The United Nations University
GEOTHERMAL TRAINING PROGRAMME
Orkustofnun, Grensásvegur 9,
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Reports 2005
Number 24

ENVIRONMENTAL IMPACT OF GEOTHERMAL DEVELOPMENT IN THE GORYACHY PLYAZH AREA, KUNASHIR ISLAND, RUSSIA

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ABSTRACT

The Goryachy Plyazh high-temperature area is located on Kunashir, one of the Kuril Islands, Far East Russia. Geothermal development of this territory started in 1993 when the Goryachy Plyazh geothermal power plant was constructed at the site of Mendeleeva volcano, 20 km from Japan. In 1997, a project for utilizing hot water for space heating was carried out, adding to the power plant. There is a large economical benefit from the exploitation of geothermal energy for people living in the southern part of Kunashir Island. The geothermal heating and power plant is very close to this area and the people are directly affected by exploitation at Goryachy Plyazh. The geothermal development has had some negative effects on the environment. The most significant are visual effects, and effects on recreation, such as surface disturbances of natural thermal springs, and negative effects on vegetation and wildlife due to land use.

1. INTRODUCTION

Significant geothermal resources exist in the South Kuril Islands, Russia. The Goryachy Plyazh geothermal system is located on Kunashir Island, near the Mendeleev volcano, 7 km southwest of the town of Yuzhno-Kuril'sk which has a population of about 4000. This geothermal system is rich in high-temperature geothermal resources. Hot springs and fumaroles are widespread in this area. In 1993, the first package-type geothermal power plant – module "Tuman-2" with a capacity of 500 kW was put into operation in this area. Today, geothermal resources are exploited for space heating and the production of electricity.

Kunashir Island has a phenomenal and diversified biology, being rich both in animals and plants, including some endemic heat-loving species.

The environmental aspects of geothermal development are receiving increasing attention with a shift in attitude towards the world's natural resources. Although the impacts of geothermal development projects are usually positive, negative impacts on the environment may also be noted. In this report, information is presented to evaluate the influence of the geothermal plant on Kunashir.

2. HISTORY OF DEVELOPMENT AND EXPLOITATION OF GEOTHERMAL ENERGY IN THE WORLD

Geothermal energy is often considered as an alternative to fossil fuels (oil and coal) or nuclear energy. Geothermal energy is usually cheaper than traditional energy resources, and in most cases it can be assumed that it does not pollute nature. Geothermal power plants contribute to a decreased use of the traditional fossil fuels such as fuel oil and coal, thus decreasing the pollution of the atmosphere. Installed electrical capacity has grown steadily; in 1975 it was 1300 MWe; in 1990 5832 MWe; and in 2005 8912 MWe (Bertani, 2005). Similar growth rate are seen in direct use of geothermal resources, in 1995 the installed capacity was 8654 MWt, but in 2005 27825 MWt (Lund et al., 2005).

2.1 History of geothermal development in the world

Electrical energy was first produced from geothermal resources in 1904, by the Italian P. Djinoni Konti. Industrial development of geothermal resources started in Italy in 1916 with the creation and start-up of a geothermal power station with a capacity of 7.5 MW, using three "Franco Toge" turbines with a capacity of 2.5 MW each. In New Zealand, the Wairakei power station was built in the 1950s and the first commercial geothermal power station in the USA started to generate electricity in 1960. In 2005 the total capacity of all geothermal power stations in the world was 8912 MWe (Bertani, 2005). In industrial countries, one megawatt suffices the needs of approximately 1000 inhabitants.

Large scale direct use of natural geothermal energy started at much the same time. The geothermal steam was used to raise liquids in primitive gas lifts and later in reciprocating and centrifugal pumps and winches, all of which were used in drilling or in the local boric acid industry in Italy. Between 1850 and 1875, the factory at Larderello held the monopoly in Europe for boric acid production. Between 1910 and 1940, the low-pressure steam in this part of Tuscany was used in industrial and residential buildings and greenhouses. Other countries also began developing their geothermal resources on an industrial scale. The first geothermal heating system was though created in Chaude Aigue in France around the year 1200. However, in 1892 the first modern geothermal district heating system began operations in Boise, Idaho, USA. In 1928, Iceland, another pioneering country in the utilization of geothermal energy, started exploiting its geothermal fluids (mainly hot water) for large scale domestic heating purposes (Dickson and Fanelli, 2004).

2.2 Exploitation of geothermal energy in the world

Since the Second World War, many countries have utilized geothermal energy, considering it economically competitive with other forms of energy, not having to be imported, and in some cases, being the only energy source locally available. Resources of geothermal energy in the world have been estimated. Table 1 shows the results for exploitable low- and high-temperature energy resources.

TABLE 1: Geothermal energy sources in the world (IGA, 2001)

Continent	High-temperature resources producing energy		Low-temperature sources suitable for direct use, (10^{12} Joule/year)
	Traditional technologies, (10^{12} W/year)	Traditional and binary technologies (10^{12} W/year)	
Europe	1830	3700	>370
Asia	2970	5900	>320
Africa	1220	2400	>240
North America	1330	2700	>120
Latin America	2800	5600	>240
Oceania	1050	2100	>110

Many countries that use geothermal energy to generate electricity are listed in Table 2, which gives their installed geothermal electric capacity in 1995, 2000 and 2005 and the increase between 2000 and the year 2005 (Bertani 2005).

TABLE 2: Electrical production in geothermal power plants
in some main producing countries in 1995, 2000 and 2005 (Bertani, 2005)

Country	1995 (MWe)	2000 (MWe)	2005 (MWe)	Increase 2005-2000	
				(MWe)	(%)
China	29	29	28	-1	Stable
Costa Rica	55	143	163	20	14
El Salvador	105	161	151	-10	Stable
Iceland	50	170	202	32	19
Indonesia	310	590	797	207	35
Italy	632	785	790	5	1
Japan	414	547	535	-12	Stable
Kenya	45	45	127	82	182
Mexico	753	755	953	198	16
New Zealand	286	437	435	-2	Stable
Philippines	1227	1909	1931	22	1
Russia	11	23	79	56	244
USA	2817	2228	2544	316	3

In 2005, 58 countries were listed as using geothermal heat directly for various purposes (Lund et al., 2005). The share of the different uses was the following:

- For geothermal heat pumps – 56%
- For heating baths and swimming pools – 18%
- For space heating – 15%
- For heating greenhouses – 5%
- For heating of water in fish farms – 2%
- In industry – 2%
- For drying agricultural productions, thawing of snow and air-conditioning – 1%
- For other purposes – 1%

3. ENVIRONMENTAL IMPACT OF GEOTHERMAL DEVELOPMENT

Geothermal means "heat from the earth". Geothermal energy is energy derived from the natural heat of the earth. Zones of high heat flow may be located at depths where convective circulation plays a significant role in bringing the heat close to the surface. The features of geothermal resources (chemical composition, temperature, areal extent) are important factors in identifying the effects/influences of geothermal development. To understand the nature of those influences, it is necessary to consider the categorization of geothermal resources. The types of geothermal resources, characteristics of each type and related effects are shown in Table 3.

