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Technological Schemes for Multipurpose Use of Heat Transfer Agents in Man-changed Soil and Rock Deposits

Prof., Dr.-habil. Rudakov D.V.,

Prof., Dr.-habil. Sadovenko I.O.

Dept. of Hydrogeology and Engineering Geology

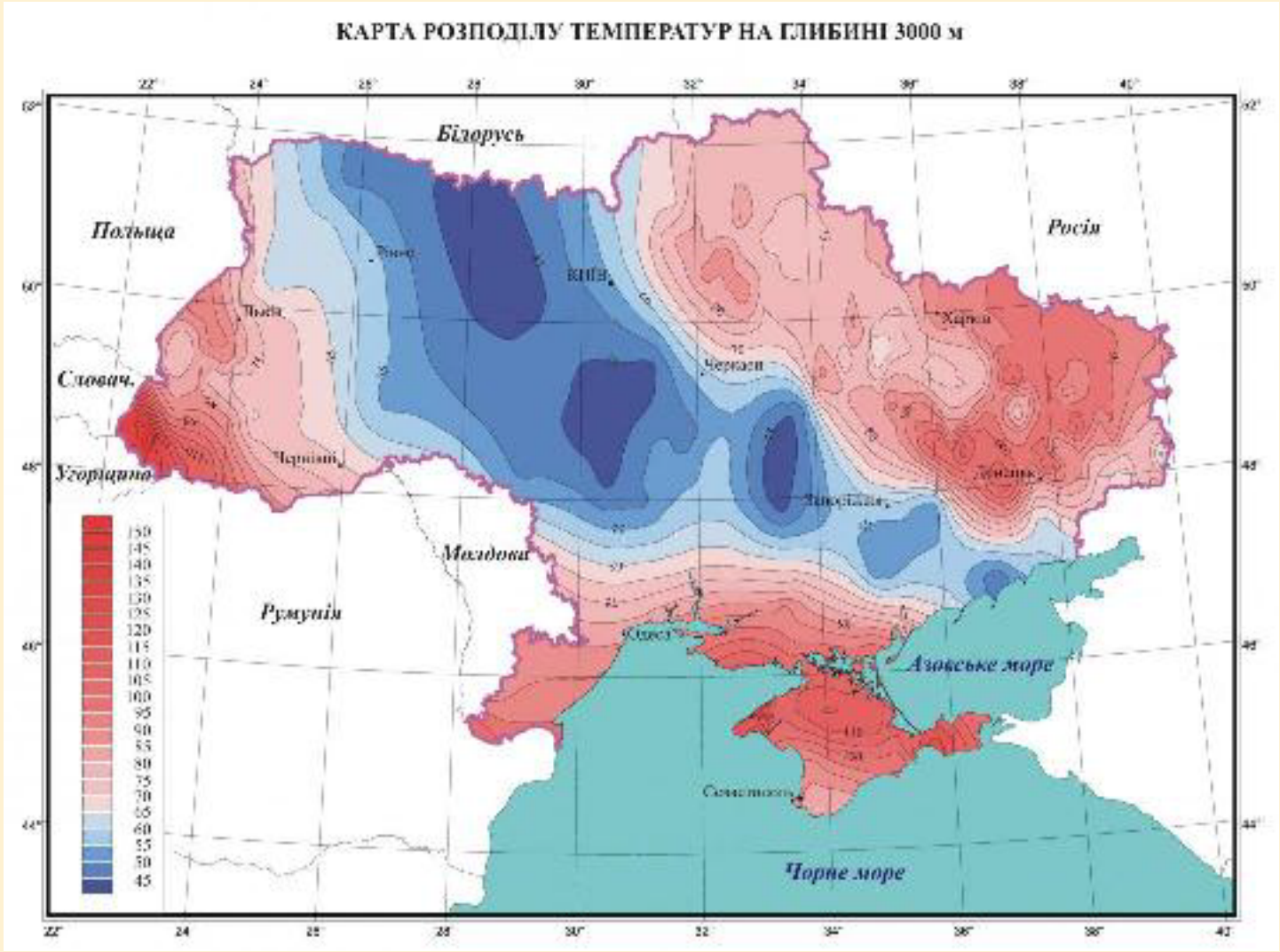
National Mining University,

Dnipropetrovsk

Content

1. Geographical distribution of geothermal resources in Ukraine
2. Geothermal resources for key applications as
   ground source heat pumps,
   deep boreholes,
   mine waters,
   sewage waters.
3. Practice of geothermal energy use in Ukraine: experience and challenges.
4. Proposed geo-technological schemes for multi-purpose use of geothermal energy.

