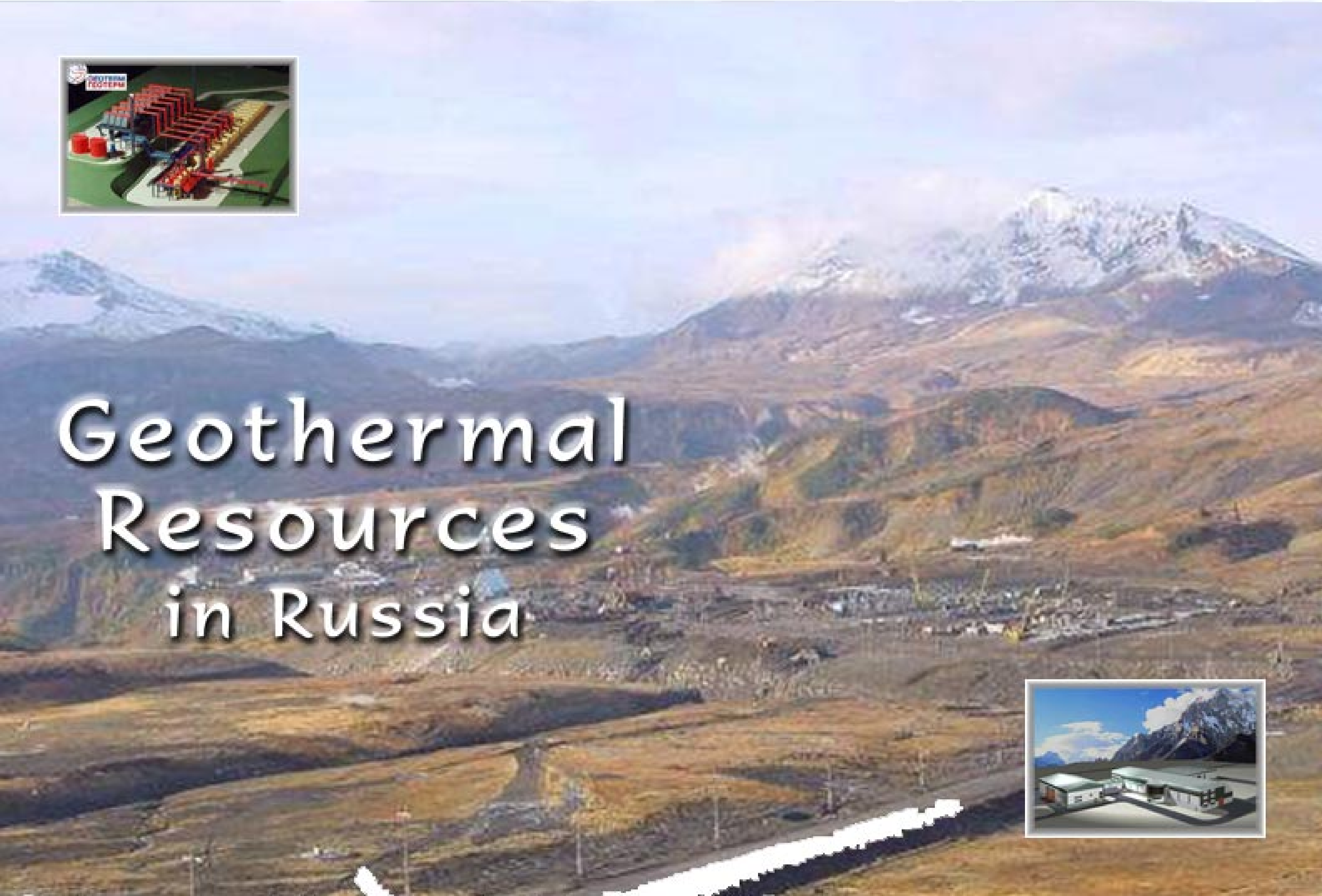
November 2000



Geothermal Resources in Russia

by Liz Battocletti

Bob Lawrence & Associates, Inc.

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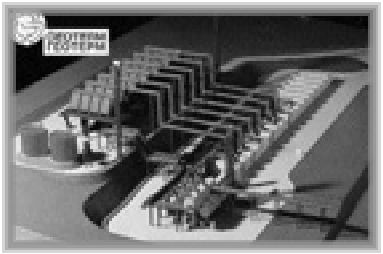

Geothermal Resources in Russia

Prepared for Idaho National Engineering
& Environmental Laboratory
Under Purchase Order No. F99-181039
And the U.S. Department of Energy,
Assistant Secretary for Energy Efficiency
& Renewable Energy,
Office of Wind & Geothermal Technologies
Under DOE Idaho Operations Office
Contract DE-AC07-99ID13727

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Introduction

The **Database of Geothermal Resources in Russia** contains information on 107 specific geothermal sites or projects with a projected electricity generation potential of 2031.7 MWe. It was compiled using information collected in an extensive data and Internet search which accessed technical literature dating back 25 years, as well as numerous other U.S. and Russian sources.

According to the Geothermal Energy Association, , using today's technology, the countries of the former USSR, including Russia, have a geothermal electricity production potential of 768-1902 MWe. Using enhanced technology, the potential is 1501-3741 MWe.[1]

According to Russian sources, geothermal energy could theoretically produce almost 2%, or 16.9 billion kWh, of Russia's electricity.[2]

1 Geothermal Energy Association, *Preliminary Report: Geothermal Energy, the Potential for Clean Power from the Earth* (Washington, D.C., April 1999).

2 Oleg Povarov, CSC Geoterm Vice President, Alexander's Gas and Oil Connections: News and Trends, CIS/Russia, http://www.gasandoil.com/goc/news/ntr02519.htm.

Kamchatka Peninsula and the Kuril Islands have the richest resources of geothermal power available with electric generation potential of up to 2000 MWe and a heat capacity of more than 3000 MWt (Povarov, 2000).

The **Database of Geothermal Resources in Russia** was compiled and built by a team led by Liz Battocletti of Bob Lawrence & Associates, Inc. for UT-Battelle LLC under Purchase Order Number F99-181039, "Collection and Assembly of Published Data on Geothermal Potential."

Thanks goes to Joel Renner of Idaho National Engineering and Environmental Laboratory (INEEL); Allan Jelacic of the U.S. Department of Energy's Office of Wind and Geothermal Technologies; and the other individuals, companies, and organizations who provided assistance and information.

Special appreciation goes to Andrey Reznichenko, Energy and Fuel Attaché at the Embassy of the Russian Federation; Oleg Povarov, Vice President, CSC Geoterm; Vladimir Kononov of the Geological Institute of the Russian Academy of Sciences; Grigoriy V. Tomarov, Director, CSC Geoterm; Nick Mikhailov, Commercial Specialist, U.S. Embassy–Moscow; Andrew Collier, International Trade Specialist, Infrastructure Division, Power Projects, U.S. Department of Commerce; and

Valentina Svalova, Head of the International Projects Department of the Institute of Environmental Geoscience, the Russian Academy of Sciences.

The three pictures of Mutnovsky on the cover of the report were provided by CSC Geoterm. The background photograph was taken in October 2000. The picture in the upper left-hand corner is a rendition of the 12 MWe (3 x 4) MWe Verkhne-Mutnovsky geothermal power plant. The picture in the lower right-hand corner is the 50 MWe (2 x 25) Mutnovsky geothermal power plant.

For immediate dissemination to the industry, the report has been converted to a PDF file.[3]

The Database includes:

- Power Profile - basic information on Russia, e.g., population, GDP, installed capacity, electricity prices, etc.;

- Power Summary - description of Russia's power sector and privatization efforts;

- Government / Legislation - relevant Russian government agencies and laws; and

- Geothermal Sites / Projects - includes a Site Summary for each:

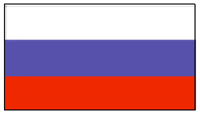
  1. Name
  2. Location
  3. Status
  4. Temperature
  5. Installed Capacity (MWe/MWt)
  6. Potential (MWe/MWt)
  7. Chronology
  8. Notes

Dynamic Database

The Database is designed to be dynamic. Created using Microsoft® Access 2000, it can be easily updated or modified to include specific data which the industry would find most useful. In addition, the Database can be made more comprehensive by adding pertinent data, e.g., local population and market data, location of transmission lines and roads, etc., using the Geographic Information System (GIS), to the present structure. Finally, the Database could be adapted for posting on the World Wide Web and searched using a variety of variables such as country, desired temperature of resource, estimated power potential, and other parameters.

[3] PDF files can be read and printed using the free Adobe® Acrobat® Reader which can be downloaded at http://www.adobe.com/products/acrobat/readstep.html.

Russia



Russia

Power Profile

Population (millions) - July 200 estimated	146.001
Overall Electrification (% of population)	99
GDP (billion US$) - 1999 estimated	620.3
Real GDP Growth Rate - 2000 estimated	7.0%
Inflation Rate (CPI) - 2000 estimated	20%
Total Installed Capacity (MWe) - January 2000	214,855
Electricity Consumption per Capita (kWh) - 1999	5790
Energy Demand Growth Rate	0
Maximum Tariffs (US¢/kWh) - 1 January 1999	
Dagestan Republic	1.26
Kamchatka Oblast	5.87
Krasnodar Krai	1.73
Omsk Oblast	1.58
Sakhalin Oblast	3.13
Stavropol Krai	1.69
Tomsk Oblast	1.62

Geothermal Power Potential (MWe)	2000

The Russian Federation ("Russia") became a country with the break-up of the Soviet Union into 15 independent states in 1991. In the years since, the country has struggled to replace a centrally-controlled Communist economic, social, and political system with democracy and a free market-based economy.

The Russian Federation is made up of 89 components (oblasts, republics, krais, and autonomous okrugs) and two federal cities — Moscow and St. Petersburg. The distribution of power between the central government and the regional and local authorities is still being worked out.

Power Summary

Russia is the second largest energy consumer, the largest exporter of natural gas, and the second largest exporter of energy and petroleum in the world. The country produced 845.8 billion kWh of electricity in 1999, and is forecasted to produce 1100-1300 TWh by 2010. As of 1 January 2000, Russia had a total installed capacity of 214,855 MWe.

Russia's electricity sector is controlled by the majority-state-owned Unified Energy System (RAO UES) which manages the country's distribution system, and oversees the country's 72 "energos," or regional electricity companies.

Fossil fuel power stations (gas, oil, and coal) generate 69% of Russia's total electric power.[4] Hydroelectric and nuclear stations generate 20% and 11% respectively. Geothermal power stations contribute only 0.06% despite recent growth in the number of power plants (Kononov et al., 2000).

Russia's natural gas industry is dominated by Gazprom, the world's largest gas company, which controls more than 95% of Russia's gas production. Gazprom controls one-fifth of the world's natural gas reserves, oversees eight production associations, operates Russia's 88,000-mile gas pipeline grid, and runs trading houses and marketing joint ventures in many European countries.

Hydropower accounts for 43 GWe of Russian generating capacity; 11 stations have more than 1 GWe total installed capacity. The country's largest power plant is the 6400 MWe-Sayano-Shushenskaya hydroelectric plant.

Hydropower is under state control and will remain so under the planned restructuring of RAO UES.

Nuclear power is controlled by the Ministry of Atomic Power (Minatom). By 2007, as many as 10 of the Russia's 29 nuclear reactors will reach the maximum prescribed service life of 30 years but most will remain online. According to Minatom, nuclear power will generate up to one-third of Russia's electricity by 2030.

About 58% of Russia's existing thermal power capacity is scheduled for retirement or rehabilitation by 2010. The investment required for the reproduction and expansion of generating capacity and grid installations from 2000-2010 is estimated at $50-75 billion. Due to the power sector's inability to finance such a massive upgrade program itself, a substantial portion of the financing will have to come from the Government of Russia (GOR), multilateral development banks, and private foreign investors.[5]

Following a sharp contraction after 1991, Russia's per capita electricity consumption is now rising, along with economic growth, and is projected to increase by 24% between 1993 and 2015.[6] (GDP is expected to rise a

4 Russia has 13% of the world's oil reserves and 45% of its natural gas reserves; the world's largest natural gas reserves, the second largest coal reserves, and the eighth largest oil reserves.

5 Foreign investment in Russia in 2000 is forecasted to be $5 billion (compared to $30 billion in Brazil in 1999).

6 "Russia: Country Analysis Brief," U.S. Department of Energy, Energy Information Administration,

record 7% this year, thanks largely to recent high international prices for energy and commodities.) Due to strong growth, RAO UES has warned that the country could face power shortages by 2004-2005 if it does not get needed investment in new generating and distribution capacity.[7]

Many barriers exist to increased foreign investment. Rule of law and respect for property rights, though improving, remain key concerns for foreign investors. Many large U.S. firms are reluctant to pursue a strategy of growth through acquisition in Russia due to potential liabilities associated with existing facilities (e.g., tax debts and environmental cleanup liabilities), political pressures which hinder economic restructuring, hidden financial liabilities, and weak protection of minority shareholder rights.

Beyond its borders[8], Russia is looking east and west to increase gas, oil, and electricity exports where low electricity prices give RAO UES a strong comparative advantage.

February 2000.

7 "Electricity Giant UES Warns of Power Crunch" (2000). Russia Today, 14 November.

8 Spanning ten time zones, Russia shares a border with 14 countries: Azerbaijan, Belarus, China, Estonia, Finland, Georgia, Kazakhstan, North Korea, Latvia, Lithuania, Mongolia, Norway, Poland, and Ukraine.

Government / Legislation

"Russia's Development Strategy to the Year 2010"[9] is to:

> qualitatively raise living standards on the basis of the self-fulfillment of every citizen, to preserve Russia's independence and cultural values, [and] to restore the country's economic and political role in the world community.

The strategy's basic elements are:

- ensuring equal conditions of competition,
- protecting the rights of ownership,
- removing administrative barriers to entrepreneurship,
- reducing government obligations and government consumption,
- improving the budgetary process,
- implementing tax reform, and
- creating an effective state which guarantees foreign and domestic security and social, political, and economic stability.

9 Russian Embassy web site, http://www.russianembassy.org/.

The new Russian Government, formed after the major reorganization of ministries in May-June 2000, has embarked on a course of reforms which the World Bank calls "unparalleled since the initial launch of reform in early 1992."[10]

The Putin Cabinet adopted a 10-year economic plan on 28 June 2000.[11] The plan includes a "wish list" of structural reforms, including decreased inflation, increased competition, deregulation, land reform, reform of the residential code, reform of the customs code, and an overhaul of the tax system. President Vladimir Putin is also trying to re-centralize certain elements of the government in order to ensure that changes made in Moscow are implemented at the regional levels.

Russian Prime Minister Mikhail Kasyanov stated that reform of RAO UES "is necessary for providing a steady rise of the Russian economy and competitiveness," adding that reforms in the energy industry should be aimed at providing reasonable prices and attracting investments.[12]

Despite talk about reform, however, generation, distribution, and transmission remain under control of state-owned RAO UES which has plans to restructure, a daunting task indeed. RAO UES CEO Chubais compares the restructuring's scale and complexity to the massive Soviet electrification campaign of 1920-1935.[13]

Ministry of Energy (Minenergo or MinEnergy)

Russia's energy sector is overseen by the Ministry of Energy (formerly the Ministry of Fuel and Energy). The GOR endorsed the country's draft energy plan drafted by Minergo. Under the energy plan, the GOR will invest up to $700 billion in the implementation of the energy strategy up to the year 2020. With the rise in prices of energy carriers, up to 80% of the required funds can come from domestic resources including higher fuel tariffs, Energy Minister Alexander Gavrin stated.[14]

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10 World Bank Group in Russia, http://www.worldbank.org.ru/eng/.

11 President Putin also established the Center for Strategic Research (CSR) which is made up of pro-market scholars led by 36-year old German Gref, Minister of Economic Development and Trade.

12 "Kasyanov, 'Reforms in Energy Industry Are Necessary for Economic Rise'" (2000). *Russia Today*, 21 November.

13 "UES to Start Restructuring in Central Russia, Urals" (2000). Russia Today, 10 November.

14 "Government Investment Into Russia Energy Development Endorsed" (2000). *PMAOnline*, 23 November.

