FY2003
Feasibility Study on the Clean Development Mechanism and Joint Implementation for Prevention of Global Warming

Fundamental Study on Introduction and Application of Geothermal Heat Pump Systems to District Heating in Irkutsk, Russian Federation

Summary Report

March 2004

Japan Metals and Chemicals Co., Ltd.

Name of the study:	Fundamental Study on Introduction and Application of Geothermal Heat Pump Systems to District Heating in Irkutsk, Russian Federation
Commissioned company:	Japan Metals and Chemicals Co., Ltd.
Preparation date:	March 2004

Objective of the study

This is a basic study conducted with regard to the replacement of a part of existing heating systems with geothermal heat pumps in order to reduce the amount of greenhouse gases emitted from conventional regional heating systems that use fossil fuels.

Foreword

This report summarizes the results of "Fundamental Study on Introduction and Application of Geothermal Heat Pump Systems to District Heating in Irkutsk, Russian Federation". This basic feasibility study was conducted as part of the FY2003 Feasibility Study on the Clean Development Mechanism and Joint Projects to Combat Global Warming.

Japan Metals and Chemicals Co., Ltd. was commissioned to conduct this study by the Global Environment Centre Foundation. The foundation has provided us with great support and careful guidance. In addition, the Russian Academy of Sciences, JSC "Irkutsk-Energo", Grand Baikal, LLC, and the Irkutsk Oblast Government has offered us full cooperation in relation to field surveys. We would like to express our deepest appreciation for all the support and cooperation.

March 2004

Shukuro Yonetsu
President
Japan Metals and Chemicals Co., Ltd.

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I. Outline of the study

1. Objective

This study has been conducted as part of the Study on Projects for the Clean Development Mechanism for Prevention Global Warming. This is the basic feasibility study in relation to the replacement of part or all of existing heating systems with geothermal heat pump systems in order to reduce the amount of greenhouse gases emitted from conventional regional heating systems that use fossil fuels in Irkutsk Oblast in the Russian Federation.

2. Contents

A heat pump system for heating is designed on the basis of data obtained from field surveys, and analyses of the system are conducted in relation to the effect of a reduction of greenhouse gas emissions, leakage, monitoring, environmental impact assessment, cost-effectiveness, the effect of a project and other matters. Based on the results of this analysis, the technical and economic aspects of the system are examined, and the feasibility of a project that employs this system is assessed. In addition, the institutional aspect related to this system is also examined. This study was conducted in relation to resort facilities owned by Grand Baikal, LLC. The site of the study is located on the right side of the Angara River in the suburbs of Irkutsk City in Irkutsk Oblast. In the resort facilities, water is heated using electric boilers and the hot water is used for heating within the buildings, and provided to a swimming pool and recuperation facilities.

3. Process

This study went through the examination of existing data, the study of the existing heating system, the design of a heat pump system for heating, the assessment of its technical and economic aspects, and a study on the system in terms of a JI project. The field survey was conducted three times to investigate the site of a project, to collect a variety of data, and to study technical aspects with Russian counterparts.

4. Executive organizations

Japan Metals and Chemicals Co., Ltd. was commissioned to conduct this study. The Energy Division of this company played a leading role in conducting this study. The company outsourced part of the design for the heat pump system for heating to JMC Engineering Co., Ltd. Russian counterparts were the Russian Academy of Sciences, JSC “Inkutsk-Energo” and Grand Baikal, LLC.

5. Results

The premise of this project is that a heat pump is utilized in an existing system for heating and supplying hot water within the range of temperatures the heat pump can supply. This will contribute to a reduction in the amount of electric energy consumption and the amount of greenhouse gas emissions. The heat pump system is composed of a heat pump, a brine pump, a hot raw water pump, a grit removal pump and a hot water pump. The following are details of the expected decline in the amount of greenhouse gas emissions that would result from the operation of this system: In the existing system to produce hot water, baseline electricity consumption is 12,578 MW/year, coal consumption 8,100 tons/year, and CO_2 emissions 23,898 tons/year. By contrast, electricity consumption would be 8,403 MW/year, coal consumption 5,412 tons/year, and CO_2 emissions 15,916 tons/year if the project is implemented. The amount of CO_2 emissions would decrease by 7,982 tons/year.