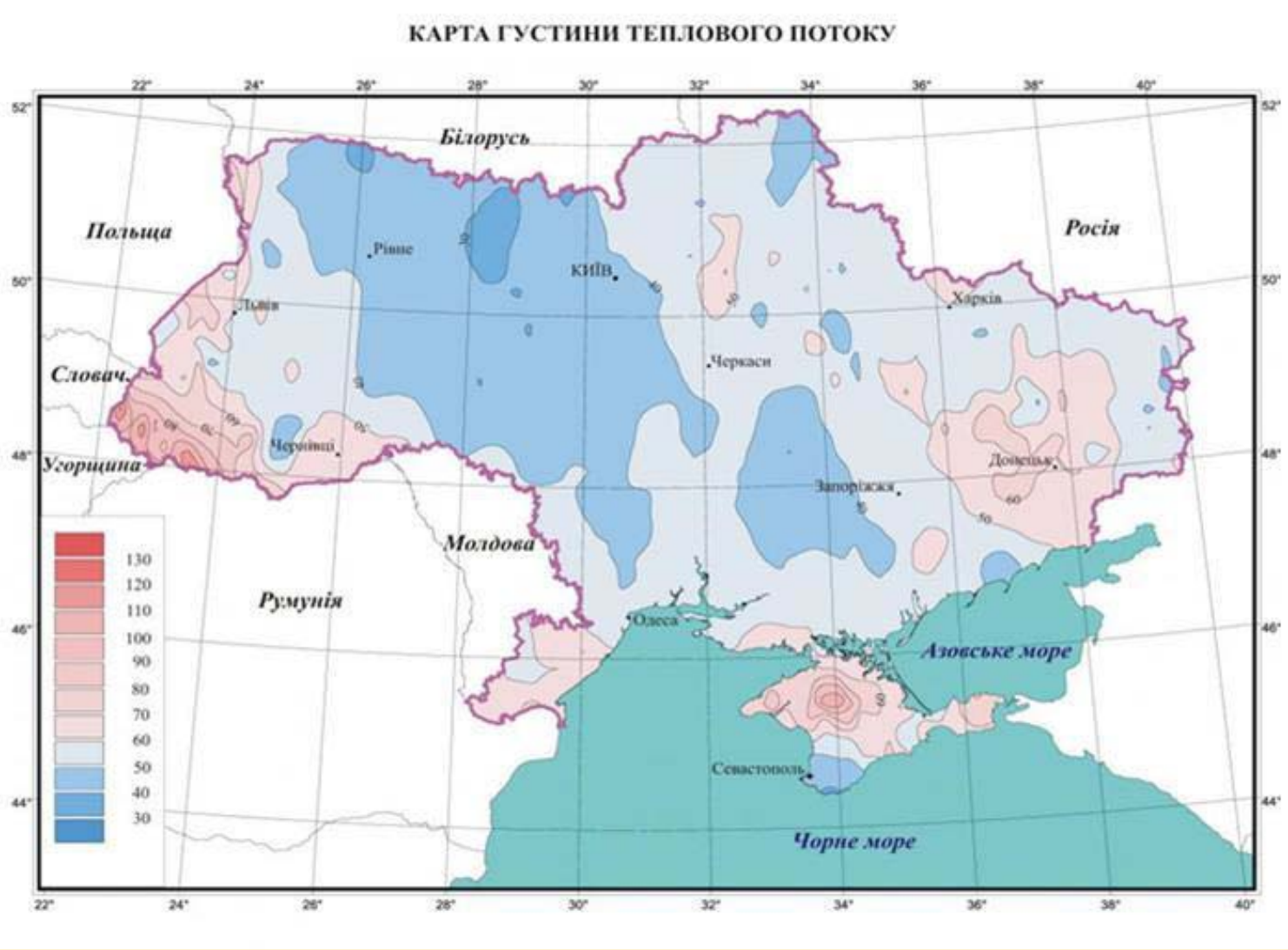
Rock Temperature on the Depth of 3000 m



Rock temperature on the depth of 1000 m varies from 20 to 70°C, on the depth of 3000 m it changes from 40 to 135°C.

