Solar energy in Spain

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***Abstract*- The article shows what kind of solar power plants is used in Spain. It describes what technologies are used to build this objects and how do they work.**

I. INTRODUCTION

Every country spends large amount of money for renewable energy sources. What type of "green energy" a country can use, depends on what climatic conditions does it have. For example in places with strong winds we can develop wind energy. Another countries, especially those lying on the south of Europe, have great conditions for using sun in their energetic economy.

Spain is one of the most attractive countries for the development of solar energy (fig. 1). The Spanish government said that they will achieve a target of 12 percent of primary energy income from renewable energy by 2010. This includes solar power system, which will be generating a capacity of 3000 megawatts (MW). Spain is the fourth largest manufacturer in the world of solar power technology and exports 80 percent of this output to Germany.

Through a ministerial ruling in March 2004, the Spanish government removed economic barriers to the connection of renewable energy technologies to the electricity grid. The widely applauded Royal Decree 436/2004 equalises conditions for large-scale solar thermal and photovoltaic plants and guarantees feed-in tariffs.

In Spain are three interesting power station using solar radiation to generate eletricicty. There are PS 10, Andasol and photovoltaic power stations.

Figure 1. Yearly total of global horizontal irradiation [kWh/m^2/year] in Spain and Portugal

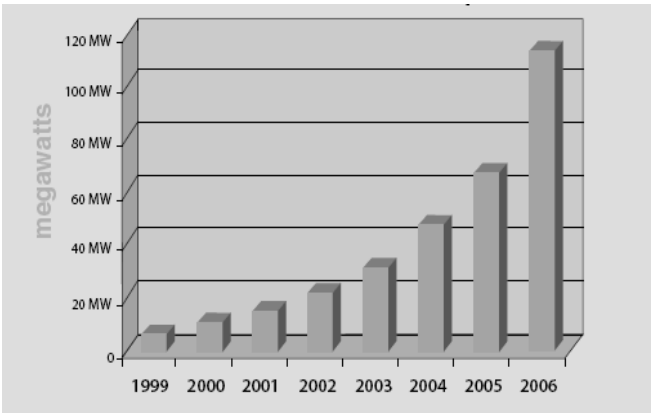

Figure 2. Growth of Solar power in Spain

II. PS 10

Construction of the PS10 project, an 11 MW Solar Thermal Power Plant in Southern Spain has been completed in 2008. This object is located in Sanlúcar la Mayor, 15 km west of the city of Seville. This type of electric power station is called Central Receiver System (CRS). The fig. 4 shows how does it work . This power plant is the first solution of this type in Europe. All technologies used in this project, like glass-metal heliostats, a pressurized water thermal storage system and a saturated steam receiver and turbine, have been developed by European companies.

The heliostat field is composed of 624 heliostats each of 120 m^2, with a mobile curved reflective surface which concentrates solar radiation on a receiver at the top of a 100 m tower. In the receiver, the steam is heated up to 40 bar (250ºC) by thermal energy supplied by the concentrated solar radiation flux.

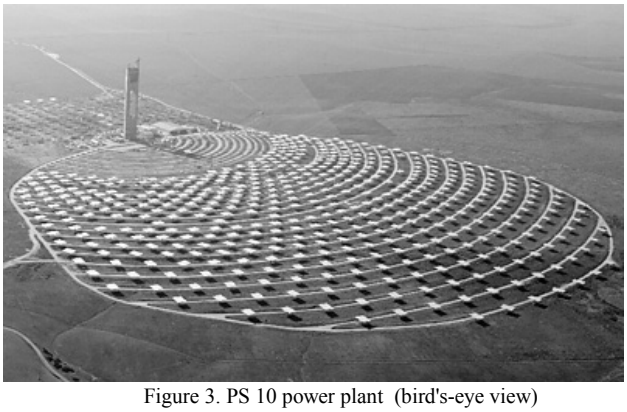

Figure 3. PS 10 power plant (bird's-eye view)

