

**Case Studies in Hot Spring Use
for
Sustainable Energy**

March 2019

**Oita Prefectural Government
Oita Prefecture Energy Industry Organization**

Greetings

The International ONSEN summit was convened based on the expectation that getting people from around the world to begin using ONSEN and understand its charm will lead to further development of the world's ONSEN areas. Leaders from ONSEN areas in 17 regions and 16 countries around the world were welcomed to the summit. There, they were joined with more than 1,000 representatives of municipalities that are home to ONSEN in Japan along with other related organizations, making for a very fruitful international conference.

Based on a theme of the "Possibility of Regional Development by Worldwide ONSEN Locations: Diverse Ways to Utilize Local Resources Connected with ONSEN," the summit was divided into three areas: Tourism, Medical · Health · Beauty, and Energy. In addition to sharing examples of regional best practices in utilizing ONSEN culture and ONSEN resources, there was also a lively discussion on new possibilities for ONSEN. The result of these discussions has been summarized in the Summit Declaration.

The Energy Subcommittee centered on the coordinators sharing various opinions on the theme of "utilization of hot springs as a sustainable energy source". As a result of those discussions, the International ONSEN Summit Declaration was adopted. Regarding the utilization of hot-spring energy, it states:

Hot springs are expected to be further utilized as an energy source. With the approaching era of energy diversification, we will promote energy use in various fields including power generation, district heating/cooling, and heat utilization combined with the agriculture and fishery industries, while harmonizing with the protection of hot spring resources and the natural environment.

Accordingly, Oita prefecture decided to publish and disseminate a collection of case studies to introduce and explain examples from Japan and relevant worldwide areas in relation to ONSEN resources. To help realize the agreed upon declaration and to make the information shared at the summit more widely available, both a written publication and a website are being used. We sincerely hope that by utilizing this information through a wide variety of venues the use of hot springs as a sustainable energy source will be advanced.

March 2019

Katsusada Hirose
Governor of Oita Prefecture

Table of Contents

1. Oita Prefecture  International ONSEN Summit	1
1.1 Outline	1
1.2 Case study speeches	4
1.3 Working groups	5
1.4 Summit declaration	7
2. Hot Spring (Geothermal) Heat Energy Utilization	9
2.1 Use as hot springs	9
2.1.1 Distribution of world hot springs	9
2.1.2 Use of hot springs in the world	10
(1) Germany	11
(2) Hungary	11
(3) Iceland	11
2.1.3 Distribution of hot springs in Japan	11
2.1.4 Definition and types of hot springs in Japan	13
2.2 Direct utilization of hot spring (geothermal) heat	15
2.2.1 Heat utilization of hot springs	16
2.2.2 Heat utilization of hot springs by temperature	17
2.2.3 Direct utilization of geothermal heat in Japan and in the world	18
2.3 Use as geothermal power generation	20
2.3.1 Distribution of geothermal resources	20
2.3.2 What is geothermal power generation	23
2.3.3 Geothermal power generation systems	25
(1) Flash steam systems	25
(2) Binary cycle systems	26
2.3.4 History of geothermal power generation	27
2.3.5 The amount of available geothermal heat and potential for introduction by region	28
2.3.6 Geothermal power generation by institution	32
3. Cases in Japan	34
3.1 Use of hot springs	34
(1) History of hot springs	34
(2) History and features of hot springs in Oita prefecture	34
3.2 Examples of hot water utilization	35
3.2.1 Examples of greenhouse cultivation use	35
3.2.2 Examples of onshore aquaculture use	37
3.2.3 Examples of other uses	39
3.3 Power plant utilizing hot springs	40
3.3.1 Small-scale binary power plants	40
3.3.2 Hot-spring power plants	43
(1) Types and characteristics of hot spring power generation	43
(2) Current status of hot spring power generation	44
3.4 Protection of hot spring resources	45
3.4.1 Laws	47
3.4.2 Guidelines	49
(1) Guidelines on the protection of hot spring resources	49
(2) Guidelines on the protection of hot spring resources (geothermal power generation related)	49

3.4.3 Regulations on geothermal resources	50
(1) Contents of the Ordinances	50
(2) Restricted areas in Beppu - “Avoid Areas”	54
(3) Revision of deliberation standards by Oita Prefecture Environmental Council	56
4. Overseas Cases	58
4.1 Heat utilization and geothermal power generation in the world	58
4.1.1 Heat utilization	58
4.1.2 Geothermal power generation	59
4.2 USA	60
4.2.1 Geothermal resources	60
4.2.2 Heat utilization	60
(1) Examples of aquaculture fishery	62
(2) Examples of agricultural drying	64
(3) Examples of other uses	64
4.2.3 Geothermal power generation	64
4.3 Indonesia	66
4.3.1 Heat utilization	66
4.3.2 Geothermal power generation	67
4.4 Kenya	68
4.4.1 Geothermal resources	68
4.4.2 Heat utilization	70
4.4.3 Geothermal power generation	70
4.5 The Philippines	70
4.6 Mexico	71
4.7 Iceland	73
4.7.1 Geothermal resources	73
4.7.2 Heat utilization	74
(1) Examples of fish drying	76
(2) Examples of outdoor heated pools	77
4.7.3 Geothermal power generation	78
4.8 New Zealand	78
4.8.1 Geothermal resources	78
4.8.2 Heat utilization	79
(1) Examples of wood drying	80
(2) Examples of shrimp farming	81
4.8.3 Geothermal power generation	82
4.9 Italy	83
4.9.1 Geothermal resources	83
4.9.2 Heat utilization	84
4.9.3 Geothermal power generation	87
4.10 Turkey	88
4.10.1 Geothermal resources	88
4.10.2 Heat utilization	88
4.10.3 Geothermal power generation	90
4.11 Germany	90
4.11.1 Geothermal resources	90
4.11.2 Heat utilization	91
4.11.3 Geothermal power generation	92

5. Individual Interviews	94
5.1 Yukemuri Power Generation (Mr. Masamoto Hayashi, CEO of Turbo Blade Co. Ltd.)	95
5.2 Tsuchiyu Onsen (Mr. Katsuichi Kato, CEO of Genki-up Tsuchiyu Co., Ltd.)	97
5.3 JOGMEC (Mr. Nobuyasu Nishikawa, General Manager of JOGMEG)	99
5.4 GNS Science (Dr. Greg Bignall)	102
6. Editor's Postscript	104