Temperature classification is most often used because temperature determines the type of geothermal development, i.e. direct uses of hot water or electrical power generation, and it is associated with the resources, its characteristics and effects on the environment.

TABLE 3: Geothermal resource categorization, characteristics and effects of development on the environment

Types of categorization	**Resource characteristics**	**Effects**
Temperature (IEA, 2004): Highest temperature: > 150°C Moderate temperature:90-100°C to 150°C Low temperature: < 90-100°C	Temperature	The highest temperature resources are generally used for electric power generation. Low- and moderate-temperature resources can be used directly, very low-temperature for ground-source heat pumps. Direct use involves using the heat in the water (without a heat pump or power plant) for heating buildings, industrial processes, greenhouses, aquaculture (growing of fish) and resorts. Direct use projects generally exploit resource temperatures between 38 and 149°C.
Fluid-phase (Hietter, 1995): Vapour-dominated Liquid-dominated Boiling Dry rock	Chemical composition	Determines nature of air emissions and the nature of the fluids that may be discharged
Heat-source (Hietter, 1995): Deep circulation of groundwater Volcanic heat	Depth and rock formation	Depth to reservoir determines the size of drill rigs required to extract from the resource. Type of rocks encountered determines drilling duration.
Resource-application (Hietter, 1995): Electric-power generation, Direct use	Areal extent	Size of the reservoir determines how many power plants may be developed, with accompanying impacts and surface disturbances

3.1 Advantages of using geothermal energy

Clean: Geothermal power plants, like wind and solar power plants do not have to burn fuels to manufacture steam to turn the turbines. Generating electricity with geothermal energy helps to conserve non-renewable fossil fuels, and by decreasing the use of these fuels, we reduce emissions that harm our atmosphere. There is no smoky air around geothermal power plants – in fact, some are built in the middle of crop lands or forests, or even in national parks, and share land with cattle and local wildlife. For ten years, Lake County, California, home to five geothermal electric power plants, was the first and only site to meet the most stringent governmental air quality standards in the U.S.

Easy on the land: The land area required for geothermal power plants is smaller per megawatt than for almost every other type of power plant. Geothermal installations do not require the damming of rivers or harvesting of forests – and there are no mineshafts, tunnels, open pits, waste heaps or oil spills.

Reliability: Geothermal power plants are designed to run 24 hours a day, all year round. A geothermal power plant sits right on top of its energy source. It is resistant to interruptions of power generation due to weather, natural disasters or political rifts.

Flexibility: Geothermal power plants can be built in modules, with additional units installed for enlargement, when needed for the growing demand for electricity.

"Keeps dollars at home" (cheap): Money does not have to be exported to import fuel for geothermal power plants. Geothermal "fuel" – like the sun and the wind – is perpetually available; economic benefits remain in the region and there are no fuel price shocks.

Helps developing countries to grow: Geothermal projects can offer all of the above benefits to help developing countries grow without pollution. Installations in remote locations can raise the standard of living and the quality of life by bringing electricity to people far from "electrified" population centres.

3.2 Construction processes/land use

The construction of geothermal stations is dependent on geographical conditions as well as the type of heat used (see Table 3). Construction is preceded by the following actions:

- Geological exploration work, including preliminary exploration studies (geology, geochemistry and geophysics) for determining the main features of the most prospective regions;
- Experimental drilling and testing of drill holes for determination of the industrial energy output and the feasibility of the project (Cataldi and Sommaruga, 1986).

Usually geothermal power stations render a basic influence on the environment during the construction of steam pipelines and the building of power stations (but usually this influence is limited to the area of manifestation). Environmental impacts from geothermal development vary during the various phases of development. Geothermal development can be described as a three-part process (Hietter, 1995; Webster, 1995):

1. Preliminary exploration, which has hardly any environmental effect: environmental effects are usually small because only geological mapping, sampling and small areas for exploration drilling are involved.
2. During drilling, each drill site is usually between 200 and 2500 m^2 in size, and the soil there is compacted and altered.
3. Production and utilization, probably this creates the greatest impact on the environment with the building of power plants and pipelines etc.

3.3 Environmental effects of geothermal energy utilization

The technology for the safe use of geothermal water is highly developed and well proven. However, intensive industrial exploitation of geothermal energy sources can result in certain negative effects. Possible disadvantageous effects of the development of geothermal power stations (Ageev, 2004) are:

1. *Alienation of the grounds*: For a workstation with a capacity of 1000 MW, 150 wells are required, in an area larger than 19 km^2.
2. *Change of ground (subsoil) water level, subsidence of ground, bogging*: Potential consequences of geothermal development include ground subsidence and seismic effects. Subsidence is possible everywhere where underlying layers cease to support the top layers of ground. This is expressed in a decrease in the charging of thermal sources and geysers and can even result in their full disappearance. For example, at one location in Wairakei (NZ) from 1954 to 1970, the surface of the ground subsided almost 4 m. The area of the affected zone, is about 70 km^2 and increases annually (Hunt, 2001).
3. *Movement of the earth's crust, increase of seismic activity*: High seismic activity is one attribute of geothermal resources that is used in the search for resources. However, many scientists consider that the intensity of earthquakes caused by volcanic activity in a zone of thermal phenomena is usually much less than that caused by rifting plate tectonics. Therefore, there is no basis for the idea that development of geothermal resources increases seismic activity.
4. *Emissions of gases*: At geothermal stations, there is no burning of fuel. The volume of the polluting gases released to the atmosphere is much less than from burning fuel. The geothermal gases have a different chemical composition than gaseous waste from stations burning organic

fuel. The steam, extracted from geothermal wells, is basically water. The main constituency of gas emissions is usually carbon dioxide, with lesser amount of methane, hydrogen, nitrogen, ammonia and hydrogen sulphide.

5. *Discharge of polluted water and condensate, pollution of underground waters and aquifers*: One possible adverse effect of geothermal stations is the pollution of surface and ground waters due to the discharge of solutions from drilled wells with fluids with high concentrations of chemicals. Discharge of the used thermal waters can cause bogging of ground sites in a damp climate, and droughty areas, and increased mineralization of soils.
6. *Emission of heat into the atmosphere or into surface waters.*
7. *Emission of brines at pipeline breaks.*

However, such adverse effects are balanced against the more obvious advantages of using geothermal energy. Precautionary measures should be put into effect during installation and implementation.

In connection to expanded use of geothermal energy, there is clearly a need to identify possible environmental effects, and to devise and adopt methods to avoid or minimize impacts from geothermal exploitation (Mongillo and Nieva, 2003), including:

- Investigation of impacts of development on natural features;
- Study of problems associated with discharge and re-injection;
- Examination of methods for impact mitigation;
- Production of a good environmental practice manual.

4. STATUS AND PROSPECTS OF GEOTHERMAL DEVELOPMENT IN RUSSIA

Russia has large resources of geothermal energy for the production of electrical power, the provision of district heating systems and for industrial and agricultural needs. Exploitation of geothermal resources and the implementation of drilling operations for geothermal heat production have been carried out for more than 50 years. Today information exists on geothermal resources in almost all of Russia. There are hot areas all over Russia with temperature gradients up to 30-40°C/km, and there are geothermal reservoirs in several regions with temperatures up to 300°C.

