Geothermal energy as renewable energy source

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I. INTRODUCTION

The earth is a dynamic planet and can be described as a gigantic thermal engine. The available heat is called geothermal energy.[1] Geothermal energy is a renewable energy source just like wind, hydro or solar power. By using geothermal energy, greenhouse gas emissions can be reduced significantly. However, other than solar or wind power, geothermal energy is neither dependent on climatic influences, nor daytime or season and is available at almost any place and time. Although as a renewable energy source geothermal energy offers many advantages and is available at many potential sites, it has so only a comparatively low proportion of the total energy supply so far. As experts assume, geothermal energy consists of approximately 30% residual heat caused by the earth´s formation process about 5 billion years ago, when gases, rocks and dust were condensed. In this process a huge amount of energy was released. Temperatures of about 6000 °C are reached in the earth´s core.[2]

II. APPLICATION

Geothermal energy is generally subdivided into depth and near-surface geothermal energy. The near-surface geothermal energy is mainly used to heat or cooling buildings. However, the depth-geothermal energy primary generates electricity and heat in (for) power plants, since this method is too complex to be used for cooling or heating individual buildings. Depth-geothermal energy, based on its technical application, is further subdivided into hydrothermal geothermal energy, HDR systems and deep geothermal heat probes. Geothermal energy enables a supply of individual homes, mostly detached houses, independently from the main power supply network.[3] In order to realize this, there are many different techniques available today, from which private households can to select the most effective according to their specific situation and region.

The heat pump is the heart of each individual plant. This heat pump receives the heat transfer medium that was headed by the ground. Then, the heat pump absorbs the heat and feeds the storage tank from which the house´s entire heating and hot water system is supplied. For security reasons, an additional boiler can be installed in the system. This is necessary because it might happen that the geothermal heat collectors are influenced by the seasons, so that during winters the energy from the ground is not sufficient in order to heat the building. The geothermal heat collectors are placed horizontally at 80 - 160 cm under the surface to be subject to weather conditions.[4] The most widespread plant is the geothermal heat probe. When installing the geothermal heat probe, first a plastic tube bundle is inserted in a prepared hole. Then the ring area is sealed with a bentonite / cement / water mixture. The Plastic tube bundle contains a heat carrying liquid, usually water with an antifreeze. They are inserted 25 to 200 meters vertically into the floor and deliver a constant temperature level. Because a legal procedure is necessary for drilling holes into the soil deeper than 100m, most of these facilities do not exceed this limit. The heat transfer medium circulates inside the heat probes, continuously receiving heat from the ground and transporting it up to the heat pump. This method does not only provide heat (and energy) for individual houses but also supplies offices and commercial buildings, even apartment complexes or whole neighborhoods.[5] Energy earthbound piles and static parts are needed for new buildings anyway. These parts can be equipped with heat exchanger tubes, so that combined with a heat pump buildings can be economically heated and cooled.

III. INVESTMENTS

Regarding the investments for a geothermal plant there are five points to consider. In the calculation the costs for official approvals, drilling (only for geothermal heat probes), the heat pump, a separate electric meter and several accessories need to be taken into account. The investments for these facilities are about € 15600-25150. Thus the costs for geothermal power plants are about € 3000-5000 higher than for gas- or oil-heaters. Since the investments for geothermal power plants are comparatively (quite) high, the government offers financial help to

Activity	Costs
Official approval	€ 500 – 1,500
Drilling	€ 60 - 90 per meter
Heat pump (to 17 kW)	€ 9,000 – 13,000
Accessories	€ 500 – 1,500
Electric meter	€ 500 – 1,500

Table 1: Overview about acquisition costs (2007) (http://www.junkers.com/de/de/beratung/technik/wp/ewp/kosten/Standardpage_7.html)

support the installations of environmentally friendly equipment.[6] Since 1.1.2008 the installation of heat pumps in the residential and commercial sector has been supported by the federal government.

