Construction of the Center for Geothermal Resources (TGS) in the Berehovsky district of the Transcarpathian region.

1. Introduction

Currently, in the world as a whole, the fast-growing trend of green energy is the use of geothermal resources of the earth, which, in terms of efficiency and cost, compete with renewable hydropower, but exceed it in other indices.
The same fast-growing trend in the world is the increase in the number of people who use natural thermal waters as therapeutic and preventive means.

1.1. Our company offers for realization a highly profitable and fast-paying project for the construction and operation of the Center for Geothermal Resources (TGS) in the Beregovo district of the Transcarpathian region.

1.2. The novelty of the project is that on one land plot that belongs to our enterprise, it is proposed to build a complex of buildings and structures with a common infrastructure, which consists of two parts:

- "Health and therapeutic part" (DST)
- "Energy part" (EC)

1.3 The health-therapeutic part of the TSR includes the following objects:
1) A complex of swimming pools with thermal and natural water.
2) Health and medical building with a complex of saunas, massage and other treatment facilities.
3) Power supply and entertainment for guests.
4) Open guarded guest cars and buses.
5) Administration block, security service and TGR service.

1.4. The power part is a geothermal power plant with a total capacity of 25 MW for energy supply and heat supply to the health-improving part of the Center, as well as for the sale of surplus electricity in the Ukrainian market or (if necessary) for export.
The structure of the "Energy Unit" of the TSC will include the following facilities:
1) Geothermal power plant with a capacity of 25.0 MW.
2) Increasing (lowering) transformer substation.
3) Heat supply station for provision of heating and hot water supply to all TGR facilities.
4) The point of water preparation for thermal and fresh water.
5) Block of treatment facilities.
6) Service center.

1.5. Ecologically clean technologies for the production of electricity due to the high temperature of rock allow the location of the energy part of the TSR on a close

ecologically permitted distance from the health-improving part.
1.6. The estimated cost of construction and commissioning of the TSR as a whole is 65 million euros, including 3 million euros - the cost of building a health and treatment unit and 62 million euros - the cost of building a power part of the TGR.
1.7. The calculations show that the payback of the "Health and Medical" part of the Center will not exceed 2 years, and the recoupment of the "Energy" part of the Center will not exceed 5 years of operation.

2. Current state of the market for the use of geothermal resources.

At present, in the world, geothermal resources are used mainly in two directions:
1) therapeutic direction - the use of underground thermal waters in the form of swimming pools (baths) for therapeutic and preventive purposes in case of problems with the locomotor apparatus, central and peripheral nervous systems, skin and metabolic problems, etc.
2) energy direction - the use of groundwater with a high temperature or hard rocks with a high temperature for the production of electricity, heat for heating and hot water supply.
2.1. Use of thermal waters for medicinal purposes.
2.1.1. World experience and trends.
Everyone knows the resorts of the thermal waters of Europe such as Baden-Baden (Germany), Karlovy Vary (Czech Republic) Heviz, Sarvar (Hungary), Turchynske Teplice, Brusno, Nimnica (Slovakia).
Statistics show that the use of thermal waters for medicinal purposes in Europe is a highly profitable business.
2.1.2. Use of thermal waters for medicinal purposes in the Transcarpathian region.
Currently, in the Transcarpathian region, three therapeutic and prophylactic complexes are most popular and operate, which use underground thermal waters:
1) Sanatorium "Teplye Vody" in the village of Velyatino, Khust district;
2) Health complex "Skylark" and an outdoor sports pool in the town of Berehove;
3) A complex of swimming pools with thermal natural water in the village of Kosino, Beregovsky district. This complex was put into operation in 2012 and its financial and economic indicators were taken as a basis for calculating the technical and economic indicators of the profitability of the "Medical Unit" TGR.
In addition, mineral springs are popular in the village of Lumshory, Sanatorium "Teplitsa" (Vinogradovo), Sanatorium "Termal Star"
2.2. Use of geothermal energy in the energy field.
2.2.1. World experience.
The world has accumulated considerable experience in using geothermal energy for energy purposes.
The world's first power station based on the use of high-temperature groundwater was built in 1904 and is still in operation in the Italian city of Larderello.
In the United States, the total capacity of existing geothermal power plants in 2016 was more than 11,000 MW.
In Iceland, more than 50% of the production of electricity and hot water, heat for

heating is provided by geothermal energy.
Currently, more than 90 countries in the world build and operate power plants using geothermal energy.
2.3. In the late 1980s, geological studies were conducted in Transcarpathia to select a location for the construction of two geothermal-based power plants. Studies have shown.