The result of the assessment of the economic aspects was summarized from the viewpoints of the payback period, and costs required for CO_2 emissions reduction. Total investment for introduction of Heat Pump System is estimated as 1,109 thousand US$ in case of 50% load, and 2,152.3 thousand US$ in case of 100% load. The payback period is about four years in both cases.

II. Basic information on the Russian Federation

1. General information

The territory of the Russian Federation is the largest in the world. Its area is 17,075,200 km^2, including the area of inland waters of 79,400 km^2, for example, the Caspian Sea. The climate is a continental cold type in general, and there is a great difference between temperatures in summer and in winter. This country has a population of 144,526,278 as of July 2003.

2. Government

The formal name of this country is the Russian Federation. The system of government is republican, with 89 administrative units, such as republics and oblasts.

3. Economy

The Russian economy plunged into a financial crisis in 1998, but took an upward turn in 1999, and there was 10% growth in GDP in 2000. Leading industries include the mining industry, such as oil, natural gas, coal, iron ore, gold and diamond, the steel industry, the machine industry, and the chemical industry. Main exports include oil, natural gas, lumber, gold, and nonferrous metals. On the other hand, main imports include machinery and equipment, food products, and grain.

4. Energy

This country is endowed with an abundance of natural resources. The confirmed deposits of the sources of primary energy include 157 billion tons of coal, 6.7 billion tons of crude oil, and 4,770 billion tons of natural gas. The basic Russian strategy for energy is improvement in efficiency of energy consumption and energy conservation.

5. The environment

Environmental conservation is one of the long-term national policies formulated by the Russian government. Specifically, the Russian government considers that industrial activities involving the development and the use of energy and the conservation of the natural environment or ecosystems should be compatible with the process of social development. Environmental pollution, however, has arisen with industrial development, and various social problems have also arisen. The most serious environmental problems include air pollution and groundwater contamination caused by the emission and discharge of hazardous substances from heavy and chemical industries.

6. Efforts for JI

A numerical target was established as part of the Kyoto Protocol in which developed nations would reduce the amount of greenhouse gas emissions by 5.2% in total from the 1990 level over the period from 2008 to 2012. In accordance with this target, Russia is required to control the emissions to the same level as 1990. Up to the present, Russia has not ratified the Kyoto Protocol. In the State Duma, however, the awareness of the protocol has been rising, and it is estimated that a group that is positive about the ratification of the protocol has been expanding. It should be noted, however, that there are pros and cons in relation to the ratification.

7. Significance and the need for this project

The Russian Federation government and oblast governments have been promoting a policy to convert energy generated from fossil fuels, for example, coal, to clean energy with lower greenhouse gas emissions. There is a variety of heat sources for heat pumps, and they are universal on this planet. Under these circumstances, there is a great need for heating and hot water supply systems using heat pumps in the whole of Russia, including Irkutsk Oblast.

III. Information on Irkutsk Oblast, such as information on energy

1. Geography and the environment

Irkutsk Oblast is situated in the center of Asian Russia, extending in areas along upper reaches of the Angara, Lena and Nizhnyaya Tunguska rivers that flow through the southern part of East Siberia. The area of the oblast is 774,800 km^2, which accounts for 4.6% of all the area of the Russian Federation. At the beginning of 2004, the population of the oblast was 2.7 million, including that of Ust-Ordynsk Buryat Autonomous District. The density of its population is as low as 3.4/km^2, compared with the average population density of the whole Russia of 8.7/km^2. The climate of the oblast is a typical continental cold one. Its winter is long and cold, and in summer there is relatively abundant precipitation. There is frost for long periods. The main environmental problem in Irkutsk Oblast is air pollution in urban and industrial areas.