In Russia, 47 geothermal regions, which can provide more than 240×10^3 m^3/day of thermal water and more than 105×10^3 m^3/day of steam, have been located (Povarov, 2000). Three types of geothermal energy sources are present: Steam areas of the volcanic regions, mineralized thermal artesian pool water areas, and dilute water hydrothermal systems in the mountain region associated with rifting. The geothermal potential of these sources differs due to different nature and possible utilization (Table 4):

TABLE 4: Total power of different types of geothermal energy sources in Russia (Vasil'ev et al., 2003)

Resources	**Production of electric power with steam turbines**		**Production of electric power using binary cycle**		**Direct use**
	(MWe)	**(1000 tons/a)**	**(MWe)**	**(1000 tons/a)**	**(MWt)**
Used	73	130			430
Confirmed	159	280			
Reconnoitred	329	590	106	190	820
Potential	950-2000	1700-3600	>1000	>1800	21000

The areas utilizing geothermal resources today and methods used, include the following:

1. Geothermal steam and a steam-water mixture are used for producing electricity using steam turbines – Kamchatka and Kuril Islands;
2. Thermal waters and brines with temperatures above 90°C are used for producing electric power in a binary cycle – North Caucasus;
3. Thermal waters with temperatures of 30-90°C have been developed for direct use - North Caucasus, West Siberia, Far East.

Russia's richest geothermal resources are in the east. Kamchatka and the Kuril Islands have hot water and steam reserves with temperatures up to at least 280°C at a depth of 700-2500 m. In practice, Kamchatka and Kuril Islands have the richest resources, with a generating power capacity of up to at least 2000 MW and a heat capacity for direct use of more than 3000 MW, utilizing a steam-water mixture and hot water (Povarov, 2000). The use of geothermal resources can significantly contribute to the fuel-energy balance in Kamchatka, Kuril Islands, and North Caucasus. The main geothermal manifestations located in the prospective geothermal zones are shown in Table 5.

TABLE 5: Reconnoitred geothermal manifestations in Russia
(Vasil'ev et al., 2003)

Manifestation	Temperature (°C)	Capacity (MWe)	Mineralization (g/l)
Mutnovskoe (Kamchatka)	250	200	0.5
Pauzhenskoe (Kamchatka)	180	11	3.5
Nizhnekoshelevskoe (Kamchatka)	250	90	1-2
Okeanskoe (Iturup, Kuril Islands)	180	25	1-2
Goryachy Plyazh (Kunashir, Kuril Islands)	180	3	5-10

5. ENVIRONMENTAL REGULATIONS AND ENVIRONMENTAL IMPACT ASSESSMENT (EIA) AROUND THE WORLD

Environmental regulations throughout the world, such as that of the European Economic Community (EEC), National Environmental Policy Act (NEPA) in the U.S.A., the UN Economic and Social Commission for Asia and the Pacific (ESCAP) etc., were created to protect and conserve the environment and human health. These environmental regulations include requirements for preparing an environmental analysis for a proposed project, as well as specific laws designed to protect air, water, land and the socio-cultural environment. There is a significant variation in the numbers of agencies involved in the environmental review of a project, and the amount of time required for an application to be given project approval (Thors and Thóroddsson, 2005).

The most important aspect of these environmental regulations is the requirement for an environmental analysis report, called an Environmental Assessment (EA), Environmental Impact Assessment (EIA), Environmental Impact Statement (EIS) or Environmental Impact Report (EIR), which is applied to any developmental project. The Environmental Impact Assessment is a tool for comparing the benefits of development with an unchanged environment, an integral part of the general planning process in developing countries (Morris and Therivels, 1995).

The purpose of an EIA is to help public officials make informed decisions, based on an understanding of environmental consequences, and take proper actions. The intent should not be to generate paperwork, but to enable superb response. This requires that an EIA be analytical rather than encyclopaedic. Not only should significant environmental issues deserving of study be identified, insignificant issues should be de-emphasized, narrowing the scope of the environmental impact assessment process accordingly (Goff, 2000).

Before the advent of EIA, decision makers often looked only at economic or engineering aspects for their decisions. Such decisions systematically and unintentionally left out most, if not all, of the natural environmental consequences of man's actions (Roberts, 1991).

The environmental regulations of different countries as regards geothermal development can be considered similar. All have regulations that require an environmental analysis of a proposed geothermal project, as well as specific regulations that define the quantities that can be emitted to the atmosphere or discharged to land or water.

Russia's geothermal law: Russia has no law concerning the development of geothermal resources. The Law on Minerals governs geothermal resources (21 February 1992, No. 2395-1). Independent Power Producers (IPPs) are allowed under Russian law and may develop projects according to the scheme negotiated. However, they need not be economically feasible, due to the existing tariff structure. Russia has limited experience, to date, in joint ventures for power generation.

The primary ministries responsible for overseeing the development of the country's geothermal resources are the Ministry of Energy and the Ministry of Natural Resources. The latter ministry handles licensing. The Federal Service of Land Cadastres, which maintains and is handled by "Geolkom", is part of the Ministry of Natural Resources. The Ministry for Economic Development and Trade and the Ministry for Industry, Science and Technology are also involved in geothermal development as part of an expert commission (Ministry of Natural Resources of the Russian Federation, 2000; Sheingauz, 2003).

6. STUDY AREA

6.1 Overview of Kuril Islands

Geography: The Kuril Islands are part of the Sakhalin Region. Total land area is 156,000 km^2 with a population of about 29,000 people. The Kuril Islands can be divided into two parallel ranges, the Great Kuril Island Chain and the Small Kuril Island Chain, which together separate the Sea of Ohotsk from the Pacific Ocean. The Great Kuril Island Chain stretches for 1200 km from Kamchatka Peninsula for most the way to Hokkaido, the northernmost main island of Japan (Figure 1). It comprises more than 30 islands, the largest of which are Paramushir, Simushir, Urup, Iturup and Kunashir. The small chain, which is about 120 km long, comprises small islands close to Japan, including Shikotan. The islands are predominantly of volcanic nature covered with mountains. There are almost 150 volcanoes in the Kuril Islands and about 40 of them are active (Sakhalin News, 2005).