〈Figures〉

Figure 2-1	Distribution of World-wide Hot Springs	9
Figure 2-2	Plates in the World	10
Figure 2-3	Hot Spring Symbols in Maps	10
Figure 2-4	Distribution of Hot Springs in Japan (Around 1994)	12
Figure 2-5	Multi-step Utilization of Geothermal Energy	16
Figure 2-6	Various Hot Spring Uses	17
Figure 2-7	Direct Utilization of Geothermal Power in Japan	19
Figure 2-8	Direct utilization of Geothermal Power in the World	19
Figure 2-9	Worldwide Geothermal Resources in Correlation to Active Volcanoes	21
Figure 2-10	Geothermal Power Generation Capacity of Countries around the World	22
Figure 2-11	Mechanism of Geothermal Power Generation	24
Figure 2-12	Life-cycle CO ₂ Emissions by Each Power Supply	25
Figure 2-13	Conceptual Diagram of a Single Flash Power Generation System	26
Figure 2-14	Conceptual Diagram of Binary Cycle Power Generation System	27
Figure 2-15	Secular Change of Installed Capacity and Electricity Output	28
Figure 2-16	Distribution of Geothermal Viability by Area	29
Figure 2-17	Distribution of Potential for the Introduction of Geothermal Power Generation by Area Based on Natural and Social Conditions	30
Figure 2-18	Distribution Map showing Potential for Introduction of Hydrothermal Resource Development (53°C ~ 120°C)	31
Figure 2-19	Location of Geothermal Power Plants in Japan	32
Figure 3-1	Mango Cultivation in Teshikaga Town	35
Figure 3-2	Banana Seedling Cultivation in Okuhida Farm	36
Figure 3-3	Shiitake Cultivation at Adonis Co., Ltd.	36
Figure 3-4	Disinfection of Soil and Materials by Steam Sterilization Tank	37
Figure 3-5	Tilapia Aquaculture at Hotel Parkway	38
Figure 3-6	Tenagaebi Aquaculture at Tsuchiyu Onsen	39
Figure 3-7	Kurodaya Absorption Type Water Cooler/Heater	40
Figure 3-8	Yuyama Geothermal Power Plant	42
Figure 3-9	Yurihama Geothermal Power Plant	42
Figure 3-10	Tsuchiyu Onsen #16 Source Binary Power Plant	43
Figure 3-11	Beppu Region Designated as “Avoid Area”	55
Figure 3-12	Change in Beppu city’s Hot Spring Protection Area	57
Figure 4-1	Ratio of Heat Utilization by Worldwide Applications	58
Figure 4-2	Changes in Installed Geothermal Power Capacity	59
Figure 4-3	Geothermal Resource Map of the United States	60
Figure 4-4	Ratio of Heat Utilization by Application in the United States	61
Figure 4-5	Aquaculture of Edible Crocodiles Using Geothermal Heat in Idaho	62
Figure 4-6	Aquaculture of Tilapia near Klamath Falls, Oregon	63
Figure 4-7	Example of Heat Utilization in the United States (Crop Drying)	64
Figure 4-8	Major Geothermal Power Plants Distributed in the Western United States	65
Figure 4-9	Example of Geothermal Power Plants in the Geysers Area (Calpine Unit)	66
Figure 4-10	Example of Mushroom Cultivation Using the Bactericidal Geothermal Action (Kamojang, Indonesia)	67
Figure 4-11	Distribution of Volcanoes and Geothermal Resources in Kenya	69
Figure 4-12	Geothermal Resource Region in Mexico	72
Figure 4-13	Geothermal Power Plant in the Los-Azufres Field	72

Figure 4-14	Volcanic Zones and Geothermal Areas in Iceland	74
Figure 4-15	Energy Sources Used for Space Heating in Iceland	75
Figure 4-16	Ratio of Heat Utilization by Application in Iceland	76
Figure 4-17	Example of Geothermal Utilization in Iceland (Drying Fish)	77
Figure 4-18	The Blue Lagoon" and the Svartsengi Geothermal Power Plant in Iceland	78
Figure 4-19	Taupo Volcanic Zone in New Zealand	79
Figure 4-20	Example of Heat Utilization in New Zealand (Drying Wood)	80
Figure 4-21	Example of Heat Utilization in New Zealand (Shrimp Farming)	81
Figure 4-22	Wairakei Geothermal Power Plant	83
Figure 4-23	Main Geothermal Fields in Italy	83
Figure 4-24	Major Geothermal Utilization in Italy	85
Figure 4-25	Geothermal Direct Usage Flowchart of Trione Hotel in Abano Terme	86
Figure 4-26	Greenhouse Flower Cultivation Using Hot Spring Heat in Monte Amiata	86
Figure 4-27	Geothermal Field in Western Anatolia, Turkey	88
Figure 4-28	Ratio of Heat Utilization by Application in Turkey	89
Figure 4-29	Greenhouse Cultivation in Turkey (Dikili Geothermal Area)	90
Figure 4-30	(Left) German Regions with Hydrothermal Resources & (Right) Crystalline Rock Distribution (proven and assumed)	91

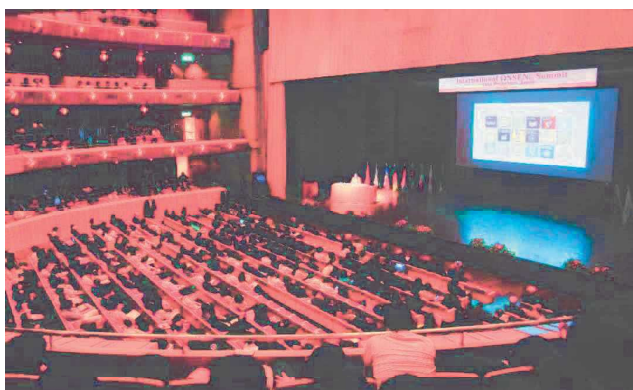
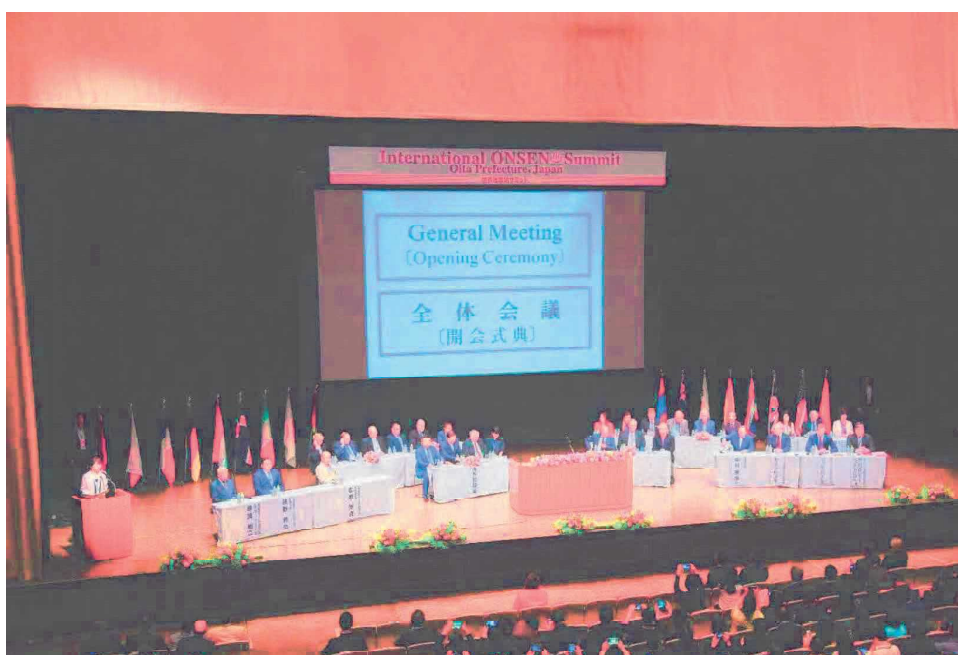
〈Tables〉