2. The society and economy

Irkutsk Oblast is divided into 33 okrugs, and there are 37 administrative units in the oblast, including six okrugs in the Ust-Ordynsk Buryat Autonomous District. The capital of the Oblast is Irkutsk City which has a population of 578,000. The main industries include mining, energy, aluminum, petrochemicals, lumber, paper and pulp, and heavy machine industries. The gross regional product of Irkutsk Oblast reached 10,690 million rubles in 2000 in terms of present price levels. This figure indicates 6.1% growth over the previous year.

3. Geology and hydrogeology

The western part of Irkutsk Oblast is the Siberian platform (Precambrian) and its eastern part is the Trans-Baikal fold mountains (Paleozoic). The border area between the two parts is referred to as the Baikal rift zone (the Lake Baikal area). One of the features of Siberian geology is permafrost with a depth of several to tens of meters.

There are underground water-recharging areas in the complex composed of strata containing water and the Quaternary to Cambrian deposits.

4. Power supply

Thermoelectric generation and hydroelectric generation are key power industries in Irkutsk Oblast. Their rated power reaches 13,251.6 MW. The peak output of 75,480 million kWh was recorded in 1989, and the highest amount of thermal energy of 44.8 million Gcal was supplied in 1991. Both power output and the amount of thermal energy supply declined slightly in 2002.

5. Heating system

Heat is supplied through thirteen thermoelectric power stations of JSC “Inrkutsk-Energo” and four other thermoelectric power stations. There are basically two types of heat supply systems in the oblast: the centralized system and the non-centralized system. In the heating system, the highest temperature of the supplied heating medium is set at 95ºC, and the temperature of backwater is set at 70ºC.

6. Water supply system

The amount of water used in Irkutsk Oblast is 175 to 180 km^3 in a year. Daily water consumption per person is 307 L. There are 203 centralized water supply systems in the oblast.

7. Billing rate policy

There are two types of billing rate systems in Irkutsk Oblast.

8. Energy supply to remote areas

There are as many as 130 residential areas that are excluded from the centralized power supply network in the oblast. Since there are considerable distances between the trunk roads and the remote residential areas, and routes for the transportation of fuel are complex, the cost of energy has become higher.

9. Energy facilities of representative areas

A survey was conducted at facilities in six representative areas in relation to heating facilities, weather conditions, heat consumption, and the specifications of heating and hot water supply systems.

IV. Contents of the project

1. Objective

This project is a basic study in relation to the replacement of part or all of existing heating systems with heat pump systems in order to reduce the amount of greenhouse gas emissions in Irkutsk Oblast in the Russian Federation.

2. Site of the project

The site of the project is located 43 km from Irkutsk City in Irkutsk Oblast in the Russian Federation, and on the right side of the Angara River. The project will be implemented at the resort facilities, the Health and Holiday Center “ELEKTRA,” managed by Grand Baikal, LLC. Since the resort facilities are situated in a scenic location, utmost attention is paid to environmental conservation in the surrounding areas. Clean energy is therefore required as a heat source for heating systems. An existing heat source is power-generated at a thermal power station using coal. Hot water is produced using electric boilers with low thermal efficiency.

3. Contents of the project

Part of the existing heating system is replaced with a heat pump system for heating at the site of this project. The existing heating system is composed of hot water production and supply equipment (including four electric boilers), utilization facilities (including buildings, recuperation facilities and a swimming pool), and wastewater treatment facilities. The newly constructed heat pump system for heating mainly operates as hot water production equipment, including a heat exchanger, a heat pump, a mixing tank and a hot water reservoir.

4. Russia’s position on this project

Russia recognizes the need for the modernization of centralized heating systems and equipment to improve efficiency from the viewpoint of its energy conservation policy. Russia also recognizes the need for conversion from heating systems that emit a great amount of CO_2 to clean heating systems from the viewpoint of its environmental conservation policy. The direct counterpart in relation to this project is Grand Baikal. BBL receives technical and financial support from the Russian Academy of Sciences and JSC “Inrkutsk-Energo”. Technology will be transferred to the counterpart through on-site technical guidance at each stage of the design, construction and trial operation of the hot water production and supply system using a heat pump.