3. The main factors contributing to the implementation of the investment project for the construction and operation of the Center for the integrated use of geothermal resources in the Transcarpathian region of Ukraine.

Center for the integrated use of geothermal resources of the Transcarpathian region (hereinafter referred to as TSC)) is planned for construction taking into account the following factors:
3.1.1. Within Transcarpathia, the most promising part of the region in terms of geothermal energy potential is the Beregovsky district.
Here the values of the heat flux of the earth reach 110-130 W / sq.cm per second, which is twice the average for the Earth.
The isothermal plane with rock temperature + 100ºC lies at depths of 1.0-2.00 km, and with a temperature of + 150ºC - at depths of 2.2 - 3.0 km.
3.1.2. In the Beregovsky district exploratory drilling proved the presence of thermal waters, which in composition and temperature are unique for use in medical and recreational purposes. So in the town of Berehovo there are two wellness complexes that can effectively treat diseases of the musculoskeletal system, central and peripheral nervous system.
In the same Beregovsky district (Kosino village) there is a year-round complex of pools with thermal water.
3.2. Infrastructure.
3.2.1. The area that is chosen for the construction of the TGR in terms of area is sufficient for location with due regard for the ecological norms of both the "Wellness" part and the "Energy" part of the center.
The land plot belongs to our enterprise. The land has no debt burdens.
3.2.2. Location.
The site for the project is located near the town of Berehove, near the road is a hard surface.
According to the general plan, the international route Hungary-Ukraine should pass near the site.
A high-voltage power line passes close to the site.
Geological studies show that the site has underground fresh water supplies for household and technical needs of the TSC in sufficient quantities. The proximity of the quarry makes it possible to solve the issue of utilization of water from the pools of the "Healthy" part.
3.2.3. The market of health services.
Currently, the market for the use of thermal waters in Ukraine is only being formed.
According to preliminary calculations, only in the Transcarpathian region to meet

the current needs for health improvement of the population, at least 10 health-improving complexes of the complex type in the village of Kosino in the Beregovsky district are required, which is designed for 500 guests per hour. At the same time in the warm season, the number of visitors per day exceeds 10,000 people.

3.3. Applied technical solutions, equipment and technologies.
3.3.1. "Energy" part of the TGR.
The main features of the geothermal power plant are:
1) Use as a source of thermal energy to convert it into electrical energy of rock temperature. The geothermal power plant (GeoTES) will have a geothermal gradient to increase the reservoir temperature to 7.0 ° C for every 100 meters of the depth of the well, and at a depth of 1000 meters the rock temperature exceeds 100 ° C. At the same time, the heat flux reaches 110-130 MW / m2 / hr.
2) Use as a thermal carrier of a special organic liquid (such as "Tosol") with a temperature of its transformation into a vapor of 78 ° C.
3) The design of the well, where it converts into a heat carrier vapor, the design of a sealed steam turbine and an electric generator, as well as the hermetic construction of a condenser-cooler, allows to organize a closed cycle of motion of a thermal carrier according to the scheme: its injection into the heating zone and vaporization - steam supply to the steam turbine blades - cooling of steam and transformation into a liquid state of the thermal carrier.
4) Block character of GeoTES elements.
Each well generates steam for generating electricity at a rate of 2.5 MW / h. Each well serves one set of generators with a capacity of 2.5 MW / h.
Thus, one power unit with a capacity of 2.5 MW / h is formed.
The designers have envisaged the construction of 10 units, which in total will generate 25 MW / h.
5) The block character of the GeoTES allows one to consistently build and commission each power unit.
6) In practice, all these technical and technological solutions were implemented by Rasen Technologies. Its 10 MW geothermal power plant was built in 11 months in Aneheim, Utah (USA). The power plant consists of 50 units, each of which independently generates electric power with a capacity of 200 kW / h.
This type of GeoTES company "Rasen Technologies" plans to build another 9 terrain stations in the United States.
Geologist Garnet Winsby, who oversees geothermal energy programs at the level of the US government, believes that the future is for GeoTES, which consists of a set of autonomous block generators that allow the rapid construction and progressive growth of the power of geothermal power plants. At the same time, the US energy agency has already formulated a criterion that the cost of electricity produced at a geothermal power plant should not exceed 5.0 US cents (0.05 US dollars).