Table 2-1	Top 5 Prefectures Showing the Number of Hot Springs & the Amount of Discharged Hot Water	12
Table 2-2	Article 2 of the Hot Spring Law, Appended Table	14
Table 2-3	Geothermal Resource and the Installed Capacity in Major Countries	20
Table 2-4	Relationship between Hot Water Resources of 150°C and the Distribution of National Parks	23
Table 2-5	Specifications of Major Power Plants	33
Table 3-1	Examples of the Main Introduction of Hot- spring Power Generation	45
Table 3-2	Laws, Enforcement Orders, and Enforcement Regulations for Hot Springs	47
Table 3-3	Contents on Protection of Hot Springs in Hot Spring Law	48
Table 3-4	List of Municipal Ordinances Concerning Geothermal Development	50
Table 3-5	Outline of Ordinances etc. of Each Municipality (1)	52
Table 3-6	Outline of Ordinances of Each Municipality (2)	53
Table 4-1	Heat Utilization in the USA (Excluding Geothermal Heat Pumps)	62
Table 4-2	Installed Capacity of Geothermal Power Plants in Indonesia	68
Table 4-3	Heat Utilization in Kenya	70
Table 4-4	Installed Capacity and Generated Electricity of the Power Plants in the Philippines	71
Table 4-5	Installed Geothermal Power Capacity of Mexico	73
Table 4-6	Installed Capacity of Direct Utilization of Mexico	73
Table 4-7	Heat Utilization in Iceland	75
Table 4-8	Heat Utilization in New Zealand	80
Table 4-9	Installed Capacity of Geothermal Power Plant in New Zealand	82
Table 4-10	Installed capacity of Geothermal Power Plants in Italy	87
Table 4-11	Heat Utilization in Turkey	89

1. Oita Prefecture International ONSEN Summit

1.1 Outline

The World's first hot-spring summit, "International ONSEN Summit" was held at the Beppu International Convention Center (B-Con Plaza) in Beppu City, Oita Prefecture for three days from Friday, May 25th to Sunday, May 27th, 2018. The participants included leaders and researchers from ONSEN areas in Japan and around the world. They exchanged information and engaged in discussions on the use of ONSEN resources and the potential for regional development. Following a keynote speech and case-study speeches, more in-depth discussions in three distinct areas were held by the separate working groups on ① Tourism, ② Medical · Health · Beauty, and ③ Energy. As a final result of that debate, the International ONSEN Summit Declaration was adopted.



Source: International ONSEN  Summit Record (2018)

Summit dates	May 25 (Fri) – 27 (Sun), 2018
Location	Beppu City, Oita Prefecture Beppu International Convention Center (B-Con Plaza)
Organizer	International ONSEN Summit Organization Board Committee Chairman Katsusada Hirose (Governor of Oita Prefecture) Vice Chairman Yasuhiro Nagano (Mayor of Beppu City) Vice Chairman Koji Yukishige (President of Tourism Oita (Oita Prefectural Tourism Association)) Auditor Shoji Himeno (Chairman of Oita Association of Corporate Executives) 14 Other Committee Members (see P51 for list of members)
Supporters	Ministry of Economy, Trade and Industry (METI) / Ministry of Land, Infrastructure and Transport (MLIT) / Japan Tourism Agency (JTA) / Ministry of the Environment (MOE) / Ministry of Foreign Affairs (MOFA) / Japan External Trade Organization (JETRO) / Japan National Tourism Organization (JNTO) / Japan Travel and Tourism Association (JTTA) / The Japan Foundation / Japan International Cooperation Agency (JICA)
Theme	Possibility of Regional Development by Worldwide ONSEN Locations: Diverse Ways to Utilize Local Resources Connected with ONSEN
Working Groups	<ul style="list-style-type: none"> ◆ Working Group (1) Tourism: New Possibilities of ONSEN Tourism ◆ Working Group (2) Medical, Health & Beauty: Vision of ONSEN Use for Healthy Life Expectancy and Healing - From Kur to Wellness - ◆ Working Group (3) Energy: Use of ONSEN as a Sustainable Energy Source
Participating Countries and Regions	17 Regions in 16 Countries (listed in alphabetical order based on United Nations nomenclature) <ol style="list-style-type: none"> 1. People's Republic of China: Xianning 2. People's Republic of China: Yantai 3. Czech Republic: Hodonin 4. French Republic: Vichy 5. Federal Republic of Germany: Bad Krozingen 6. Republic of Hungary: Budapest 7. Republic of Iceland: Grindavik (Blue Lagoon) 8. Italian Republic: Abano 9. Hashemite Kingdom of Jordan: Ma'in 10. Mongolia: Bayankhongor Province 11. New Zealand: Taupo 12. Republic of Korea: Busan 13. Kingdom of Spain: Madrid 14. Kingdom of Thailand: Chiang Mai Province 15. United Kingdom: Bath 16. United States of America: Hot Springs (Arkansas) 17. Socialist Republic of Viet Nam: Tuyen Quang Province
Summit in Figures	<ol style="list-style-type: none"> 1. Summit Participants: 1,039 Participants from overseas: 86 Participants from Japan: 953 (Local Government: 272, Societies and Companies, etc.: 262, other: 419) 2. Registered Media Representatives: 46 Overseas Media: 18 Representatives from 6 Countries (France, Germany, Italy, Spain, United Kingdom, United States) Japanese Media: 28 Representatives from 20 Media Companies 3. Administrative Staff: 185 Prefectural and Municipal Staff: 152 Student Volunteers: 33

Source: International ONSEN Summit Record (2018)

May 25 (Fri)

14:00-16:30	3rd Japan ONSEN Summit (Organizer: Ministry of the Environment)
17:45-20:00	Welcome Reception for the International ONSEN Summit & 3rd Japan ONSEN Summit

May 26 (Sat)

9:00-12:00	<p>International ONSEN Summit Plenary Session</p> <p>Organizer Greetings Katusada Hirose, Governor of Oita Prefecture Chairman of the International ONSEN Summit Organization Board Committee</p> <p>Guest Greetings Masaharu Nakagawa, Minister of the Environment, Japan</p> <p>Introduction Speech from Overseas Participants</p> <p>I. Keynote Speech Sustainable Tourism & Possibility of Further Development of Hot Spring Locations in the World [Spain] Yolanda Perdomo, Former Director, UNWTO Affiliate Members Programme</p> <p>II. Case Study Speeches</p> <p>(1) Tourism Attracting Tourists Utilizing ONSEN Hot Springs in France [France] Jérôme Phelipeau, CEO, Compagnie de Vichy</p> <p>(2) Medical, Health & Beauty Situation of Hot Spring Medical Treatment in Italy and New Vision for Hot Spring Medical Treatment Pursuing Health and Beauty [Italy] Massimo Sabbion, Former Manager, Abano-Montegrotto Hotel Association</p> <p>(3) Energy Energy and Tourism: Multiple Use of Geothermal Power and Resources at Blue Lagoon in Iceland [Iceland] Ása Brynjólfssdóttir, Director of Research and Development, Blue Lagoon Ltd.</p>
12:00-13:00	Lunch Break * Standing Buffet
13:00-16:00	<p>III. Working Group Session</p> <p>Working Group (1) Tourism Theme: New Possibilities of ONSEN Tourism</p> <p>Working Group (2) Medical, Health & Beauty Theme: Vision of ONSEN Use for Healthy Life Expectancy and Healing - From Kur to Wellness -</p> <p>Working Group (3) Energy Theme: Use of ONSEN as a Sustainable Energy Source</p>
17:00-18:00	Working Group Summary & Summit Declaration
18:10-18:40	Press Conference
19:00-21:00	Farewell Dinner

May 27 (Sun)

	Excursions
9:30-13:20	(1) Tourism Course (Beppu City)
8:15-13:20	(2) Medical, Health & Beauty Course (Beppu City)
9:30-13:20	(3) Energy Course (Beppu City)
9:00-16:20	(4) ONSEN & Gastronomy Walking Tour Course (Nakatsu City)

Related Events

International ONSEN Tourism & Products Exhibition

May 26 (Sat) – 27 (Sun), 2018: Convention Hall, B-Con Plaza

Features include booths showcasing the countries and local governments participating in the Summit, booths selling produce from different parts of Japan, refreshments booths, and stage events.