5. Technical contents

Pumps for fluids, for example water, are devices to send fluids from low positions to higher positions. Similarly, heat pumps are devices to send heat from heat accumulations at low temperatures to heat accumulations at higher temperatures. The heat pumps can be used with river water, groundwater, wastewater and well shafts as heat sources.

The existing heating systems produce hot water using electric boilers. These boilers are operated by power generated at thermal power stations using coal. Consequently, CO_2 emission is inevitable. The heat pump system would contribute to a reduction in the amount of CO_2 emissions by reducing the amount of consumed power from the present level.

V. Methodology of the baseline

1. Baseline system

The baseline refers to a scenario in relation to the amount of greenhouse gas emissions if this project is not implemented. The baseline system in this project is defined as a heat supply system using power generated at thermal power stations using coal.

2. Details of the baseline

The boundary line of this project site can be clearly drawn because the site is completely separated from residential areas or villages in the vicinity. Reduction in CO_2 emissions is limited to the reduction in CO_2 emitted from the heating and hot water supply system within the project site.

In the process of producing hot water during this project, water is heated to a temperature of 55 ºC using a heat pump. This production of hot water would result in halving the power consumed by electric boilers, and the amount of CO_2 emissions would also be halved because the amount of reduced CO_2 emissions is proportionate to the amount of reduced power consumption.

The baseline annual power consumption is 12,578 MW. If heat generated using the heat pump is still generated using the electric boilers, power consumption would be 7,969 MW/year. Since the coefficient of performance (COP) of the heat pump is 2:1, power consumed by the heat pump would be 3,795 MW/year. Consequently, 4,174 MW/year of power would be reduced. The amount of power reduced accounts for 33.2% of the baseline annual power consumption. The baseline amount of greenhouse gas emissions is 23,898 tons of CO_2 per year. By contrast, if this project is implemented, the amount of greenhouse gas emissions would be 15,964 tons CO_2 per year. This is derived from the following formula: amount of greenhouse gas emissions = amount of baseline greenhouse gas emissions (tons/year) x (1 - Reduction rate). Consequently, the amount of reduced greenhouse gas emissions is 7,934 tons of CO_2 per year if this project is implemented.

There are no CO_2 emissions within the site of the project. CO_2 is emitted from the thermal power station using coal outside the site of the project. In the calculation, the change in the CO_2 emissions is dealt with as the change in the baseline, and it is assumed that there is no leakage.

VI. Effects of the project

1. Energy conservation effect

The baseline amount of power consumption is 12,578 MW per year. The amount of crude oil consumption is 3,195 kL/year. If heat generated using the heat pump is still generated using electric boilers, 7,969 MW of power would be consumed per year. Accordingly, 2,024 kL of crude oil would be required to generate this amount of power per year. 3,795 MW/year of power would be consumed in order to operate the heat pump. This corresponds to the annual consumption of crude oil of 964 kL. Since the COP of the heat pump system is 2:1, the reduction in energy is 964 kL in terms of crude oil. The energy conservation effect by use of the heat pump is therefore 1,060 kL in terms of crude oil.

2. Effect of reduction in greenhouse gas emissions

The table below indicates the effect of reduction in the amount of CO_2 emissions by means of this project.

	Electricity consumed	Coal consumed	CO_2 emissions
Baseline case	12,578 MW/year	8,100 ton/year	23,898 ton/year
Project case	8,403 MW/year	5,412 ton/year	15,916 ton/year
Reduction	4,175 MW/year	2,688 ton/year	7,982 ton/year

3. Potential of the introduced technology

This project aims to reduce the amount of CO_2 emissions by improving the efficiency of energy conversion. River water, groundwater, wastewater and well shafts can be used for the heat pump system as heat sources. If the conventional system using electric boilers is employed in combination with the heat pump system, CO_2 emissions can also be reduced. By utilizing existing facilities and equipment, the operation of heating and hot water supply systems can be maintained without great change. If the system introduced by this project is adopted in the whole of Irkutsk Oblast, the amount of reduction in consumed energy would be 427 (1,709/4) times the value resulting from the trial calculation. The amount of reduction in CO_2 emissions would be 1,564,590 tons/year. The system used in this project can be adopted not only in Irkutsk Oblast, but also in the whole of the Russian Federation, so the potential market is very wide and there would be considerable effect in conserving energy.

