GEOTHERMAL ENERGY RESOURCES OF UKRAINE AND THE STATE OF THE ART OF UTILIZATION THEREOF

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KEY WORDS

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ABSTRACT

The main geological structures of Ukraine providing the formation of usable geothermal energy reserves within their boundaries are identified. The present state of the art of geothermal energy utilization in Ukraine is described.

1. GEOTHERMAL ENERGY IN UKRAINE

The geothermal energy in Ukraine is represented by thermal and superheated waters as well as by the heat of dry rocks. The reserves of thermal and superheated waters are formed and circulate at the depths exceeding 1000 metres within the boundaries of geosynclinal type artesian basins. Of these basins containing industrially feasible reserves of thermal and superheated waters Ukraine has four: Zakarpatsky, Predkarpatsky, Dnyeprovsko-Donyetsky and Prichernomorsky basins According to the estimates by the Ukrainian State Committee for Geology the total potential reserves of the above-mentioned basins amount to 27.3 mln. cub. m/day, the weighed mean temperature being 70°C [1]. It should be pointed out that within the boundaries of these basins there are localities containing waters superheated to more than 170°C at the depths exceeding 3500 metres. The analysis of exploratory wells testing has shown that the pioneering work on superheated waters extraction can be organized on Zaluzhska (Zakarpatska obl.), Novochybylovska (Kharkovska obl.) and Tarhankutska (AR Crimea) localities.
As for the dry-rocks-accumulated heat, the great bulk of such deposits is concentrated on the territory of Ukrainian Crystalline Shield and partly on Voronyezhsky Crystalline Massif. The potential reserves of heat accumulated in these structures are estimated to be around $322.7 \cdot 10^{12}$ GJ [1].
Presently, however, industrial utilization of the geothermal reserves in full measure is rather problematic due to the comparatively low (up to 100°C) temperature of the major part of the thermal waters and dry rocks. Thus, their use is limited mainly to heating purposes and is possible within the limits of cities and settlements. The present assessment of predicted usable geothermal reserves of Ukraine, as distinct from previous ones, has been done against the background of existing concrete consumers of heat and with the following points in mind:

1. The predicted usable reserves of thermal and superheated waters of the artesian basins and the amount of heat stored in dry rocks have been evaluated down to a 5000 metres depth, as that attainable by standard-made drilling equipment.
2. The reserves are estimated for the environmentally-friendly exploitation technology implying the pumping of spent heat carrier back into the reservoir.
3. The generally known methods and techniques were used in the process of evaluation.

4. The system of geothermal heat supply are correlated to the area of settlements-consumers.
5. The energy potential of predicted usable reserves is estimated with due regard for the peculiarities of design and exploitation of geothermal equipment adopted. The term "energy potential" is taken to mean the quantity of thermal and electric power which is possible to generate using relevant equipment with the currently accepted efficiency and the load of energy-generating capacities. It should be pointed out that the load of energy-generating capacities depends on a number of working hours per year and is calculated in the following manner:

1. For heat-supply installations

$$E^{therm} = 0.65N^{g}_{h}t_{h} + N^{g}_{hws}t_{hws} \quad (1)$$

assuming:

$$N^{g}_{hws} = 0.2N^{g}_{h} \quad \text{и} \quad N^{g} = N^{g}_{h} + 0.2N^{g}_{h} \quad (2)$$

substituting of (2) in E_Q (1) gives:

$$E^{th} = \frac{0.65t_{h} + 0.2t_{hws}}{1 + 0.2} \quad (3)$$

Where:

E^{th} – energy potential of predicted usable reserves of geothermal energy;

N^{g}_{h}, N^{g}_{hws} – thermal capacity of geothermal installation for heating and hot water supply;

t_{h}, t_{hws} – number of working hours per year of heating and hot water supply system;

N^{g} – thermal capacity of geothermal energy source calculated in the following manner:

а) For thermal waters

$$N^{g} = Q^{twi} \cdot C \cdot \Delta T \cdot \eta \quad (4)$$

б) For dry rocks

$$N^{g} = \frac{S \cdot m \cdot \rho \cdot C_{t} \cdot \Delta T}{t^{*}} \alpha \cdot \eta \quad (5)$$

Q^{twi} – capacity of thermal water intake;

C and C_{t} – specific heat of thermal waters and dry rocks;

ΔT – water temperature difference at the mouths of producing and injection wells;

m – effective capacity of producing layer;

ρ – density of rocks;

t^{*} – exploitation time of geothermal field;

η – coefficient accounting for heat losses during the transport of heat carrier;
α – heat transfer coefficient of the rock massif

Table 1. Predicted usable reserves of geothermal energy in Ukraine and energy potential thereof