ONSEN & Gastronomy Walking Tour

May 26 (Sat) 2018: Beppu, May 27 (Sun): Nakatsu

Walking around these ONSEN areas will take participants along routes of rich nature, history and culture unique to each community. Participants will be able to **savor** the delicious foods and *sake* (rice wines), **soak** in the ONSEN waters, and **experience** the charms of the particular ONSEN areas.

Source: International ONSEN summit record (2018)

1.2 Case study speeches

Presentations were given in the three fields: ① Tourism, ② Medical · Health · Beauty, and ③ Energy. Ása Brynjólfssdóttir, from Iceland, gave a case study speech in the field of energy.

(3) Energy

Energy and Tourism: Multiple use of Geothermal Power and Resources at Blue Lagoon in Iceland

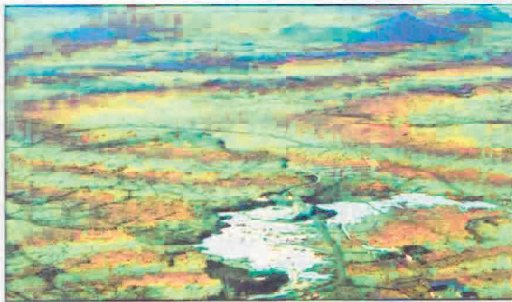


Ása Brynjólfssdóttir

[Iceland] Director of Research and Development, Blue Lagoon Ltd.

Ása Brynjólfssdóttir holds a master's degree in pharmacy from the University of Iceland. Since joining the Blue Lagoon Ltd., a company engaged in researching the healing properties of geothermal seawater, she has spent many years researching the geothermal seawater of the Blue Lagoon and its constituent elements, and subsequently a range of skin-care products has been developed. She has been one of the key personnel in the management team, helping to elevate the Blue Lagoon Ltd. into one of Iceland's leading firms in health tourism.

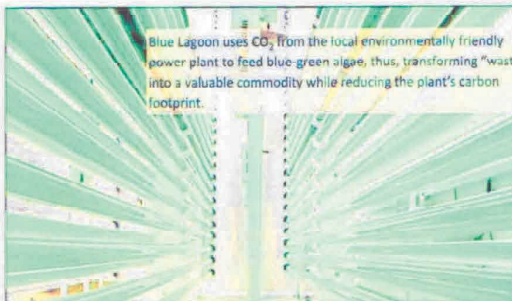
Geothermal energy has been utilized extensively in Iceland, where (similar to Japan) there are many active volcanoes. Director of Research and Development at the Blue Lagoon Ltd., Ása Brynjólfssdóttir, presented specific examples regarding multiple use of geothermal energy at the Blue Lagoon, sizeable hot spring facilities that capitalize on geothermal resources from a nearby geothermal power plant.



- The Blue Lagoon was listed by National Geographic as one of the Wonders of the World.
- The lagoon's geothermal seawater flows from volcanic aquifers 2000 meters within the earth, emerging at the surface enriched with algae, silica and minerals.
- Studies suggest that the unique elements of the lagoon have healing properties and are especially effective for psoriasis.



- Silica is a characteristic element of the lagoon and gives it its blue color. It precipitates to form the white iconic Blue Lagoon silica mud mask available to all guests.
- Blue Lagoon is a venture company, leading in health tourism and skin care.
- It represents both a destination and a unique brand on a global base.



Blue Lagoon uses CO₂ from the local environmentally friendly power plant to feed blue-green algae, thus transforming "waste" into a valuable commodity while reducing the plant's carbon footprint.

- The company's philosophy is to utilize local geothermal resources in a sustainable manner.
- A photobioreactor system uses CO₂ emitted from the geothermal plant to cultivate algae. Thus, transforming a resource, otherwise discarded, into a valuable commodity while reducing the plant's carbon footprint.



- Capital is currently being invested into a new luxury hotel, The Retreat at Blue Lagoon Iceland. The hotel has 62 suites, and the beautiful buildings have been designed to fit the surrounding volcanic landscape.
- Blue Lagoon is now known the world over, and is a destination that everyone wants to visit. The Blue Lagoon is to provide guests with an unforgettable experience.

Source: International ONSEN Summit Record (2018)

1.3 Working groups

In the subcommittee meetings, each venue was divided into three categories, ① Tourism, ② Medical · Health · Beauty, and ③ Energy, and participants engaged in deeper discussions within each field. In the energy group, discussions were held in a symposium format with the theme of "utilization of hot springs as sustainable energy". The coordinator was Dr. Kasumi Yasukawa of the National Institute of Advanced Industrial Science and Technology.



Working Group (3) Energy

Date: May 26 (Sat), 2018

Location: Conference Room, B-Con Plaza

Theme: Use of ONSEN as a Sustainable Energy Source

Coordinator: **Dr. Kasumi Yasukawa** (Deputy Director, Renewable Energy Research Center, Fukushima Renewable Energy Institute, National Institute of Advanced Industrial Science and Technology)

Panelists: **Mr. Kouichi Fukuda** (General Manager, Geothermal Power Department, Thermal Power Division, Energy Service Headquarters, Kyushu Electric Power Co., Inc.)

Mr. Shigeto Yamada (General Manager - Geothermal Power Thermal & Geothermal Power Plant Engineering Department, Power Plant Division, Power & New Energy Business Group, Fuji Electric Co., Ltd.)

Dr. Greg Bignall ([New Zealand] Head of Department, Geothermal Sciences, GNS Science)

Ms. Ása Brynjólfssdóttir ([Iceland] Director of Research and Development, Blue Lagoon Ltd.)

Issues

- (1) How should geothermal energy be utilized?
- (2) How should we promote sustainable energy use in ONSEN area?

Summary of Panelist Remarks



Mr. Kouichi Fukuda

- At Kyushu Electric Power's Hatchobaru and Otake power plants located in Kokonoe Town, Oita Prefecture, the hot water and steam used to generate geothermal power is utilized in heating facilities and in the greenhouse cultivation of roses and gypsophila.
- Kyushu Electric Power adopted binary cycle power generation systems in 2006, 2015 and 2018. It has further expanded its use and application of geothermal energy, carrying out geothermal power generation in Indonesia, too, since May 2018.
- To protect ONSEN areas, it is important to undertake regular monitoring and prescribed environmental assessment for preserving nature. That alone though is not enough. Mutual understanding, communication, and building trusting relationships based on these are also important.
- As a form of communication and in order to increase understanding about geothermal power generation, an open day event has been held once a year at the Hatchobaru Power Plant since the start of its operations, opening the plant

premises up to the public. A permanent exhibition center has also been set up, visited by 22,000 people throughout the year.