4. Other effects

This project would also promote a cooperative relationship between Japan and the Russian Federation at both the private level and national level.

VII. Environmental impact analysis

There would be no environmental impact caused by power generation because power is not generated on the site of this project. In addition, since there would be a decline in the consumption of power that is generated at a thermal power station, it is believed that the project would not harm the environment outside of the project site.

VIII. Financial plan of this project

1. Financial plan

   The funds required for this project will be covered by investments from Japanese companies and Russian companies and loans from Japanese and Russian banks.

2. Information on public funds

   ODA can be pointed out in relation to public funds.

3. Prospect for the procurement of funds

   Since projects for the reduction of greenhouse gas emissions will contribute to worldwide environmental conservation, state governments and international organizations would be required to support these projects. Loans from banks and investments from investors can be expected on the basis of this project plan.

IX. Study on economic aspects

The economic aspects of the heat pump system for heating designed for this project are studied in relation to the internal rate of return, the payback period, and costs required for CO_2 emissions reduction.

Trial calculations of the internal rate of return were made in relation to the periods of six, ten and twenty-one years from the launch of the project. The prices of carbon credit were set at zero, two, five and ten US dollars per one ton.

In relation to the payback period, the prices of carbon credit were also set at zero, two, five and ten US dollars per one ton. The results of trial calculations revealed that the payback period would be four years in all the cases.

The trial calculations also revealed that the amount of CO_2 emissions would decrease by 3,662 tons/year. On the basis of this value, costs required for CO_2 emissions reduction were estimated.

X. Impact on interested parties

1. Impact on the natural environment

   It is believed that there would be almost no impact on the natural environment and residents inside and on the periphery of the project site. Although waste hot water and sludge are discharged outside the project site, wastewater is treated at a wastewater treatment facility before discharging, and sludge is transported to a waste disposal site to be treated. Energy is discharged outside the project site as heat energy in waste hot water. The temperature of the waste heat, however, falls to around outside air temperatures. Accordingly, the amount of the waste heat energy is not so great.

2. Socioeconomic impact

This project is concerned with the heating system (the hot water supply system) in the resort facilities owned and managed by the private company. Therefore, outside of these resort facilities, there are no people connected with the management of this system.

XI. Monitoring plan

1. Method of monitoring

The baseline is set at the amount of greenhouse gas emitted under the condition that heat for supplying hot water is generated using conventional electric boilers alone. Specifically, in order to obtain the amount of heated water, measurements are carried out in relation to the temperature of water before heating, the temperature of hot water after heating, and the amount of hot water to be supplied. The term “leakage” means the greenhouse gas emissions outside the project site, resulting from the implementation of the project. As stated above, it can be considered that there are no leakages.

2. Quality control of monitoring data

The quality of monitoring data can be assured and controlled using thermometers and a flow meter with an automatic recording function. In relation to the effect of energy conservation, the amount of power consumed listed on the utility bill from the power company is regarded as consumed power. The utility bill is helpful in assuring and controlling the quality of monitoring data.

XII. Conclusion

In the Russian Federation, in general, collective housing, company offices, and buildings of public institutions are heated by means of hot water circulation produced by boilers that burn fossil fuels. Coal is used in most cases, emitting a great amount of CO_2, NOx, SOx, soot and dust. The combustion of fossil fuels has been causing air pollution and has been involved in global warming.

The site of this project is situated in the suburbs of Irkutsk City in Irkutsk Oblast in the Russian Federation. The project will be implemented at the resort facilities managed by Grand Baikal, LLC. The newly installed heat pump system for heating is comprised of heat exchanging equipment, hot water production equipment, hot water circulation equipment, and heating equipment.

The following are details of the expected decline in the amount of greenhouse gas emissions that would result from the operation of this system: In the existing system to produce hot water, baseline electricity consumption is 12,578 MW/year, coal consumption 8,100 tons/year, and CO_2 emissions 23,898 tons/year. By contrast, electricity consumption would be 8,403 MW/year, coal consumption 5,412 tons/year, and CO_2 emissions 15,916 tons/year if the project is implemented. The amount of CO_2 emissions would decrease by 7,982 tons/year.