Russian Joint Stock Company-Unified Energy System of Russia (RAO UES or UESR)

Established in 1992 by Presidential Decrees No. 923 and 1334, majority state-owned [15] RAO UES replaced the Ministry of Electric Energy to become the world's largest electric power utility. The RAO UES Holding Company is composed of:

- 74 joint stock power suppliers (energos) that supply electricity and heat to consumers throughout the Russian Federation,
- 26 power stations that operate independently on the national wholesale electric power market,
- 6 power stations currently under construction,
- the Central Dispatch System (CDU), and
- 86 other subsidiaries and affiliates which produce, transmit, and distribute electricity and heat across Russia.

As of January 2000, the Holding Company's installed capacity was 156,200 MWe, or 72.7% of Russia's total installed capacity.

[15] As of the end of 1999, UES was 52.55% owned by the Russian Ministry of State Property, 30.59% owned by foreign shareholders, and 16.86% owned by Russian entities and individuals.

RAO UES owns and operates the United Power Grid of Russia (the national electricity grid and the world's largest power pool with centralized management) through the wholly-owned central and regional dispatch centers and all high-voltage electric lines. The Holding Company owns 2.6 million km of electric power transmission lines, 96.3% of the country's total.

RAO UES has stakes in most of the country's regional utility companies, and establishes the prices at which these utility companies can buy and sell electricity from the grid, posing a significant conflict of interest. Industrial customers are not able to buy directly from the grid. This restriction hinders industrial customers from having a choice of electricity providers and means that there is no incentive for utility companies to compete. In addition, industry continues to subsidize consumers for their electricity use (Valladares, 1999).

RAO UES earns the bulk of its revenues from a flat transmission fee. Only 9% of revenues comes from electricity generation. Non-payment is a major problem. RAO UES is working to increase the proportion of cash payments, managing to collect 73% of its payments in cash from January to September 2000, reducing the amount it is still owed to 131.4 billion rubles (US$4.71 billion).

In 1998, as a result of payment defaults and low electricity prices, Magadan, Kamchatka, Sakhalin, and Chukotka in the Far East had such severe power and heat difficulties that local administrations evacuated people from remote towns. Due to large outstanding debts at the regional level, local energy companies have cut off power to many entities.[16]

Exporting electricity is a high priority for RAO UES as a major source of capital. Cooperation has begun with power companies and firms in Germany, Italy, Poland, France, China, Japan, the European Union, and other Commonwealth of Independent States (CIS) countries. Russia began exporting electricity to Germany through Belarus and Poland in August 2000, has agreed to supply Turkey with 100 million kWh of electricity per month in a deal that may help to alleviate expected energy shortages this winter, and is in talks with the European Union to increase exports.[17]

At home, RAO UES has submitted its restructuring proposal to the GOR. Under the proposal, RAO UES's generation, distribution, and marketing units would be spun off (with the exclusion of hydropower plants), and the electricity market deregulated.[18] About 10-15 separate national power generation companies are envisaged. They will become competitors on the open market in the first stage of the restructuring which is be completed by December 2001.

RAO UES would retain control of the national and regional electricity networks, indeed, according to Trade and Economic Development Minister German Gref, State control over the power transmission grid would increase.[19] Restructuring would begin in central Russia and the Urals followed by Siberia.

16 Power has been cut off to the Trans-Siberian and Trans-Baikal Railroads, the Russian Academy of Sciences, Krasnoyarsk TV, and strategic defense industry plants. In 1999, three patients in intensive care at a clinic in Western Siberia died after their life-support systems stopped working when the power company cut off the hospital's electricity for non-payment.

17 Western Europe was swept by protests in September over high energy prices following a sharp rise in oil prices. Blockades by truckers and farmers brought several European Union (EU) countries to a near standstill, putting pressure on EU leaders to find ways to cut fuel costs. Closer cooperation with Russia would reduce the EU's reliance on imported oil from the Organisation of Petroleum Exporting Countries (OPEC). One issue is how much investment the EU would provide to improve Russia's infrastructure.

18 Minority shareholders are worried that sales will obtain only a fraction of the plants' true value until realistic energy tariffs are put into place.

19 "Government Backs UES Reform, Opposes Price Hikes" (2000). *Russia Today*, 22 November.

The GOR will consider RAO UES's restructuring concept in mid-December 2000.[20] Bills on electricity and heating tariffs and amendments to the Civil Code relating to the RAO UES restructuring will be drafted and presented to parliament in early 2001.

<u>Federal Wholesale Electricity Market (FOREM)</u>

The Federal Wholesale Electricity Market (FOREM) was created at the end of 1999 by the RAO UES Board. It is expected that FOREM will become involved in trading electrical energy in sectors where deliveries are free, binding, and coordinated; and also in trading on the exchange.

The goal is to make FOREM a competitive wholesale electrical energy market which will:

- develop competitive relations between participants in FOREM;
- maximize participation of electricity producers in trade on a single wholesale market and ensure non-discriminatory access to the grid;
- improve the efficiency of wholesale trading by introducing a competitive pricing mechanism on FOREM, combined with state regulation of electricity transmission charges;
- optimize the use of power stations equipment and reduce fuel expenses;
- optimize the development of generating capacity and network infrastructure; and
- radically improve the liquidity of settlements with suppliers of electrical energy.

<u>Federal Energy Commission (FEC)</u>

FEC is the primary regulator of Russia's electricity market. At the Federal level, FEC regulates:

- the subscription charge for services in organizing the operation and development of RAO UES;
- tariffs for electricity and power, as supplied to the wholesale market in electricity and capacity by generating stations operating on that market, and regional power companies with surplus product; and
- tariffs at which regional power companies with a shortfall of product and major industrial consumers included in FOREM buy electricity.

[20] "UES to Start Restructuring in Central Russia, Urals" (2000). *Russia Today*, 10 November.

Regional Energy Commissions (RECs)

Regional Energy Commissions (RECs) set the tariffs for end-users on the local retail electricity market. Local tariffs include the energy system's costs for subscription tariffs to RAO UES and the purchase of electricity from FOREM.

Local power prices are political as much as economic. RECs are dependent upon regional authorities which generally oppose tariffs increases as they could endanger their re-election. ed. Regional authorities also oppose their local companies and energy producers from operating on the wholesale energy market as it takes tax revenues away from the regions.[21]

Household electricity prices vary by region and are usually based on the costs of both locally produced and imported power. Most regions' electricity supplies come from a combination of sources, including power purchased from FOREM.[22]

Several political and economic factors have caused tariffs to decline sharply (relative to other prices) since Russia's August 1998 financial crisis. While these declines helped to improve many manufacturing companies' profitability, they have decimated the electricity sector's financial position and undermined its attractiveness to foreign investors. Continued unclear and overlapping regulatory jurisdictions of the FEC, the RECs, and other federal and regional government agencies have also discouraged foreign investment in Russia's power sector.[23]

Tariffs

President Putin stated that Russian electricity tariffs should be determined by the market rather than set by the government.[24] According to Energy Minister Gavrin, electricity tariffs will increase 170% under the proposed energy plan.[25]

Currently, electricity tariffs are established by the Federal Energy Commission, which sets much lower tariffs for

21 "Russia's FEC grapples with household tariff policy," *East European Energy Report*, FT Energy, Issue 80, 28 May 1998.

22 "Russia/Wholesale electricity prices rise 35%, " *East European Energy Report*. FT Energy, Issue 104, 26 May 2000.

23 "Chubais Faces Investor Revolt at UES," *Monitor*, Jamestown Foundation, Volume 6, Issue 118, June 16, 2000.

24 "Market Should Set Russian Electricity Tariffs" (2000). *Russia Today*, 17 November.

25 "Government Investment Into Russia Energy Development Endorsed" (2000). *PMAOnline*, 23 November.

household consumers than for industry. The problem has remained unaddressed for years for fear of igniting social discontent, but in recently UES has pushed for tariff increases for households.

Tariffs for electricity and heat energy are subject to state regulation in accordance with Government Order 1444, “On state regulation of charges for electricity and heat energy in the Russian Federation.” Prices for electricity and heat energy, which lag behind prices in industry, do not allow companies in the power sector to function in a commercially viable manner. Electricity tariffs for industrial and residential users only cover about 50% of costs.

Tariffs have been increased significantly over the last few years yet remain very low. Maximum tariffs for energy charges in areas which have geothermal power generation potential range from 1.26¢/kWh in the Dagestan Republic to a countrywide high of 5.87¢/kWh in Kamchatka Oblast (as of 1 January 1999). Tariffs in the other regions of Russia that have significant high enthalpy geothermal resources are on page 3 of this report.[26]

[26] Resolution on the Basis of Pricing Related to Electric Energy Consumed by the Population, 7 December 1998, N. 1444. Exchange rate used is US$1 = 27.76 rubles (14 November 2000).

In almost all cases, Russian utilities sell power for rubles and export little if any electricity to higher-priced foreign markets to supplement their earnings (Maximov, 1996).

Tariff realignment is unlikely before 2001. The GOR also plans to end the practice of “cross subsidies” under which residential tariffs are subsidized by higher tariffs.

Legislation

In general, Russia has a evolving body of conflicting, overlapping, and rapidly changing laws, decrees, and regulations which has resulted in an ad hoc and unpredictable business environment. The legislative and regulatory framework related to foreign investments in the Russian energy sector consists of more than 85 legislative acts, including Federal Laws, Decrees of the President, and Government Resolutions and Instructions.

Additionally, some regions pursue “glocalization”—establishing direct links with foreign partners making them more dependent on international markets than on decrees signed in Moscow. President Putin issued a decree to unite Russia’s 89 regions into seven federal districts headed by representatives appointed by him to combat glocalization (Nesterenko, 2000).

Investment Code

The 1991 investment code guarantees foreign investors rights equal to those enjoyed by Russian investors. The law was amended by new legislation effective 9 July 1999, and includes a grandfather clause protecting certain investments from unfavorable changes in tax and other laws for up to seven years. However, it also widens somewhat the legal criteria for restricting foreign investment in some sectors. The code also prohibits the nationalization of foreign investments except following legislative action and where deemed to be in the national interest.

Prior approval is required for investment in new enterprises using assets of existing Russian enterprises, investment in the exploitation of natural resources, all investments over 50 million rubles (about $1.8 million), and investment ventures in which the foreign share exceeds 50%. Additional registration requirements exist for investments exceeding 100 million rubles (about $3.6 million).

Energy Charter Treaty

Russian lawmakers will consider signing the Energy Charter Treaty which, among other aims, lays down ground rules for the protection of investments in the energy sector in central and eastern Europe and the former Soviet Union.

Geothermal Law

Russia has no law specific to the development of geothermal resources. Geothermal resources are governed by the Law on Minerals.

Law on Minerals (21 February 1992, No. 2395-1)[27]

According to the Law on Minerals:

> Minerals within the borders of the territory of the Russian Federation including subterranean space, and which are contained in mineral, energy, and other resources, are the property of the State. Issues of the possession, use, and disposal of minerals are jointly managed by the Russian Federation and subjects of the Russian Federation. Mineral sites cannot be the subject of purchase, sale, donation, inheritance, investment, and security or alienated in other form. Mineral use rights can be transferred from one person to another as allowed by Federal laws. The extraction of mineral and other resources according to licenses can be located on the property of the Federal Government, other subjects of the Russian Federation, or the property of municipalities, individuals, and other forms. (Article 1.2)

[27] Modified 3 March 1995 (N. 27-F3), 10 February 1999 (N. 32-F3), and 2 January 2000 (N. 20-F3).

Mineral users can be subjects of enterprise activity, including participants in simple associations; foreign citizens; and legal entities if by Federal Laws there are no limits imposed on mineral use rights. (Article 9)

Mineral sites are granted for use for certain terms or without restriction of term. The term for geological study is up to 5 years. The term for mineral or water extraction is 25 years. (Article 10)

Licensing for mineral use is carried out by a Federal organ managed by the State fund of minerals or its territorial divisions in conjunction with the organ of the executive power of the relevant bodies of the Russian Federation. (Article 13)

Licenses are awarded by competition or auction. Licenses can be granted to a sole applicant. The basic criteria for selecting the winner of a competition are: the scientific and technological level of the program of geological study and the mineral use, the extraction of minerals, the contribution to the social and economic development of the region, the program's term, and the efficiency of environmental protection measures. Information on upcoming competitions or auctions as well as results of previous competitions and auctions will be published in all-Russian and relevant regional mass media. (Article 13.1)

The State licensing system is a uniform procedure of granting licenses which includes the informative, scientific, analytical, economic, and legal preparation of materials and their formalization. The tasks of the State licensing system include ensuring...the necessary guarantees to license holders (including foreign) and protection of their mineral use rights. (Article 15)

Independent Power Producers (IPPs) are allowed under Russian law and may be developed according to the scheme that is negotiated (e g., BOO, BOOT, etc). They are not economically feasible, however, 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 MinEnergy and the Ministry of Natural Resources. The latter ministry handles licensing. The Federal Service of Land Cadastres, which maintains a database 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 the expert commission.

Additionally, local governments have officials which are responsible for that area's natural resources use. Project developers should first contact the Ministry of Natural Resources in Moscow.

Key Ministerial Contacts:

Anatoly B. Yanovsky
Stats Secretary-Deputy Minister,
Ministry of Energy
Tel: [7] (095) 220-5989
Fax: [7] (095) 925-9621
— *Responsible for new technologies, including geothermal, and all renewable energy resources used for power generation*

Alexander Misylin (speaks English)
Deputy Director, Department of International Cooperation and Investment Policy,
Ministry of Energy
Tel: [7] (095) 220-5885
Fax: [7] (095) 975-2045

Sergei E. Bednaruk
Director,
Department of the Use and Recovery of the Water Fund
Ministry of Natural Resources
Tel: [7] (095) 202-2184

Rustem G. Mamin (speaks English)
Director,
Department of International Cooperation
Ministry of Natural Resources
Tel: [7] (095) 254-1565
— *Contact for a list of geothermal sites; minimal fee required*

Russia: Administrative Divisions

Kamchatka Peninsula

Geothermal Sites / Projects

Russia has substantial geothermal resources for both electric power generation and direct use. Drilling and exploitation of resources for geothermal heat production have been carried out in Russia since the mid-1950s.

Geothermal exploration for electric power use began in Russia in 1957 when the first boreholes were drilled in the Pauzhetka thermal field in southern Kamchatka. Two 2.5-MWe single flash units went online in 1966-67 at Pauzhetka, and have been operating since. The 800 kWe experimental Paratunka Geothermal Power Plant (GeoPP), the world's first geothermal binary plant, began operating the same year but was abandoned in 1978.

From 1970 to 1990, the Soviet State completely financed the development of geothermal science and industry, and more than 50 geothermal fields were discovered across the country. The construction of geothermal power plants, however, was suspended in the 1970s-80s due to the low price of oil. Exploration ended following the dissolution of the Soviet Union in 1991, the subsequent political upheaval, and financing cuts.

Almost all the territory of Russia is well investigated. Numerous regions have reserves of hot water with temperatures of 50-200ºC at depths of 200-3000 m. The most important geothermal areas are:

1. Kamchatka Peninsula
2. Kuril Islands
3. Northern Caucasus
4. Dagestan Republic
5. West Siberia

The seismically active[28] Kamchatka Peninsula and Kuril Islands have Russia's richest geothermal power generation resources. The power generation potential of Kamchatka's high enthalpy (> 150ºC) geothermal resources (excluding the areas in the Kronotsky Reservation which are off limits to development) is about 1130 MWe for 100 years; the potential of its low enthalpy fields (< 150ºC) is 1345 MWt for 100 years (Sugrobov, 1995; Britvin et al., 2000).

More than 20 geothermal fields in Kamchatka have been explored; 385 wells have been drilled, including 44 production wells that have a temperature of over 150ºC (Povarov and Povarov, 1999). The Mutnovsky field is the most significant and is currently under development.

The Kuril Islands include the following larger islands from north to south: Paramushir, Simushir, Urtup, Iturup, and Kunashir. They are part of the same chain of eastern Pacific dislocations as Japan and Kamchatka. Consequently, the same tectonic and volcanic forces cause

[28] Kamchatka has 127 volcanoes, 22 of which are active. The Kuril Islands have 100 volcanoes; 21 active.

the geothermal phenomena on these islands. The islands are formed from Neogene volcanic sedimentary deposits broken by a number of major dislocations that focus the thermal activity (Stoyanov and Taylor, 1996).