Mr. Shigeto Yamada

- According to data on capacity (power generation capacity) of the world's geothermal power plants, there has been considerable growth in Iceland and Turkey. Developing a wide range of businesses and actively utilizing geothermal energy is commendable.
- Geothermal power generation is not just about heat. There is potential to expand business in a variety of ways.
- Some people think that geothermy is not beneficial to primary industry. In addition to using energy for ONSEN, it is vitally important that there be people in each region who can examine and plan broader energy uses best suited to the region.
- Although expanding geothermal power generation is important, so too is widening opportunities for the use of ONSEN resources. A good idea would be for consultants and companies to come to the fore, leading to broader use.



Source: International ONSEN Summit Record (2018)



Dr. Greg Bignall

- In New Zealand, geothermal energy accounts for about 19–20% of power. This presents an opportunity to close the fossil fuel power plants. In the medium term, I would like to consider future investment in, and future expansion of, the

geothermal power generation.

- What is important is how the community wants to use geothermy. The position of the Maori people is that they want to protect nature, rather than own it. Whether it be hot springs or geothermal energy, it is important to have a conviction and sentiment of protecting—not owning.
- Even if the power plant is very small in scale, it supplies power to greenhouses and dairy factories, creates jobs, and generates profits. In this respect, it is a big positive for regional economic development.
- When pumping hot water up from underground, we need to balance the lost water and the replenishment rate, that is, replenishing water to nature. There was a time in New Zealand when that rate was wrong, and we placed a burden on the planet. However, as long as we keep that balance, geothermal resources will be a renewable energy.



Ms. Ása Brynjólfssdóttir

- At Blue Lagoon, we view the hot springs, hotel, skin care shop and restaurant as a single enterprise group (Resource Park), and we utilize the hot springs in a variety of ways, such as having the hot water produced in generating

power utilized by each of the facilities in a sustainable manner.

- Monitoring is crucial in order to promote sustainable energy use. Education, communication, and the building of relationships of mutual trust lead to sustainable development.
- We are striving to generate energy using natural resources wherever possible in order to improve the quality of life for the local people.
- Through the hot springs, being able to create and supply jobs in various industry sectors is also important. It is imperative to proceed with development collaboratively while considering the potential in sector.



Panel exhibition of initiatives by participating organizations



Booklet of initiatives by participating organizations

Working Group Summary

Dr. Kasumi Yasukawa

- Regarding the point on how geothermal energy should be utilized, there are industrial applications. In utilizing geothermal energy in industrial settings, it is important to consider the characteristics of local resources and to also take the social environment into consideration when planning.
- Regarding new possibilities for power generation using ONSEN, particularly on islands and in remote locations, since power transmission is sometimes cut during times of disaster, a power plant that uses hot springs—even a small-scale plant—would be extremely effective.
- Regarding the point on how sustainable energy use should be promoted in ONSEN areas, many in the conference room are of the view that development of large-scale geothermal power generation would perhaps have an impact on ONSEN, and so it is necessary to consider whether there is a separate way of successfully using ONSEN in ONSEN areas and using the energy without adversely affecting the ONSEN.
- In examining energy use that does not affect the source of an ONSEN, it is important to conduct effective numerical modeling based on monitoring data to make forecasts for the future. Furthermore, it is also important to produce technical guidelines that can also be understood by non-specialists, and to develop a social environment for building management systems that avoid wanton development.
- Regarding harmony with the natural environment, the landscape and the living environment, it is important to have a design that meets with the approval of the community. Rather than just hiding the plant from view, there also needs to be facilities on show from the perspective of environmental education and tourism.
- Regarding sustainable development based on consensus-building with local stakeholders, it is important to build consensus in close communication with the local community, and to consider ways of using ONSEN for multiple purposes, which will contribute to sustainable development of the region.



Source: International ONSEN@Summit Record (2018)

1.4 Summit declaration



Summit Declaration

Date: May 26 (Sat), 2018

Location: Philharmonia Hall, B-Con Plaza

The working group coordinators presented a summary of discussions from the three working groups, and lastly, the Summit Declaration was announced by Ms. Yolanda Perdomo, former Director of the UNWTO Affiliate Members Programme. The Summit Declaration included an affirmation by leaders from ONSEN areas around the world to contribute to development of ONSEN areas by utilizing the knowledge and networks gained at the Summit, and to promote uses for ONSEN in the three areas of tourism; medical, health & beauty; and energy. In addition, the leaders declared to continue the Summit as a forum for ongoing information exchange and discussion. The Summit Declaration was approved with great applause by Summit participants.



Source: International ONSEN Summit Record (2018)

Declaration for the International ONSEN Summit

We, the leaders of the world's ONSEN, gathered information on and actively discussed the theme of the "Possibility of Regional Development by Worldwide ONSEN Locations" at the "International ONSEN Summit" held in Beppu City, Oita Prefecture, Japan. In the future, we hope that people from across the world will begin to use ONSEN and understand its charm. In order to further develop the world's ONSEN, we will make appeals to the world on the following points to declare our intent to implement them.

1. Contribution to Developing the World's ONSEN Locations

We will use the examples of practical applications for ONSEN culture and ONSEN resources, the specialized knowledge concerning the natural blessings that are ONSEN resources, and the networks we gained with various organizations at this Summit to the fullest extent. In addition to endeavoring to create an ONSEN related database, we will contribute to the world's ONSEN locations while creating new values for ONSEN and striving for mutual exchange.

2. ONSEN and Tourism Promotion

Tourism is a transformative tool, and has the capability of reducing poverty, wealth and gender inequality, preserving culture, protecting of tangible and intangible heritage. It can also promote environmental, social, and economic progress and sustainability.

ONSEN are an important natural and cultural resource in the tourism field. In addition to working to improve environmental awareness and preserving the natural blessings that are ONSEN resources, we will aim to enhance charms of each region by differentiating the regional specialties, and create ONSEN tourism even more people can enjoy.

3. Medical, Health, and Beauty Uses for ONSEN

ONSEN are an incredibly beneficial resource in the medical, health, and beauty fields. We will propel research via industrial, academic, and government cooperation and promote use of ONSEN in these fields as a resource for all humanity while conveying information about the new possibilities and charms of ONSEN. Especially, it is notable that the use of ONSEN has expanded to wellness field (health promotion and beauty) in addition to cure (medical treatment).

4. Use of ONSEN Energy

ONSEN are a resource whose application as an energy source is expected to grow. As we enter into the age of energy diversification, we will continue to advance sustainable use and application of ONSEN, including protecting ONSEN resources, using ONSEN energy in a variety of fields such as power generation, local air conditioning, and thermal use with agriculture and fishery while aiming for harmony with the natural environment.

5. Continuation of the International ONSEN Summit

We, with the purposes mentioned, will continuously hold the Summit in order for leaders of the world's ONSEN to share information and discuss with each other.

We declare the above.

May 26th, 2018

2. Hot Spring (Geothermal) Heat Energy Utilization

A hot spring consists of groundwater heated by geothermal energy. Hot spring heat and geothermal have the same heat source. The methods of utilizing these heat sources are divided into two uses: a method of direct use as heat and a method of generating electricity by using hot spring heat/geothermal heat.

2.1 Use as hot springs

The most widely used method of utilizing hot spring(geothermal) heat energy is for bathing.

