in northern Honshu and Kyushu Islands, are in operation with a total capacity of 537 MWe. This amounts to about **5.3 % of the world total capacity** of geothermal power plants.

HISTORY

The first experimental geothermal power generation in Japan was conducted by Dr. H. Tachikawa in 1925 (capacity: 1.12 kWe). The first and second geothermal power plants in Japan began their operation in 1966 and 1967 at Matsukawa and Otake, respectively. After the first oil shock in 1973, the Ministry of International Trade and Industry (presently the Ministry of Economy, Trade and Industry) initiated the Sunshine Project to promote "new energy", including geothermal R&D. Four more power plants in '70s, three plants in '80s, and six plants + two units opened in '90s. In 2000, World Geothermal Congress was held in Oita and Iwate, Japan. Development had been very slow since then, but surveys for new power plants were restarted recently.

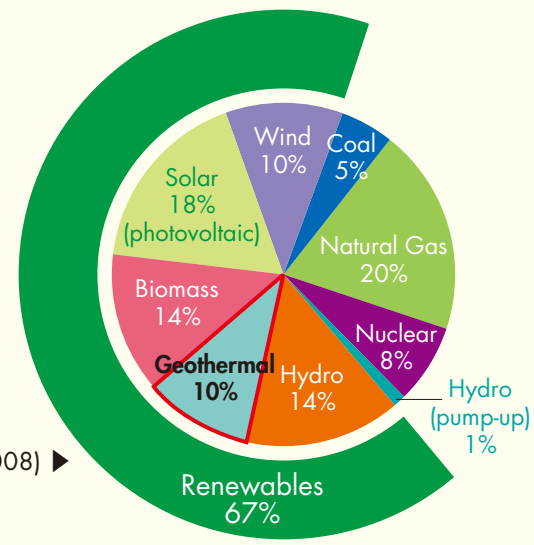
Dr. Heiji Tachikawa



▲Capacity and power production of geothermal power plants in Japan (1967-2009)

TASKS IN PROMOTING DEVELOPMENTS

As an environment-friendly energy system, geothermal power generation should be promoted. One of the obstacles against geothermal development in Japan is the fact that most of the promising fields are located near or inside national parks or spa resorts. In geothermal development, careful steps must be taken to preserve the scenic beauty and hot spring resources for the local residents. Another obstacle is its high development costs. The industry, the academia and the government need to make more efforts to reduce the costs by improving technology and changing related regulations for bigger and wider utilization of geothermal energy.



Power supply in Japan, 2050 prospect (ISEP, 2008) ▶

Beppu, Japan (photo by M. Hamada)

POTENTIAL OF POWER GENERATION USING HOT SPRINGS

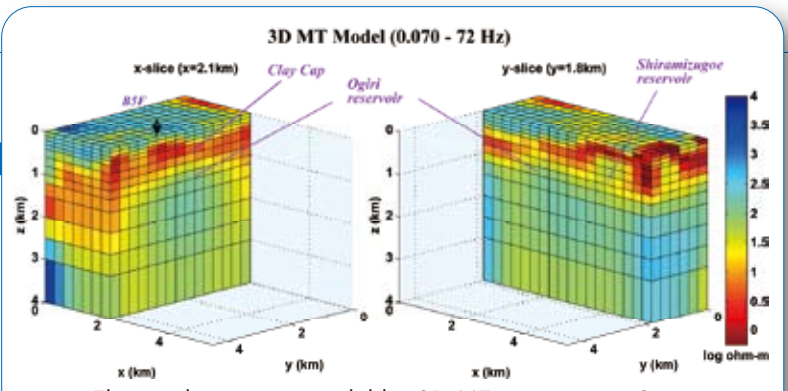
High temperature hot spring water (about 80-120℃) can be utilized for power generation by applying the Kalina cycle system. Japan has about 28,000 hot springs that are naturally discharging or artificially drilled. An estimation suggests that, using 1,500 hotter wells and springs among them, as much as 723 MWe could be generated without additional drillings.

GEOTHERMAL TECHNOLOGIES IN JAPAN

Japan has the most advanced technologies on geothermal exploration, development, utilization, and monitoring, which are used not only domestically but in international co-operations. Followings are examples of these technologies.

Exploration

Geology: remote sensing, alteration dating, etc.
Geochemistry: fluid inclusion, isotope analysis, etc.
Geophysics: 3D magnetotelluric (MT) method, high temperature well logging, seismic and VSP methods, etc.