National Atlas of Ukraine (2007): Kyiv, "Cartography"

Heat Flux Distribution



Heat flux density varies from 25-30 to 100-110 mW/m^2

National Atlas of Ukraine (2007): Kyiv, "Cartography"

Ukraine's Thermal Water Resources

Potential geothermal resources amount to 27,3 millions m^3/day of thermal waters. Taking into account cogeneration capacity and thermal water specifics, these resources are estimated at 84 millions GCalories/year.

2009 National Report about Implementation of the Energy Efficiency State Policy National Agency of Ukraine on Ensuring of Efficient Use of Energy Resources Management

Regional distribution of thermal water resources

#	Region (Location in Ukraine)	Thermal water resources, **MW**	Profitable resources	
			kWh per year **($\times 10^9$)**	In terms of tons of fuel per year **($\times 10^6$)**
1	Zakarpatya (W)	490	0,97	0,33
2	Nikolayev (S)	2820	4,07	1,22
3	Odessa (SW)	2350	3,03	1,03
4	Poltava (C,NE)	9,2	0,018	0,006
5	Sumy (N)	15,8	0,035	0,012
6	Kharkov (NE)	1,3	0,003	0,001
7	Kherson (S)	4230	5,5	1,87
8	Chernigov (N)	58,3	0,12	0,04
9	Crimea (S)	37600	48,5	16,5
Total		**47574,6**	**61,8**	**21**

Ground Source Heat Pumps

9,3 mil. houses on homesteads have the total heated area of 515,8 millions m^2. They need roughly 160 millions MWh for heating and hot water supply annually.

Potential resource of soil heat pumps (mostly prospective regions)

#	Region	Resource of low-potential soil heat and groundwater, thousands MWh/year		
		Total	Technically achievable	Profitable
1	Vinnitsa	4731	3379	513
2	Dnipropetrovsk	15438	11027	424
3	Donetsk	15422	11015	2656
4	Zhitomir	3374	2410	428
5	Kirovograd	3720	2657	833
6	Lugansk	10571	7551	1958
7	Cherkassy	4286	3061	476
Total in Ukraine		**157530**	**112521**	**10564**

Unlimited resource: Ukrainian potential of renewable energy resources (2007): Fuel and power complex, N 8. P.40-46.

Constrains on Heat Pump Introduction

High installation costs and long payback time

Prices on heat pump installation in Ukraine

Power, kW	4-5	5-10	10-15
Costs, €	3000-7000	4000-8000	5000-10000

Passive cooling mode is most profitable (90-95% saving costs) but is possible in summer time (100-150 days) and can be profitable in southern regions of Ukraine. Additionally 20% savings.

Maximal estimated savings owing to reduction of fuel consumption amount 700-1000 € annually. It is not profitable under conditions of high interest rates.

R&D of NMU researchers in Heat Pump Usage

- **Technical essence.** Mine water temperature (12 ... 26°C) is increased by heat pumps up to 42 ... 45°C. Equipment uses low-potential heat of waste water from bath for miners (temperature 30°C). Using this water enables increasing the rate of heat transformation to 7.0 ... 8.0.
- **Main specifications** of the heat pump system implemented at the mine "Blagodatnaya"of "DTEK Pavlogradugol" (Central Ukraine).

Heat output	**800 kW**
Mine water flow rate	**200 m^3/h**
Mine water temperature	**16 ... 17° C**
Hot water temperature	**42 ... 45° C**
Recyclable thermal power	**572 kW**
Electric power	**228 kW**
Heat conversion factor	**3,5**
Annual saving	**470000 UAH / year (appr. 45000 € /year)**
Payback period of capital costs	**3,5 years**

V.I. Samusia, Yu.I. Oksen, Yu.O. Komissarov, M.V. Radiuk, Patent of Ukraine N 61130.

Mine waters

Resources

- Annually more than 500 mil. m^3 mine waters are pumped in Donetsk Coal basin and discharged into ponds and rivers. The temperature of this water ranges from 16 to 22 °C depending on the season.
- The annual low-potential heat loss is estimated at 5 millions GCalories.
- Temperature of mine waters deeper than 700 m reaches 30-33 °C.