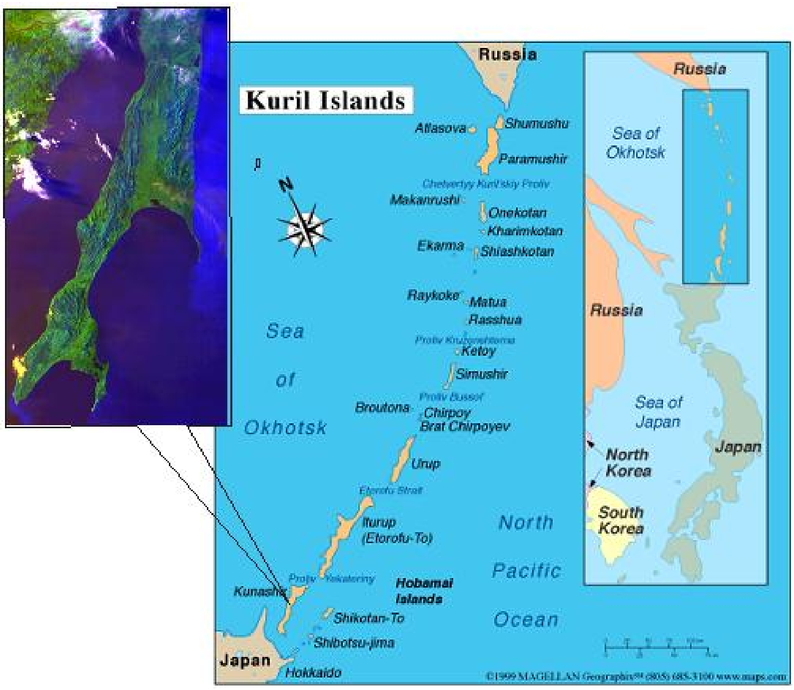

FIGURE 1: Location map of Kuril Islands showing also a satellite image of Kunashir Island (map from Yahoo, 2005)

Geology: Kuril Islands can be rightfully named volcanic, being comprised almost exclusively of rocks formed by volcanic eruptions. Volcanic formations occupy about 90% of the area. The Kuril Islands are famous for their numerous hot springs and mineral water with a wide spectrum of balneological properties.

Climate: The climate in the Kuril Islands is moderately cold monsoon. Average temperatures in the coldest month (February) are -6/7°C and in the warmest month (August) +10°C in the north and +17°C in the south. The largest number of sunny days is in August, but this season is also characterized by typhoons and hurricane winds.

Biology: The Kuril Islands abound with natural phenomena. They look like vast botanical gardens with subtropical representatives (yew, Kuril's bamboo, wild grapes and hydrangea) neighbouring flora of the polar regions (pine, alder and stone birch). Vegetation of the taiga is widely represented. Nevertheless, the high bamboo plants and gigantic herbs are the most dramatic. The Kuril Islands have huge seabird colonies with the highest seabird diversity in Asia. Red-crowned cranes (*Grus japonensis*) and other rare species breed on Kunashir and the Lesser Kurils Islands. There are 22 species of fishes in fresh-water reservoirs (humpback salmon, smelt-catfish, stickleback, flounder in one river, etc.), (Sakhalin News, 2005).

Tourism: Natural sites worth visiting include mineral springs, therapeutic mud sources, and geothermal springs with therapeutic properties, volcanoes and waterfalls. The region's uniqueness draws large numbers of tourists, who have the opportunity to visit the world-famous Goryachy Plyazh on Kunashir Island where it is possible to walk on a soft comfortable beach and get an unaided view of Japan. There are also unique archeological sites and places associated with aboriginal cultures.

Environment: The environment in this area is complex. Pollution of surface waters is caused by discharges from a pulp and paper industry, urban wastewater and the power industry. The largest contributors to air pollution in the area are the power industry, the pulp-and-paper industry, the oil-extracting industry, and transport. There is a problem in processing and destroying toxic waste.

Economy: Assessment of the geopolitical situation indicates that South Kuril is of significant importance for Russia from a strategic and economic standpoint. The economic importance of the Kuril Islands is notable.

The seas of Okhotsk and Japan and the eastern part of the Pacific Ocean are of paramount importance to the economy of the Sakhalin Region; the Far East, has the largest fisheries of the country's economic districts. The fishing industry, which has more than a 30% share in total commercial production, is the region's most developed and best-equipped industrial sector. The Sea of Okhotsk has some of the largest fish stocks among the seas bordering Russia. In recent years, fishing vessels from the area have been operating in the Indian Ocean. Factory ships and a whaling fleet have also been put into operation. The main fish processing centres are Kholmsk, Korsakov, Nevelsk and Yuzhno-Kuril'sk.

Fuel-energy complex, a key factor which provides public economic well-being on the islands, renders a significant influence upon shaping the budget and disposition of the powerful resource for further development. The development of energy in the Kuril Islands is oriented towards local natural sources of energy, such as geothermal and hydro.

6.2 General background of Kunashir Island

Kunashir means "Black Island" in the Ainu language. Kunashir - one of the great Kuril Ridge Islands - is by far the most beautiful of the islands. It is also most densely populated. It is located close to Hokkaido, it is 120 km long and, at it narrowest point, 13 km wide.

Much of the island's territory is mountainous with volcanic formations. Four active volcanoes, Tyatya, Ruruy (1465 m), Mendeleeva (890 m) and Golovnina (541 m), are located on Kunashir Island, making it a fascinating site for volcanic research. Mineral and thermal springs are found throughout the island with varying temperatures and mineral and gas compositions.

The major settlement in Kunashir is Yuzhno-Kuril'sk with a population of 4200, located on Yuzhno-Kuril'sky Cape and at Serebryanka River. It is a large port, a centre for fishing and fish processing and an emerging tourism centre. The town is crisscrossed by gravel roads and is built along the banks of the river.

Outside the city, however, with beaches serving as roads, a wonderful wild nature awaits, the island's dark coniferous forest the most conspicuous. The amount of heat-loving endemic species in the Kunashir flora is large, some only occurring on this specific island. The uniqueness of this flora was the reason for the creation of two nature reserves on the island, one in the north and another in the south. The northern part of the island is beautiful, but mostly wilderness. It is possible to climb the still active Tyatya volcano. The territory is full of bears and wild horses. The southern territory is abundant with thermal wonders and geothermal activity. Mendeleev, another volcano, is easily accessible as well as the Golovnin Caldera which has two crater lakes.

The main object of this study is the *Goryachy Plyazh geothermal system*, which is located near the Mendeleev volcano between the Kislaya and Lechebnaya rivers, 7 km, southwest of the town of Yuzhno-Kuril'sk (Figure 2). Hot springs and fumaroles are widespread in this area. The Goryachy Plyazh area is world famous. Similar natural miracles are not to be seen anywhere in the world. The strip of hot sand stretches for almost one kilometre along the coast. Here, the hot water reaches ninety-eight degrees. The water is used for heating year round as well as for bathing and laundry facilities.

On the slopes of Mendeleev volcano, there is abundant output of mineral and thermal sulphurous waters. Except for scientific value, these are primarily balneological resources. Therefore, this territory was made part of the Kuril National Park some years ago.