3.3.2. Power equipment for geothermal power plants produce many enterprises in Europe, the United States and the former USSR.

The most famous:
1) In Europe: 'Siemens',' E. Terras AG, Geothermie, Neubrandenburg GmbH (Germany), ENEL Green Power, Rasen Technologies (USA), TURBODEN (Italy).
3.3.3. Equipment and technologies for the "Health and medical part of the TGR.
All the equipment of the "Health and medical part of the TGH can be divided into groups:
I. Equipment providing high-quality and safe operation of pools with thermal and fresh water. These are pumps, water vacuums, skimmers, water treatment systems, its disinfection and cleaning.
II. Equipment for water attractions and entertainment.
III. Equipment for the organization of quality nutrition for guests and patients.
IV. Medical equipment of diagnostic procedures, physiotherapy and medical control.
3.3.4 The project provides for the use of equipment and technologies that have a solid reputation, are provided with a service and are certified in accordance with the legislation.

4. Calculation of payback.

For the purpose of flexibility in financing the construction and commissioning project
TGR calculation of return on investment is carried out in two versions:
Option 1 - the return on investment in the construction of the "Health and Medical Unit" of the TSR as the first stage using the purchased electricity was completed.
Option 2 - an estimate of the return on investment in the construction of the "Energy Unit" TGR - a geothermal power plant with a capacity of 25 MW.
4.1. Calculation of the recoupment of investments in the construction of the "Health and Medical Unit" TGR:

Estimate No. 1
Construction costs of the complex Pools with thermal and fresh water

No. P / p	**Object name**	**Cost of thousands of euros**		
		Total	**including**	
			building	**equipment**
	OBJECTS OF THE COMPLEX			
1	The administrative-Household from the built in medical Premises (70x20 meters)			
2	Thermal pool (№1) 15x15x1,35 (300 m3 of water)			

3	Fresh water pool for 950 cu. Meters (№2)			
4	Swimming pool thermal water (№ 3) - children's 90 cu.m.			
5	Attraction of the "octopus"			
6	Swimming pool thermal (№4) (per 1000 cubic meters) with attractions			
7	Fresh swimming pool (№5) at 470 cubic meters. (25x12.5x1.5)			
8	Complex for food intake (40x50 = 2000 m²) for 6000 seats			
	TOTAL:	**1600.0**		
	ENGINEERING SUPPORT			
9	Well (1) of thermal water + a trail of 1 km long.			
10	Well (2) fresh water			
11	Transformer 400 kW substation			
12	Parking lot open for 400 cars (13000 square meters)			
	TOTAL	**1400.0**		
	TOTAL IN ESTIMATE №1	***3000.0***		

4.1.2. Estimated annual costs No.2 for the operation of swimming pools with thermal and fresh water.

1) Payment of electricity:
400 kWh12 hour.x365дх1,0grn. = 1752100: 15 = 10,700 euros

2) Payment for fresh water:
100 m³x365дх15грн = 36 500 euros

3) Salary of staff:
150 people. 5000 5000 uah12 months = 9,000,000 (/ 15) = 60,000 euros