The greatest post-breakup increase in the cost of energy occurred in the remote areas of the Far East — Kamchatka and the Kuril Islands — which use mostly imported fuel. The cost of electricity in these areas ranges from 10-30¢/kWh (Britvin et al., 2000; Povarov and Povarov, 1999).

The platform geothermal province of the Northern Caucasus, including Krasnodar and Stavropol Krais, includes several artesian basins. The thermal waters are contained in multi-layered aquifer systems enclosed within Mesozoic-Cenozoic sedimentary cover. The waters contain mostly HCO_3-Na or Cl-Na dissolved solids; their salinity varies from 0.5 to 65 g/kg, the temperatures range up to 80-110ºC at depths of 1-2 km. The geothermal waters in these regions are used primarily for agricultural and industrial purposes (Kononov et al., 2000).

Dagestan is situated within the range of the eastern fore-Caucasus and the northeastern slope of the Caucasus. Tectonically, the area covers part of the folded mountains of the Great Caucasus and the fore-Caucasus Herzinian platform which are divided by the Terek-Caspian foredeep. The Herzinian platform is complicated in the north by the Karpinsky swell and the east-Manych foredeep. The majority of the geothermal reservoirs are located in the areas of these depressions. Dagestan has seismic activity.

A total of 51 geothermal reservoirs have been found in Dagestan; about 20 are utilized. Estimates of water resources with temperatures up to 80ºC are 180,000 m^3/day; for temperatures of 100ºC or more, 500,000 m^3/day (Sardarov, 1990). Thermal water — more than 7.5 million m^3/year of hot 50-110ºC water — is used primarily for space and district heating. Other uses include greenhouses, balneotherapy, and mineral water production. About 180 wells from 200-5500 m have been drilled in Dagestan, all are artesian (Povarov, 2000).

Attempts to use Dagestan's geothermal resources for power generation have encountered two main problems. Deep wells (up to 5500 m) must be drilled to find water of 150ºC or more and drilling is expensive. Secondly, concentrated brines cause a problem.

The Western Siberian plate is a promising region for direct use of geothermal resources. Sedimentary cover of this epi-Herzinian plate of 3 x 106 km^2 in area encloses an artesian basin of thermal waters. In the marginal parts of the basin, aquifers with a high hydrostatic pressure, temperatures of 35-75ºC, and suitable TDS (1-25 g/kg) are located down to 3 km, and are capable of producing about 180 m^3/s (Mavritsky, 1971; Kononov et al., 2000). Up to now, however, these geothermal resources are used on a very insignificant scale. The region is very rich in natural gas and oil, which hampers geothermal development.

Across Russia, geothermal issues are studied in 14 research centers[29]. These research centers include 26 scientific institute labs, three universities, and five project bureaus. Research is coordinated by the Russian Academy of Sciences and the special Scientific Council on Geothermal Problems. In addition, several joint stock companies are involved in the exploration and utilization of geothermal resources, e.g., Geotermneftegas, Neftegasgeoterm, Kamchatskenergo, Geoterm, KamES, Energiya-M. The government enterprise, Kamchatskburgeotermiya takes part in geothermal development in Kamchatka, and the Podzemgidromineral Institute constructs installations for extraction of chemical row from thermal brines in the Northern Caucasus (Kononov et al., 2000).

Direct Use

Direct use of geothermal resources in Russia dates back several centuries. Since the 11th century, salt was extracted from geothermal hot springs in Novgorod. Siberian Cossack Vladimir Atlasov and his associates bathed in the hot lakes and cooked food in the boiling springs of Kamchatka and the Kurils in the late 17th century, lowering meat and vegetables in baskets into the salty, boiling water (Svalova, 2000).

In the 18th century, following the "Second Kamchatka" or the "First Academic" expedition (1733-1743), S.P. Krasheninnikov published *Description of the Land of Kamchatka* in 1756. The work included the first scientific data on Kamchatka's rivers, lakes, hot springs, volcanoes, and geysers, including temperature measurements for six groups of hot springs (Svalova, 2000).

Today, geothermal fluids are used in Russia primarily for space and district heating, and are also used for a range of agricultural purposes (e.g., greenhouses[30], soil heating, fish and animal farming, cattle-breading), for various

29 Geothermal centers are located in Moscow, St. Petersburg, Makhachkala, Gelendjik, Kazan, Yaroslavl, Ekaterinburg, Novosibirsk, Apatity, Arkhangelsk, Samara, Yakutsk, Petropavlovsk-Kamchatsky and Yuzhno-Sakhalinsk.

30 The Russian Government has a program which supports agricultural greenhouse companies in order to better supply the market with domestically produced fresh vegetables. The program includes limited credits, exemption from import duties, and tax deferrals. Some of Russia's northern and far eastern regions, where geothermal resources are abundant and could be used to heat greenhouses, import fresh vegetables year round.

On 7 January 1999, Prime Minister Primakov signed Decree #23, Measures to Increase Effectiveness of Greenhouse Companies, which was drafted by the Ministry of Agriculture and Food. The program hopes to increase cultivation of vegetables in greenhouses to 550,000 tons of vegetables annually.

industrial processes (e.g., manufacturing, wool washing, paper production, wood drying, oil extracting), and for balneological and recreational applications (e.g., resorts, swimming pools, etc.). Direct use is most widespread in the Kuril, Kamchatka, Northern Caucasus, West Siberia, and Baikal regions (Kononov et al., 2000).

As of 31 December 1999, Russia had a total direct use installed capacity of 307 MWt yielding 6132 TJ/yr of energy.

Power Generation

The contribution of geothermal energy to Russia's electricity generation is relatively small, about 0.06% of the country's total production. Oleg Povarov, CSC Geoterm Vice President, asserts that geothermal energy could theoretically produce almost 2%, or roughly 16.9 billion kWh, of Russia's electricity.[31]

Although significant resources are available, the present economic situation in Russia hampers widespread development of geothermal energy potential.

As of January 2000, Russia had an installed geothermal power generation capacity of 34.8 MWe:

- 12 MWe at Verkhne-Mutnovsky,
- 11.3 MWe at Pauzhetka,
- 8 MWe at Okeanskaya (Iturup Island),
- 2 MWe at Ebeko (Paramushir Island),
- 800 kWe at Paratunka, and
- 700 kWe at Goriachy Plyazh (Kunashir Island).

The plants at Ebeko, Okeanskaya, Goriachy Plyazh, and Paratunka are not operating.

An additional 309 MWe is under construction or scheduled to be online by 2005:

- 9 MWe at Verkhne- Mutnovsky,
- 18 MWe at Pauzhetka,
- 32 MWe at Okeanskaya, and
- ~ 250 MWe at Mutnovsky.

Between 1999 and 2005, there are plans to install about 300 MWe on the Mutnovsky and Verkhne-Mutnovsky steam fields. Iturup Island has up to 300 MWe of industrial reserves of geothermal fluid (Povarov and Povarov, 1999).

The **Database of Geothermal Resources in Russia** contains information on 107 specific geothermal sites or projects with a projected electricity generation potential of 2031.7 MWe. A table listing the sites, as well as detailed descriptions of each, follows.

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31 Alexander's Gas and Oil Connections: News and Trends, CIS/Russia, http://www.gasandoil.com/goc/news/ntr02519.htm.

GEOTHERMAL SITES/PROJECTS IN RUSSIA

SITE/PROJECT NAME	STATUS	TEMPERATURE ºC	INSTALLED CAPACITY (MWE)	POTENTIAL (MWE)
Achisu	Direct use -- developed	N/A	0	Unknown
Akhty	Direct use -- developed	60	0	Unknown
Anavgai	Direct use -- developed	63-81	0	Unknown
Apapel	Preliminary identification/report	200	0	Unknown
Avachinsky	Well(s) or hole(s) drilled	N/A	0	250
Baran	Preliminary identification/report	N/A	0	Unknown
Bashkiriya	Direct use -- developed	N/A	0	Unknown
Bolshe-Bannoe	Well(s) or hole(s) drilled	148-200	0	58
Buksansk	Preliminary identification/repor0	N/A	0	Unknown
Bystrinsk	Preliminary identification/report	N/A	0	Unknown
Chankals	Preliminary identification/report	N/A	0	Unknown
Chanti-Argun	Well(s) or hole(s) drilled	55	0	Unknown

SITE/PROJECT NAME	STATUS	TEMPERATURE ºC	INSTALLED CAPACITY (MWE)	POTENTIAL (MWE)
Cherek-Baksan	Preliminary identification/report	N/A	0	Unknown
Cherkessk	Direct use -- developed	50-75	0	Unknown
Chervleny Buruny	Direct use -- developed	82	0	Unknown
Chevlen	Preliminary identification/report	N/A	0	Unknown
Dagestano-Kurdship	Direct use -- developed	79-91	0	Unknown
Ebeko	Direct use -- developed	70-90	2	2
Esso	Direct use -- developed	52-83	0	Unknown
Georgievsk	Direct use -- developed	55	0	Unknown
Geyserny	Preliminary identification/report	N/A	0	Unknown
Goitin	Well(s) or hole(s) drilled	66-83	0	Unknown
Gorely	Preliminary identification/report	N/A	0	Unknown
Goriachy Plyazh	Power plant(s) on site	70-105	0.7	0.7
Griaznorechen	Direct use -- developed	106	0	Unknown
Grozny	Direct use -- developed	80-96	0	Unknown

SITE/PROJECT NAME	STATUS	TEMPERATURE ºC	INSTALLED CAPACITY (MWE)	POTENTIAL (MWE)
Gudermes	Preliminary identification/report	N/A	0	Unknown
Hankal	Well(s) or hole(s) drilled	88-98	0	Unknown
Harkov	Well(s) or hole(s) drilled	98	0	Unknown
Hodzev	Direct use -- developed	70-86	0	Unknown0
Izerbash	Direct use -- developed	40-77	0	Unknown
Jushnosukhokumsk	Construction underway	160-240	0	Unknown
Kalinov	Well(s) or hole(s) drilled	57-92	0	Unknown
Karym	Preliminary identification/report	200	0	146
Kayakent	Direct use -- developed	45-62	0	Unknown
Kayasula	Well(s) or hole(s) drilled	150-170	0	3
Kazminsk	Direct use -- developed	103-128	0	Unknown
Ketlin	Direct use -- developed	60	0	Unknown
Khodutkin	Preliminary identification/report	200	0	117
Kireuna	Preliminary identification/report	200	0	68

SITE/PROJECT NAME	STATUS	TEMPERATURE ºC	INSTALLED CAPACITY (MWE)	POTENTIAL (MWE)
Kizlyar	Direct use -- developed	44-110	0	0
Kolpachev	Preliminary identification/report	N/A	0	Unknown
Kordonov	Well(s) or hole(s) drilled	44-103	0	Unknown
Krainov	Direct use -- developed	40	0	Unknown
Ksudach	Preliminary identification/report	N/A	0	Unknown
Kupin	Preliminary identification/report	N/A	0	Unknown
Labinsk	Preliminary identification/report	N/A	0	Unknown
Lorino	Preliminary identification/report	80	0	Unknown
Mahachkalin	Well(s) or hole(s) drilled	30-70	0	Unknown
Maikop	Direct use -- developed	73.86	0	Unknown
Makhachkala-Ternair	Direct use -- developed	42-100	0	Unknown
Malkin	Direct use -- developed	78-88	0	Unknown
Manas	Direct use -- developed	40	0	Unknown
Mezhchohrak	Well(s) or hole(s) drilled	86	0	Unknown

SITE/PROJECT NAME	STATUS	TEMPERATURE ºC	INSTALLED CAPACITY (MWE)	POTENTIAL (MWE)
Moscow	Well(s) or hole(s) drilled	N/A	0	Unknown
Mostovskoe	Direct use -- developed	68-75	0	Unknown
Mutnovsky	Construction underway	147-320	0	460
Mykop	Preliminary identification/report	N/A	0	Unknown
Nachikin	Direct use -- developed	8-84	0	Unknown
Nalchinsko-Dolin	Preliminary identification/report	N/A	0	Unknown
Nalychev	Preliminary identification/report	N/A	0	Unknown
Nizhne-Baksan	Direct use -- developed	56-58	0	Unknown
Nizhne-Koshelev	Well(s) or hole(s) drilled	220-240	0	350
Nizhne-Ozernov	Direct use -- developed	87	0	Unknown
Nizhne-Zelenchuk	Direct use -- developed	118	0	Unknown
Novogroznene	Well(s) or hole(s) drilled	75-77	0	Unknown
Okeanskaya	Power plant(s) on site	250-320	8	300
Omsk	Direct use -- developed	N/A	0	Unknown

SITE/PROJECT NAME	STATUS	TEMPERATURE °C	INSTALLED CAPACITY (MWE)	POTENTIAL (MWE)
Otradnen	Direct use -- developed	88-100	0	Unknown
Ozernoye	Direct use -- developed	N/A	0	Unknown
Palana	Preliminary identification/report	95	0	Unknown
Paratunka	Direct use -- developed	40-106	0.8	0.8
Pauzhetka	Power plant(s) on site	180-225	11.3	68
Pinachev	Preliminary identification/report	N/A	0	Unknown
Priurupsloe	Direct use -- developed	99-103	0	Unknown
Pushchin	Well(s) or hole(s) drilled	60-63	0	Unknown
Rechnin	Direct use -- developed	42-104	0	Unknown
Rodnikovskaya	Direct use -- developed	74	0	Unknown
Rusakov	Preliminary identification/report	95	0	Unknown
Rychal-Su	Direct use -- developed	N/A	0	Unknown
Sabin	Preliminary identification/report	N/A	0	Unknown
Semyachik	Preliminary identification/report	250	0	5

SITE/PROJECT NAME	STATUS	TEMPERATURE ºC	INSTALLED CAPACITY (MWE)	POTENTIAL (MWE)
Severo-Eremin	Direct use -- developed	107-117	0	Unknown
Severo-Mutnovsky	Well(s) or hole(s) drilled	220-301	0	172
Surgut	Preliminary identification/report	N/A	0	Unknown
Tarumovka	Direct use -- developed	62-195	0	0.2
Tavatum	Preliminary identification/report	N/A	0	Unknown
Terekly-Mekteb	Direct use -- developed	81-88	0	Unknown
Termalny	Direct use -- developed	40-97	0	Unknown
Tersko-Galiugaev	Direct use -- developed	55	0	Unknown
Tirniauz	Well(s) or hole(s) drilled	170-250	0	10
Tobol’sk	Preliminary identification/report	N/A	0	Unknown
Tumlat	Preliminary identification/report	N/A	0	Unknown
Tyrnyaus	Well(s) or hole(s) drilled	N/A	0	Unknown
Tyumen	Direct use -- developed	N/A	0	Unknown
Ulianovsky	Direct use -- developed	75-82	0	Unknown

SITE/PROJECT NAME	STATUS	TEMPERATURE °C	INSTALLED CAPACITY (MWE)	POTENTIAL (MWE)
Uzhno-Berezhnoe	Direct use -- developed	72	0	Unknown
Uzhno-Sovet	Direct use -- developed	116	0	Unknown
Uzhno-Voznesen	Direct use -- developed	83-87	0	Unknown
Uzon-Geyser	Reconnaissance	100	0	Unknown
Verkhne-Mutnovsky	Power plant(s) on site	170	12	21
Verkhne-Paratunka	Direct use -- developed	70-106	0	Unknown
Voskresen	Direct use -- developed	112-116	0	Unknown
Vostochno-Baksan	Direct use -- developed	56-58	0	Unknown
Voznesen	Direct use -- developed	82-111	0	Unknown
Yaroslavl	Well(s) or hole(s) drilled	60	0	Unknown
Zhirov	Preliminary identification/report	N/A	0	Unknown
TOTALS			**34.8**	**2031.7**

Achisu

LOCATION North Caucasian economic district, Dagestan Republic, south of Makhachkala	
STATUS Direct use – developed	
TEMPERATURE (°C)	—
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for a spa.	

Akhty

LOCATION North Caucasian economic district, Dagestan Republic	
STATUS Direct use – developed	
TEMPERATURE (°C)	60
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for spa. The Akhty resource is one of the oldest used for balneology, since time immemorial. It is fed by natural springs with temperatures of up to 60ºC. The combination of mountain air (1200 masl) and carbonate waters creates the possibility of building a cardiological health resort for children (Sardarov, 1990).	

