District heating systems using geothermal sources, a contribution towards a carbon- neutral Europe

Sisteme de încălzire urbană care utilizează surse geotermale, o contribuție la o Europă neutră în materie de carbon

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Abstract: *At the European Union level, there has been and is a continuing concern regarding the reduction of greenhouse gas emissions, in particular by reducing energy consumption and ensuring energy from renewable sources. Europe aims to become the first carbon-neutral continent by 2050. Renewable energy sources across the European Union are diverse, the potential being different from one country to another. Energy from geothermal sources is still considered to be a less developed technology at the European Union level. However, there are multiple possibilities of use, and concrete examples of success, especially regarding the supply of thermal energy from geothermal sources, in centralized systems. It is expected that in the future, this energy source will become one of the most important in order to reach the objectives of the European community.*

Keywords: *geothermal energy, district heating, European Union, carbon-neutral*

Rezumat: *La nivelul Uniunii Europene, a existat și există o preocupare continuă cu privire la reducerea emisiilor de gaze cu efect de seră, în special prin reducerea consumului de energie și asigurarea energiei din surse regenerabile. Europa își propune să devină primul continent neutru de carbon până în 2050. Sursele de energie regenerabile din întreaga Uniune Europeană sunt diverse, potențialul fiind diferit de la o țară la alta. Energia din surse geotermice este considerată în continuare o tehnologie mai puțin dezvoltată la nivelul Uniunii Europene. Cu toate acestea, există multiple posibilități de utilizare și exemple concrete de succes, în special în ceea ce privește furnizarea de energie termică din surse geotermale, în sistemele centralizate. Este de așteptat ca, în viitor, această sursă de energie să devină una dintre cele mai importante pentru a atinge obiectivele comunității europene.*

Cuvinte cheie*: energie geotermică, încălzire urbană, Uniunea Europeană, neutru de carbon.*

1. Introduction

Primary energy consumption in the European Union has reached in the year 2015 the level of the 1990s. This, because between the years 2005 and 2016, the primary energy consumption decreased by 10%, mainly due to energy efficiency improvements and the increase in the use of renewable energy resources. However, Primary energy consumption in the European Union shows that in the year 2015, 31% of the energy counted from petroleum products and only 14% of it counts from renewable resources. The residential sector is a major contributor to this, and currently, the final energy consumption from the residential sector in European Union consists of 27% from the total, being the third energy- consuming sector after transport and industry. Heating and hot water count for 78,9% of this sector's total final energy use [1].

Energy consumption and CO_2 emissions trends are different from country to country, for this reason, it is needed for further actions to be taken at the European Union level to reduce greenhouse gas emissions and the final energy consumption, especially in the residential sector.

European Union adopted in the year 2014 the climate and energy framework, through which it is committed to fight against climate change. The targets for renewables and energy efficiency were revised in the year 2018. The framework imposes targets for the Member States for the period 2021 - 2030 - at least 40% cuts in greenhouse gas emissions (from 1990 levels), at least 32% share for renewable energy and at least 32.5% improvement in energy efficiency. These targets aim also to fulfill the commitments under the Paris agreement. European Union set out a vision in the year 2018, for a long-term strategy up to 2050 to become climate- neutral, the first economy with net-zero greenhouse gas emissions. To achieve this, all parts of society and economic sectors will play a role, especially the energy sector. One of the objectives is to decarbonise the energy sector, by investing in environmentally friendly technologies and the increase in energy efficiency. All Member States have to adapt to European Union's vision, based on the European Climate Law, proposed in 2020, which turns commitments to legal obligations. According to EEA (Environmental Energy Agency), with the actual measures, European Union will not meet the 2030 emissions targets, therefore is a need for more actions to be taken. More investments in renewable energy and energy efficiency is required and also to stop funding for environmentally damaging activities, especially fossil fuels.

2. District heating systems from geothermal sources

District heating systems are used in the European Union since the 14th century, with northern European countries leading the use.

These are also often called district energy systems due to the ability to provide both heating and cooling, by the use of heat pumps or absorption chillers [3]. District heating systems can be classified based on the energy source, the most used being fossil fuels, waste heat, and renewable sources, as biomass, geothermal and solar

thermal energy. In Europe, most centralized heating systems use as a source of energy coal, natural gas, and biomass. The use of geothermal energy for district heating in Europe has increased, which counts for 49% of the total installed capacity [3], but still considered poorly developed technology [5]. The installed geothermal district heating systems in the European Union at the end of 2016 counted 190 applications, with a total capacity of 1.7 GW and an annual production of 4.3 GWh. The top contributors were France, Germany and Hungary, and the UK, Czech Republic and Switzerland having the fewest geothermal applications. Beyond the European Union, Iceland and Turkey Iceland and Turkey are the largest contributors to the supply of thermal energy from geothermal sources [2].