Electrical resistivity model by 3D MT inversion at Ogiri geothermal field, southwestern Japan (Uchida et al.)

Drilling rig at Kakkonda, which recorded the world highest temperature of 500˚C (Geo-E)

Development

Drilling: directional drilling in very high temperature reservoir. **The world's highest drilling temperature (over 500˚C)** was recorded in 1995 at a depth of 3700m at Kakkonda field, Japan.
HDR/EGS: At Hijiori and Ogachi fields in north-eastern Japan, research of HDR/EGS system was carried out with circulation and tracer test, micro-earthquake monitoring, binary power generation test, etc. The results are applied in overseas projects.

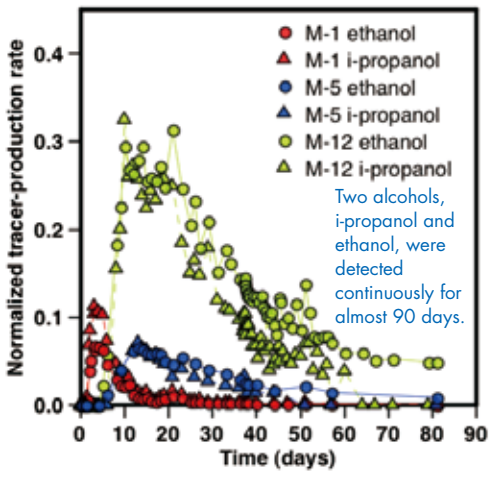
Turbine at Kawerau, NZ (Fuji Electric)

Utilization

Power plants (turbines): Japanese turbines have been used worldwide with **a share of 75%** of capacity for conventional steam power plants and in the recent 10 years 67% for all geothermal power plants including binary systems.
Scale prevention: scale inhibitor (polyacrylate), etc.

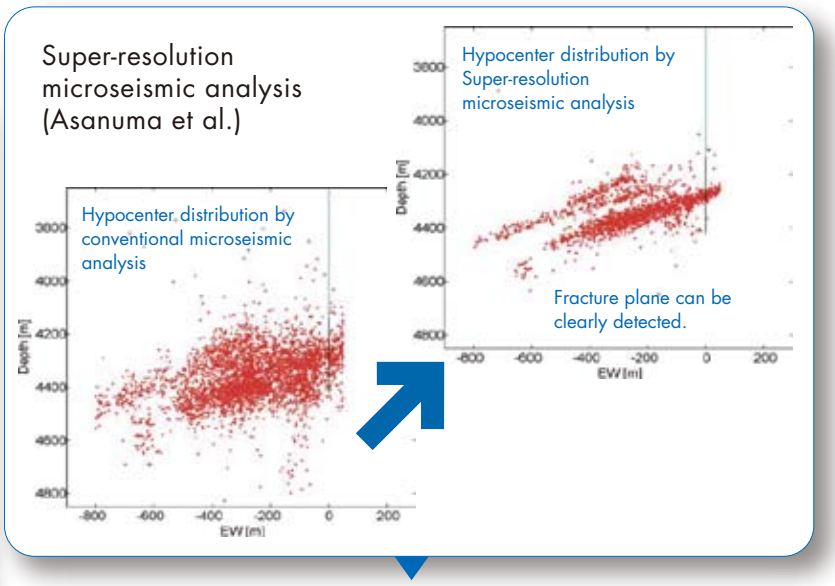
Monitoring

Geochemistry: chemical monitoring of produced fluid, two-phase tracer test, etc.



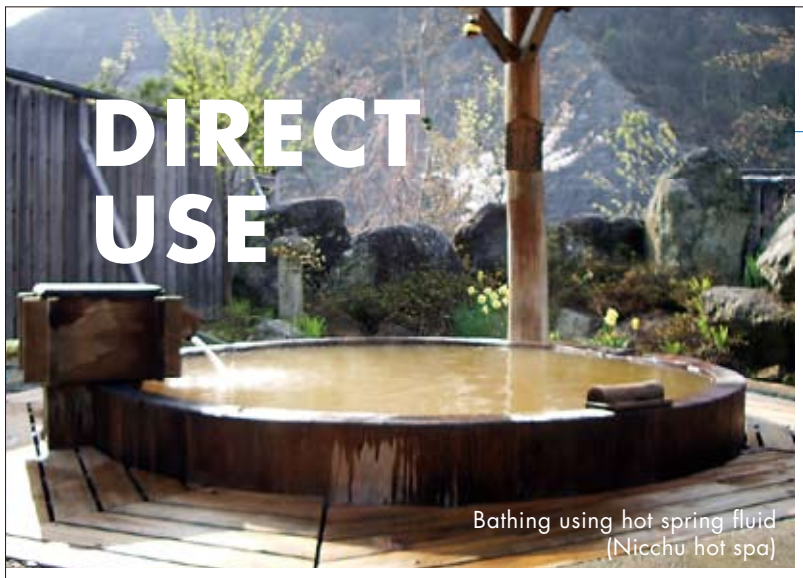
World's first two-phase tracer test: normalized tracer-return curves from the tracer test at Matsukawa in 2000 (Fukuda et al.)