2.1.1 Distribution of world hot springs

Hot springs are located worldwide, especially in Europe and the Pacific Rim countries. There are many located in North and South America, New Zealand, China, and in eastern and southern African countries. These hot springs are frequently found in the new orogenic zones where volcanic activity and crustal movements are active, such as the Alps, the Himalayan Orogenic Belt, and the Ring of Fire which stretches out from the Japanese Archipelago through the Rocky and Andean Mountains to the South Pacific Ocean. On the other hand, high-temperature hot springs may sometimes be found in volcano-free areas such as the Himalaya / Tibetan Highlands; China and Siberia around Lake Baikal; and in the northwest and the south of the African Continent. It is well-known that these hot springs are located along faults. In addition, hot springs are also located in places called hot spots where high-temperature magmas penetrate the plate and appear on the surface, such as on Hawaii Island and in Yellowstone in North America.

Since hot springs exist on a global scale in places where crustal deformation is thriving, it can be said that hot springs are a "gift from the earth." The worldwide hot spring distribution is shown in **Figure 2-1**, and the world plates are shown in **Figure 2-2**.

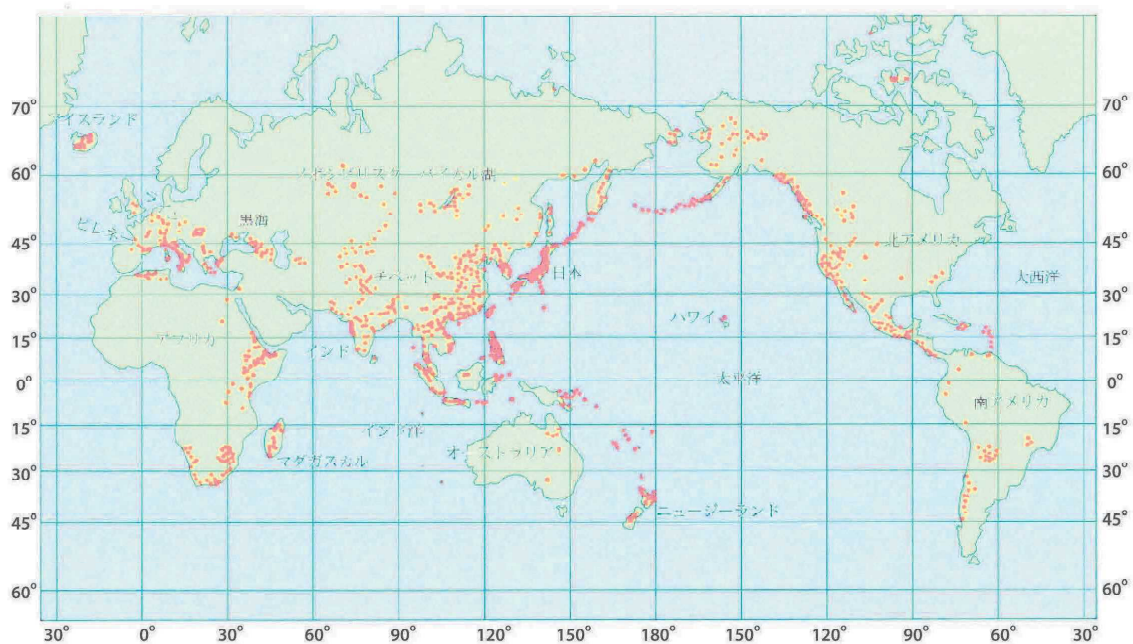


Figure 2-1 Distribution of Worldwide Hot Springs

Source: The Japan Hot Spring Association (2006): Onsen nature and culture, distribution of hot springs in the world (Yuhara · Seno /original drawing)

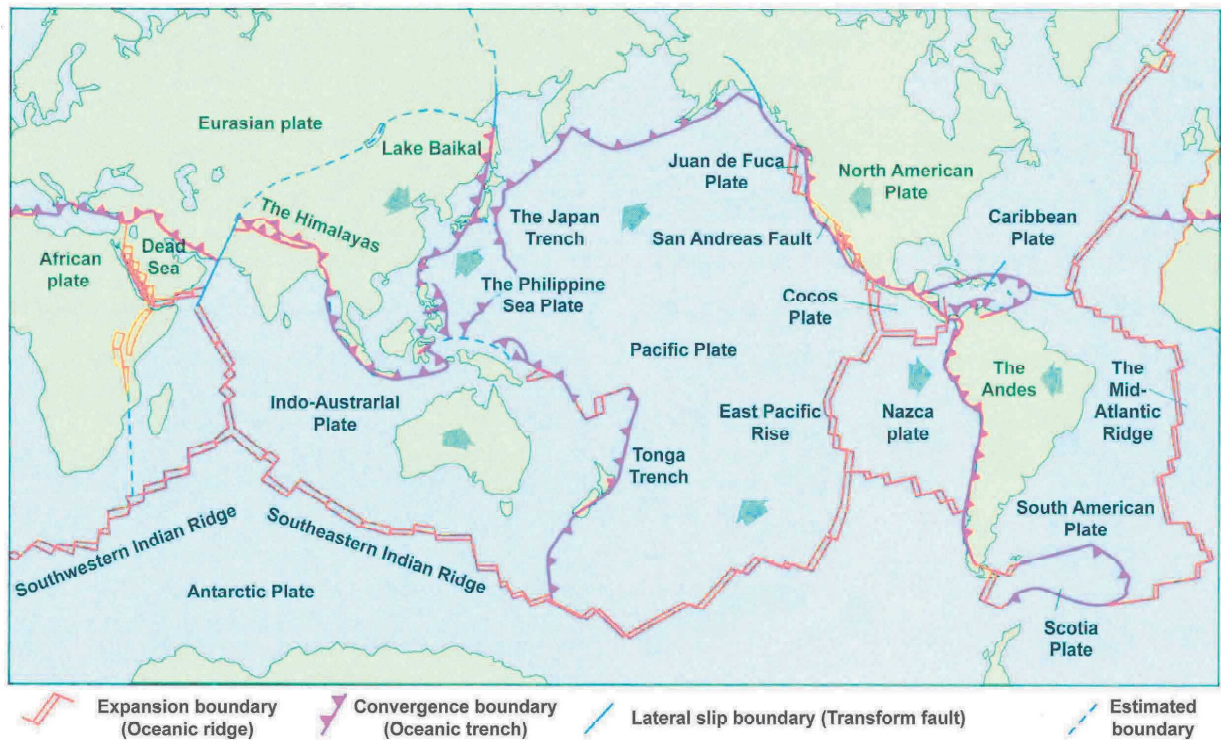


Figure 2-2 Plates in the World

Source: The Japan Hot Spring Association (2006): Onsen, nature and culture, the world's plates (Kaneoka Ichiro / original drawing)

2.1.2 Use of hot springs in the world

As shown in the hot spring distribution map above, hot springs are located all over the world, but hot-spring culture also differs from country to country due to differences in the natural environment, lifestyle, religion, and language. As there are many high-temperature hot springs in Japan, they are mostly used for “Yuami/Ofuro” or hot baths. In other countries, especially in Europe, where the amount of hot water, as well as its temperature, is low due to few volcanic zones, hot springs are often used for “pools/bathing.”

A hot spring is defined as having a temperature of over 25°C in Japan. In European countries such as Germany, the UK, France, and Italy, it is defined as more than 20°C. In North America, it is defined as more than 70°F (21.1°C). Another interesting difference is seen in the symbols used to designate hot springs. In France, the image is reminiscent of a fountain whereas in Japan the symbol shows hot steam rising from water.