Geothermal energy sources are mostly exploited through hydro- geothermal resources from deep reservoirs or through hot rocks. Geothermal energy sources can be characterized based on the temperature of the geothermal fluids as high or low temperature, the physical state of the geothermal fluids as vapor or liquid dominated, and the nature of its system as volcanic, convective, sedimentary, geo-pressured and hot dry rock systems [4]. In Europe, the main geothermal potential areas are Iceland and Turkey, but also areas in central and eastern Europe.

The benefits of geothermal district heating systems are both economical and environmental. Geothermal district heating systems generate less expensive heat compared to traditional fossil fuel systems, especially natural gas. Natural gas is widely used because of its availability, lower price and lower emissions compared to other fossil fuel sources. Furthermore, the greenhouse gas emissions from district heating systems using geothermal sources are much lower, compared to traditional fossil fuel systems, or zero, in most cases. District heating systems using geothermal energy, especially hydro-geothermal resources are considered also to be a reliable and safe alternative to fossil fuels, having nearly unlimited availability. At the same time, from the environmental point of view, by replacing the individual heating sources with sources that use a geothermal district heating system, a transition from technically inefficient systems using fossil fuels, which are greenhouse gas emitters, is reached. When using geothermal systems, more efficient and with less impact on the environment heating sources are used.

Financial evaluation is also a very important factor in decision making. Geothermal district heating systems usually have high implementation costs and low operation costs. From this, between 40% and 60% represents the source of geothermal energy and about 50% represents the transport and distribution part. Such systems show to have high economic benefits for high-density populated urban areas or industrial complex and lower economical benefit for lower-density populated areas, but which depend very much on the energy source, the lengths of the networks and the types of connections to consumers [3].

In district heating systems, monitoring and user control are very important, so that the heating supply can be controlled by the consumer's heating demand. Consumer metering measures the actual heating demand, which means that the consumers have an incentive to save heat. Heat losses on the transmission and distribution networks are very important in the context of the feasibility of centralized heating projects because

their costs are borne by the end-user. At the same time, heat losses lead to an increase in the use of primary energy sources. For this reason, they must be reduced or even eliminated. All this can lead to lower energy consumption of the entire system and lower consumption of resources needed to provide the necessary energy.

The implementation and operation of geothermal energy may also come with certain issues, especially environmental. Within the centralized heating systems, depending on the capacity, a very large quantity of water can be used. Increased attention should be paid to deep wells, both in execution and in operation. It is possible to contaminate soil and groundwater sources with different chemicals used in the drilling fluid, or even with chemical components already existing in geothermal water. Improper design and execution of geothermal wells can lead to contamination during operation. At the same time, it is recommended to use re- injection wells, in order to discharge the wastewater, so the environmental impact of the fluid will be minimal. If discharged into surface water sources after use, it is recommended to be treated before.

Hydro-geothermal resources often contain associated gases, mostly high concentrations of Methane. At the same time, there is not enough information throughout the whole of Europe regarding the geothermal sources that contain associated gases, especially Methane. Methane is a powerful greenhouse gas, so having a clear picture of the geothermal sources and the Methane concentration is of great importance. The utilization of waste gases can be used in cogeneration applications, to provide electricity and heat. This can increase fuel efficiency by up to 90% because of the waste recovery, and the overall efficiency of the system. [3]. The use of hybrid sources must also be considered. Depending on the temperature of the geothermal water, in order to provide the thermal energy in a centralized system, heat pumps can be used. At the same time, the use of geothermal sources together with biomass sources and solar sources is of great importance and an increase of such systems is expected in the future [5].

3. Final remarks

Geothermal energy sources are of great importance at the European Union level. These can contribute substantially to achieving the objectives set, respectively to reduce greenhouse gas emissions and increase the share of energy production from renewable sources. However, geothermal energy sources may differ from country to country. Geothermal water sources may have different temperatures from one region to another, so the range of use may be limited. However, although geothermal energy is considered a less developed technology, it is expected that its use, especially in centralized heating systems, will increase.

The heat provided by centralized heating systems, which use geothermal energy, is much cheaper for final consumers compared to the use of individual systems using fossil fuels. Even though they have a high implementation cost, they have a low operating cost. At the same time, these, if properly designed and exploited, have no danger of affecting the environment. Geothermal systems can have

an advantage both economically and ecologically, not only compared to conventional sources, but also with other renewable energy sources.

From a technological point of view, there is still space for research and development and contributions are still expected in the development of these technologies. At the same time, it is expected that decision-making entities will contribute to the promotion and implementation of such projects, which use geothermal energy in centralized systems.

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