Utilization of mine water heat using heat pumps ("KiEM" #4, 2011)

Technical problems

- High salt content (3 - 60 g/l).
- Necessity to isolate mine waters from surface waters.

Conclusion

Mine waters and heat pumps have to be used together to increase the effectiveness of heating and hot water supply.

Donetsk Coal Basin

Map on http://uk.wikipedia.org/wiki/%D0%A4%D0%B0%D0%B9%D0%BB:Donbass_economic.jpg

Municipal Sewage Waters

- The total annual volume of municipal waste water is estimated at about 3,740 million m^3. The waste water temperature ranges from 12 to 20 °C depending on the season.
- The annual technically achievable quantity of this kind of energy equals to 18 million tons of s. f., its use could save about 15,6 billion m^3 of natural gas.

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- There are technical difficulties to extract sewage water heat under complex conditions of obsolete underground infrastructure, water and heat supply networks in Ukrainian cities.

Estimation of Heat Flux of the Earth on the Base of Deep Borehole Drilling

Source of assessment. Results of deep drilling in Crimea; measurements of borehole liquid temperatures and computations and heat flux before and after well rinse.

G.P. Starodub (L'viv State University of life safety), V.M. Karpenko, V.M. Stasenko (Naftogaz of Ukraine), M.S. Nykoryuk (Donetsk National Technical University), O.V. Karpenko (Institute of Geophysics of NASU)

Temperature distribution in the borehole #189 (at Karadag, SE of Crimea)

Depth, m	0	1100	1800	2800	3765
Stationary borehole liquid temperature, °C	18	51	59	70	85
Borehole liquid temperature after washing out of drilling face at the depth of 3765 m, °C	33				70
Borehole liquid temperature after washing out of drilling face at the depth of 1800 m, °C	36		47,5		

CONCLUSION. Authors suggested that Earth's heat flux reaches roughly 400 W/m^2 instead of usually accepted values ranging from 0,035 to 0,110 W/m^2.

Comparison of Geothermal Energy Use in Different Countries

Country	Capacity, MW	Annual Use, TJ/yr	Annual Use, GWh/yr	Annual Use per capita, KWh/(yr person)*	Capacity Factor
Germany	2 485,4	12 764,5	3 546,0	43,35	0,16
Russia	308,2	6 143,5	1 706,7	11,9	0,63
Ukraine	10,9	118,8	33,0	0,72	0,35
U.S.A.	12 611,4	56 551,8	15 710,16	49,87	0,14
World	**50 583**	**438 071**	**121 696,0**	**17,38**	**0,27**

Lund J.W., Freeston D.H., and Boyd T.L. (2010): Direct Utilization of Geothermal Energy 2010 Worldwide Review Proceedings World Geothermal Congress 2010. Bali, Indonesia, 25-29 April 2010.

* Calculated according to (Lund et al. 2010)

Ukrainian Institutions Carrying Out R&D in the Field of Geothermal Energy

- National Agency of Ukraine on Ensuring of Efficient Use of Energy Resources Management,
- Institute of General Energetics (Kyiv),
- Institute of Renewable Energy (Kyiv),
- Institute of Engineering Thermophysics (Kyiv),
- Kyiv Polytechnical University,
- L'viv State University of life safety,
- Donetsk National Technical University,
- Institute of Geophysics of NASU (Kyiv),
- Ivano-Frankivsk national technical university of oil and gas,
- Research branches of Naftogaz of Ukraine,
- Charkiv National University,
- National Mining University (Dnipropetrovsk), and others.

Some R&D in the Field of Heat Pump Use

Institute of General Energetics

- A heat pump installation for the autonomous heating and conditioning of industrial space with a capacity of up to 100 kW with using equipment heat loss.
- A heat pump installation with an individual-purpose peak-standby gas-fired boiler for the areas of unreliable power supply.
- Increasing oil production efficiency by using heat of associated hot waters of oil and gas deposits.

Institute of Engineering Thermophysics

- Heat pump technologies for heat supply and conditioning.
- A technology for heat storage and extraction.
- The indicator for diagnosis of heat loss spots underground.

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Thank you for attention!