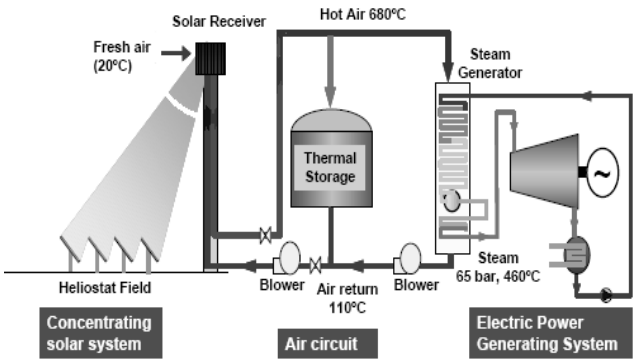

Figure 4. Main schema of working PS 10

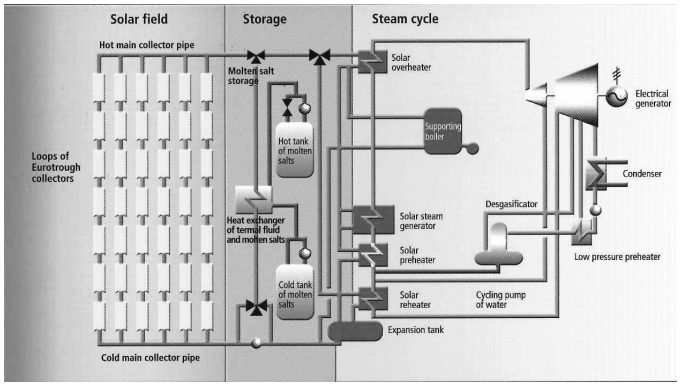

Figure 5. Main schema of working Andasol

Next, the steam is sent to the turbine, where it produces mechanical work, which is in the next step changed into electricity by synchronic generator. The turbogenerator output goes to a water-cooled 0.06 bar pressurized condenser. The condenser output is preheated by 0.8 bar and 16 bar turbine extractions. The output of first preheater is sent to a deaerator fed with steam from another turbine extraction. A second preheater is fed with steam coming from the receiver. This preheater increases the water temperature to 245ºC. This solution has a task to increase the water returning from the drum to temperature to 247ºC, which is flowing out from the condenser.

Sometimes clouds curtain the sun. In that case , the plant has a 20-MWh thermal capacity saturated water thermal storage system (equivalent to 50 minutes of 50% load operation). The system is made up of 4 tanks that are sequentially operated in order of their charge status. On the figure 4 is shown, that part of the 250ºC/40 bar steam produced by the receiver is going to the thermal storage system. When energy is needed to cover a transient period, the energy is recovered from the saturated water at 20 bar to run the turbine at 50% load.

This is a big structure, so to reduce the visual impact of this building the body of the tower is rather thin when we look at from the side. The tower has 115m total height, 18m wide and is just 8m width. The front has to have that length because it has to allocate the 14 m wide receiver. A large space has been left open on the bottom of the tower to give the impression of a lightweight structure. For the visitors there is a special platform, which is 30 m height. From that places there is a good view of the heliostat field lying north of the tower, and the Sevilla photovoltaic plant (PV) south of the PS10 power plant.

III. ANDASOL SOLAR POWER STATION

This kind of solar power plant was for first time used in commercial operation in California in 1985. Parabolic trough power plants have already generated over twelve billion kilowatt hours of solar electricity, which equates to providing 12 million people with electricity for one year. In parabolic trough power plants electricity is generated using a steam turbine which is connected with the generator. This is the same solution like the one which is used in conventionally fuelled power plants, including nuclear power plant. However, in Andasol power station steam is not produced by burning fossil fuels but by usage of solar energy. The solar radiation is captured and concentrated by long rows of parabolic mirrors. The radiation from the sun is reflected from the mirrors and concentrates on long pipes filled with water or another liquid, which has big heat capacity and small viscosity. The heat generated in this way is enough to produce the steam required.