Figure 2-3 Hot Spring Symbols in Maps

Source: Geographical Survey Institute website: Geographical Survey Home > Children's Page > Map Symbols > Various Map Symbols > Foreign Map Symbols

<http://www.gsi.go.jp/common/000206972.jpg>

(1) Germany

Germany is famous worldwide as a hot spring nation. “Balneology,” the practice of using natural mineral water for treating and curing disease, has a long history and played a major role in the development of hot springs as a modern medical spa as now typified in Baden-Baden.

Unlike other countries in Europe, this area has abundant hot springs with high temperatures of 70°C. The Friedrich Therme, built in the 19th century, is a traditional bathhouse for recuperation, which offers multiple baths, saunas, and massage. Visitors follow a series of programs for bathing in which even the time to stay in the bath is set in detail. Doctors and other experts give advice according to individual health conditions.

(2) Hungary

A large number of hot spring facilities exist in Budapest, the capital of Hungary, where hot springs have been used since Roman times. Lake Hévíz is a natural thermal lake near the western end of Lake Balaton, and it is available for bathing. The water temperature is around 30°C throughout the year. People bathing with inner tubes are often seen because some places in the lake are as deep as 35 meters.

(3) Iceland

Blue Lagoon, one of Iceland's leading tourist destinations, is the world's largest hot spring lake. However, it is a hot spring lake made up of drainage from underground hot water drawn by the adjacent geothermal power plant, not as a spa originating from natural springs. As its name suggests, it is a pastel blue hot spring. Because these waters contain a large amount of silica and sulfur, skincare products utilizing mud from these hot springs are also being developed for their curative effects for various skin conditions.

2.1.3 Distribution of hot springs in Japan

The Japanese archipelago is located in the Pacific Orogenic Belt and is often hit by volcanic activities and earthquakes. Hot springs exist in all 47 prefectures throughout the country. With 27,421 hot springs nationwide, the amount of gushing hot water reaches about 2,564,123L per minute. Japan is the world's leading hot-spring country and has enjoyed abundant natural gifts from mother earth (See **Table 2-1**). Hot spring distribution around 1994 is shown in Figure 2-4.

Many of the hot springs throughout Japan are volcanic hot springs, but there are also many non-volcanic hot springs coming from heated groundwater with a geothermal heat source. These are mainly located in urban areas. Improved drilling techniques used in recent years have made deep drilling easier.

Source: Ministry of the Environment (2018): 2016 hot spring use situation
<https://www.env.go.jp/nature/onsen/data/>

Table 2-1 Top 5 Prefectures - Showing the Number of Hot Springs & the Amount of Discharged Hot Water

Ranking	Number of sources of hot springs		Amount of hot water (L / Minute)	
1	Oita	4,385	Oita	281,331
2	Kagoshima	2,764	Hokkaido	206,564
3	Shizuoka	2,261	Kagoshima	156,346
4	Hokkaido	2,230	Aomori	153,054
5	Kumamoto	1,352	Kumamoto	133,661
Japan Total		27,421		2,564,123

【Created based on hot spring usage in 2017.

*Source number is the sum of the number of used and unused sources 】

Source: Ministry of the Environment (2018): 2017 hot spring use situation
<https://www.env.go.jp/nature/onsen/data/>

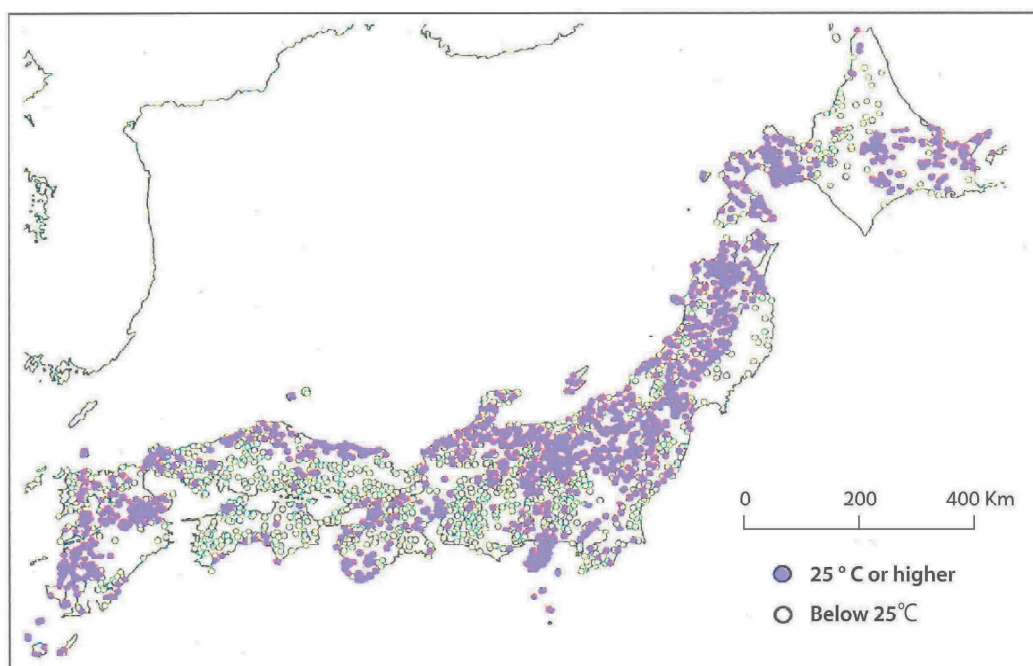


Figure 2-4 Distribution of Hot Springs in Japan (Around 1994)

Source: The Japan Hot Spring Association (2004): Hot Springs Nature and Culture, Japanese Hot Spring Distribution (Original Masao Oyama)

2.1.4 Definition and types of hot springs in Japan

According to the Japanese "Hot Spring Act" enacted in 1948, a hot spring was defined as a spring comprised of either gushing hot water, mineral water, steam, or other gasses (excluding natural gas whose main component is hydrocarbons) which rises from the ground with a temperature over 25°C or as a hot spring that contains one of the substances listed in Table 2-2. "Temperature," "pH," "Osmotic pressure," and "Spring quality" were used as a way of classifying hot springs. A common and familiar way of hot spring classification is by using the recognized qualities of the waters and listing them on the bathhouse.

The quality of hot springs was previously classified into 11 categories with listings such as "simple hot spring," "simple carbon dioxide spring," or "iron spring." However, to be in accordance with international standards, changes were made in 1979. The terms were adjusted to listings such as "sodium-chloride spring" or "sodium-hydrogen carbonate spring" to indicate the chemical components of the spring. However, as it is generally difficult to understand the hot spring's efficacy by only using the name of the chemical ingredients, in 1982, "the name of the spring quality for posting" was decided. According to the revision in 2014, hot spring quality is now classified into 10 categories. These include: "Simple spring," "Carbon Dioxide spring," "Chloride spring," "Hydrogen Carbonate spring," "Sulfate spring," "Iron-containing spring," "Iodine-containing spring," "Sulfur spring," "Acid spring," and "Radioactive spring."