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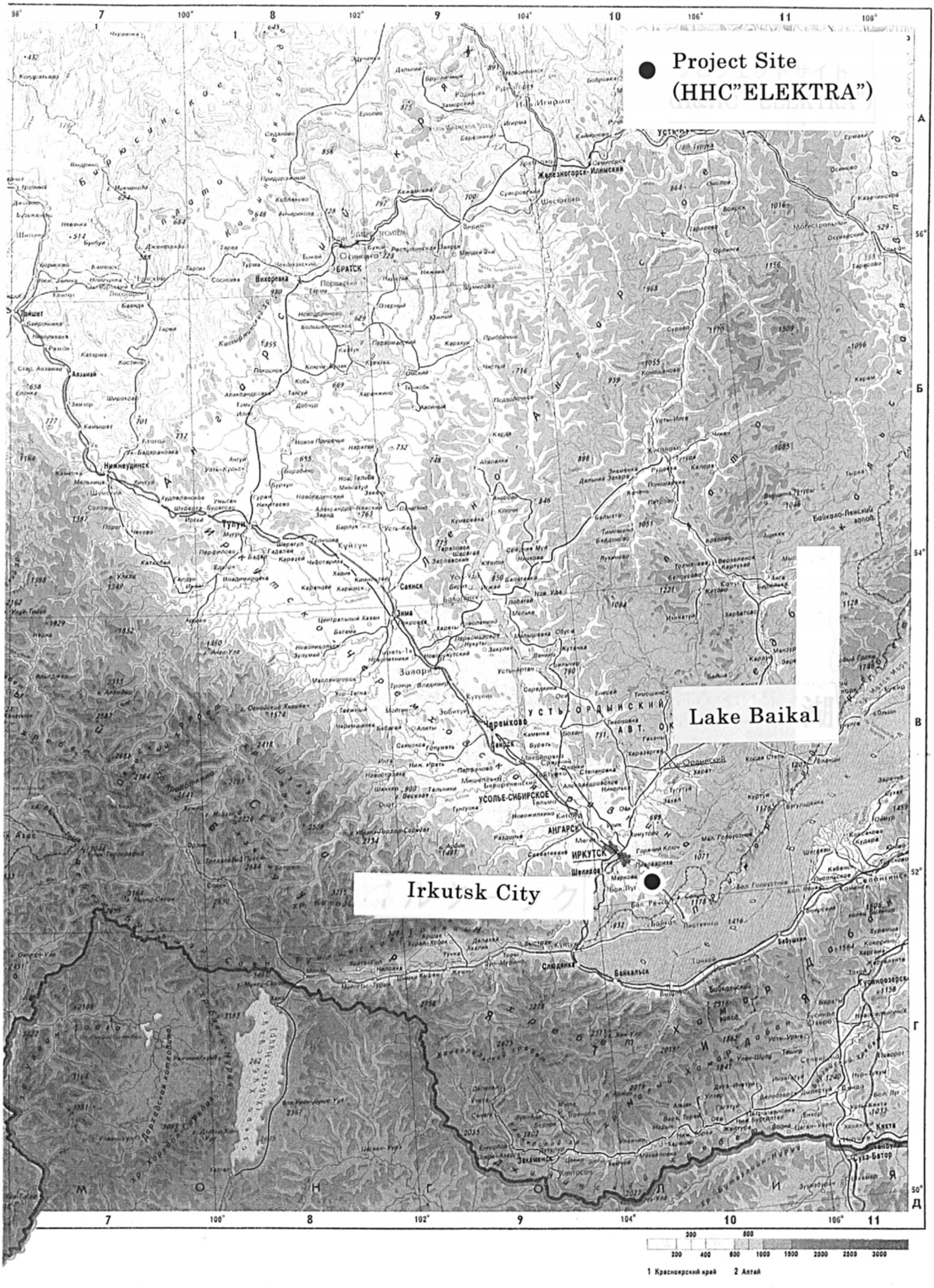

