Hybrid Geothermal/Solar Energy Technology For Power Generation

Dr. Hussain Alrobaei
Higher Institute of Engineering
P.O.Box: 61297 ; HOON ; LIBYA
E-mail : xyccaa@yahoo.com

Overview

As energy costs continue to rise worldwide, innovators desire to seek out new technologies to meet the rising demand for sustainable energy. Future security of supply, particular of oil and gas is uncertain, and indigenous production is declining rapidly. Therefore, finding an inexpensive and reliable source of energy is a challenge in many developed and developing countries. Renewable forms of energy are the only energy sources that become cheaper with time. Due to research and development and to the effects of mass production and larger unit scales, the cost of most renewable forms of energy is reduced by 10 to 20 % each time the installed capacity doubles [**1,2**]. Further, renewable energy can provide the necessary amount of clean energy to achieve the targets for climate stabilization and reduce the consumption of fossil fuels to the rare times when renewable energy supply and electricity demand do not coincide. Using fossil energies exclusively for backup purposes will reduce their consumption to a sustainable level and will reduce the quickly escalating cost of power generation. Fossil fuels will be used to provide firm capacity, while renewable will serve to reduce fossil fuel consumption. A well-balanced mix of renewable energy sources with fossil fuel backup can provide affordable power capacity on demand. The geographical location, climate, and local conditions are the most important factors that determine the possibilities of applying solar energy and other renewable and methods of energy conversion. Due to these factors some methods of energy conversion and some types of the system are preferable, and some are limited or even ineffective in the given conditions.

Sustainable power in Europe can be based to a great extent on renewable generation including solar electricity import from the Middle East and North Africa (MENA) [**2**]. Solar electricity generated under the ideal meteorological conditions in the MENA and transferred to Europe via high voltage direct current transmission can provide firm capacity for base load, intermediate, and peaking power, effectively complementing European electricity sources.
Moreover, due to a higher solar irradiance, the cost of solar electricity is usually lower in MENA than in Europe. Therefore, there will be a significant market for solar electricity imports to complement

Solar tower (or **solar chimney**) is one of the alternative technologies proposed as a device to economically generate electricity from solar energy in large-scale [**3**]. In the ***Solar Chimney Power Plant*** (**SCPP**) (figure 1), the sun heats the air under a large collector roof made of glass or plastic foil. The warm air flows to a chimney located at the center of the collector roof where it then ascends. Thus solar radiation causes a constant updraught in the chimney. The energy this contains is converted into mechanical energy by pressure-staged wind turbine at the base of the chimney, and into electrical energy by conventional generator. SCPP function solely with air and do not need any cooling water. This fact is a major advantage in many sun-rich countries, which already have serious problems with water supply. Since, unlike the concentrating solar thermal power plants, the solar irradiation is not concentrated, diffuse radiant energy can also heat the air underneath the glass roof. The power plant can therefore operate even when the skies are partly or completely overcast. Additionally, the ground underneath the collector can serve as a natural heat storage medium and hence ensure uniform electricity generation. SCPP could make important contributions to

the energy supplies in Africa and Asia because more than enough space and sunlight are available there. However, an economic drawback of such power plants is the low overall conversion efficiency from solar energy to electricity, which negatively effect on the levelized solar electricity cost. Continuous improvement of the concept has involved the investigation of methods to increase power station efficiency and capacity in parallel to reducing design dimensions for greater commercial feasibility. Correspondingly, being one of the most effective technologies in terms of technical, economic and environmental sustainability. From this standpoint the author proposes a new approach to prospective SCPP in the south region of Libya. This approach includes the combining of the following grid connected technologies for proposed plants at AL-Jufra region: ***Hybrid Geothermal / Solar Chimney Power Plant*** (figure 2) and ***Hybrid Geothermal / PV / Solar Chimney Power Plant*** (figure 3). The novel proposed schemes of hybrid SCPP offer a number of potential advantages and represents an innovative way to reduce cost, optimizing the consumption of fossil fuel, and minimizing the environmental impact. They are based on thermal conversion, which allows hybrid operation with both solar heat and low temperature geothermal to continue generating electricity even when sunlight is not available. Attractive alternative is to use geothermal energy for electricity generation, because it is available around the clock and can be regulated according to the demand. Geothermal power generation could thus provide a major contribution to the basic supply of solar electricity. This is a major advantage since it enables operation according to the actual demand for electricity, without limitation to sunlight hours only and considerably improves SCPP ability to compete with conventional power plants.