Super-resolution microseismic analysis (Asanuma et al.)



Geophysics: super-resolution microseismic analysis, micro gravity, self potential, reservoir simulation with geophysical post-processors, etc.

DIRECT USE



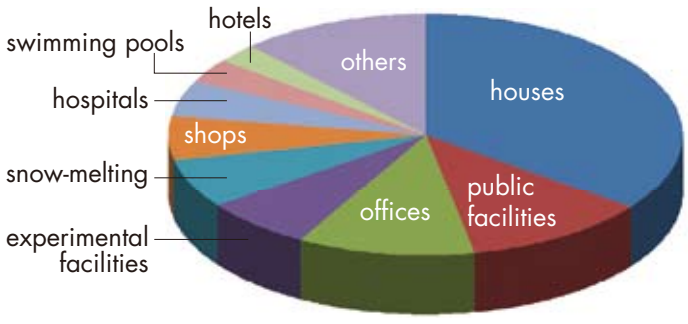
Bathing using hot spring fluid (Nicchu hot spa)

Conventional direct use

In Japan, larger part of direct use of geothermal energy has been for bathing, and the rest for many other purposes including space heating, agriculture, snow melting, etc. At 2005, the total capacity of direct use was about 400 MWt and its used energy was 41.5 PJ.

GEOCOLOR (Hachimantai Geothermal Dyeing Inc.)

Geothermal Heat Pump (GHP)



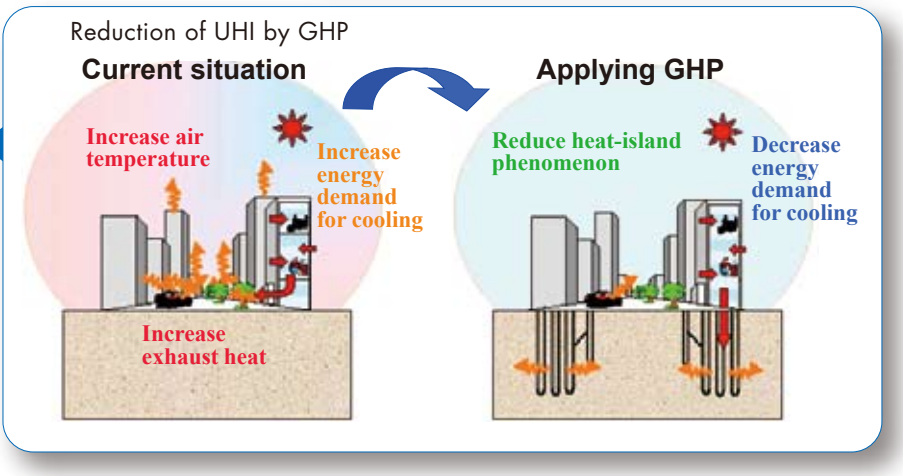
GHP utilization in Japan: the number of installation, 275 in total, based on 2007 statistics. (Geo-Heat Promotion Association of Japan)

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. Snow melting systems with GHP are used in northern districts. 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.

A GHP system with borehole heat exchangers is common in Japan. Recently, **utilization of building foundation piles** as underground heat exchangers has been increasing for newly constructed buildings. **Retrofit to old buildings** is another challenge for promotion of GHP.

Retrofit of GHP system to an office building in central Tokyo: inserting U-tube (Sasada Building)

GHP does not emit any heat to outside atmosphere unlike conventional air-conditioners, thus it is quite effective for **reducing urban heat island (UHI) phenomenon** that is a serious problem especially in mega cities like Tokyo. An on-going national project evaluates the effectiveness of GHP for the mitigation of UHI. Adoption of GHP is a good practice for mega cities in other countries with a similar problem.



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