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# Union of Soviet Socialist Republics: Survey of low-temperature geothermal energy

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## Geography

Area 22,740,000 $km^2$

Population 260,000,000 (1977)



## Information

The questionnaire was sent to six individuals in the USSR. Replies were received from three of these. Kutateladze replied in Russian and gave information on the 750 kW binary plant at Paratunski. Gutsalo said he worked in geochemistry and had no information on utilization. Kononov with I.M. Duvorov and V.I. Dvorov sent a good reply - it appears that the Scientific Council on Geothermal Studies of the Academy of Sciences of the USSR is the correct institution to contact for information on geothermal energy. Several papers were consulted for background information.

## Utilization

Almost all published (Barbier & Fanelli 1977, Howard 1975) values on geothermal utilization in the USSR are based on papers by Soviet authors at the 1970 U.N. Symposium in Pisa. District heating being reported 114 MW thermal and greenhouses 5000 MW thermal. The latter value was derived indirectly from average energy requirements (0.2 $kW/m^2$) of greenhouses and reported area of "hotbeds and hothouses" (5000 x 5000 25,000,000 $m^2$) at Makhachkala. However, the stated area (or a small part of it) was heated only by one borehole discharging 1800 $m^3$ per 24 hours of 63°C geothermal water, corresponding to 48 MW if cooled down to 40°C. The estimated 5000 MW were therfore 100 times greater than was actually used. This "error" resulted in distorted values for geothermal energy use in agriculture in the world because 5000 MW represented 90% of the installed thermal capacity in 1975.

In the 1979 P.R. Pryde published a good overview of geothermal energy development in the USSR. According to a Soviet reference the total

amount of geothermal fluids axtracted in 1976 was 26.4 x $10^6$ $m^3$ with an average temperature of 70°C. About 62% went for space heating, spas and industrial applications, 25% went into agricultural applications (mostly hothouses) and 13% was used in the two geothermal electrical generating stations on the Kamchatka Peninsula. These values are therefore both low and high temperature waters. However, the low teperature waters acconunt probably for at least 90% at the total. Tables 1 and 2 show the thermal energy used and the estimated thermalpower associated with that energy use, assuming 50% load factor. In practical situations in many countries the average energy use during one year corresponds roughly to 1/2 the innstalled capacity being used all year. The values in Table 2 are only estimates.

In Kutateladze's reply there was information about the experimental binary cycle plant at Paratunski. In the 1960's they investigated the hot spring at Paratunski and in 1965 a 0.75 MW electrical generator was constructed. The plant uses 200 $m^3$/h (56 l/s) of 80°C water that is cooled to 50°C. This corresponds to 7 MW thermal. At reference tempertures 0°C, 15°C and 40°C the thermal energy uses corresponds to 19 MW, 15 MW and 9 MW thermal, respectively. Hot water from the Paratunski geothermal area is also used for space heating (homes and greenhouses). Total flowrate of hot water from the area 167 l/s.

In the reply from Dvorov, Kononov & Dvorov, at the Scientific Council on Geothermal Studies, the use of low-temperature geothermal energy was given on 3 typed pages and listed under the heatings " Characteristic of the Present State and Perspectives of Utilization of Low-Temperature Underground Waters of the USSR" as: I-1 District heating, I-2 Utilization in agriculture, I-3 Fish-breeding, I-4 Utilization for industrial purposes, I-5 Utilization for medicinal-rehabilitation purposes. II Past and future utilization. III Exploration projects. IV Potential resources of low-temperature hydrothermal systems in USSR. Actual numbers/values to quatify geothermal energy use in the above categories were limited. Temperatures of waters were given and typical flowrates from boreholes, but not the number of boreholes nor total amount of fluids produced. The thermal energy and power associated with the various uses were therefore not given.

Dvorov, Kononov & Dvorov stated that district heating was in three regions. The Caucasus, West Siberia and Kamchatka. For the first of these the number of inhabitants using thermal waters was given as 110,000 people. To estimate the associated thermal power here, some values from the two papers by P.R. Pryde (1979) will be used. He stated that in the town of Kizlyar (in the Daghestan Autonomous Republic in the Caucasus) in 1974 there were 5 boreholes yielding 17,340 $m^3$/day of 105°C water and 4 boreholes yielding 16,950 $m^3$/day of 60°C water. Dvorov, Kononov & Dvorov stated that 90°C water was used for the heating in Kizlyar with a discharge temperature of 58°C. Assuming, however, that district heating scheme in Kizlyar uses 200 l/s (17,340 $m^3$/day) of 105°C water and 196 l/s (16,950 $m^3$/day) of 60°C water, the thermal energy was estimated. The number of inhabitants in Kizlyar using thermal water is 30,000 according to Dvorov, Kononov & Dvorov. With reference discharge temperature of 40°C the thermal power of the Kizlyar district heating systems becomes 82 MW or 2.7 MW per 1000 inhabitants. According to Einarsson (1975) the corresponding figures for Reykjavík (Iceland) are 4.4 MW per 1000 inhabitants and 4.9 MW per 1000 inhabitants when considering all the district heating systems in Iceland. However, on the assumption that the Kizlyar value above is representative for the other towns in the Caucasus with geothermal heating, the total thermal power was estimated and is shown in Table 3. Dvorov, Kononov & Dvorov did not provide any data on district heating in the regions of West Siberia and Kamchatka. Limited data was given on categories I-2 to I-5, execept "the total area of all greenhouses in the USSR heated by thermal waters is at present 420,000 $m^2$". Tikhonov & Dvorov (1970) in a paper presented in Pisa stated that 45-50 $m^3$/h of 60-65°C water was required to heat one hectar (10,000$m^2$) of greenhouses in the USSR. Taking the average of these (47.5 $m^3$/h and 62.5°C) corresponds to 0.345 kW/$m^2$, 0.262 kW/$m^2$ and 0.124 kW/$m^2$ for 0°C, 15°C and 40°C reference temperature, respectively. For comparison it may be stated that in Iceland it is estimated tha 0.233-0.250 kW/$m^2$ (200- 250 kcal/h $m^2$) are required for typical greenhouses. Based on the USSR values given by Tikhonov & Dvorov it takes 52 MW, 110 MW and 145 MW thermal to heat 420,000 $m^2$ at 40°C, 15°C and 0°C reference temperature, respectively.