Anavgai

LOCATION Far Eastern economic district, Kamchatka Oblast, in central Kamchatka, at the junction of the Anavgai and Bistroi rivers	
STATUS Direct use – developed	
TEMPERATURE (°C)	63-81
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY 1971 - RAO Gazprom developed geothermal resource for space heating.	

NOTES
Geothermal resource is used for district heating and health resorts.

Thermal Cl-Na waters with T=80-100ºC and TDS=1-5 g/kg are utilized for space heating.

One of 24 thermal spring groups in mid-Kamchatka (Kononov et al., 2000).

The geothermal hot water resource has a potential of 3370 m^3/day for commercial direct use (Stoyanov and Taylor, 1996).

Demand is 4.8 x 10^3 m^3/day; 0.01-0.34 MPa pressure at wellhead; 1.4-2.0 g/l mineralization; contamination: arsenic (0.01-0.16 mg/l), fluorine (0.9-2.8 mg/l), and metaboric acid (3.7 mg/l).

Reserves have been explored and studied in detail. The data obtained assure determination of basic stratigraphic features, structure, and recharge sources for replenishing exploitable resources of subsurface water. Water quality has been studied to the point where its use may be established. Exploitable reserves of subsurface water at a site of projected supply have been determined on the basis of pump (flowing) tests and extrapolated estimates.

Apapel

LOCATION
Far Eastern economic district, Kamchatka Oblast, in central Kamchatka

STATUS
Preliminary identification/report

TEMPERATURE (°C)	100-200
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	16

CHRONOLOGY

NOTES
Overheated and saturated steam at the surface; 16 MWt natural heat capacity (Leonov, 2000).

One of 24 thermal spring groups in central Kamchatka; has great potential (Kononov et al., 2000).

The spring discharges chloride-sodium waters (Sugrobov, 1995).

Inferred mean temperature in reservoir is 200ºC (Sugrobov, 1995).

Avachinsky

LOCATION Far Eastern economic district, Kamchatka Oblast, near the Avachinsky Volcano in southeastern Kamchatka	
STATUS Well(s) or hole(s) drilled	
TEMPERATURE (°C)	250
INSTALLED CAPACITY (MWe)	—
POTENTIAL (MWe)	250
CHRONOLOGY 1945 - Avachinsky Volcano, which has been active from the Upper Pleistocene to the present time, erupted. The volcano has erupted 11 times since 1737.	
NOTES Geothermal resource is high temperature (> 150ºC). According to gravimetric, magnetic, and seismic data, an anomalous zone suspected to be a peripheral magma chamber exists under the Avachinsky Volcano. The capacity of a thermal reservoir with a volume of 1 km^3 at a depth of 5 km and a distance of 6 km from the volcano would be 2 x 10^{14} kcal, extractable under non-stationary conditions, which could provide 250 MWe for 100 years (Fedotov et al., 1975).	

Baran

LOCATION Far Eastern economic district, Kuril Islands	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	—
INSTALLED CAPACITY (MWe)	—
POTENTIAL (MWe)	—
CHRONOLOGY	
NOTES Geothermal resource is a steam-water mixture	

Bashkiriya

LOCATION West Siberian economic district	
STATUS Direct use – developed	
TEMPERATURE (°C)	—
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY

NOTES
Geothermal resource used to increase oil extraction (Kononov et al., 1995).

Bolshe-Bannoe

LOCATION
Far Eastern economic district, Kamchatka Oblast, in the northern part of southern Kamchatka, 80 km west of Petropavlovsk-Kamchatsky; 60 km from Elizovo, in the Bannoi River valley

STATUS
Well(s) or hole(s) drilled

TEMPERATURE (°C)	148-200
INSTALLED CAPACITY	—
POTENTIAL (MWe) / (MWt)	58 / 79

CHRONOLOGY

NOTES
Bolshoe Bannoe means “big bath.”

The resource has been placed under conservation (not being exploited) by the Russian Federal Authorities.

This field is well explored. Resources have been determined by a long-term multi-well flow test. The wellhead parameters of the production wells at the end of the test was constant. Total mass flow rate of the 15 production wells was 157 kg/s and average enthalpy was 657 KJ/kg (Kraevoy et al., 19876; Delnov and Shulyupin, 1996).

Electrical generation potential is 58 ± 17 MWe for 100 years (Sugrobov, 1995).

Mean temperature of the first 1-km layer is 200ºC. Available energy in the 1-km layer with a temperature decrease of 50ºC is 20 x 10^{13} kcal (Fedotov et al., 1975).

0.1-0.35 MPa pressure at wellhead; 1.0-1.4 g/l mineralization; contamination: arsenic (0.04-0.5 mg/l) and fluorine (2-11 mg/l) (Stoyanov and Taylor, 1996).

Boiling water at the surface; natural heat capacity is 79 MWt (Leonov, 2000).

Buksansk

LOCATION
Kabardino-Balkarian Republic

STATUS
Preliminary identification/report

TEMPERATURE (°C)	—

INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	
NOTES	

Bystrinsk	
LOCATION Far Eastern economic district, Kamchatka Oblast, 55º55'N latitude 158º40'E longitude	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	75
INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	
NOTES	

Chankals	
LOCATION North Caucasian economic district, Chechen Republic	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	—
INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	
NOTES	

Chanti-Argun	
LOCATION North Caucasian economic district, Chechen Republic, 45 km south of Grozny	
STATUS Well(s) or hole(s) drilled	
TEMPERATURE (°C)	55
INSTALLED CAPACITY	—
POTENTIAL	—

CHRONOLOGY
NOTES The geothermal hot water resource has a potential of 348 m³/day for commercial direct use (Stoyanov and Taylor, 1996). Reserves have been explored and studied to the degree that the data assure complete understanding of stratigraphy, structure, pressure heads, and permeability of water-bearing rock. The means by which water-bearing formations are replenished and their potential to add to exploitable reserves have been ascertained. The volume of subsurface water has been determined with a certainty that assures the useful life and the potential for a desired purpose. Exploitable reserves of subsurface water have been determined at the water supply site using pump (flowing) tests and/or other means.

Cherek-Baksan	
LOCATION North Caucasian economic district, Kabardino-Balkarian Republic	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	—

INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	
NOTES	

Cherkessk	
LOCATION North Caucasian economic district, Stavropol Krai	
STATUS Direct use – developed	
TEMPERATURE (°C)	50-75
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for space heating, hot water supply, and a swimming pool. Mineralization of 0.7-2.9 g/l; 0.03-0.87 MPa at borehole; 1000 m³/day flow rate; average depth of boreholes is 1000-1500 m (Stoyanov and Taylor, 1996). The geothermal hot water resource has a potential of	

4800 m³/day for commercial direct use (Stoyanov and Taylor, 1996). This amount includes the resources of the Karachayevo-Cherkessian Republic.

Reserves have been explored and studied to the degree that the data assure complete understanding of stratigraphy, structure, pressure heads, and permeability of water-bearing rock. The means by which water-bearing formations are replenished and their potential to add to exploitable reserves have been ascertained. The volume of subsurface water has been determined with a certainty that assures the useful life and the potential for a desired purpose. Exploitable reserves of subsurface water have been determined at the water supply site using pump (flowing) tests and/or other means.

Chervleny Buruny

LOCATION
North Caucasian economic district, Dagestan Republic

STATUS
Direct use – developed

TEMPERATURE (°C)	82
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY

NOTES
Geothermal resource is used for space and district heating, completely satisfying the needs of the town (Kononov et al., 2000).

Mineralization of 8.6-8.9 g/l; phenol contamination (0.88-1.18 mg/l); 0.15-0.20 MPa at borehole; 500 m³/day flow rate; average depth of boreholes is 1500 m (Stoyanov and Taylor, 1996).

The geothermal hot water resource has a potential of 5000 m³/day for commercial direct use (Stoyanov and Taylor, 1996).

Reserves have been explored and studied to the degree that the data assure complete understanding of stratigraphy, structure, pressure heads, and permeability of water-bearing rock. The means by which water-bearing formations are replenished and their potential to add to exploitable reserves have been ascertained. The volume of subsurface water has been determined with a certainty that assures the useful life and the potential for a desired purpose. Exploitable reserves of subsurface water have been determined at the water supply site using pump (flowing) tests and/or other means.

Chevlen	
LOCATION North Caucasian economic district, Chechen Republic	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	—
INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	
NOTES	

Dagestano-Kurdship	
LOCATION North Caucasian economic district, Adygeya Republic	
STATUS Direct use – developed	
TEMPERATURE (°C)	79-91
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	

NOTES Geothermal resource is used for space heating. Mineralization of 0.95-1.1 g/l; 1.5-1.7 MPa at borehole; 500 m³/day flow rate; average depth of boreholes is 2000 m (Stoyanov and Taylor, 1996).	

Ebeko	
LOCATION Far Eastern economic district, Sakhalin Oblast, on Paramushir Island, the most northern in the Kuril Archipelago; south of Pauzhetka	
STATUS Direct use – developed	
TEMPERATURE (°C)	70-90
INSTALLED CAPACITY (MWe)	2
POTENTIAL (MWt)	20
CHRONOLOGY 1998 - 2 MWe single flash Ebeko GeoPP went online. 2000 - Plant is currently not operating.	
NOTES Geothermal resource used to provide district heating for Severo-Kuril’sk city.	

Drilling works for hot water (70-90ºC) and advanced work on a 20 MWt Geothermal Heat Plant (GeoHP) are being implemented (Povarov and Povarov, 1999).

Geothermal resource is a steam-water mixture.

Esso

LOCATION
Far Eastern economic district, Kamchatka Oblast, in central Kamchatka; in the valleys of Bistroi River and its left tributary, Uksichan; in the Bystrinsky region

STATUS
Direct use – developed

TEMPERATURE (°C)	52-83
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY
1970 - RAO Gazprom developed resource for space heating; 32 wells drilled; 12 are production.

1995 - Heat output of geothermal heating system totaled 171.660 Gcal/yr (Perveev and Shumakova, 1996).

NOTES
Water-dominated geothermal resource is used for district heating, health resorts, and greenhouses.

Thermal Cl-Na waters with T=80-100ºC and TDS=1-5 g/kg are utilized for space heating.

One of 24 thermal spring groups in central Kamchatka (Kononov et al., 2000).

The geothermal hot water resource has a potential of 3888 m^3/day for commercial direct use (Stoyanov and Taylor, 1996).

Demand is 17.2 x 10^3 m^3/day; capacity is 12.2 x 10^3 tons/day; 0.03-0.41 MPa pressure at wellhead; 0.96-1.30 g/l mineralization; contamination: arsenic (< 0.2 mg/l), fluorine (< 3.5 mg/l), metaboric acid (< 1.8 mg/l), and lithium (0.1-2.5 mg/l).

Reserves have been explored and studied in detail. The data obtained assure determination of basic stratigraphic features, structure, and recharge sources for replenishing exploitable resources of subsurface water. Water quality has been studied to the point where its use may be established. Exploitable reserves of subsurface water at a site of projected supply have been determined on the basis of pump (flowing) tests and extrapolated estimates.

Georgievsk

LOCATION North Caucasian economic district, Stavropol Krai	
STATUS Direct use – developed	
TEMPERATURE (°C)	55
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for hot water supply. Mineralization of 12.3 g/l; 0.5 MPa at borehole; 1000 m^3/day flow rate; average depth of boreholes is 900-1200 m (Stoyanov and Taylor, 1996).	

Geyserny

LOCATION Far Eastern economic district, Kamchatka Oblast, in the Nalycheva River valley, in the Kronotsky Reservation	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	100
INSTALLED CAPACITY	—
POTENTIAL (MWt)	321.5
CHRONOLOGY	
NOTES Saturated steam and boiling water at the surface; 321.5 MWt natural heat capacity (Leonov, 2000). Located within the boundaries of the Kronotsky Reservation where any industrial or agricultural activity is prohibited. Boiling spring waters have sodium-chloride composition (Sugrobov, 1995).	

Goitin

LOCATION North Caucasian economic district, Chechen Republic, in the southwestern outskirts of Grozny	
STATUS Well(s) or hole(s) drilled	
TEMPERATURE (°C)	66-83
INSTALLED CAPACITY (MWt)	—

POTENTIAL (MWt)	—
CHRONOLOGY	

NOTES
The geothermal hot water resource has a potential of 1150 m³/day for commercial direct use (Stoyanov and Taylor, 1996).

Reserves have been explored and studied to the degree that the data assure complete understanding of stratigraphy, structure, pressure heads, and permeability of water-bearing rock. The means by which water-bearing formations are replenished and their potential to add to exploitable reserves have been ascertained. The volume of subsurface water has been determined with a certainty that assures the useful life and the potential for a desired purpose. Exploitable reserves of subsurface water have been determined at the water supply site using pump (flowing) tests and/or other means.

Gorely

LOCATION
Far Eastern economic district, Kamchatka Oblast

STATUS
Preliminary identification/report

TEMPERATURE (°C)	150
INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	

NOTES
Geothermal resource is high temperature (> 150ºC).

Goriachy Plyazh

LOCATION
Far Eastern economic district, Sakhalin Oblast, on the eastern shore of Kunashir Island, the most southern in the Kuril Archipelago; near the Mendeleev volcano; 7 km southwest of the town of Uzhno-Kurilsk

STATUS
Power plant(s) on site / Direct use – developed

TEMPERATURE (°C)	70-105
INSTALLED CAPACITY (MWe)	0.7
INSTALLED CAPACITY (MWt)	20
POTENTIAL (MWe)	0.7

CHRONOLOGY
1992 - 700 kWe single flash Goriachy 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 (Povarov and Povarov, 1999).

1997 - a 20 MWt geothermal heat plant (GeoHP) was put into operation.

2000 - Power plant is currently not operating.

NOTES
Geothermal resource is used to provide district heating for Uzhno-Kurilsk.

The geothermal field is located in a narrow coastal stretch, about one kilometer long and a quarter of a kilometer wide. The geothermal water system is bedded in a fissured Neogene layer of tuffs, sandstone, conglomerates, and redeposited volcanic rocks and has total thickness of 570 meters (Stoyanov and Taylor, 1996).

The geothermal steam resource has a potential of 4147 m³/day (Stoyanov and Taylor, 1996).

Demand is 3.5 x 10^3 m³/day; 1.8 MPa pressure at wellhead; 3.5-10 g/l mineralization.

Griaznorechen

LOCATION
North Caucasian economic district, Krasnodar Krai

STATUS
Direct use – developed

TEMPERATURE (°C)	106
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY

NOTES
Geothermal resource is used for space heating.

Mineralization of 1.1 g/l; phenol contamination; 1.4 MPa at borehole; 1000 m³/day flow rate; average depth of boreholes is 2000 m (Stoyanov and Taylor, 1996).

Grozny

LOCATION
North Caucasian economic district, Chechen Republic, 43º13'N latitude 45º41'E longitude

STATUS
Direct use – developed

TEMPERATURE (°C)	80-96
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY

NOTES
Geothermal resource is used for district heating in a small part of Grozny covering 5000 inhabitants. Thermal water has a TDS of 5 g/kg and a temperature of 80-96ºC (Kononov et al., 1995; Kononov and Dvorov, 1990).

Gudermes

LOCATION
North Caucasian economic district, Chechen Republic

STATUS
Preliminary identification/report

TEMPERATURE (°C)	—
INSTALLED CAPACITY	—
POTENTIAL	—

CHRONOLOGY

NOTES

Hankal

LOCATION
North Caucasian economic district, Chechen Republic, 10 km south of Grozny

STATUS
Well(s) or hole(s) drilled

TEMPERATURE (°C)	88-98
INSTALLED CAPACITY	—
POTENTIAL	—

CHRONOLOGY

NOTES
The geothermal hot water resource has a potential of 9500 m³/day for commercial and potential direct use (Stoyanov and Taylor, 1996).

Reserves have been explored and studied to the degree that the data assure complete understanding of stratigraphy, structure, pressure heads, and permeability of water-bearing rock. The means by which water-bearing formations are replenished and their potential to add to exploitable reserves have been ascertained. The volume of subsurface water has been determined with a certainty that assures the useful life and the potential for a desired purpose. Exploitable reserves of subsurface water have been determined at the water supply site using pump (flowing) tests and/or other means.