IV. POTENTIAL

The geothermal energy offers a big potential as an alternative energy source for the future. To reach an exact appraisal of this form of power generation it is necessary to look at the energy-political aims. These aims concern the economic efficiency, environmental compatibility and last but not least the security of the energy supply. Concerning the environmental compatibility, the emission of greenhouse gases of alternative energy sources should be as low as possible which helps to protect the climate and environment with a friendly energy supply. The security of energy supply should be improved by the high-priority use of locally available ressources. The steadily rising energy prices are in the focus of the economic efficiency and the alternative energy source should allow an increasingly economic use and offer independence from high energy expenses.[7]

In the following it is demonstrated to what extend the geothermal energy, as an alternative energy source, fulfill the energy-political objectives. A cost saving potential of approximately 80% was identified in comparison to fossil energy sources by the use of the geothermal energy. Furthermore the geothermal heating installation needs only small quantities in electric energy in comparison to gas heating installations or oil heating installations. It has to be mentioned here, that the effectiveness of this technology is a multiple higher than with fossil heating systems. A further advantage of these systems is that the whole installation could not only be used for heating in winter, but also for cooling in summer. Because of this advantage the user does not have to pay for an additional cooling system. Moreover the costs of maintenance are less expensive than for traditional heating systems. After some time it is only necessary to substitute filters of the heat pump and gaskets of the whole cycle system. Geothermal installations can be also installed in any building to any time and they have a life span of approximately 50 years. However, negative points are the high costs and requirements for the building insulation. The requirements for the building´s insulation are so high because geothermal systems heat a building substantially slower than customary systems and take a lot of time when the building has an insufficient insulation. Finally it is to ascertained that this form of power production is absolutely economic.[8]

When you take a look to the environmental compatibility, a representation of the environmental consequences of the geothermal energy must follow. First, there should not be released any CO_2-emissions by the use of geothermal energy. The only component which needs electric energy is the heat pump. Because of this, the usage of this energy form is directly connected to the CO_2-intensive generation of electricity. Moreover share-fluoridated hydro-fluorocarbons (HFC) are used in heat pumps. These media do not attack the ozonosphere; nevertheless, they forward the greenhouse effect. If these HFCs reach the atmosphere the influence to the greenhouse effect is approximately 1500-3000 stronger than CO_2-emissions.[9] Another disadvantageous is that with very low outside temperatures an additional heating system like gas- or oil heating is needed because the energy from the earth is not sufficient. There are often problems with the geothermal energy collectors, because these lie close under the earth's surface and can only record a relatively little warming up. At last it is ascertained that the geothermal systems are absolutely environment-friendly as an alternative energy source, but there is still a big need for action concerning the used cooling medium.

The security of the energy supply is for all systems guaranteed, when the geothermal energy is only used privately. Then there are no regional restrictions. Indeed, it is to be noticed, that at some places the geothermal energy cannot be used, even if the geologic conditions would be given. This is justified upon to the fact that geothermal energy probes and geothermal energy collectors needs a lot of space. A surface which is one and a half times larger as the surface to be heated is an approximate value. This is especially problematic for households which are based on a relatively small property. These households could install only smaller variations of this technology in the earth and use them merely for heating or cooling support which is economically questionable. So they have to abdicate of this alternative energy source. The application ranges of depth-geothermal energy are more limited than near-surface geothermal energy. This energy system type can be used for electricity and heat generation in power plants. But the

geothermal requirements must be given. This is only possible at places where the points of the tectonic disks are. Otherwise the bores are too deep in the earth and a cost-covering production is impossible. In summary geothermal energy is theoretically available everywhere, but in many areas there are restrictions for the use in private households.[10]

IV. SUMMARY

About 0.4% of the worldwide power generation is geothermal energy. The annual growth rate was stable in the last decade and is still at about 5.0% (about 200-250 MW capacity increase p.a.). Illustration 1 shows the previous development and the future trend in comparison to other energy forms. The geothermal capacity installed worldwide will exceed 10 GW (year 2008) soon, for 2010 the forecast is about 11 GW. Within the next 30 years an increase to about 85 GW is regarded as possible. The most important markets for this energy form are the USA, Philippines, Mexico, Indonesia, Japan, New Zealand, Italy and Iceland. Iceland is advancing the development of the geothermal capacity and the research very actively at present.