4.1.3. Average monthly expenses for the operation of the "Health and Medical Unit of the TSR": EUR 50.4 thousand

TOTAL EXPENDITURE IN ESTIMATE №2: 647 200,0 euros

4.1.4. TAXES
The total taxes for the year of operation of the complex are 5% of the proceeds, or 210 thousand euros.
4.1.5. Total annual expenses:
647.0 thousand euro + 210.0 thousand euro = 857.0 thousand euros

4.1.6. The average monthly expenditure is 71.41 thousand euros

4.2. Estimated income "Health and medical part TGR."
4.2.1. Initial data
Number of visitors:
In the summer - 1000 people
In winter - 500 people

a. Customer expenses - 15 euros / person / day
B. Proceeds from the sale of tickets:

1) In the summer: 1000x200 days x15 euro = 3.0 million euro.
2) In winter: 500x165 days15 euro = 1.237 million euros

Total annual revenues of 4,237 million euros
4.2.2. Average monthly revenue:
4237: 12 = 353,083.0 euros

4.2.3. Payback
4.2.4. The average monthly expenditure on taxes and operation of the complex is 71.41 thousand Euro.
4.2.5. The average monthly income from the sale of tickets - 353.1 thousand euros
4.2.6. The average monthly profit is 353, 1 - 71.41 = 281.69 thousand euro
4.2.7. The recoupment of the months: 3000.0 thousand euro: 281.69 thousand euro = 11 months.

4.3. Calculation of the recoupment of investments in the construction of the "Energy Sector of the TSR"
4.3.1. The energy part of the TGS should be allocated to a separate stage, since wells can be drilled using energy from diesel generators that complete the drilling rigs.
4.3.2. The amount of investment in the construction of the "Energy Center TGR" facilities is given in the estimate:

Estimate

Expenses for the construction of the facilities of the "Energy Sector of the TSR"

No. P / p	Object name	Cost of thousands of euros		
		Total	**including**	
			building	**equipment**
	First of all			
1.1	Thermal well - 1T			
1.2	Set of block generator with total power 2.5 MW			
1.3	Thermal Water Treatment Station for hot water supply and heating			
1.4	Water treatment station			
1.5	Block of treatment facilities			
1.6	Service center with workshop (80 sq.m.)			
1.7	Transformer substation increasing capacity of 20 MW.			
1.8.	Joining Power Transmission Line Oblenergo			
	TOTAL:	**8000,00**		
	The second stage			
2.1	Thermal well - 2T			
2.2	Set of block generator with total power 2.5 MW			
2.3.	Loop and connection to power lines			
	TOTAL:	**6000,00**		
	Third line			
3.1	Thermal well - 3T			
3.2	Set of block generator with total power 2.5 MW			
3.3	Loop and connection to power lines			

	TOTAL	**6000,00**		
	Fourth line			
4.1	Thermal well - 4T			
4.2	Set of block generator with total power 2.5 MW			
4.3	Loop and connection to power lines			
	TOTAL	**6000,00**		
	Total for wells 1 (T) - 4 (T)	**26 000,00**		
5.1	***Fifth Line*** Wells 5-T, 6-T, 7-T, 8-T	**24 000,00**		
	Total in lines 1-5	**50 000,00**		
6.1	***The sixth line*** Wells 9-T, 10-T.	**12 000,00**		
	Total in queues 1-6	**62 000,00**		

4.3.3. Revenues from the sale of electricity generated after the commissioning of the first stage with a capacity of 2.5 MW.
The amount of electricity produced per month:
2.5 MW x 24 hours x 30 days = 1800 MW.
The cost of one MW is accepted at a rate of 150 euros. This is a pismemistic estimate of the price of one megawatt per hour for electricity, which is generated from renewable energy sources.
The revenue per month from the sale of electricity in the first-stage unit is:
1800 MW x 150 euro = 270,000 euros.
4.3.4 In total, 10 sets of block generators, each with a capacity of 2.5 MW, are to be built for the commissioning of all generating capacities in the amount of 25 MW.