Fig.1 Location of the Project Site

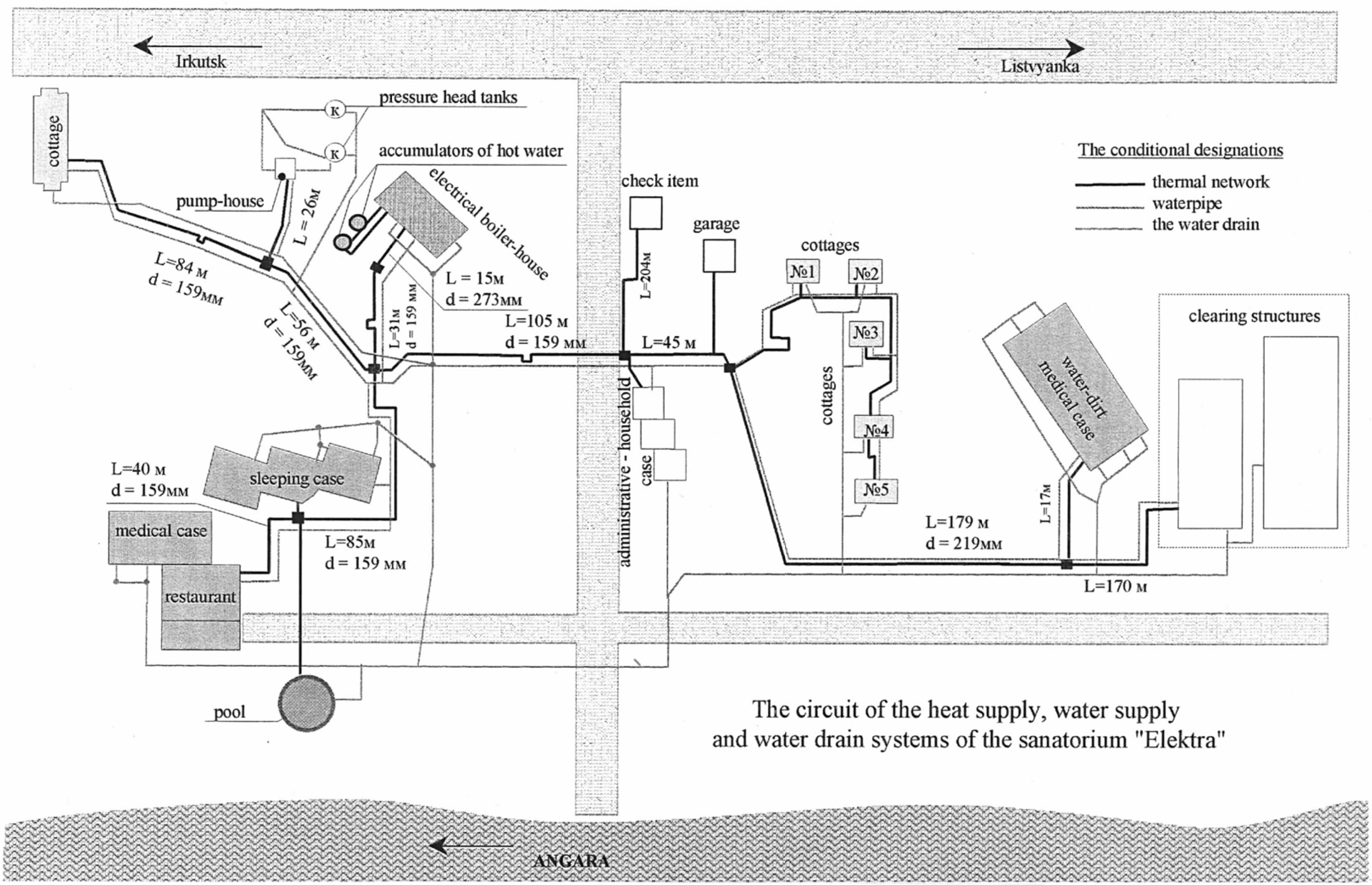

Fig.2 Existing Heating System of the HHC"ELEKTRA"