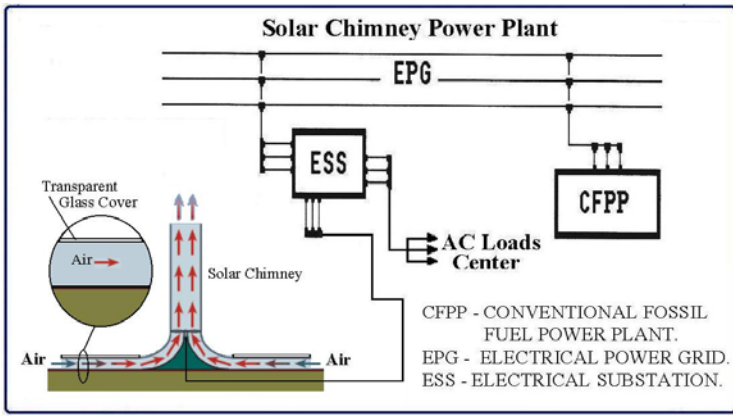

Figure.1 Schematic diagram of a solar chimney power plant.

The hybrid Geothermal / Solar Chimney power Plant (**GSCP**, figure 2) has generated much interest because it offers an innovative way to continuous 24 hours-operation, and improve the maneuver characteristic, of grid connected SCPP. The main target of GSCP design approach was to achieve high renewable share with little or no fossil fuel back up requirements in electrical power grid. Moreover, there is an increase in the useful operating time of the SCPP by reducing the daily start-up and shut-down

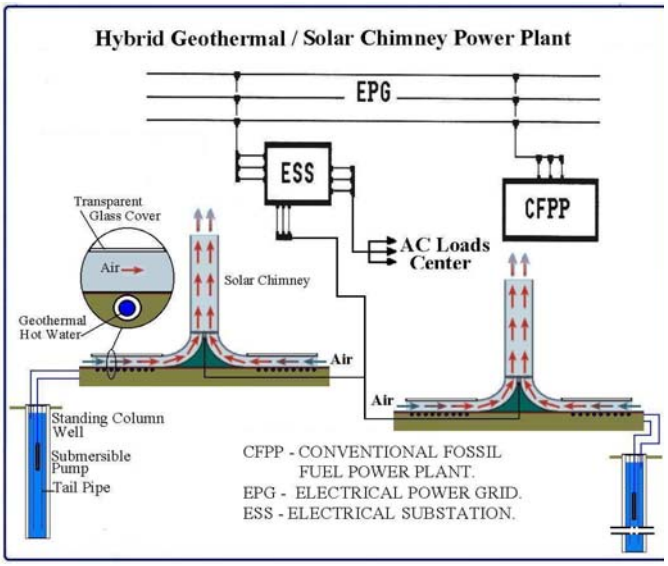

Figure.2 Schematic diagram of the hybrid Geothermal / Solar Chimney power Plant (GSCP).

times due to continuous operation of the power conversion system. The initially proposed operation strategy of GSCP is very simple: the plant operates during sunny periods as a conventional grid connected SCPP. While during cloudy periods and at night the plant may be applied to the following modes of operation:

– Full geothermal mode of operation (Air underneath a glass ceiling is heated by geothermal energy so that it rises through a chimney).

– Hybrid geothermal / solar mode of operation (Air underneath a glass ceiling is heated by geothermal energy and solar radiation so that it rises through a chimney). That would fully exploit the potential of the geothermal / solar combination to provide a major contribution to the basic supply of renewable electricity.