Harkov

LOCATION North Caucasian economic district, Krasnodar Krai	
STATUS Well(s) or hole(s) drilled	
TEMPERATURE (°C)	98
INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	
NOTES Geothermal resource is currently under conservation (not being exploited). Mineralization of 1.6 g/l; 500 m³/day flow rate; average depth of boreholes is 2000 m (Stoyanov and Taylor, 1996).	

Hodzev

LOCATION North Caucasian economic district, Adygeya Republic	
STATUS Direct use – developed	
TEMPERATURE (°C)	70-86
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for space heating. Mineralization of 2.3-2.8 g/l; phenol contamination; 0.4 MPa at borehole; 1000 m³/day flow rate; average depth of boreholes is 2100-2400 m (Stoyanov and Taylor, 1996).	

Izerbash

LOCATION North Caucasian economic district, Dagestan Republic, 42º49'N latitude 47º52'E longitude	
STATUS Direct use – developed	
TEMPERATURE (°C)	40-77
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	

NOTES
Geothermal resource is used for hot water supply and space and district heating, completely satisfying the needs of the town (Kononov et al., 2000).

Mineralization of 1.29-6.22 g/l; 0.06-0.32 MPa at borehole; 400-500 m³/day flow rate; average depth of boreholes is 800-1600 m (Stoyanov and Taylor, 1996).

The geothermal hot water resource has a potential of 4540 m³/day for commercial direct use (Stoyanov and Taylor, 1996).

Reserves have been explored and studied to the degree that the data assure complete understanding of stratigraphy, structure, pressure heads, and permeability of water-bearing rock. The means by which water-bearing formations are replenished and their potential to add to exploitable reserves have been ascertained. The volume of subsurface water has been determined with a certainty that assures the useful life and the potential for a desired purpose. Exploitable reserves of subsurface water have been determined at the water supply site using pump (flowing) tests and/or other means.

Jushnosukhokumsk

LOCATION
North Caucasian economic district, Dagestan Republic, in the northern part of the republic

STATUS
Construction underway

TEMPERATURE (°C)	160-240
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY

NOTES
High-temperature waters (160-240ºC) containing high concentration of rare elements and mineral salts are found in northern Dagestan at 3.3-5.5 km depth.

The Jushnosukhokumsk geothermal field is one of the most promising in the region. Production rates of 2.5 million m³/day are expected.

The construction of a plant to process 3 million m³/year of high salinity (130-140 g/l) geothermal brine is underway. The plant will use the heat of the thermal waters in complex operations to extract iodine, lithium, rubidium, cesium, and NaCl from the brine (Magomedov et al., 1999).

Kalinov	
LOCATION North Caucasian economic district, Dagestan Republic	
STATUS Well(s) or hole(s) drilled	
TEMPERATURE (°C)	57-92
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is currently under conservation (not being exploited). Mineralization of 5.78-20.07 g/l; phenol contamination (0.7-1.8 mg/l); 1.0-1.4 MPa at borehole; 1000 m^3/day flow rate; average depth of boreholes is 1500-2500 m (Stoyanov and Taylor, 1996).	

Karym	
LOCATION Far Eastern economic district, Kamchatka Oblast, in the Nalycheva River valley	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	100-200
INSTALLED CAPACITY (MWe)	—
POTENTIAL (MWe) / (MWt)	146 / 146
CHRONOLOGY	
NOTES Geothermal resource is most promising for agricultural and balneological applications (Kononov et al., 2000). Electrical generation potential is 146 ± 44 MWe for 100 years (Sugrobov, 1995). Boiling water at the surface; 146 MWt natural heat capacity (Leonov, 2000). A short-term but powerful phreatic-magmatic eruption occurred in the Karymsky geothermal area in the Akademy Nauk caldera where the Karymskoe Lake, which until 1996 was a fresh-water one, was located. Enormous quantity of erupted material was ejected (Karpov et al.., 2000).	

Kayakent
LOCATION North Caucasian economic district, Dagestan Republic

STATUS Direct use – developed	
TEMPERATURE (°C)	45-62
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for hot water supply and space and district heating, partially satisfying the needs of the town, and for a spa (Kononov et al., 2000). Mineralization of 1.29-1.66 g/l; 0.08-0.15 MPa at borehole; 500 m³/day flow rate; average depth of boreholes is 700-900 m (Stoyanov and Taylor, 1996).	

Kayasula

LOCATION North Caucasian economic district	
STATUS Well(s) or hole(s) drilled	
TEMPERATURE (°C)	150-170
INSTALLED CAPACITY (MWe)	—
POTENTIAL (MWe)	3
CHRONOLOGY	
NOTES A 3 MWe plant was planned, however, technical challenges, associated high costs, and potential environmental problems related to the resource having high TDS (>100 g/kg), relatively low temperatures (150-170ºC) at 4000-4400 m depth, and high injection pressures to 7 MPa, currently make the development of this project problematic (Kononov et al., 2000; Huttrer, 2000).	

Kazminsk

LOCATION North Caucasian economic district, Stavropol Krai	
STATUS Direct use – developed	
TEMPERATURE (°C)	103-128
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for space heating and industrial heat.	

Mineralization of 1.26-3.92 g/l; arsenic (0.05-0.1 mg/l) and phenol (0.05 mg/l) contamination; 0.3-1.2 MPa at borehole; 2000 m³/day flow rate; average depth of boreholes is 2100-2700 m (Stoyanov and Taylor, 1996).

Ketlin	
LOCATION Far Eastern economic district, Kamchatka Oblast, 5 km southeast of Elizovo	
STATUS Direct use – developed	
TEMPERATURE (°C)	60
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY 1990 - KamchatGeologKom developed resource for road de-icing and balneotherapy.	
NOTES Geothermal resource is used for road de-icing and balneotherapy. Demand is 12.2 x 10³ m³/day; 2.4-11.4 g/l mineralization; contamination: arsenic (0.08 mg/l) (Stoyanov and Taylor, 1996).	

Khodutkin	
LOCATION Far Eastern economic district, Kamchatka Oblast, in southern Kamchatka	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	38-200
INSTALLED CAPACITY (MWe)	—
POTENTIAL (MWe)	117
CHRONOLOGY	
NOTES Electrical generation potential is 117 ± 35 MWe for 100 years. Hot water springs (38ºC); inferred mean temperature in reservoir is 200ºC (Sugrobov, 1995).	

Kireuna	
LOCATION Far Eastern economic district, Kamchatka Oblast, in central Kamchatka	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	100-200

INSTALLED CAPACITY	—
POTENTIAL (MWe) / /MWt)	68 / 24

CHRONOLOGY

NOTES
Electrical generation potential is 68 ± 20 MWe for 100 years. Inferred mean temperature in reservoir is 200ºC. Spring discharges chloride-sodium waters (Sugrobov, 1995).

The field discharges boiling water at the surface which is estimated to provide 24 MWt (Kononov et al., 2000).

One of 24 thermal spring groups in central Kamchatka; has great potential (Kononov et al., 2000).

Mean temperature of the first 1-km layer is 200ºC. Available energy in the 1-km layer with a temperature decrease of 50ºC is 20 x 10^{13} kcal (Fedotov et al., 1975).

Kizlyar

LOCATION
North Caucasian economic district, Dagestan Republic, 43º48'N latitude 46º41'E longitude

STATUS
Direct use – developed

TEMPERATURE (°C)	44-110
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY

NOTES
Geothermal resource is used for space and district heating, partially satisfying the needs of the town; hot water supply; and greenhouses (20,000 m^2) (Kononov et al., 2000).

The local population is supplied by one deep well which can produce from two different aquifers, separately or simultaneously, and it is used as a heat exchanger. Salinity brine (110ºC, 25 g/l) from the Mid-Miocene sandstone layers rises through the well annulus from 2840 m depth, and transfers heat at a depth of 1000 m to 44ºC, 2.1 g/l water from Quaternary sandstone horizons (Magomedov et al., 1999).

Phenol content is 2.3 mg/dm^3 (Omarov and Chalaev, 1998).

Mineralization of 1.29-6.94 g/l; 0.35-1.4 MPa at borehole; 1000 m^3/day flow rate; average depth of boreholes is 1000-2900 m (Stoyanov and Taylor, 1996).

Thermal water, suitable for utilization, is taken from a depth of 1000-1050 m with a temperature of 44-47ºC and a well yield of 5300 m³/day, and from 2600-2900 m with a temperature of 107ºC and a well yield of 3000 m³/day (Sardarov, 1990).

The field consists of two geothermal reservoirs: the lower complex (depth of about 3000 m, Chokrak in age) with temperatures in excess of 100ºC and flow rates from 3000 to 5000 m³/day, and the upper complex (depth of 1000-1200 m, Apsheron in age) with a temperature of 47ºC and flow rates of 3000-6000 m³/day. The joint separate development of the two complexes allows users to obtain 5000 m³/day water at 85-87ºC (Mavritsky and Khelkvist, 1975).

Kolpachev

LOCATION
West Siberian economic district

STATUS
Preliminary identification/report

TEMPERATURE (°C)	—
INSTALLED CAPACITY	—
POTENTIAL	—

CHRONOLOGY

NOTES

Kordonov

LOCATION
North Caucasian economic district, Dagestan Republic

STATUS
Well(s) or hole(s) drilled

TEMPERATURE (°C)	44-103
INSTALLED CAPACITY	—
POTENTIAL	—

CHRONOLOGY

NOTES
Geothermal resource is currently under conservation (not being exploited).

Mineralization of 2.2-22.3 g/l; phenol contamination (1.4801.70 mg/l); 0.82-1.4 MPa at borehole; 1000 m³/day flow rate; average depth of boreholes is 1000-2800 m (Stoyanov and Taylor, 1996).

Krainov

LOCATION
North Caucasian economic district, Dagestan Republic

STATUS

Direct use – developed	
TEMPERATURE (°C)	40
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for hot water supply. Mineralization of 2.1 g/l; 0.2 MPa at borehole; 1000 m^3/day flow rate; average depth of boreholes is 700-800 m (Stoyanov and Taylor, 1996).	

Ksudach

LOCATION Far Eastern economic district, Kamchatka Oblast	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	150
INSTALLED CAPACITY (MWe)	—
POTENTIAL (MWe)	—
CHRONOLOGY	
NOTES Geothermal resource is high temperature (> 150ºC).	

Kupin

LOCATION West Siberian economic district	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	—
INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	
NOTES	

Labinsk

LOCATION North Caucasian economic district, Stavropol Krai	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	105
INSTALLED CAPACITY	—

POTENTIAL	—
CHRONOLOGY	
NOTES Phenol content is 0.42 mg/dm³ (Omarov and Chalaev, 1998).	

Lorino

LOCATION Far Eastern economic district, Magadan Oblast, Chukotka Autonomous Okrug, 28 km southwest of Lavrentia village; 12 km northeast of Lorino village	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	60-80
INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	
NOTES ChukoGeolKom has plans to develop the resource for space heating and balneotherapy. Due to the severe climatic conditions, the region is poorly studied (Stoyanov and Taylor, 1996).	

The geothermal hot water resource has a potential of 2200 m³/day for commercial direct use (Stoyanov and Taylor, 1996).

Mahachkalin

LOCATION North Caucasian economic district, Dagestan Republic	
STATUS Well(s) or hole(s) drilled	
TEMPERATURE (°C)	30-70
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES The geothermal hot water resource has a potential of 6100 m³/day for potential direct use (Stoyanov and Taylor, 1996). Reserves have been explored and studied in detail. The data obtained assure determination of basic stratigraphic features, structure, and recharge sources for replenishing exploitable resources of subsurface water. Water quality has been studied to the point where its use may be established. Exploitable reserves of subsurface water at a site of projected supply have been determined on the	

basis of pump (flowing) tests and extrapolated estimates.

Maikop

LOCATION
North Caucasian economic district, Adygeya Republic, Krasnodar Krai

STATUS
Direct use – developed

TEMPERATURE (°C)	73-86
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY

NOTES
Geothermal resource is used for industrial heat and space heating.

Mineralization of 3.1-8.5 g/l; phenol contamination; 0.5 MPa at borehole; 500 m³/day flow rate; average depth of boreholes is 1800 m (Stoyanov and Taylor, 1996).

The geothermal hot water resource has a potential of 4980 m³/day for commercial direct use (Stoyanov and Taylor, 1996).

Reserves have been explored and studied to the degree that the data assure complete understanding of stratigraphy, structure, pressure heads, and permeability of water-bearing rock. The means by which water-bearing formations are replenished and their potential to add to exploitable reserves have been ascertained. The volume of subsurface water has been determined with a certainty that assures the useful life and the potential for a desired purpose. Exploitable reserves of subsurface water have been determined at the water supply site using pump (flowing) tests and/or other means.

Makhachkala-Ternair

LOCATION
North Caucasian economic district, Dagestan Republic, in a suburb of Makhachkala, 6 km west of the city; the capital of Dagestan; 42º56'N latitude 47º29'E longitude

STATUS
Direct use – developed

TEMPERATURE (°C)	42-100
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY

NOTES
Geothermal resource is used for space and district

heating, partially satisfying the needs of the town, and greenhouses (60,000 m^2) (Kononov et al., 2000).

Hothouse waters containing phenols are injected back into the producing aquifer at a rate of about 1000 m^3/day (Magomedov et al., 1999).

Phenol content is 7.4-12.5 mg/dm^3 (Omarov and Chalaev, 1998).

Mineralization of 2.2-12.8 g/l; phenol contamination (0.0084-4.0 mg/l); 0.12-1.3 MPa at borehole; 600-1000 m^3/day flow rate; average depth of boreholes is 900-2100 m (Stoyanov and Taylor, 1996).

The geothermal hot water resource has a potential of 4800 m^3/day for commercial use.

Reserves have been explored and studied in detail. The data obtained assure determination of basic stratigraphic features, structure, and recharge sources for replenishing exploitable resources of subsurface water. Water quality has been studied to the point where its use may be established. Exploitable reserves of subsurface water at a site of projected supply have been determined on the basis of pump (flowing) tests and extrapolated estimates.

Malkin

LOCATION Far Eastern economic district, Kamchatka Oblast	
STATUS Direct use – developed	
TEMPERATURE (°C)	78-88
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for fish farming.	

Manas

LOCATION North Caucasian economic district, Dagestan Republic	
STATUS Direct use – developed	
TEMPERATURE (°C)	40
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY

NOTES
Geothermal resource is used for space heating and hot water supply.

Mineralization of 2.5-6.2 g/l; 0.05 MPa at borehole; 500 m^3/day flow rate; average depth of boreholes is 1400 m (Stoyanov and Taylor, 1996).

Mezhchohrak

LOCATION
North Caucasian economic district, Krasnodar Krai

STATUS
Well(s) or hole(s) drilled

TEMPERATURE (°C)	86
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY

NOTES
Geothermal resource is currently under conservation (not being exploited).

Mineralization of 2.9-8.6 g/l; phenol contamination; 0.4 MPa at borehole; 500 m^3/day flow rate; average depth of boreholes is 2000 m (Stoyanov and Taylor, 1996).

Moscow

LOCATION
Central economic district, Moscow Oblast

STATUS
Well(s) or hole(s) drilled

TEMPERATURE (°C)	—
INSTALLED CAPACITY	—
POTENTIAL	—

CHRONOLOGY

NOTES
Total energy of discovered resources is equal to 44 billion tons of conventional fuel (Boguslavsky et al., 1995).

The Moscow artesian basin is a large sedimentary basin covering an area of 500,000 km^2. The area is a depressed structure of the East-European platform, and is located between the Baltic Shield, Voronezh, and Volga-Urals anticlines.

Mostovskoe

LOCATION
North Caucasian economic district, Krasnodar Krai, 44º25'N latitude 40º12'E longitude

STATUS
Direct use – developed

TEMPERATURE (°C)	68-75
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY

NOTES
Water at 75ºC is used in a multi-purpose, cascading system which includes greenhouses (180,000 m^2); space heating for 10,000 inhabitants, cow sheds, pig farms, and poultry yards; concrete block fabrication; and wool drying. The waste water at 20-30ºC is used for a swimming pool and a fish farm (Kononov et al., 2000).

The geothermal hot water resource has a potential of 11,100 m^3/day for commercial use. Mineralization is 1.4-2.5 g/l; 0.1-.05 MPa pressure at borehole; 800 m^3/day flow rate; average depth of boreholes is 2000-2200 m (Stoyanov and Taylor, 1996).