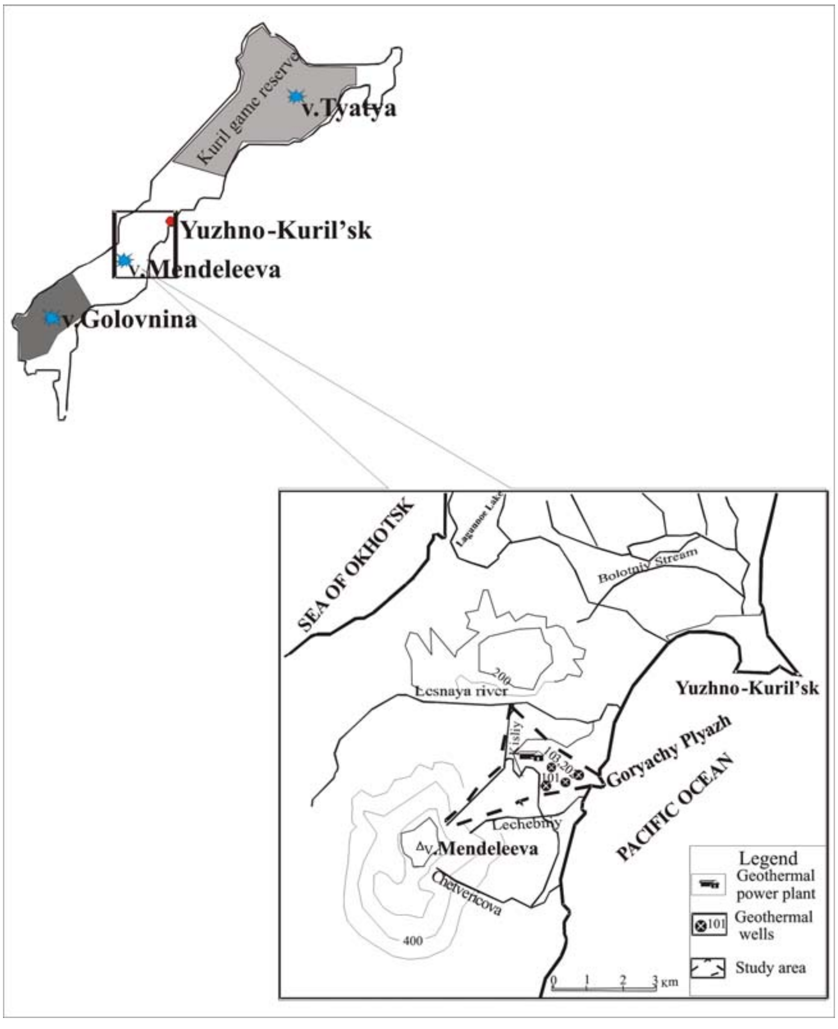

FIGURE 2: The location of the Goryachy Plyazh geothermal field

6.3 Geothermal exploitation

Hot springs and mixed water-steam springs, important for the practical use of hot water and for the power industry, are located on the Kuril Islands. Enormous amounts of steam and hot water are expelled from the depths of Mendeleev volcano every minute. The 200°C volcanic steam-water mixture is today used by two alternative installations. They provide for all the heat and hot water necessary for the village of Goryachy Plyazh. Geothermal water is used in Yuzhno-Kuril'sk in the Japanese fashion of "imperial baths". The water is 35-40°C year round. In essence, the whole island of Kunashir is swamped with geothermal water. The idea of using it for the production of electricity was put forward as far back as 70 years ago, but was implemented only 30 years ago.

In 1993 a modular geothermal power plant (N=0.7 MW) was installed on Kunashir Island, and in 1997 at the same place, a geothermal heat power plant was commissioned, too. A geothermal power plant was also installed in Paramushir Island. The capacity of the plants varies from 3 to 20 MW (Table 6). Forecast estimates for the geothermal reservoir Goryachy Plyazh – Mendeleevskoe are valued at 52 MW (Povarov, 2000). In Iturup Island, about 30 wells have been drilled and at present 8 or 4×2 MWe GeoPP are delivered there (News in Russian Electric Energy, 2002).

The resource basis of modern geothermal plants are geothermal fields with geothermal fluid temperatures higher than 150°C.

TABLE 6: Utilization of geothermal energy for electric power generation in Kuril Islands as of December 31, 2004

Locality	Power Plant	Year commiss.	No. of units	Status[1]	Type of unit[2]	Unit rating (MWe)	Tot. installed capacity (MWe)
Paramushir Isl.	Ebeko	1998	1	N	1F	2	2
Iturup Isl.	Okeanskaya	1999	4	N	1F	2	8
		2000	1		1F	1.7	n.i.
		2001	2		1F	1.7	n.i.
		2004	2		1F	1.7	3.4
Kunashir Isl.	Goryachy Plyazh	2004	2		1F	1.7	2.6

[1]N – Not operating (temporary) [2]1F – Single Flash
n.i. – no information

7. HEATING AND POWER PLANT IN THE GORYACHY PLYAZH GEOTHERMAL AREA - ENVIRONMENTAL IMPACT ASSESSMENT

7.1 Technical description

Production of electrical power from a steam-water mixture - an important step in the improvement of the standard of living for the population - was the goal of the enterprises in Goryachy Plyazh. A by-product of the production was hot water with a temperature of about 100°C. Currently the volume is about 200 tons/hr, but at full capacity, the water volume can reach more than 400 tons/hr. This quantity is sufficient to supply the heating needs of Yuzhno-Kuril´sk.

Since 2001, the geothermal plant (Appendix I), using a borehole of 1200 m depth and a 0.2 km pipeline for a steam-water mixture, has supplied heat to the village of Goryachy Plyazh. The land occupied by the station, including the powerhouse and pump, is approximately 0.03 km^2. The geothermal station (Figure 3) comprises 2 buildings housing a turbine inside with pipelines outside.

7.2 Checklist

The key elements of the project are all included in the checklist (Appendix II). Only those elements of the environment that were subject to influence are included in the discussion.

FIGURE 3: The geothermal station on the Kunashir Island (Sakhalin News, 2005)

7.3 Landscape impact and land use

Geothermal power development begins with surface exploration studies once a geothermal prospect area has been identified. Surface exploration has the least affect on the environment. There are no major environmental impacts for instance when carrying out surface geological mapping as it only involves walking across the exploration area. There could though be a slight environmental impact due to the construction of access tracks for geochemical and geophysical measurements.

Land is required for drill pads, access roads, steam lines, power plant and transmission lines. A drill rig seen from afar may be a prominent feature during drilling and can cause visual impact, but disappears after the start of production. Some people, on the other hand, like school and college groups who visit the project find drill rigs magnificently beautiful (Kubo, 2003).

Transmission lines require an area, about 40 m wide, free from overlying vegetation for a 220 kV line. Electrical power from the GeoPP in Yuzhno-Kuril´sk is transmitted via lines extending 13 km. To avoid significant losses over such a distance, voltage in the electric mains should be at least 35 kV, but is in fact 10 kV. At the present production at Yuzhno-Kuril´sk, it is not possible to transfer more than 1-1.2 MW at this voltage, or only 1/3 of all Yuzhno-Kuril´sk's needs for electrical power.

Road construction: The amount of land that is disturbed by road construction during geothermal development can be quite large. Brown (1995) estimated that about 0.35 km^2 are needed for road construction alone when drilling 4 wells. The general topography of the geothermal area has a large effect on such construction. Geothermal systems are usually located in volcanic environments with the Goryachy Plyazh area no exception, where the terrain is steep and access difficult. Furthermore, such an environment may also have severe erosion problems, particularly if rainfall is high. Rainfall in Kunashir is more than 1000 mm/year. Stabilization of roads in such an environment is difficult and the land affected by development is correspondingly increased. Road construction in such territory involves extensive intrusion into the landscape and can cause slumping or landslides with consequent loss of vegetation cover.