Oblast (region)	Operational reserves		Energy potential, thermal/ electrical mln. MWh/year	Annual saving in fuel, mln. tons of conditional fuel
	geothermal/ superheated waters, thous. cub.m/day	dry rocks, thermal capacity, MW		
1. Autonomous Republic of Crimea (including Sevastopol)	475/388	–	5.43/0.86	1.11
2. Vinnitska	–	169	0.7	0.09
3. Volynska	–	85	0.35	0..045
4. Dnipropetrovska	–	1078	4.45	0.58
5. Donetska	298	–	2.84	0.37
6. Zhytomirska	–	103	0.42	0.054
7. Zakarpatska	264/371	–	2.77/1.0	0.84
8. Zaporozhska	–	401	1.65	0.22
9. Ivano-Frankivska	181	–	1.89	0.24
10. Kyivska (including Kyiv)	–	569	2.35	0.31
11. Kirovogradska	–	228	0.94	0.13
12. Luganska	–	872	3.6	0.47
13. Lvivska	197	–	2.07	0.27
14. Mykolayivska	409	–	4.21	0.54
15. Odesska	475	–	4.89	0.63
16. Poltavska	134	–	1.66	0.22
17. Rivenska	–	57	0.24	0.031
18. Sumska	–	226	0.93	0.13
19. Ternopilska	–	77	0.32	0.04
20. Kharkivska	147/249	–	1.82/0.5	0.47
21. Khersonska	391	–	4.03	0.52
22. Khmelnitska	–	130	0.54	007
23. Czerkasska	–	216	0.89	0.12
24. Czernovitska	–	155	0.64	0.08
25. Czernigivska	122	–	1.51	0.2
Total in Ukraine	3093/1008	4366	51.14/2.36	7.78

2). For electricity-generating plants

$$E^{el} = Q^{twi} \cdot C \cdot \Delta T \cdot \eta_{eff} \cdot t \cdot 0.75 \qquad (6)$$

where η_{eff} – efficiency coefficient of geothermal electricity-generating unit;
t – number of working hours in a year;
0.75 – coefficient accounting for the electricity consumed by the generating unit proper.

Table 1 contains the results of assessment of predicted usable geothermal energy reserves in Ukraine. The Ukrainian Government is taking effective measures for harnessing these resources. Currently, the State R&D Program "Environmentally-Friendly Geothermal Power Engineering

of Ukraine" is being implemented with the financial support of the State. The Administration of Crimea, as well as those of Zakarpatska and Lvivska Oblast earmarked funds for building new geothermal units in addition to already existing installations listed in Table 2.

Table 2. Operational geothermal installations in Ukraine

Name of installation	Year of commissioning	Thermal (electrical) capacity, MW	Annual saving in fuel, tons of conditional fuel
1. System of geothermal heat supply of Beregivsky Sport Complex. (Beregivsky District, Zakarpatska Oblast).	1978	2.1	1 215
2.. System of geothermal heat supply of Sanatorium "Kosino". (Beregivsky District, Zakarpatska Oblast).	1998	1.2	860
3. System of geothermal heat supply of Sanitation Complex "Latoritsa". (Mukachivsky District, Zakarpatska Oblast).	1985	0.2	210
4. System of geothermal heat supply of the settlement of Yantarne. (Krasnogvardyeisky District, AR of Crimea).	1991	4.6	2 700
5. System of geothermal heat supply of municipal facilities of the settlement of Changar. (Khersonska Oblast).	1998	1.0 (0.1)	900
6. System of geothermal heat supply of the kindergarten and cultural facilities in the settlement of Medvedivka. (Jankoysky District, AR of Crimea).	2002	0.8 (0.07)	650
7. System of geothermal heat supply in the settlement Zyernovoye. (Saksky District, AR of Crimea).	1997	0.4	335
8. System of geothermal heat supply of the communal facilities in the settlement Pyatikhatki. (Krasnogvardyeisky District, AR of Crimea).	1996	0.3	300
9. System of geothermal heat supply in settlement Nizinnoye. (Saksky District, AR of Crimea).	1998	0.3	300
Total in Ukraine		10.9 (0.17)	7 470

2. CONCLUSIONS

1. Predicted usable geothermal energy reserves in Ukraine are the following: thermal waters – 3 093 thous. cub. m/day; superheated waters – 1 mln.; dry rocks – 4 thous. MW.

2. Energy potential of usable geothermal energy reserves is 51.14 mln. MWh/year (thermal) and 2.36 mln. MWh/year (electrical).

3. The incorporation of predicted usable geothermal energy reserves into Fuel-and-Energy Complex of Ukraine will make it possible to:

- create 12 390 MW of thermal and 414 MW of electric capacities;
- save annually 7.78 mln. tons o conditional fuel;
- cut down the use of fossil fuel in energy sector by 8.35%.
- reduce annual CO_2 emissions by 17 mln. tons.

4. Total thermal and electric al capacity of the operational geothermal energy units in Ukraine today amounys to 10.9 MW and 0.17 MW respectively. Exploitation of the units results in saving 7 470 tons of conditional fuel per year.

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