Reserves have been explored and studied in detail. The data obtained assure determination of basic stratigraphic features, structure, and recharge sources for replenishing exploitable resources of subsurface water. Water quality has been studied to the point where its use may be established. Exploitable reserves of subsurface water at a site of projected supply have been determined on the basis of pump (flowing) tests and extrapolated estimates.

Mutnovsky

LOCATION
Far Eastern economic district, Kamchatka Oblast, in southern Kamchatka; 50 km from nearest village, Termalny; 75 km south of Petropavlovsk-Kamchatsky; 80 km from Elizovo; at the springs of the Falshiv and Zhirov Rivers; near the northern foothills of the Mutnov volcano; 800-900 masl; 52º30'N latitude 158º10'E longitude

STATUS
Construction underway

TEMPERATURE (°C)	147-320
INSTALLED CAPACITY (MWe)	—
POTENTIAL (MWe) / (MWt)	460 / 129

CHRONOLOGY
1978 - Exploration work began.

1983 to 1988 - Flow tests conducted in wells 016, 26, 01, 014, 1, 24, and 013 (Kiryukhin, 1992).

1987 to 1989 - Exploratory drilling was initiated in the central part of the field in the Dachny section to confirm the occurrence of superheated water and steam in the underground system. Total of 95 wells drilled: 58 production (1500-2500 m), 24 thermal gradient, and 13 injection. Found a maximum temperature of 305ºC (Kononov and Dvorov, 1990).

August to September 1989 - A 33-day tracer test was performed using an injection of fluorescein dye into a central observation well in the field; an estimate of the thermal cool down was also made (Kiryukhin and Kruger, 1990).

1990 - Sufficient steam resources to generate 78 MWe were confirmed (Kiryukhin, 1992).

1991 - Estimation of reserves was calculated to be 156.2 kg/c for 30 years. As a result of the sum of real steam rates of all two-phase wells by the end of four-year interference flow tests plus steam rates of other wells during single flow tests, the field was classified “C1" for industrial development (Perveev and Shulupin, 1995).

A 3-D mapping of the lithologic units, temperature, and pressure fields, and a natural-state (pre-exploitation) model of the fluid flow within the Dachny site were completed. Mapping indicated that two upflow zones and one relatively cool downflow zone exist in the Dachny site. Based on the simulation studies carried out with the computer code TOUGH2, the total rate of upflow is estimated at the upflow rate is 165 kg/s and permeability is 150 mD. Concluded that the total steam output of wells 1, 01, 24, 26, 014, 013, and 037 is sufficient to generate 30 MWe for 20 years (Kiryukhin et al., 1991; Kiryukhin, 1992).

June to December 1995 - West JEC conducted a feasibility study, funded by the European Bank for Reconstruction and Development (EBRD), which included collection, analysis, verification, and confirmation of data and information; evaluation of the geothermal field; plan for the steam transportation system; process design of the combined power plant; cost estimates; and economic, financial, and environmental analyses.

EBRD lent the Russian Government $99.9 million for the Mutnovsky Independent Power Project. Total costs are expected to reach $500 million for the power plant and $120 million for the pipeline. The loan is backed by a sovereign guarantee and a power purchase agreement (PPA), the first for Russia, which ensures tariffs that will cover loan payments for its 10-year term.

December 21, 1996 - A 4.5 magnitude earthquake occurred 91 km from the Mutnovsky field.

2000 - The GeoPP site civil preparatory and advance steam field works are being completed. The design, manufacture, supply and “turn-key” construction of the geothermal power plant have been started. Under the drilling and well repair contract, geothermal steam will be supplied at the rate of 320 t/h and a pressure of 7 bar (Britvin et al.., 2000).

More than 90 boreholes have been drilled in the field which covers a total area of 21.7 km²; two-phase fluids with wellhead temperatures of 160-180ºC have been discovered.

March 2000 - At 0700 on 17 March, a short-lived explosion sent a gas-and-steam plume to heights of ~1,000 m above the volcano; the plume disappeared within 30 minutes. At 1300, another gas-and-steam plume rose to about the same altitude and extended to the southeast; activity ended by 1700.

August 2000 - Psychrometric Systems, Inc. (PSI), a subsidiary of Global Water Technologies, Inc., was awarded a $2.7-million contract to supply two water cooling towers for the Mutnovsky GeoPP. The cooling water system supplied by PSI will cool 50,000 gallons of water per minute.

End of 2001 - CSC Geoterm, which has the concession for the entire Mutnovsky geothermal field, plans to complete the $150-million Mutnovsky 50 MWe (two 25-MWe units) GeoPP, Stage I of development. A Control Center located in the Termalny settlement will manage 20 geothermal power plants.

2004 - II stage of Mutnovsky GeoPP of about 100 MWe to go online.

2005 - III stage of Mutnovsky GeoPP of about 100 MWe to go online.

NOTES

Electrical generation potential is 460 ± 138 MWe for 100 years (Sugrobov, 1995). Overheated and saturated steam at the surface; 129 MWt natural heat capacity (Leonov, 2000).

The Mutnovsky field is marked by surface manifestations of boiling hot springs and saturated steam vents. The geologic structure of the hydrothermal system is very complex, contained in a tectonic zone of intersecting fractures in a north-easterly direction, bounded by the ancient Zhirov volcano to the east, the caldera of the Gorel volcano to the west, and the Mutnov volcano to the south. The production zone is in the Dachny area (Kiryukhin and Kruger, 1990).

Heat emission from the sinkholes is steam with temperatures of 400-500ºC at 400,000 kcal/s. Steam vents emissions are released at 93,000 kcal/s with a maximum temperature of 305ºC. The boiling waters in the Zhirov and Mutnov River valleys release 3,800 kcal/s of superheated water and 2,000 kcal/s of hot water at 93ºC (Kiryukhin and Kruger, 1990).

Mutnovsky is a liquid-dominated reservoir with fluid temperatures of 235-270ºC. Reservoir fluids contain approximately 1% non-condensible gas, mostly CO_2. Pressure conditions are close to two-phase, and permeability is fracture-dominated (Kiryukhin and Pruess, 2000).

The geothermal steam resource has a potential of 17,280 m^3/day. Demand is 10.4 x 10^3 m^3/day; capacity is 10.4 x 10^3 tons/day; 0.7 MPa pressure at wellhead; 0.6-2.5 g/l mineralization; contamination: arsenic (0.01-2.5 mg/l), and fluorine (0.4-3.2 mg/l) (Stoyanov and Taylor, 1996).

Average temperature of the two-phase zone is 245ºC; the single-phase zone is 250-320ºC. Enthalpies of the two-phase wells vary from 1000 kJ/kg to 2700 kJ/kg, depending on discharge conditions. Average weight gas content of fluids is 0.14%; gas composition is carbonate or carbonate-nitric, with 6% sulphur hydrogen volumetric content. Single-phase zone fluids have chloridium-natrium composition with 250-300 mg/kg chloridium content and 120-820 mg/kg silica acid content; total mineralization is 1.5-2.5 g/kg; pH is about or slightly more than 7.0 (Perveev and Shulupin, 1995).

EBRD's loan to Geoterm will create the first IPP in the Kamchatka region. Geoterm–a joint stock company owned by RAO UES, the Kamchatka regional administration, and the private engineering company, Nauka–will sell electricity to Kamchatskenergo, the regional power distribution company. The transmission line (90 km, 220 kV), road (60 km), and the major power plant in Elizovo which is capable of taking up to 120 MWe, all belong to Kamchatskenergo. It is expected that the IPP structure and commercial operation of Geoterm will facilitate future privatization of the company.

The transfer of Kamchatka to geothermal power supply will save approximately 900,000 tons of fuel each year (Britvin et al., 2000), reducing Kamchatka's imported fuel costs by an estimated US$15 million per year.

The biggest question is whether the local utility, Kamchatskenergo, and its customers can pay for the electricity so that Geoterm can repay the loan. More than half the population of Kamchatka lives below the poverty level. The peninsula is unconnected to Russia's energy grid and is dependent on imported oil and diesel. Severe climatic conditions in Mutnovsky limit construction to 4-5 months a year. The average annual temperature is -1.9ºC (in August, 25ºC, in winter -37ºC); snow cover may reach up to 10 m (Povarov and Povarov, 1999).

The Mutnovsky volcano is one of about 30 which stretch down the peninsula, which is roughly half the size of Texas. Mutnovsky is a composite stratovolcano with a large twin crater at its summit. These craters have crater lakes in them and very active fumaroles. Pumice beds, cones and lava flows can be found on the slopes of these craters. Explosive eruptions producing ash occurred in 1945-52 and then again in 1960. It is thought that this volcano possibly located in an old ruined caldera with a diameter of about 9 km. The mountain itself could have been formed by two merging cones. Originally there had been one stratovolcano then later on a second emerged on the northwestern slope of the first. Over time the caldera of the first volcano got filled with ejecta from the second cone. A 3 x 1.5 km pear shaped crater exists at the summit of Mutnovsky, here one can find its two lakes and steam vents that emit huge quantities of volcanic gases (http://volcano.und.nodak.edu).

Mykop

LOCATION
North Caucasian economic district, Krasnodar Krai

STATUS
Preliminary identification/report

TEMPERATURE (°C)	87
INSTALLED CAPACITY	—
POTENTIAL	—

CHRONOLOGY

NOTES
Phenol content is 0.94 mg/dm³ (Omarov and Chalaev, 1998).

Nachikin

LOCATION
Far Eastern economic district, Kamchatka Oblast, 1.5 km north of Nachiki village, 60 km west of Petropavlovsk-Kamchatsky

STATUS
Direct use – developed

TEMPERATURE (°C)	8-84
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY
1950 - The Federation of Independent Trade Unions developed the resource for space heating and balneotherapy.

NOTES
Geothermal resource is used for space heating and an hydropathic establishment.

Demand is 1.5 x 10^3 m³/day; capacity is 1.5 x 10^3 tons/day (Stoyanov and Taylor, 1996).

Nalchinsko-Dolin	
LOCATION North Caucasian economic district, Kabardino-Balkarian Republic	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	—
INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	
NOTES	

Nalychev	
LOCATION Far Eastern economic district, Kamchatka Oblast	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	< 150
INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	
NOTES Geothermal resource is low temperature (< 150ºC).	

Nizhne-Baksan	
LOCATION North Caucasian economic district, Kabardino-Balkarian Republic	
STATUS Direct use – developed	
TEMPERATURE (°C)	56-58
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for space heating. Mineralization of 8.1 g/l; phenol contamination (0.032 mg/l); 1500 m³/day flow rate; average depth of boreholes is 1900 m (Stoyanov and Taylor, 1996).	

Nizhne-Koshelev

LOCATION
Far Eastern economic district, Kamchatka Oblast, in southern Kamchatka, near the Pauzhetka field

STATUS
Well(s) or hole(s) drilled

TEMPERATURE (°C)	220-240
INSTALLED CAPACITY	—
POTENTIAL (MWe) / (MWt)	350 / 314

CHRONOLOGY
1971 - Well drilling began.

1978 - Well drilling concluded as attention turned to developing the Mutnovsky field.

1991 - Attempt to restart drilling failed due to a lack of investment. Fluids have enthalpies of up to 2800 kJ/kg.

NOTES
Saturated steam and boiling water at the surface; 314 MWt natural heat capacity (Leonov, 2000).

Geothermal reserves of approximately 350 MWe have been proven (Povarov and Povarov, 1999).

Well test data shows that the Koshelev field resources are approximately equal (maybe slightly smaller) to the Mutnovsky field (Delnov and Shulyupin, 1996).

Electrical generation potential is 215 ± 64 MWe for 100 years or Koshelev, and 100 ± 30 MWe for 100 years for Nizhne-Koshelev (Sugrobov, 1995).

Nizhne-Ozernov

LOCATION
Far Eastern economic district, Kamchatka Oblast, in southern Kamchatka; includes the Zaporozhe and Ozernovsky regions

STATUS
Direct use – developed

TEMPERATURE (°C)	87
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY
1983 - RAO Gazprom developed geothermal resource for space heating.

NOTES
Geothermal resource is used for space heating.

0.03-0.08 MPa pressure at wellhead; 14-23.2 g/l mineralization; contamination: arsenic (< 0.6.8 mg/l) (Stoyanov and Taylor, 1996).

Nizhne-Zelenchuk

LOCATION
North Caucasian economic district, Stavropol Krai

STATUS
Direct use – developed

TEMPERATURE (°C)	118
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY

NOTES
Geothermal resource is used for hot water supply and space heating.

Mineralization of 23.0 g/l; 0.562 MPa at borehole; 1500 m^3/day flow rate; average depth of boreholes is 2300-2400 m (Stoyanov and Taylor, 1996).

Novogroznene

LOCATION
North Caucasian economic district, Chechen Republic, 18 km southeast of Gudermes

STATUS
Well(s) or hole(s) drilled

TEMPERATURE (°C)	75-77
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY

NOTES
The geothermal hot water resource has a potential of 3410 m^3/day for commercial and potential direct use (Stoyanov and Taylor, 1996).

Reserves have been explored and studied to the degree that the data assure complete understanding of stratigraphy, structure, pressure heads, and permeability of water-bearing rock. The means by which water-bearing formations are replenished and their potential to add to exploitable reserves have been ascertained. The volume of subsurface water has been determined with a certainty that assures the useful life and the potential for a desired purpose. Exploitable reserves of subsurface water have been determined at the water supply site using pump (flowing) tests and/or other means.

Okeanskaya (Kipiashty)

LOCATION
Far Eastern economic district, Sakhalin Oblast, on the Okhotsk Sea coast of Iturup Island; in the Kurile Archipelago; on the Baransky volcano slope near the Sernaya River; 17 km from town of Kurllsk

STATUS
Power plant(s) on site

TEMPERATURE (°C)	250-320
INSTALLED CAPACITY (MWe)	8
POTENTIAL (MWe)	300

CHRONOLOGY
1997 - The Okeanskaya geothermal heating facility was commissioned; managed by SahalinGeolKom.

1999 - 8 MWe (four 2-MWe single flash units) went online.

2000 - Power plants are currently not operating. A new 4 MWe single flash unit is to go online.

2001 - Two 4 MWe single flash units to go online.

2003 - 20 MWe single flash unit to go online.

2005 - 32 MWe total installed capacity planned.
The field is projected to generate 30 MWe; 9 wells are ready for exploitation (Kononov et al., 2000).

NOTES
Iturup Island has up to 300 MWe of industrial reserves of geothermal fluid (Povarov and Povarov, 1999).

The Okeanskaya system belongs to the progressive haloid-sulphurous-carbon acid gas stage of development, and is younger and hotter than the Pauzhetka system (Ladygin et al., 2000).

According to the mineralogical data the Okeanskaya system has a zonal structure with the following zones from bottom up: high-medium temperature secondary quartzites (350-450ºC), medium temperature quartz-albite-chlorite propylites (260-350ºC), low-temperature zeolites and calcite-hydromica propylites (180-260ºC), argillized propylites (150-200ºC), hydrothermal argillites (100-150ºC), opalites (nearly 100ºC) (Ladygin et al., 2000).

Demand is 3.3×10^3 m^3/day; 250-320ºC at wellhead; 1.6-3.2 MPa pressure at wellhead; 2.7-7.5 g/l mineralization (Stoyanov and Taylor, 1996).

Omsk

LOCATION West Siberian economic district, Omsk Oblast	
STATUS Direct use – developed	
TEMPERATURE (°C)	—
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Thermal waters provide the space heating for small settlements and several buildings in the city of Omsk. Geothermal water is also used to heat oil-bearing horizons and decrease oil viscosity thus enhancing recovery, for the extraction of iodine and bromine contained in thermal brines, for fish farming, etc. West Siberia is very rich in natural gas and oil, which hampers geothermal development (Kononov et al., 2000).	

Otradnen

LOCATION North Caucasian economic district, Krasnodar Krai	
STATUS Direct use – developed	
TEMPERATURE (°C)	88-100
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for space heating. Mineralization of 1.1-2.0 g/l; 0.5-0.9 MPa at borehole; 800 m³/day flow rate; average depth of boreholes is 1800 m (Stoyanov and Taylor, 1996).	

Ozernoye

LOCATION Far Eastern economic district, Kamchatka Oblast	
STATUS Direct use – developed	
TEMPERATURE (°C)	—

INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for greenhouses.	