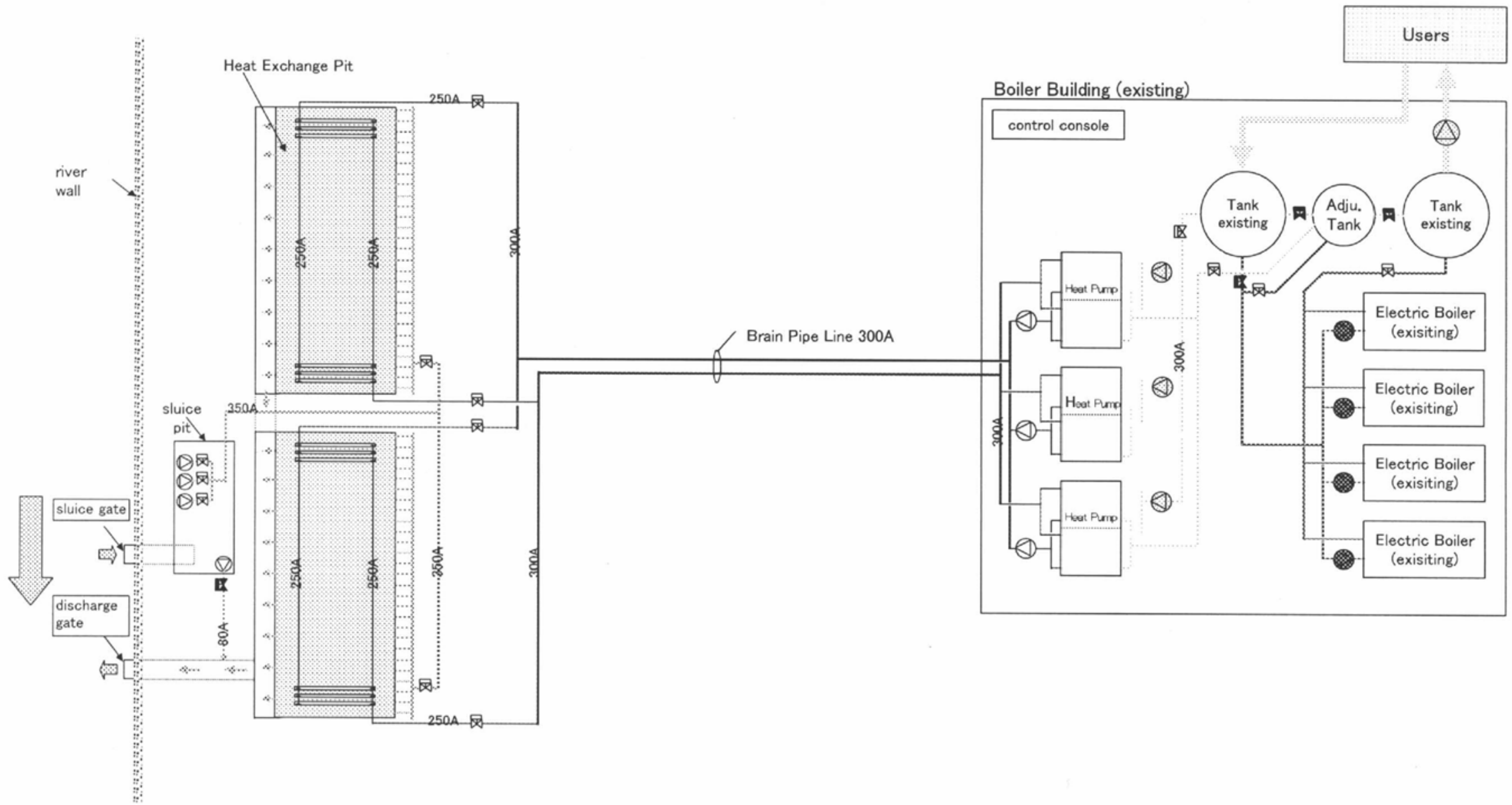

Fig. 3 Heat Pump System of the HHC"ELEKTRA"