The proposed concept meets these conditions and makes it possible to take the crucial step toward a global renewable energy economy. Continuous improvement of the GSCP (figure 2) concept has involved the investigation of methods to increase the efficiency of the collector zone of a GSCP. Solar photoVoltaic (**PV**) power is already in widespread use and the costs of PV systems keep on reducing. Consequently, there is growing interest in grid-connected PV systems. However, the solar PV array convert **8 : 15 %** of the absorbed solar radiation to electricity, the rest dissipates as heat [**4**]. This motivates a solar PV/ Thermal (**PV/T**) cogeneration system ,where heat is removed from the transparent PV array, used to heat the air underneath a collector roof. Further, the heat production per square meter of solar PV array can be as much as four times greater than the electrical energy produced so putting this heat to use improves the system total efficiency and cost effectiveness. Thereupon, the transparent solar PV/T arrays proposed for adaptation to the GSCP concept will introduce the ability to dramatically improve the performance of the collector zone and introduce a method of solar power generation (previously unavailable to the concept) creating greater base load electrical power generation. A new scheme of Hybrid Geothermal / PV / Solar Chimney power Plant (**GPVSCP**, figure 3) is proposed here, that would fully exploit the potential of the geothermal/solar combination, based on the following principles:

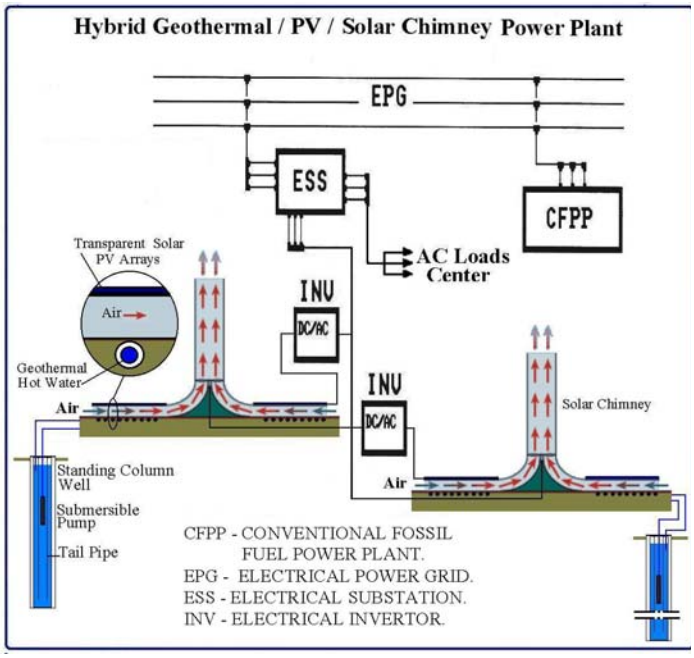

Figure.3 Schematic diagram of the hybrid Geothermal / PV /Solar Chimney power Plant (GPVSCP).

– supply solar heat to the transparent solar PV/T arrays , to achieve the highest possible conversion efficiency,

– supply low temperature geothermal heat to the collector zone, to achieve the highest possible geothermal contribution,

– hybrid geothermal/solar operation, to provide dispatchable full capacity at sunny and cloudy periods of operation, without solar-specific restrictions on the plant's operation.

It is worthwhile to mention that the shear of thermal water can also be used as irrigation water once it has cooled down. Providing power, irrigation water, shadow and foreign exchange from the export of green power and revived agriculture, such multi-purpose plants could provide all what is needed to effectively combat desertification and create labor opportunities in the agriculture and food sector. Tourism and other industries could follow.

REFERENCES

1. **NREL , 2003, Assessment of Parabolic Trough and Power Tower Solar Technology Cost and Performance Forecasts, National Renewable Energy Laboratory, Chicago Oct. 2003.**
2. **MED-CSP, 2005, MED-CSP Study Team, Concentrating Solar Power for the Mediterranean Region. / Study commissioned by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Stuttgart 2005/ www.dlr.de/tt/med-csp. (Internet communication)**
3. **Schlaich, J., 1995, "The Solar Chimney: Electricity from the Sun". C. Maurer, Geislingen, Germany.**
4. **F. LASNIER and T.G. ANG., 1990, Photovoltaic Engineering Handbook , The Adam Hilger .**