Palana

LOCATION Far Eastern economic district, Kamchatka Oblast, in northern Kamchatka	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	75-95
INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	
NOTES One of 16 thermal spring groups in northern Kamchatka considered most attractive for geothermal use (Kononov et al., 2000). Springs discharge nitrogen rich water containing predominantly calcium sulphate and sodium (Sugrobov, 1995).	

Paratunka

LOCATION Far Eastern economic district, Kamchatka Oblast, 30 km from Petropavlovsk-Kamchatsky; in the Elizovsky region; 52º40'N latitude 158º15'E longitude	
STATUS Direct use – developed	
TEMPERATURE (°C)	40-106
INSTALLED CAPACITY (MWe)	0.8
POTENTIAL (MWe)	0.8
CHRONOLOGY 1967 - An experimental 800 kWe binary power plant, the first binary geothermal power plant in the world, using freon-12 and 80ºC water, was designed and successfully tested by the RAS Siberian Branch. 1968 to 1970 - Geothermal space heating, including greenhouses covering an area of 60,000 m², and balneotherapy systems began operating; managed by RAO Gazprom. 1978 - 800 kWe binary plant ceased operation.	

1995 - Heat output of geothermal heating system totaled 275,080 Gcal/yr (Perveev and Shumakova, 1996).

NOTES
Geothermal resource is used for district heating, health resorts, greenhouses, and fish farming.

Thermal Cl-Na waters with T=80-100ºC and TDS=1-5 g/kg are utilized for space heating.

The Paratunskaya system has the following zones: zeolite, albite-zeolite, albite-calcite with sericite, albite, albite-epidote, and albite-actinolite (Ladygin et al., 2000).

The geothermal hot water resource has a potential of 14,5000 m^3/day for commercial direct use (Stoyanov and Taylor, 1996).

Demand is 33.2 x 10^3 m^3/day; 0.00-0.11 MPa pressure at wellhead; 0.8-2.2 g/l mineralization; contamination: arsenic (0.01-1.0 mg/l), fluorine (0.2-3.0 mg/l), and silicic acid (50-80 mg/l).

Reserves have been explored and studied in detail. The data obtained assure determination of basic stratigraphic features, structure, and recharge sources for replenishing exploitable resources of subsurface water. Water quality has been studied to the point where its use may be established. Exploitable reserves of subsurface water at a site of projected supply have been determined on the basis of pump (flowing) tests and extrapolated estimates.

Pauzhetka

LOCATION
Far Eastern economic district, Kamchatka Oblast, in southern Kamchatka; south of Petropavlovsk; on the western coast of southeastern Kamchatka; 28 km from Ozernovsky; at the mouth of the Ozernoi River; in the Ust-Bolsheretsky region; 51º27'N latitude 156º50'E longitude

STATUS
Power plant(s) on site

TEMPERATURE (°C)	180-225
INSTALLED CAPACITY (MWe)	11.3
POTENTIAL (MWe) / (MWt)	68 / 104.6

CHRONOLOGY
1957 - First boreholes drilled, beginning the Soviet Union's geothermal exploration for electric power generation.

1958 to 1963 - 21 wells were drilled in a 0.7 km^2 large discharge area in the Pauzhetka River valley. The total withdrawal of 124 kg/s of steam-water mixture at pressures of 0.8 MPa and a mean enthalpy of 710 kJ/kg proved the resource exploitable (Sugrobov, 1995).

1962 to 1963 - Well tests conducted with a discharge of 128 kg/s (Kiryukhin and Sugrobov, 1985).

1966 - 5 MWe (two 2.5 MWe single flash units) came online, becoming the first geothermal power plant in the then-USSR. Managed by RAO Gazprom.

A steam-water mixture with a mean heat content of 175 Cal/kg is produced by 8 boreholes. The electric station used only steam and a considerable volume of hot water is discharged into a stream. Plans call for the expansion of the power station to 9 MWe, to use the hot water as well as the steam (Popov, 1975).

1970 - Prospecting drilling of deeper wells was continued in the southeastern part of the field to increase the power plant's capacity; 57 wells, including 24 production and 12 reinjection, were drilled up to depths of 1200 m; mass flow potential according to modeling data was determined to be 400 kg/s (Sugrobov, 1995). Temperatures at depth reached 225ºC, averaging 180-210ºC at depths of 300-800 m (Kiryukhin and Sugrobov, 1985).

1975 to 1976 - Well tests conducted with a discharge of 200 kg/s (Kiryukhin and Sugrobov, 1985).

1980 - Additional 6 MWe single flash geothermal power plant came online.

1987 - Experimental 300 kWe back-pressure turbine was installed.

1991 - Reconstruction plan developed to install 18 MWe additional (three 6-MWe turbines from Kaluga Turbine Plant) and to build an electric transmission line running east to west, thereby using the plant's full capacity (Delnov and Shulyupin, 1996).

1995 - A plan to use the discarded 130ºC water from the plant by piping it to Ozernovsky for district heating will cost US$25 million. Compared with the cost of traditional imported heat energy, the project will cover its costs in 5 years (Perveev and Shumakova, 1996).

1999 - Plant produced about 35 GWh/yr; the cheapest power in Kamchatka Oblast (Povarov, 2000). Seven wells utilize 240 kg/s of fluids with an enthalpy of 760-800 kJ/kg; 79 productive wells are drilled in the field so the capacity of the station can be increased to 18 MWe when three new 6 MWe units come into operation (as the old units are retired) (Kononov et al., 2000).

2000 - New 6 MWe single flash unit to come online.

2005 - 18 MWe total planned to be online.

2010 - 7 MWe addition planned to be online.

NOTES
Geothermal resource is used for power generation and space heating.

The estimated electrical generation potential of the Pauzhetka geothermal field is 50-60 MWe for 30 years (Povarov, 2000), or 68 ± 20 MWe for 100 years (Sugrobov, 1995).

88ºC springs at the surface; 104.6 MWt natural heat capacity (Leonov, 2000).

The Pauzhetka hydrothermal system includes the Pauzhetka springs and the Kambalny steam grounds. A shallow magma body with an anomalous temperature of 700-1000ºC and a volume of 20-30 km^3 may be a heat source for the formation of the Pauzhetka hydrothermal system. The water feeding source of the system may be meteoric waters which are infiltrated at an average rate of 5-10 kg/s•km^2 (Kiryukhin and Sugrobov, 1985, 1986).

Pauzhetka is a vapor-dominated field. The system belongs to regressive sulphurous-carbon acid gas stage of development (Ladgyin et al., 2000).

The Pauzhetka system is older and cooler than the Okeanskaya system, and belongs to the regressive stage of evolution. As a result it has somewhat different hydrothermal zoning with only two zones: the zone of low-temperature propylites (with two subzones - transilvanian and zeolite) and the zone of hydrothermal argillites with high-silicon zeolites (Korobov, 1993; Ladygin et al., 2000).

Thermal Cl-Na waters with T=80-100ºC and TDS=1-5 g/kg are utilized for space heating.

The geothermal steam resource has a potential of 15,200 m^3/day (Stoyanov and Taylor, 1996).

Demand is 42.2 x 10^3 m^3/day; 0.64-0.88 MJ/kg enthalpy; 0.15-0.18 MPa pressure at wellhead; 2.5-3.8 g/l mineralization; contamination: arsenic (1.2-4.4 mg/l).

Pinachev

LOCATION
Far Eastern economic district, Kamchatka Oblast

STATUS
Preliminary identification/report

TEMPERATURE (°C)	< 150
INSTALLED CAPACITY	—
POTENTIAL	—

CHRONOLOGY

NOTES
Geothermal resource is low temperature (< 150ºC).

Priurupsloe

LOCATION North Caucasian economic district, Krasnodar Krai	
STATUS Direct use – developed	
TEMPERATURE (°C)	99-103
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	

NOTES
Geothermal resource is used for hot water supply and space heating.

Mineralization of 1.5-1.7 g/l; 11.0 MPa at borehole; 800 m^3/day flow rate; average depth of boreholes is 2200 m (Stoyanov and Taylor, 1996).

Pushchin

LOCATION Far Eastern economic district, Kamchatka Oblast, 18 km north of Pushtino village; 70 km northwest of Milkovo settlement; in the Kashkan River valley	
STATUS Well(s) or hole(s) drilled	
TEMPERATURE (°C)	60-63
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	

NOTES
The resource has been placed under conservation (not being exploited) by the Russian Federal Authorities.

Demand is 1.3 x 10^3 m^3/day; 0.15-0.28 MPa pressure at wellhead; 4.6-7.0 g/l mineralization; contamination: arsenic (0.04-0.18 mg/l) (Stoyanov and Taylor, 1996).

Rechnin	
LOCATION North Caucasian economic district, Dagestan Republic	
STATUS Direct use – developed	
TEMPERATURE (°C)	42-104
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is under conservation (not being exploited). Mineralization of 2.7-26.84 g/l; phenol contamination (0.0048-2.86 mg/l); 0.04-1.12 MPa at borehole; 1000 m³/day flow rate; average depth of boreholes is 1000-3000 m (Stoyanov and Taylor, 1996).	

Rodnikovskaya	
LOCATION North Caucasian economic district, Krasnodar Krai	
STATUS Direct use – developed	
TEMPERATURE (°C)	74
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is under conservation (not being exploited). 500 m³/day flow rate; average depth of boreholes is 1800 m (Stoyanov and Taylor, 1996).	

Rusakov	
LOCATION Far Eastern economic district, Kamchatka Oblast, in northern Kamchatka	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	75-95
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	

NOTES One of 16 thermal spring groups in northern Kamchatka considered most attractive for geothermal use (Kononov et al., 2000). Springs discharge nitrogen rich water containing predominantly calcium sulphate and sodium (Sugrobov, 1995).

Rychal-Su	
LOCATION North Caucasian economic district, Dagestan Republic	
STATUS Direct use – developed	
TEMPERATURE (°C)	—
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for drinking water.	

Sabin	
LOCATION North Caucasian economic district, Krasnodar Krai	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	—
INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	
NOTES	

Semyachik	
LOCATION Far Eastern economic district, Kamchatka Oblast, near the famous Geyser Valley in the Kronotsky Reservation, in the Nalycheva River valley	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	100-250
INSTALLED CAPACITY	—
POTENTIAL (MWe) / (MWt)	5 / 314

CHRONOLOGY	
NOTES Located within the boundaries of the Kronotsky Reservation where any industrial or agricultural activity is prohibited. (Kononov et al., 2000). Limited use of the Semyachik field (for construction of a small power station of 5 MWe capacity) could help development of tourist services in the reservation (Kononov et al., 2000). Saturated steam at the surface; 314 MWt natural heat capacity (Leonov, 2000). Boiling spring waters have sodium-chloride composition (Sugrobov, 1995). Mean temperature of the first 1-km layer is 250ºC. Available energy in the 1-km layer with a temperature decrease of 50ºC is 24 x 10^{13} kcal (Fedotov et al., 1975).	

Severo-Eremin

LOCATION North Caucasian economic district, Krasnodar Krai	
STATUS Direct use – developed	
TEMPERATURE (°C)	107-117
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is currently under conservation (not being exploited). Mineralization of 2.5-2.9 g/l; phenol contamination; 0.7 MPa at borehole; 1000 m³/day flow rate; average depth of boreholes is 2200 m (Stoyanov and Taylor, 1996).	

Severo-Mutnovsky

LOCATION Far Eastern economic district, Kamchatka Oblast, in southern Kamchatka	
STATUS Well(s) or hole(s) drilled	
TEMPERATURE (°C)	220-301
INSTALLED CAPACITY (MWe)	—
POTENTIAL (MWe)	172
CHRONOLOGY 1960 - Dacha Springs found.	

Mid-1970s - Power plant construction proposed.

1979 - Exploration drilling began; 82 boreholes were drilled to depths of 255-2266 m.

1998 - There were 17 wells capable of producing 330 kg/s of fluids with an average enthalpy of 1600 kJ/kg. These are now being used to supply 12 MWe via three 4 MWe Tuman 4K plants in the Verkhne (“upper”) part of the field.

1999 - A transmission line from the 12 MWe Verkhne-Mutnovsky complex to the market was completed.

2000 - Seventeen wells producing 330 kg/s of fluids with average enthalpy of 1600 kJ/kg are ready for exploitation. A shallow vapor-dominated reservoir containing fluid (steam) with an enthalpy of 2100-2700 kJ/kg was found at depths of 700-900 m. It is underlain by a liquid-dominated reservoir holding fluids with an enthalpy of 1000-1500 kJ/kg (T=250-310ºC) (Kononov et al., 2000).

NOTES
Electrical generation potential is 172 ± 52 MWe for 100 years (Sugrobov, 1995).

A shallow, vapor-dominated resource with an enthalpy of 2100-2700 kJ/kg has been defined between 700 and 900 m deep with a liquid-dominated reservoir having an enthalpy of 1000-1500 kJ/kg below it (Huttrer, 2000).

Plans are in place for a consortium comprising Nauka (Russia), West JEC (Japan), and GENZL (New Zealand) to build the second, third, and fourth power plants in the Mutnovsky and Verkhne-Mutnovsky areas.

Surgut

LOCATION
West Siberian economic district, Khanty-Mansi Autonomous Okrug

STATUS
Preliminary identification/report

TEMPERATURE (°C)	—
INSTALLED CAPACITY	—
POTENTIAL	—

CHRONOLOGY

NOTES

Tarumovka

LOCATION
North Caucasian economic district, Dagestan Republic

STATUS
Direct use – developed

TEMPERATURE (°C)	62-195
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWe)	0.2

CHRONOLOGY
1917 - Resource discovered while investigating Mesozoic sedimentation.

NOTES
Geothermal resource is used for space and district heating, completely satisfying the needs of the town (Kononov et al., 2000).

A geo-technological complex is being planned in this field. The complex will include a chemical and mineral extraction plant and a geothermal power station to provide electricity to the complex (Magomedov et al., 1999).

A project to construct a 200 kWe geothermal power plant encountered engineering difficulties and is suspended.

The Tarumovka geothermal field is one of the most promising in the region. Production rates of 2.5 million m^3/day are expected (Magomedov et al., 1999).

The Tarumovska deposit has geothermal reserves with high salinity (200 g/l) and temperatures up to 195ºC. Six wells have been drilled to depths of about 5500 m, the deepest geothermal wells in Russia. Tests indicate high reservoir permeability with wells producing between 7500 and 11,000 m^3/day at 14-15 MPa wellhead pressures (Magamedov K.M. et al., 1999, Povarov, 2000).

Mineralization of 4.0-26.0 g/l; phenol contamination (0.16-0.94 mg/l); 4.7 MPa at borehole; 600 m^3/day flow rate; average depth of boreholes is 1500-2000 m (Stoyanov and Taylor, 1996).

A steam-water mixture with a temperature of 160ºC and a mineralization of 220 g/l is obtained from a depth of 5429 m. The water is a calcium chloride brine and is known for its health properties (Sardarov, 1990).

Tavatum

LOCATION
Far Eastern economic district, Magadan Oblast, on the north coast of the Gizhiginskoe cove of Shelehov Bay; 7.5 km from the mouth of the Tavatum River; 70 km west of Evensk

STATUS
Preliminary identification/report

TEMPERATURE (°C)	59
INSTALLED CAPACITY (MWt)	—

POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES SevVostGeolKom has plans to develop the resource for space heating and balneotherapy. Due to the severe climatic conditions, the region is poorly studied (Stoyanov and Taylor, 1996). The geothermal hot water resource has a potential of 135 m³/day for commercial direct use (Stoyanov and Taylor, 1996).	

Terekly-Mekteb	
LOCATION North Caucasian economic district, Dagestan Republic	
STATUS Direct use – developed	
TEMPERATURE (°C)	81-88
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES	

Geothermal resource is used for space heating.

Mineralization of 0.25-6.94 g/l; phenol contamination (2.8 mg/l); 0.37-0.40 MPa at borehole; 600 m³/day flow rate; average depth of boreholes is 1900-2000 m (Stoyanov and Taylor, 1996).

The geothermal hot water resource has a potential of 5000 m³/day for commercial direct use (Stoyanov and Taylor, 1996).