7.4 Air

Water is emitted to the atmosphere from a geothermal system in the form of steam (Table 7). The basic polluting component, released out into the atmosphere is hydrogen sulphide (H_2S), which is found in the initial thermal carrier. The "greenhouse gases" released are carbon dioxide (CO_2) and some methane (CH_4).

TABLE 7: Steam released into the atmosphere
(Chief engineer of ZAO "Energy Yuzhno-Kuril'sk" Lebedev, V.V., pers. comm.)

	Well 201 (main)	Well 202	Well 101	Well 103
Pair (tons/hr.)	12-14	11	4.5	9

The calculation of amounts of gases emitted is based on the production of electrical energy. Since 2001, emissions of hydrogen sulphide from the "Mendeleevskogo power unit" have increased due to the input from a new well and increased development of electrical energy.

7.5 Vegetation

About 1055 species of plants are registered on Kunashir Island (Figure 4), the main vegetation being Kuril's bamboo. Also on Kunashir Island there are widespread dark-coniferous woods with a mixture of broad leafy types. Many plants, such as *Magnolia obovata* sprout, are only found here. A unique combination of dark coniferous wood and Kuril's bamboo is typical south of the Sakhalin, on the south Kuril Islands and Hokkaido. This ecosystem needs protection (Sakhalin Regional Museum, 2005).

The condition of the vegetation cover is an integral factor in the condition of the environment. The aspectual, spatial and ecological structure of the phytocenosis, indicators of the condition of ecosystems as a whole, are characterized by their changes. Monitoring the vegetation cover is a basis for complex ecological monitoring for studying anthropogenic influences on nature.

FIGURE 4: Vegetation on Kunashir Island

Investigation of a steam-water deposit around Goryachy Plyazh showed that the vegetation has undergone significant anthropogenic changes; at some sites the vegetation was destroyed, on others plant community types were changed. Although construction and maintenance were basically carried out in the broken territories, the process of influence on the vegetation continued, changed only in the intensity of its effects. We can describe the following types of influence on the vegetation:

- The vegetation cover was removed during drillsite preparation and the construction of buildings, pipeline, power lines and roads. This effect is partly reversible because the drill site can be re-vegetated with the same species after drilling and well testing are completed.
- Changes of a vegetation cover as a result of steam release during testing of wells.
- Influence on vegetation by discharged water.
- Change of the vegetation, connected with change by hydrological balnelogical and recreational use of hot springs of Goryachy Plyazh
- Actions of geothermal power and heating plant (large amounts of steam emitted to the atmosphere) led to ruined vegetation in the vicinity of the GeoPP in the Goryachy Plyazh area (radius 100 m) (Figure 5).

FIGURE 5: Destruction of vegetation in vicinity of the GeoPP plant (photos by O.V. Chudaev)

7.6 Fauna

The richest fauna of the Kuril Islands is birds, with more than 260 species, and 4 species of reptiles, including three species of snakes and one specie of lizard, the - Far East Szink (Figure 6). There are three species of amphibians on the island. The major big animal is the brown bear. Whitetails, white shoulder bald eagles, and golden eagles are rare. The largest nocturnal ravenous bird is a fish eagle owl; only several groups of ten pairs remain in the world, (State Nature Reserve Kuril'sky, 2005).

During exploration for geothermal energy in this area, animals are unlikely to be affected. During construction of roads, the preparation of drill sites and drilling, the noise from the drill and well testing would cause most animals to move from the vicinity.

The most significant effect of geothermal power plant operation on animals is air pollution: the sensibility threshold of animals to the smell of gas is the same as for humans. The same applies to water pollution. On Kunashir Island, changes in the number of Far East Szink (*Eumeces latiscutatus)* which lives only in the southern and central parts of the island, were observed. This specie generally gravitated to areas on the edge of thermal waters. Principal causes of a decrease in numbers could be pollution and the destruction of habitats by warm effluents from drill holes (Korotkov and Borkin, 1989).

7.7 Noise

Usually, noise occurs during exploration drilling and construction phases. Limited information on the effects of noise from geothermal projects, such as drilling and well testing, on the environment exists, see e.g. Brown (1995). The greatest noise during power plant operation is from the cooling tower, transformer, and turbine-generator building. When the power plant started work, mufflers were used to keep the noise levels below 65 dB (limit set by the U.S Geological Survey (D'Alessio and Hartley, 1978)) in order to minimize environmental impacts.

7.8 Seismic activity

About 40-50 years ago, the government of the USSR considered drilling wells near an active volcano economically advantageous. But without constant monitoring of a volcano's activity, one cannot predict its behaviour, which may affect the well's function, It may be damaged or destroyed as a result of earthquakes.

There may be another side to seismic activity of a volcano. In February-April, 1997, a swarm of earthquakes (more than 200) with a focal depth larger than 20 km occurred beneath the Mendeleev volcano. The earthquakes may have been triggered by changes in a stress field in the upper crust, possibly in response to drilling at the Goryachy Plyazh geothermal field. Speculations have at least been put forward that the activization of the magma source of the volcano was caused by this activity (Abdurakhmanov et al., 2004).

FIGURE 6: Fauna on Kunashir Island

7.9 Effect on water

When assessing the characteristics of the chemistry of the springs, rivers and streams, reference is made to Russian and European standards of water quality for drinking water and aquatic life. In general, the geothermal waters with the highest pollution potential are those of high salinity and are discharged from very hot reservoirs. As pointed out by Ellis (1978), the concentrations of heavy metals in geothermal waters tend to increase in proportion to the square of the mineralization. The most common pollutants in geothermal waters are hydrogen sulphide, arsenic, boron, mercury, aluminium and some other trace metals (Ármannson and Kristmannsdóttir, 1992).

The geothermal group of the Far East Geological Institute collected water samples from wells and hot springs along the Kislaya River in 2004. The water samples were filtered on site through a 0.45 µm pore filter into low-density polyethylene bottles using a polypropylene filter holder. Measurements of pH, Eh, conductivity, carbonate carbon and dissolved oxygen were carried out on site. Major ion concentrations were analysed using colorimetric, AAS and ICP-AES methods. The trace elements were analysed by ICP-MS. Table 8 shows the chemical composition of water from the Goryachy Plyazh wells. Thermal waters from these high-temperature wells display some variations in dissolved solids (TDS) and individual elements content.

Trace element analyses of waters from the Kislaya River are presented in Table 9. The contents of Fe, Al, As, Mn and Zn are higher than permissible values for drinking water according to European Union standards, and for aquatic life according to Russian standards.

In the future, a prepared water-steam mixture, currently dumped into nature, will be used for drying seaweed and for a balneological complex.