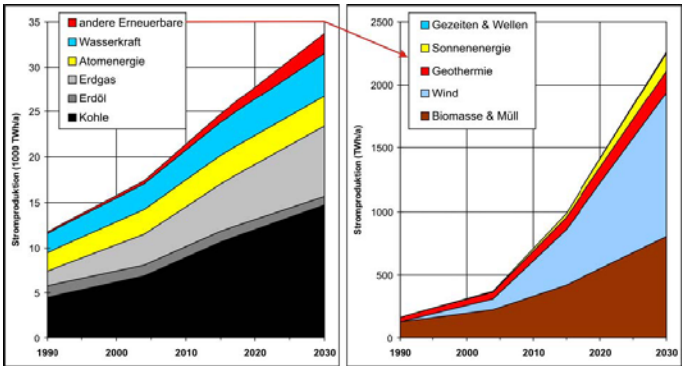

Illustration 1: Electricity generation (in TWh/a)-temporal development of the different energy sectors to 2005 and forecast to 2030 (http://www.eeg.tuwien.ac.at/events/iewt/iewt2009 /papers/3D_4_PONWEISER_K_P.pdf)

The biomass still dominates globally the field of the warmth generation. By the increase in the world population the need for heated rooms and energy supply for the eating preparation also rises further strongly. For this 58% of renewable energies are used. The renewable energies which fundamentally contribute to the supply of useful heat are solar energy and geothermal energy. The capacity of the geothermal energy installed at present is only a third in comparison to the solar heat because of the higher degree of utilization the energy output is comparable. An increase for these energy forms around 10-fold at solar energy utilization and 6-fold at geothermal energy is forecast for the year 2030, how illustration 2 shows. World market leaders in the area of direct use will be China, Sweden, the USA, Turkey, Iceland and Japan. Leading and at the same time the largest growth market is the People's Republic of China at this energy form. But Iceland is worldwide at first place with 25% of the electricity and 85% of the required space heating made out of geothermal energy.[11]

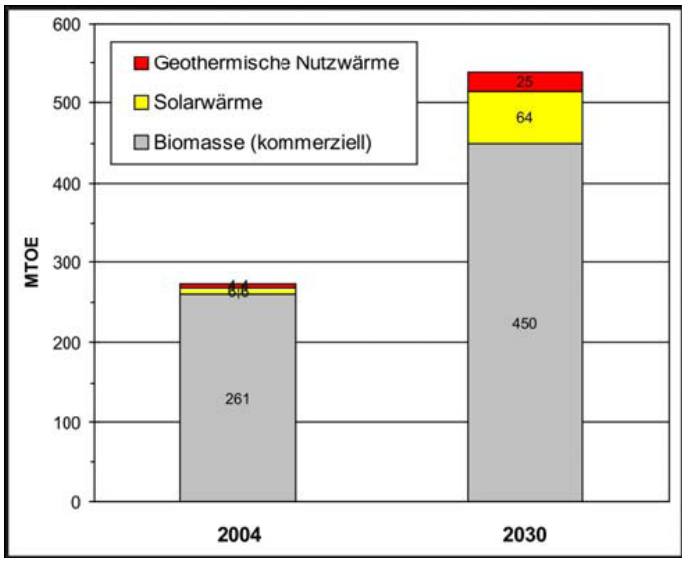

Illustration 2: Quota of the relevant energy sectors of the worldwide provision to geothermal using warmth (in MTOE) for 2004 and forecast for 2030 to IEA 2007 (http://www.eeg.tuwien.ac.at/events/iewt/iewt2009 /papers/3D_4_PONWEISER_K_P.pdf)

The geothermal energy offers an enormous rate of potential for the generation of electricity and heat. The two and a half-fold amount of energy which the mankind needs rises from the inside of the earth daily. The geothermal energy is available every day and season and is independent of weather influences or climate conditions. The huge potential of this alternative energy source was recognized meanwhile and utilization was started. Nowadays geothermal energy gets more and more frequently in the focus of political discussions about the future energy supply. This has been the case since the costs for fossil fuels increase rapidly. Due to the long-term safeguarding of the geothermal energy as an alternative energy source in combination with the flexible use possibilities in the areas of heating, cooling and electricity generation the number of plants which are planned and installed worldwide, increase steady.

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