Reserves have been explored and studied to the degree that the data assure complete understanding of stratigraphy, structure, pressure heads, and permeability of water-bearing rock. The means by which water-bearing formations are replenished and their potential to add to exploitable reserves have been ascertained. The volume of subsurface water has been determined with a certainty that assures the useful life and the potential for a desired purpose. Exploitable reserves of subsurface water have been determined at the water supply site using pump (flowing) tests and/or other means.

Tectonically, the Terekly-Mekteb region is attached to the plate slope of the Terek-Caspian foredeep. Thermal waters of 88ºC come from a depth of 2000-2055 m. Well yields are not great, reaching 1000 m³/day. Miocene waters are rather mineralized (up to 25 g/l) and possess high health properties, and are recommended for treating motor and nervous system problems and skin diseases (Sardarov, 1990).

Termalny	
LOCATION Far Eastern economic district, Kamchatka Oblast	
STATUS Direct use – developed	
TEMPERATURE (°C)	40-97
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for greenhouses. Demand is 33.2 x 10^3 m³/day; 0.00-0.11 MPa pressure at wellhead; 0.8-2.2 g/l mineralization; contamination: arsenic (0.01-1.0 mg/l), fluorine (0.2-3.0 mg/l), and silicic acid (50-80 mg/l) (Stoyanov and Taylor, 1996).	

Tersko-Galiugaev	
LOCATION North Caucasian economic district, Stavropol Krai	
STATUS Direct use – developed	
TEMPERATURE (°C)	55
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for hot water supply. Mineralization of 12.3 g/l; 0.5 MPa at borehole; 1500 m³/day flow rate; average depth of boreholes is 2600-2700 m (Stoyanov and Taylor, 1996).	

Tirniauz	
LOCATION North Caucasian economic district, Kabardino-Balkarian Republic, near the Elbrus Mountain	
STATUS Well(s) or hole(s) drilled	
TEMPERATURE (°C)	170-250
INSTALLED CAPACITY (MWe)	—
POTENTIAL (MWe)	10

CHRONOLOGY

February 1991 - First hydrofracture experiment in hot dry granitic rock was carried out in the former Soviet Union in a deep well (3830 m) with a temperature of more than 200ºC.

The results of the two-stage experiment were mixed: the experiment was terminated suddenly on the second day due to uncontrolled lost circulation which developed in the tubing zone.

Several organizations participated in the experiment, including NPO “Nedra” headquartered in Yaroslavl, Gipronikel which runs Tirniauz Tungsten-Molybdenum Combine (TVMK), and the Saint Petersburg Mining Institute.

In addition to creating a prototype geothermal circulation system (GCS), the project was also designed to construct an industrial hot water supply system for TVMK mining operations, and build a 10 MWe geothermal electric power plant (GeoTES).

The potential of the Tirniauz HDR resource was estimated to be an energy extraction of 100-400 GJ/hr using a circulating fluid with flow rates of 200-500 m^3/hr and temperatures of 170-250ºC (Kruger, 1992).

February 1992 - Announced that a second well would be drilled in the field.

NOTES

Tobol’sk

LOCATION

West Siberian economic district, Khanty-Mansi Autonomous Okrug

STATUS

Preliminary identification/report

TEMPERATURE (°C)	—
INSTALLED CAPACITY	—
POTENTIAL	—

CHRONOLOGY

NOTES

Tumlat

LOCATION

STATUS

Far Eastern economic district, Kamchatka Oblast, in northern Kamchatka

TEMPERATURE (°C)	< 150

INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	

NOTES
One of 16 thermal spring groups in northern Kamchatka considered most attractive for geothermal use (Kononov et al., 2000).

Geothermal resource is low temperature (< 150ºC).

Tyrnyaus

LOCATION
North Caucasian economic district,
Kabardino-Balkarian Republic

STATUS
Well(s) or hole(s) drilled

TEMPERATURE (°C)	—
INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	

NOTES
Hydro-fracturing experiments were carried out; 85 m^3 of water under pressure of 60 MPa was injected for 46.5 minutes into granitic rocks with a temperature of 210ºC at a depth interval of 3721-3820 m. The experiment was unsuccessful: the injection tube broke at 3606-3610 m (Slysarev et al., 1991; Kononov et al., 1995).

Tyumen

LOCATION
West Siberian economic district, Tyumen Oblast

STATUS
Direct use – developed

TEMPERATURE (°C)	—
INSTALLED CAPACITY	—
POTENTIAL	—
CHRONOLOGY	

NOTES
Thermal waters provide the space heating of small settlements and several buildings in the city.

Geothermal water is also used heat oil-bearing horizons to decrease oil viscosity thus enhancing recovery, for the extraction of iodine and bromine contained in thermal brines, for fish farming, etc.

This region is very rich in natural gas and oil, which hampers geothermal development (Kononov et al., 2000).

Ulianovsky	
LOCATION North Caucasian economic district, Krasnodar Krai	
STATUS Direct use – developed	
TEMPERATURE (°C)	75-82
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for space heating. The geothermal hot water resource has a potential of 1864 m³/day for commercial direct use. Mineralization of 1.8-2.3 g/l; phenol contamination; 0.8 MPa pressure at borehole; 900 m³/day flow rate; average depth of boreholes is 2000-2200 m (Stoyanov and Taylor, 1996). Reserves have been explored and studied to the degree that the data assure complete understanding of stratigraphy, structure, pressure heads, and permeability of water-bearing rock. The means by which water-bearing formations are replenished and their potential to add to exploitable reserves have been ascertained. The volume of subsurface water has been determined with a certainty that assures the useful life and the potential for a desired purpose. Exploitable reserves of subsurface water have been determined at the water supply site using pump (flowing) tests and/or other means.	

Uzhno-Berezhnoe	
LOCATION Far Eastern economic district, Kamchatka Oblast, in the outskirts of Petropavlovsk-Kamchatsky	
STATUS Direct use – developed	
TEMPERATURE (°C)	72
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY 1989 - RAO Gazprom developed geothermal resource for space heating.	
NOTES Geothermal resource is used for space heating. Measured 0.01 MPa pressure at wellhead; < 11.1 g/l mineralization; contamination: arsenic (1.0 mg/l),	

arsenious acid (1.68 mg/l), and metaboric acid (17.1 mg/l) (Stoyanov and Taylor, 1996).

Uzhno-Sovet	
LOCATION North Caucasian economic district, Krasnodar Krai	
STATUS Direct use – developed	
TEMPERATURE (°C)	116
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for hot water supply and space heating. Mineralization of 1.4 g/l; 17.0 MPa at borehole; 1000 m³/day flow rate; average depth of boreholes is 2200 m (Stoyanov and Taylor, 1996).	

Uzhno-Voznesen	
LOCATION North Caucasian economic district, Krasnodar Krai	
STATUS Direct use – developed	
TEMPERATURE (°C)	83-87
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for space heating. Mineralization of 1.4-1.8 g/l; 600 m³/day flow rate; average depth of boreholes is 2000 m (Stoyanov and Taylor, 1996).	

Uzon-Geyser
LOCATION Far Eastern economic district, Kamchatka Oblast, in the Nalycheva River valley within the Kronotsky Reservation; in the eastern volcanic belt of Kamchatka
STATUS

Reconnaissance	
TEMPERATURE (°C)	100
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	268
CHRONOLOGY	

NOTES
Saturated steam and boiling water at the surface; 268 MWt natural heat capacity (Leonov, 2000).

Located within the boundaries of the Kronotsky Reservation where any industrial or agricultural activity is prohibited.

Boiling spring waters have sodium-chloride composition (Sugrobov, 1995).

The Uzon-Geyser hydrothermal system is typical of areas of recent tectonic activity (e.g., New Zealand, California, etc.). The system is controlled by the volcanic-tectonic pre-Pleistocene dome, in the center of which a series of eruptions occurred and subsidence calderas formed.

The western portion of the structure, the Uzon caldera, is an almost closed hydrogeological structure. The eastern part is opened by a NNW-oriented tension rupture (spreading), the intense activity of which in Holocene predetermines the functioning of the thermally anomalous zones of the Geyser Valley (Dmitriev and Karpov, 1990).

Verkhne-Mutnovsky

LOCATION
Far Eastern economic district, Kamchatka Oblast

STATUS
Power plant(s) on site

TEMPERATURE (°C)	170
INSTALLED CAPACITY (MWe)	12
POTENTIAL (MWe)	21

CHRONOLOGY
1998 - 4 MWe single flash geothermal power plant went online.

1999 - Two additional 4 MWe single flash units went online. Commissioned by CSC Geoterm.

The geothermal power plants are of the block type and consist of 14 containers equipped with facilities that have been completely factory-tested. The construction and installation take less than two years (Povarov, 2000).

2002- Two additional units, a 3 MWe single flash and a 6 MWe binary unit, expected online. The binary unit will increase the overall geothermal's system efficiency by 20-40% (Povarov and Povarov, 1999).

From the existing wells surplus two-phase fluid not used by the first three power units will be transported to the fourth power unit of Verkhne-Mutnovsky GeoPP. At the upper part of the cycle a modular back-pressure steam turbine with the capacity of 3 MWe will be used.

Total capacity of the power unit will be 9 MWe. The binary installation will be designed, constructed, and tested under nominal capacity of 6.8 MWe, as a pilot model of serial binary power modules. These power modules will be used in future combined power units of the second stage of Mutnovsky GeoPP, and for the extensive application of binary GeoPP with the capacity of 6 and 12 MWe for other new projects.

2005 - 21 MWe total installed capacity planned

NOTES

The Verkhne-Mutnovsky (VM GeoPP) is a pilot geothermal power project.

The design, creation, equipment production and construction of VM GeoPP, the first multi-module geothermal power plant with a capacity of 12 (3x4) MWe was organized by CSC Geoterm with support from the Russian Federation Ministry of Science. The equipment for the power plant was manufactured at "Kaluga Turbine Works" SC.

The creation of the Verkhne-Mutnovsky GeoPP was based on new approaches to power plant construction:

1) A pre-assembled modular steam preparation system;

2) A 100% factory-assembled modular power plant with turbogenerators, electrotechnical equipment, main control panel and etc.; and

3) An ecologically clean cycle of geothermal fluid utilization with an air condenser that prevents direct contact of the working medium with the environment.

The climatic conditions of the Mutnovsky area are rather unique due to the location in a northern region at a substantial elevation above the sea level. The average annual air temperature is -1.5ºC. The average temperature over the duration of eight months (from October till May) is lower at -5ºC. This low ambient temperature allows reducing the design condensate temperature in the power cycle to 10-20ºC yielding considerable power output increase (by 20-40%) compared to GeoPP located in hot or moderate climate (Britvin et al., 2000).

Verkhne-Paratunka

LOCATION
Far Eastern economic district, Kamchatka Oblast, 30 southwest of Petropavlovsk-Kamchatsky; 10 km south of the Termalny settlement; in the upper Paratunka River valley; in the Elizovsky region

STATUS
Direct use – developed

TEMPERATURE (°C)	70-106
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—

CHRONOLOGY
1981 - Exploitation of geothermal resource began; 24 wells drilled; 5 are production wells.

1995 - Heat output of geothermal heating system totaled 3147 Gcal/yr. The large field does not operate in practice due to a lack of water transmission to large consumers. The cost of such a system is estimated at US$24 million. Heat output is expected to be 426,000 Gcal/yr. Compared with the cost of traditional imported heat energy, the project will cover its costs in 4.5 years (Perveev and Shumakova, 1996).

NOTES
Verkhne-Paratunka is a hot water resource which is used for swimming pools and space heating.

The geothermal hot water resource has a potential of 23,300 m^3/day for commercial and potential direct use (Stoyanov and Taylor, 1996).

Demand is 21.6 x 10^3 m^3/day; 0.46-1.19 MPa pressure at wellhead; 0.9-1.5 g/l mineralization; contamination: arsenic (0.13-1.0 mg/l) and fluorine (2.8-4.4).

Reserves have been explored and studied in detail. The data obtained assure determination of basic stratigraphic features, structure, and recharge sources for replenishing exploitable resources of subsurface water. Water quality has been studied to the point where its use may be established. Exploitable reserves of subsurface water at a site of projected supply have been determined on the basis of pump (flowing) tests and extrapolated estimates.

Voskresen

LOCATION
North Caucasian economic district, Krasnodar Krai

STATUS
Direct use – developed

TEMPERATURE (°C)	112-116

INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is currently under conservation (not being exploited). Mineralization of 1.5-3.5 g/l; phenol contamination; 1.28 MPa at borehole; 1000 m³/day flow rate; average depth of boreholes is 2200 m (Stoyanov and Taylor, 1996).	

Vostochno-Baksan	
LOCATION North Caucasian economic district, Kabardino-Balkarian Republic	
STATUS Direct use – developed	
TEMPERATURE (°C)	56-58
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for space heating. Mineralization of 8.1 g/l; phenol contamination (0.032 mg/l); 1500 m³/day flow rate; average depth of boreholes is 1900 m (Stoyanov and Taylor, 1996).	

Voznesen	
LOCATION North Caucasian economic district, Krasnodar Krai	
STATUS Direct use – developed	
TEMPERATURE (°C)	82-111
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	—
CHRONOLOGY	
NOTES Geothermal resource is used for space heating. Mineralization of 1.0-4.7 g/l; phenol contamination; 0.2-1.2 MPa at borehole; 1000 m³/day flow rate; average depth of boreholes is 2500 m (Stoyanov and Taylor, 1996).	

Yaroslavl

LOCATION Central economic district, Yaroslavl Oblast	
STATUS Well(s) or hole(s) drilled	
TEMPERATURE (°C)	60
INSTALLED CAPACITY (MWt)	—
POTENTIAL (MWt)	55

CHRONOLOGY

1993 - Injection bore hole drilled; construction of a geothermal circulation system using a natural collector was begun.

The bore hole penetrated the aquifer, composed of sand-clay deposits, including water with a temperature of more than 60ºC, at a depth of 2250 m. The production bore hole was drilled 800 m from the first one.

The water rate in circulation contour was projected as 100 m^3/hr with a capacity of 55 MWt heat production and 25,000 Gcal/yr (Khakhaev, Pevsner, 1993; Kononov et al., 1995).

NOTES

Zhirov

LOCATION Far Eastern economic district, Kamchatka Oblast	
STATUS Preliminary identification/report	
TEMPERATURE (°C)	200
INSTALLED CAPACITY	—
POTENTIAL	—

CHRONOLOGY

NOTES

Mean temperature of the first 1-km layer is 200ºC. Available energy in the 1-km layer with a temperature decrease of 50ºC is 12 x 10^{13} kcal (Fedotov et al., 1975).

Conclusion

Russia has at least 15 high-enthalpy (T>150ºC) sites, most located in the Far East:

SITE/PROJECT NAME	ECONOMIC DISTRICT	TEMP. ºC
Okeanskaya (Kipiashty)	Far Eastern	320
Mutnovsky	Far Eastern	320
Severo-Mutnovsky	Far Eastern	301
Tirniauz	North Caucasian	250
Semyachik	Far Eastern	250
Jushnosukhokumsk	North Caucasian	240
Nizhne-Koshelev	Far Eastern	240
Pauzhetka	Far Eastern	225
Apapel	Far Eastern	200
Karym	Far Eastern	200
Khodutkin	Far Eastern	200
Kireuna	Far Eastern	200
Bolshe-Bannoe	Far Eastern	200
Tarumovka	North Caucasian	195
Kayasula	North Caucasian	170

MinEnergy has expressed a strong interest in attracting U.S. investment to develop the country's significant high enthalpy geothermal resources with the following caveat: that such investment supports Russian economic development on Russian soil. The example cited is the presence of Japanese automobile manufacturing plants in the United States. MinEnergy is particularly interested in geothermal power generation development in the Far East, specifically Kamchatka and the Kuril Islands; and in Omsk and Tomsk in West Siberia.

Currently, however, Russia's power sector is in a state of transition. RAO UES has submitted a restructuring proposal to the GOR which includes spinning-off its generation capacity while retaining control of the country's distribution grid. Over the next few years, subsidies to electric consumers will end, electricity tariffs will be modified to reflect real costs, and an electricity market will be created. Once these measures are adopted, greater, more secure investment opportunities for U.S. companies will arise.

In the interim, U.S. companies are focusing their sales efforts on power enterprises on Russia's periphery, which can generate export revenues, as well as independent operators which are not affiliated with RAO UES. If individual producers can secure rights to compete on price, to halt service to non-paying customers, and to retain their earnings, then significant investment should follow.

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