Exploration

Two projects: a) Hydrogeological and geothermal studies in the region of the Baikal-Amur railway line for space heating and other purposes in next few years. b) Drilling of deep wells to investigate hot-dry-rock possibilities in the western regions of the European part of the USSR (Carpathians) and in the Caucasus (e.g. Daghestan) in the future.

Assessment

A heat flow map of the USSR in available. Main geothermal areas are on Kamchatka and in the Caucasus. Buachidse et. al. (1970) presented data on thermal waters in Georgia. Mentioned more than 50 groups of outlets of thermal waters with temperatures 35-105°C and total flowrate of more than 1000 l/s. Data shows 30 MW, 150 MW and 260 MW thermal flowing from these outlets at 40°C, 15°C and 0°C reference temperatures, respectively.

For the whole of the USSR Tikhonov & Dvorov (1970) stated that 7.9. x $10^6$ $m^3$/day was the "thermal water reserve". Dvorov (1970) stated the average temperature of these waters as 65 to 70°C and gave the reserve as 7.90 x $10^6$ $m^3$/day of waters with mineralization up to 10 g/l. Dvorov (1974) stated the reserve of thermal waters with mineralization up to 35 g/l as 19.75 x $10^6$ $m^3$/day. Dvorov, Kononov & Dvorov (in reply to questionnaire) gave the "regional resource of thermal waters in the USSR" as 19.75 x $10^6 m^3$/day with mineralization up to 35 g/l and stated that the temperature of the waters ranged from 50°C to 180°C. A table showed the reserve of 5 regions of the USSR. From the available data the thermal power of these reserves can be estimated indirectly. By using an average temperature of 65°C for all the thermal water reserves (see Dvorov 1974) and the table given by Dvorov, Kononov & Dvorov, Table 5 was constructed.

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TABLE 1

Geothermal energy use in 1976

| Type of use | Thermal energy TJ | | |
|---|---|---|---|
| | 0°C | 15°C | 40°C |
| Space heating (62%) | 4797 | 3769 | 2056 |
| Agriculture (25%) | 1934 | 1520 | 829 |
| Electricity (13%) | 1006 | 790 | 431 |
| Total | 7737 | 6079 | 3316 |

TABLE 2

Estimated thermal power in 1976

| Type of use | Thermal power MW | | |
|---|---|---|---|
| | 0°C | 15°C | 40°C |
| Space heating (62%) | 304 | 204 | 130 |
| Agriculture (25%) | 122 | 96 | 52 |
| Electricity (13%) | 64 | 50 | 28 |
| Total | 490 | 386 | 210 |

TABLE 3

District heating in the Caucasus

| Type of use | Thermal power MW | | |
|---|---|---|---|
| | 0°C | 15°C | 40°C |
| Kizlyar (30,000) | 137 | 117 | 82 |
| Total (110,000) | 502 | 429 | 301 |

TABLE 4

Known use of low-temperature geothermal waters in the USSR

| Type of use | Thermal power MW | | |
|---|---|---|---|
| | 0°C | 15°C | 40°C |
| District heating | 500 | 430 | 300 |
| Greenhouses | 150 | 110 | 55 |
| Electricity | 19 | 15 | 9 |
| Total | 669 | 555 | 364 |

TABLE 5

Regional resources of thermal waters in the USSR

| Region | Discharge | | Thermal power GW[x] | | |
|---|---|---|---|---|---|
| | $\times 10^{-6}$ $m^3$/day | $m^3$/s | 0°C | 15°C | 40°C |
| European USSR | 3.02 | 35 | 9.5 | 7.3 | 3.6 |
| Middle Asia | 1.43 | 17 | 4.6 | 3.5 | 1.8 |
| Kazakstan | 1.2 | 14 | 3.8 | 2.9 | 1.5 |
| West Siberia | 10.75 | 124 | 33.7 | 25.9 | 13.0 |
| East Siberia & Far East | 3.35 | 39 | 10.6 | 8.2 | 4.1 |
| Total | 19.75 | 229 | | 47.8 | 24.0 |

x Assuming 65°C average temperature.