TABLE 8: Chemical composition of thermal water from the Goryachy Plyazh geothermal field (Chudaev et al., 2005)

Components	**Main well**	**Well 101**	**Well 103**	**Well 202**
Depth (m)	1200	1000	1000	1000
Flow (tons/hr.)	40	-	-	11
pH	7.07	4.91	5.8	7.86
Concentration (ppm)				
Cl	1260	4193.3	133.3	2600
SO_4	203.3	26.7	3.35	14.5
Total Fe	1.7	44.86	8.69	0.16
SiO_2	71.17	163.8	21.57	219
TDS	2370	7020	286	4.04
Al	0.0205	0.06	0.0015	0.234
Pb	0.00	0.00	0.00	0.00
Zn	0.0018	0.0045	0.003	0.00002
Ag	<0.0001	0.0001	<0.0001	<0.0001
Cu	0.045	0.198	0.0077	0.0913
Ni	0.0011	0.443	0.0002	0.0004
Cd	0.0001	0.00002	0.0001	0.000005
Mn	0.7045	3.380	0.269	0.0382
Co	0.0001	0.052	-	0.00011
Hg	0.0002	0.0002	0.0002	0.00024
As	0.493	0.997	0.059	0.0015

TABLE 9: Water quality standards and average concentrations of trace elements in surface water at Goryachy Plyazh geothermal area (Chudaev et al., 2005)

Components	**Average in surface water**	**Recommended maximum**	
		European Union standard[1]	**Russian standard[2]**
pH	3.03	9.5	7-8
TDS	456.5		
O_2 (dissolved)	7.6		Not less 7-8
Concentration (ppm)			
Cl	76.834		5
SO_4	96.686	250	5
Total Fe	**14.546**	0.2	0.3
Al	**9.26**	0.2	
Pb	0.013	0.05	0.1
Zn	**0.136**		0.01
Ag	0.00	0.001	
Cu	0.003	2.0	0.01
Ni	0.003	0.02	0.01
Cd	0.001	0.005	0.005
Mn	**0.424**	0.05	50
Co	0.005		0.01
Hg	0.00	0.001	
As	**0.055**	0.01	0.05

[1]European Union standard for domestic waters;
[2]Russian standard for water supply of salmon fishing farm;

7.10 Visual effects

The geothermal development in Goryachy Plyazh area is very noticeable due to the nature of the landscape. Unfortunately, "development of the thermal riches" on Kunashir Island has also led to degradation of natural thermal springs. The existence of Goryachy Plyazh as a recreational territory is threatened. On a spot where several years ago you could take a hot bath, only small streamlets flow today. Natural outlets of thermal water along the seacoast of Mendeleev volcano have run low because of water exploitation for a greenhouse (at present not in operation), and a small factory for manufacturing pemzo-blocks (no longer in operation). Other visual impacts are due to the road, power lines, power plant buildings and the emission of steam.

7.11 Socio-economic effects

Electricity prices for residents on the Kuril Islands are the highest in the country. The economical benefit that people experience from the exploitation of geothermal energy is primarily a lower price for their electricity and hot water. Electrical power on Kunashir Island is supplied by engine generators for reception electricity, and coal boiler-houses used for industrial heating and house heating. Today, the use of fuel "eats" almost one third of the regional budget - tens of millions of roubles. Therefore, construction of a geothermal power plant to provide all the electrical power for the city of Yuzhno-Kuril'sk and the settlement of Goryachy Plyazh would be economically beneficial. At the same time, geothermal energy would save more than 10 thousand tons of oil and lower the negative effects of emissions from fuel burning into the atmosphere.

7.12 Tourism

The development of geothermal energy in this territory might bring more tourism and visitors. Kunashir Island could become a prime objective for international tourism in the Far East. The area consists of re-vegetated land that has pedestrian tracks that may attract tourists. Tourist sites on the island are unique: different geothermal sources, balneological clay etc. (Figure 7). On the basis of these sources, it is possible to create splendid tourist complexes, emphasizing the ecology, sports, hunting, fishing, and scientific and adventure tourism (source: Pressroom of the Administration of Sakhalin area). After the solution of power problems, the island could become a favourite vacation spot not only for tourists from Russia, but from Japan, USA and other countries (Sakhalin News, 2005).

FIGURE 7: Tourist potential on Kunashir

8. CONCLUSIONS

The large-scale development of using local renewable sources of energy, i.e. geothermal and hydroenergy on the Kuril Islands started in 1993 with the operation of the first geothermal power station (500 kW) on Kunashir Island. The price of the electrical power produced is less than half the cost of using a diesel power station in this region. In 1997, a geothermal heat power plant was taken into operation.

Construction and operation of GeoH&PP on Kunashir Island has had a large economical benefit for the people living in this area. The geothermal plant is located close to the settlement and people are directly affected by the utilization in this area.

In this paper, the environmental impact of operation in this area is evaluated:

- During construction of roads, preparation of drill sites and drilling, there are effects on the vegetation and fauna and visual effects on the land.
- Noise from the drill rig and well testing drives most of the animals away from the vicinity of the drill rig. When the power plant started operation, noise mufflers were used to keep the environmental noise levels below 65 dB. This level is not dangerous to animals or humans.

The main environmental impact of the operation is air pollution with a consequently negative effect on vegetation and fauna:

- Hydrogen sulphide (H_2S) is released to the atmosphere during power plant operation. In high concentrations in steam it can have an effect on vegetation (mainly wood) in the area and has led to the destruction of vegetation in the vicinity of the plant.

In addition, high concentrations of trace elements in water from the wells have had an adverse effect on the surface water quality in the area. The main pollutants in this water, according to chemical data, are Cl, Mn, Al and As.

However, such adverse factors are balanced against the more obvious advantages of using geothermal energy: geothermal energy has great potential in Kunashir Island and plays an important role in developing the local economy.

ACKNOWLEDGEMENTS

I would like to give my grateful thanks to Dr. Ingvar B. Fridleifsson, director of the UNU Geothermal Training Programme, for his helpful guidance, Mr. Lúdvík S. Georgsson, deputy director, for offering me the great opportunity to participate in this special training, and Mrs. Gudrún Bjarnadóttir for her unceasing help during the time of my stay in Iceland. My special thanks go to my supervisor, Dr. Gunnar Steinn Jónsson for his great help and critical advice during all stages of the preparation of this report; and Einar Gunnlaugsson and Halldór Ármannsson for sharing their knowledge and experience in geothermal utilization. I would like to thank all lecturers and staff of Orkustofnun/ISOR. I am also grateful to the other UNU Fellows for mutual support over these six months.

In addition, I express my thanks to my colleagues from the Pacific Institute of Geography and Far East Geological Institute of Russian Academy of Sciences; special thanks to Dr. Valentina A. Chudaeva and Dr. Oleg. V. Chudaev for supplying the data presented here. Finally, I want to express my gratitude to my family and friends who have been supportive throughout my six months absence from home.

Finally, some photos used in composite figures (Figures 4, 6 and 7) were taken from the following sources: Via Grande (2005, photos by V. Shtrik), Sakhalin Regional Museum (2005), and Fauna (2005) and not referred to at the figure locations. Here, my thanks are acknowledged.