4.3.5. The investment schedule of the proposed project is designed for parallel execution of works, in which the drilling rig performs drilling operations in the following sequence:
- well with mineral water;
- well with process water (1st stage of the project);
- Drilling operations on geothermal wells from well 1-T to borehole 10-T.

The enlarged schedule of the project's investment and its payback is given in Appendix No. 1 to the Business Plan, which shows that the whole project worth 62 million EUR will be paid for 25 calendar months.

5. Social and economic consequences of the implementation of the investment project.

5.1. After putting into operation the "Health and medical part of the TGR", 150 full-time jobs will be created all year round and additional employees for the summer period will be created in the amount of 60 people.
5.2. After commissioning of the "Energy Part of the TGR", 30 full-time jobs will be created to service well equipment, block generators and other energy and heat engineering equipment.
5.3. The commissioning of the "Energy Part of the TGR" with a capacity of 25 MW of clean electric energy based on cheap renewable energy sources will allow stabilizing the energy supply of the Berehovsky district of the Transcarpathian region. At the same time, unlike ecologically clean electric power that is produced in hydroelectric power plants, but depends on the time of year (in summer, the amount of generated electricity decreases), the electric power received on the basis of the geothermal heat flux of the earth does not depend on the time of the year.

6. Influence on ecology.

6.1. Influences on the ecology of the environment of the "Health and therapeutic part of the TSR".
6.1.1. All the objects of the "Health and medical part of the TGR" will be designed taking into account the existing sanitary and hygienic standards and norms. Before the construction starts, the project will pass a state examination of the design estimates.
6.1.2. For the reclamation of fresh and mineral water, its own treatment facilities have been designed.

6.2. Influence on the ecology of the environment "Energy part of the TSR".
6.2.1. The process of drilling wells will be carried out in accordance with the project, which will necessarily pass all the necessary expertise.
6.2.2. The technology of converting thermal geothermal energy into electrical energy does not require the lifting of thermal waters from the wells to the surface of the earth, which can be a source of pollution of the environment.
6.2.3. As the working fluid of the coolant circulating through the "well" - "turbine" - "condenser-cooler" contour, the project envisages the use of an organic liquid of the type

R 245, which has a hygienic certificate confirming that this substance is not dangerous for humans, animals And earth plantings.
6.2.4. All materials, equipment, consumables, which the project provides for use at the TGF facilities are widely used in Europe, North America, have the relevant sanitary and hygienic certificates, thus the operation of the TSR does not pose a threat to the environment and the environment.

Supplement number 1

Schedule

Investment for the project

"Construction of geothermal center in Beregovo district of Transcarpathian region"

thousand. euro

number p / p	Description of the project	Total, EUR
1.	Complex pool	3000000
2.	The first phase (2.5 MW) of power	8000000
3.	The second phase (2.5 MW) of power	6000000
4.	The third stage (2.5 MW) of power	6000000
5.	Fourth stage (2.5 MW) of power	6000000
6.	Fifth stage (10.0 MW) of power	24000000
7.	Sixth stage (5.0 MW) of power	12000000
	Total	65000000

Schedule

generate revenue and payback period of the project

"Construction of geothermal center in Beregovo district of Transcarpathian region"

number p / p	Description of the project	Money income, EUR			
		2019	2020	2021	2022
1.	Complex pool	3384000	3384000	3384000	3384000
2.	The first phase (2.5 MW) of power	3240000	3240000	3240000	3240000
3.	The second phase (2.5 MW) of power	3240000	3240000	3240000	3240000
4.	The third stage (2.5 MW) of power	3240000	3240000	3240000	3240000
5.	Fourth stage (2.5 MW) of power	3240000	3240000	3240000	3240000
6.	Fifth stage (10.0 MW) of power	6480000	12960000	12960000	12960000
7.	Sixth stage (5.0 MW) of power	3240000	6480000	6480000	6480000
	Total	**26064000**	**35784000**	**35784000**	**35784000**
	Cumulative		**61848000**	**97632000**	**133416000**

Note: Serial commissioning of the investment will allow investments in the amount of 65 million. Euro recoup three years from the beginning of investment, ie by the 2021.