Solar Millennium developed parabolic trough power plants in Europe. The Andasol 1 plant works since autumn 2008, Andasol 2 and 3 are currently under construction in southern Spain. The amount of electricity this power station produces is about 180 GWh per year. The collector surface area can be compared to 70 football fields. This is over 510,000 m^2.

When the Andasol 2 and 3 will be finished they will supply over 200,000 people with solar electricity. The construction will probably last about two more years. They will also contribute to Spain's supply reliability and in particular, cover the demand peaks in the Spanish electricity grid during the summer months. Each power plant has an electricity output of 50 megawatts and operates with a thermal storage. The task of this storage is the same like in the PS 10. There are two tanks which have 36m in diameter and 14m in height. Each of them can be filled with 28,500 tons of the storage medium. A full thermal reservoir can continue to run the turbines for about 7.5 hours at full-load, even if it rains or long after the sun has set.

Figure 6. Andasol solar power station (bird's-eye view)

IV. PHOTOVOLTAIC POWER STATIONS

Photovoltaics is a method for transform a solar radiation into electrical power. Photons from sunlight knock electrons into a higher state of energy, creating electricity. It can be achieved by using solar cells packaged in photovoltaic modules, often electrically connected in multiples, as solar photovoltaic arrays, to convert energy from the sun into electricity. The term photovoltaic denotes the unbiased operating mode of a photodiode in which current through the device is entirely due to the transduced light energy.

Solar cell is a device that converts sunlight directly into electricity, which can be used to power equipment or to recharge a battery. The first practical application of photovoltaics was to power orbiting satellites and other spacecrafts, but today they are used usually as photovoltaic modules, used for grid connected power generation. There is a smaller market for off grid power for remote dwellings, roadside emergency telephones, remote sensing and cathodes protection of pipelines.

Cells are sensitive for the environment so they are packaged usually behind a glass sheet. To achieve more power from the photovoltaic modules we can connect them together to form solar panels. Cells can be connected in series creating an additive voltage. Connecting cells in parallel will yield a higher current Although the price of modules is still too high to compete with grid electricity in most places, significant financial incentives in Japan and then Germany triggered a huge growth in demand, followed quickly by production.

In last years many solar photovoltaic power stations have been built in Spain. As of January 2009, the largest photovoltaic power plants in Spain are the Parque Fotovoltaico Olmedilla de Alarcon (60 MW), Planta Solar Arnedo (30 MW), Parque Solar Merida/Don Alvaro (30 MW), Planta solar Fuente Álamo (26 MW), Planta fotovoltaica de Lucainena de las Torres (23.2 MW), Parque Fotovoltaico Abertura Solar (23.1 MW), Parque Solar Hoya de Los Vincentes (23 MW), Huerta Solar Almaraz (22.1 MW), Solarpark Calveron (21 MW), and the Planta Solar La Magascona (20 MW).

Figure 7. Solar Panels – Spain

V. CONCLUSION

The Spanish government continues to promote the investment and expansion of both photovoltaic and solar thermal power in the country, with a goal of 400 MW installed power for PV and 500 MW for solar by 2010. This is still only a small piece of the country's total power use and total renewable energy production.

The government, however, is committed to advance this sector. The new requirements of 2006 requires increased energy efficiency and an obligation to meet a significant part of the hot water demand with passive solar heating. The Plan of Renewable Energies sets lofty goals of 5 million square feet of solar collectors by 2010. They new Royal Decree approved in May 2007 improves the feed-in tariffs for both solar thermal and photovoltaic facilities. Spanish companies and research institutions plan to continue to be at the forefront of the growing global field.

The president of the Spanish Photovoltaic Industry Association, Javier Anta said that the solar industry will be a major part of the government's goal of 20 percent renewable energy by 2020. This is still a small percentage of renewable power. However, it's grown more than 100 percent a year in the past few years. Anta wants to continue developing new technology which improve using solar energy.

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