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APPENDIX I: Feature of the GeoH&PP on Kunashir Island (Povarov, 2000)

Location:	Far East economic district, Sakhalin Oblast, on the eastern shore of Kunashir island, the most southern in the Kuril Archipelago.
Status:	Power plant(s) on site / direct use developed.
Temperature (°C):	70-105
Installed capacity (MWe/MW):	0.7/20
Potential (MWe):	0.7
Chronology:	1992 – The 700 kWe single flash Goryachy Plyazh GeoPP went online. The small condensing unit, which was constructed at Kaluga Turbine Works SC, is inexpensive, rapidly constructed, and easy to operate and maintain. 1997 – A 20 MW geothermal heat plant (GeoHP) was put in to operation. 2000 – Power plant is not operating. 2002-2004 – Industrial platform GeoPP with the established capacity 1,8 MW ais put into operation. 2005-2006 – Planned to realise the project's full capacity, 3.6 MW with the connection of the second power module and to perform works on a heat supply providing submission of heat in the regional centre Yuzhno-Kuril'sk.
Notes	Geothermal resources are used to provide district heating for Yuzhno-Kuril'sk. The geothermal field is located in a narrow coastal stretch, about 1 km long and ¼ km wide. The geothermal water systems is bedded in a fissured Neogene layer of tuffs, sandstone, conglomerates, and redeposit volcanic rocks and has total thickness of 570 m (Stovanov and Taylor, 1996). The geothermal stream resource had a potential of 4147 m^3/day. Demand is 3.5×10^3 m^3/day; 1.8 MPa pressure at wellhead; 3.5-10 g/l mineralization.

APPENDIX II: Environmental Impact Checklist for geothermal utilization in the Goryachy Plyazh area

Subjects	Drilling		Construc-tion		Operation	
	Yes	No	Yes	No	Yes	No
1. Earth. The proposal has resulted in:						
a. Unstable earth conditions or in changes in geologic substructures?	X		X			X
b. Disruptions, displacements, compaction or over covering of the soil?	X		X			X
c. Change in topography or ground surface relief features?	X			X		X
d. The destruction, covering or modification of any unique geologic or physical features?		X		X		X
e. Any increase in wind or water erosion of soils, either on or off the site?		X		X		X
f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion, which may modify the channel of a river or stream or the bed of the ocean or any bay, in let or lake?		X		X		X
g. Exposure of people or property to geologic hazards such as earthquakes, landslides, mudslides, ground failure, or similar hazards?	X			X		X
2. Air. The proposal has resulted in:						
a. Substantial air emissions or deterioration of ambient air quality?		X		X	X	
b. The creation of objectionable odours?	X			X	X	
c. Alteration of air movement, moisture, or temperature, or any change in climate, either locally or regionally?		X		X		X
3. Water. The proposal has resulted in:						
a. Changes in currents, or the course of direction of water movements, in either marine or fresh water?		X		X		X
b. Changes in absorption rates, drainage patterns, or the rate and amount of surface water?		X		X	X	
c. Alteration to the course or flow of flood waters?		X		X		X
d. Change in the amount of surface water in any water body?	X			X	X	
e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen or turbidity?	X			X	X	
f. Alteration of the direction or rate of flow of ground waters?		X		X		X
g. Changes in the quantity of ground waters, either through direct additions or withdrawals, or through interception of an aquifer by cuts or excavations?	X			X	X	

h. Substantial reduction in the amount of water otherwise available for public water supplies?		X		X		X
i. Exposure of people or property to water related hazards such as flooding tidal waves?		X		X		X
4. Plant life. The proposal has resulted in:						
a. Changes in the diversity of species, or number of any species of plants (including trees, shrubs, grass, crops, aquatic plants)?		X		X	X	
b. Reduction of the numbers of any unique rare or endangered species or plants?	X			X	X	
c. Introduction of new species of plants into an area or in a barrier to the normal replenishment of existing species?		X		X		X
d. Reduction in acreage of any agricultural crop?		X		X		X
5. Animal life. The proposal has resulted in:						
a. Change in the diversity of species, or number of any species of animal (birds, land animals such as reptiles, fish and shellfish, benthic organism or insects)?		X		X		X
b. Reduction of the numbers of any unique, rare or endangered species of animals?	X			X	X	
c. Introduction of new species of animals into an area or in a barrier to the mitigation or movement of animals?		X		X		X
d. Deterioration to existing fish or wildlife habitat?	X			X		X
6. Noise. The proposal has resulted in:						
a. Increases in existing noise levels?	X		X		X	
b. Exposure of people to severe noise levels?	X			X		X
7. Light and glare. The proposal produced new light or glare?	X		X		X	
8. Land use. The proposal has resulted in a substantial alteration of the present or planned land use of an area?						
Present:		X		X		X
Planned:		X		X		X
9. Natural resources. The proposal has resulted in:						
a. Increases in rate of use of any natural resources?		X		X	X	
b. Substantial depletion of any non-renewable natural resources?		X		X		X
10. Risk of upset. The proposal has involved:						
a. A risk of an explosion or the release of hazardous substance (including but not limited to oil accident, chemical or radiation in the event of an accident or upset conditions)?		X		X		X
b. Possible interference with an emergency response plan or emergency evacuation plan?		X		X		X
11. Population. The proposal has changed the location, distribution, density or growth rate of the human population of an area?	X		X			X
12. Housing. The proposal has mentioned existing or has created a demand for additional housing?	X		X		X	
13. Transportation/circulation. The proposal has resulted in:						
a. Generation of substantial additional vehicular movement?	X		X		X	

b. Effects on existing parking facilities or demand for new parking?		X	X		X	
c. Substantial impact upon existing transportation systems?		X	X		X	
d. Alteration to present patterns of circulation or movement of people and/or goods?		X		X		X
e. Alteration to waterborne, rail or air traffic?		X		X		X
f. Increase in traffic hazards to motor vehicle, bicyclists or pedestrians?		X		X		X
14. Public services. The proposal has an effect in any of the following areas:						
a. Fire protection?		X		X		X
b. Police protection?		X		X		X
c. Schools?		X		X		X
d. Parks or other recreational facilities?		X		X		X
e. Maintenance of public facilities, including roads?	X		X		X	
f. Other governmental services?		X		X		X
15. Energy. The proposal has resulted in:						
a. Use of substantial amounts of fuel or energy?		X		X	X	
b. Substantially increased demand upon existing sources of energy or require the developm. of new sources of energy?		X		X		X
16. Utilities. The proposal has resulted in a need for new systems, or substantial alterations to the following utilities:						
a. Power or natural gas?		X		X	X	
b. Communications systems?		X		X	X	
c. Water?	X		X		X	
d. Sewer or septic tanks?		X	X		X	
e. Solid waste and disposal?	X		X		X	
17. Human health. The proposal has resulted in:						
a. Creation of any health hazard or potential health hazard (excluding metal health)?		X		X		X
b. Exposure of people to potential health hazards?		X		X		X
18. Aesthetics. The proposal has resulted in the obstruction of any scenic vista or view open to the public or the proposal has resulted in the creation of an aesthetically offensive site open to public view	X		X		X	
19. **Recreation.** The proposal has resulted in an impact upon the quality or quantity recreational opportunities?	X		X		X	
20. Cultural resources.						
a. The proposal has resulted in the alteration of or the destruction of a prehistoric or historic archaeological site?		X		X		X
b. The proposal has resulted in adverse physical or aesthetic effects to a prehistoric or historic buil. structure or object?		X		X		X
c. Does the proposal have the potential to cause a physical change, which would affect unique ethnic cultural values?		X		X		X