Table 2-2 Article 2 of the Hot Spring Law, Appended Table

Chemical Substance	Content (in 1 kg)
Dissolved substances (excluding gaseous ones)	Total volume of more than 1,000 mg
Free carbonic acid (CO ₂)	Over 250mg
Lithium ion (Li ⁺)	Over 1mg
Strontium ion (Sr ²⁺)	Over 10mg
Barium ion (Ba ²⁺)	Over 5mg
Ferro or ferri ions (Fe ²⁺ ,Fe ³⁺)	Over 10mg
First manganese ion (Mn ²⁺)	Over 10mg
Hydrogen ion (H ⁺)	Over 1mg
Bromide ion (Br ⁻)	Over 5mg
Iodide ion (I ⁻)	Over 1mg
Fluoride ion (F ⁻)	Over 2mg
Hydrocitrate ion (HAsO ₄ ²⁻)	Over 1.3mg
Metaphosphate (HAsO ₂)	Over 1mg
Total sulfur (S) [corresponding to HS ⁻ +S ₂ O ₃ ²⁻ +H ₂ S]	Over 1mg
Metaboric acid (HBO ₂)	Over 5mg
Metasilicic acid (H ₂ SiO ₃)	Over 50mg
Bicarbonate soda (NaHCO ₃)	Over 340mg
Radon (Rn)	20 (ten billionths of a Curie* or more)
Radium salt (as Ra)	1/100 million mg or more

【 * Unit of radioactivity, 1 Curie is 37 giga-becquerels】

【References】

- Yoshimi Kawasaki (2002): Atichi's hot spring classroom - Things you need to know about hot springs, How to use hot springs, Civil Law Study Group, pg. 223
- Yamamoto Masataka (2006): World Hot Spring Travel-66 Hot Springs, Kumazasa Publishing Company, pg. 199
- Hiroyuki Agishi and Yuichi Iijima (2006): Walking in Hot Spring Resorts in Europe, Iwanami-shoten, pg. 162
- Edited by the Japanese Society of Hot Spring Science (2005): Introduction to Hot Springs - Invitation to Hot Springs, Coronasha, pg 128
- Junji Yamamura (2015): 47 Prefectural Hot Springs Encyclopedia, MARUZEN, pg 311
- Ministry of the Environment HP: Outline of the hot spring law (<https://www.env.go.jp/nature/onsen/outline/>)

2.2 Direct utilization of hot spring (geothermal) heat

Heat utilization is the use of steam or hot water as a heat source for various applications after using it for geothermal power generation or in hot springs.

It is called a “multistage utilization of geothermal power generation—cascade utilization” to carry out geothermal power generation. This cascade method uses the steam or hot water from the highest temperatures and then uses the remaining heat from higher to lower temperatures in a number of stages. Direct use of geothermal heat can effectively utilize unused energy and offers great merit in terms of cost (JOGMEC, 2018).

Figure 2-5 shows the heat utilization at each stage from the highest temperature range to the lower temperature ranges (Yasukawa 2018). By utilizing geothermal energy in multiple stages, both thermal efficiency and cost efficiency can be realized, making it possible to realize a usage method without profitability alone.

【References】

JOGMEC (2018): HOME> Geothermal general information> Geothermal and hot spring> Effective utilization of hot water

Kasumi Yasukawa (2018): International ONSEN summit material

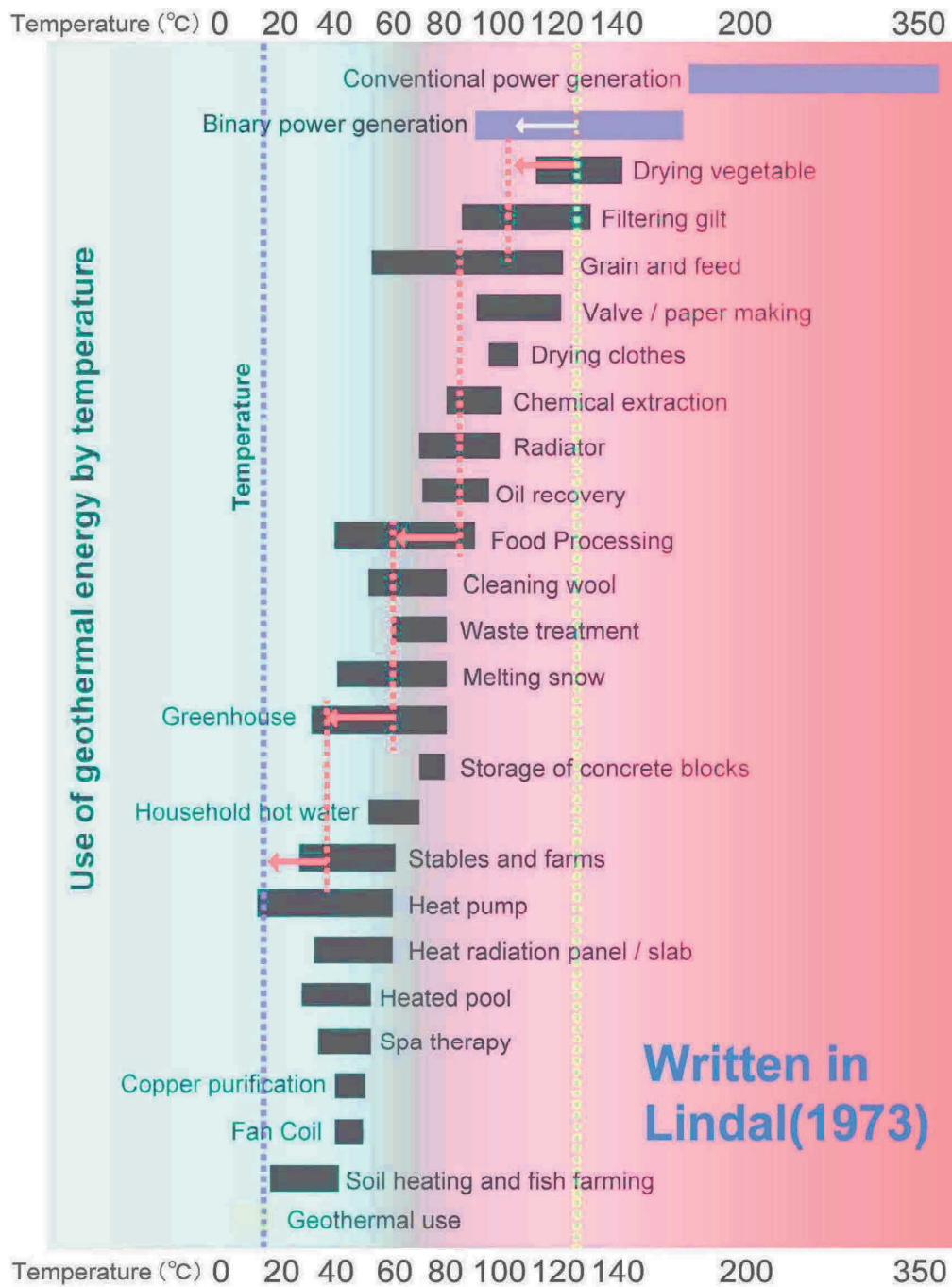


Figure 2-5 Multi-step Utilization of Geothermal Energy

Source: Kasumi Yasukawa (2018): World ONSEN summit materials (Written in Lindal, 1973) Lindal, B. (1973): Industrial and Other Applications of Geothermal Energy. Geothermal Energy, (ed.H. C. H. Armstead), Earth Science, Vol.12, UNESCO, Paris, pp.135-148.

2.2.1 Heat Utilization of Hot Springs

Hot springs produce output at a wide range of temperatures from 20°C to over 100°C. The temperature suitable for bathing is around 40°C. For this reason, hot springs gushing out at higher temperatures, suitable for bathing, are used after cooling naturally or by adding water. Hot spring water, after bathing,