



THE FUTURE IS LOOKING BRIGHTER FOR SPAIN

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Spain hosts the first futuristic looking commercial solar tower in the world.

It is an 11 mega watt facility called PS10, developed by Solucar, the solar arm of engineering firm Abengoa.

The tower, located in San Lucar la Mayor 15 miles west of the city of Seville, was inaugurated, emitting not a single puff of greenhouse gas, on 30 March 2007.

PS10 is the first tower technology, solar thermoelectric power plant constructed for commercial operation, evolved due to solar radiation reaching the earth's surface daily with a density that is adequate enough to heat systems but not, however, efficient enough to produce self sufficiently the end product: electricity.

Due to exciting developments taking place with the beginning of CSP (Concentrating Solar Power), new options to combat climate change and increase energy security are evolving. With an expected 2,600MW of CSP in the pipeline spread across the US, Spain, North Africa and Middle East, Spain and the US have the most advanced and, at present, the upper hand in the CSP market.

With CSP emerging behind wind as a significantly potential source of renewable energy, it has the capacity to produce enough energy to provide electrical power to the domestic market.

New Spanish regulations in 2004 removed barriers and gave the green light for renewable systems to be able to be connected into the national grid, which is why projects like the Seville solar station have the potential to create a massive impact upon the way we live today. The plant is a first-of-its-kind solar central receiver system (CRS) producing electricity in grid-connected mode.

The plant has created local employment: 1,000 jobs are associated with the manufacturing and construction phase along with 300 service and maintenance jobs for the array of power plants.

The EU has been supporting CSP for more than ten years now, spending some €25 million researching the area. The potential contribution of concentrating solar power plants to a more sustainable energy system has still to be fully exploited.

The Seville CSP plant has been partly financed with EU funds, the project required in total an enormous investment of €1.2 billion. With costs soaring on the build of the Seville plant it only became viable due to generous subsidies from the Spanish government and the EU. The final budget required to build PS10 amounted to €35 million with €5 million coming from the EU's fifth framework programme for research awarded due to the project's innovative approach.

Abengoa is a technology company that applies innovative solutions for sustainable development in the infrastructure environment and energy sectors. As a company it operates in seventy countries and functions through five different business units. Abengoa first became involved in solar energy in the 1980s and has been involved in similar projects to PS10 in countries such as Israel.

PS10 is the first of a set of solar electric power generation plants to be constructed totalling more than 300MW by 2013, to be accomplished using a variety of different technologies.

The solar tower complex contains two plants: the PS10 and Seville PV. Used from two different fields, one field of heliostats concentrates sunlight on a solar thermal receiver. The other, smaller, field of heliostats concentrates sunlight from photovoltaic panels on the other side of the same tower. The second, Seville PV, is the largest low concentration system photovoltaic plant in Europe. PS10 was the first to be built, with two other power towers planned. PS20 is estimated to produce 20MW and A2 20MW, the first of which began construction in October 2006.

The remaining power plants will be staggered over the next six years to convert the platform into a diverse technology macro-project including tower thermo electrics, parabolic trough collectors, Stirling dish, low and high concentration photovoltaic plants. CSP plants have few environmental impacts as they produce no environmental contaminants or greenhouse gases. Nonetheless, the one problem of harnessing solar energy is the amount of space needed to create these solar stations. The Seville plant currently occupies 60 hectares of land.

If technologies such as the one in Seville were to be implemented across the globe, the land requirement isn't as simple as perceived; positioning and location are the key variables when it comes to stations' productivity.

Seville annually receives up to 300 days of sunshine: this statistic and Abengoa bio-energy are the primary reasons why a 2005 policy analysis from Greenpeace identified Spain as one of the five most promising regions in the world for development of large-scale thermal solar projects.

The European commission has published a map of the solar power potential of Europe. The map is produced by the photovoltaic geographical information system of the joint research centre, aimed at helping to increase the share of renewable energy in its consumption to 20% in 2020.

CSP can provide regular and pre-forecasted power as (apart from the obvious sunshine) heat can be stored easily.

By using molten salt storage liquids it is possible to run the plant through the night using the excess heat stored during the day. The most recent heat transfer material that has been successfully demonstrated is liquid sodium. Sodium is a metal with a high heat capacity allowing energy to be stored and drawn off throughout the evening. However, this isn't always the better option.

The PS10 is highly dependent on variables such as weather conditions and daylight hours. Making use of well-proven technologies like glass-metal, heliostats, pressurised water thermal storage systems, saturated steam receiver and turbines, all technologies developed and already tested, avoids technology uncertainties giving priority to scale.

Solucar's tower, unlike its rivals that use salt storage, uses water



to prolong the life of the tower to reduce fatigue on the system components. PS10 doesn't need salt water due to the management focusing on technical reliability and lower temperature water storage. When the sun goes down enough heat is stored in the form of steam to enable generation for another hour at half speed (this may be longer in time), thus avoiding penalties for failing to meet grid obligations.

There is in addition a fourth power tower planned, 17MW Solar Tres, by the Spanish company Sener, which will employ molten salt technology providing a 16-hour back up facility to enable 24 hour production of electricity.

Heliostats

Unlike photovoltaics, which generate electricity directly from the sunlight, CSP uses the sun to generate heat to produce electricity in a similar way to a power station.

PS10 draws on 624 large mirrors called heliostats. Each mirror has a surface measuring 120 square metres, concentrating the sun's rays and using the tower to receive the focused sunlight – the target. The mirrors reflect the sun's rays to a central receiver located at the top of the tower directed by a central computerised system.

The area around the tower becomes so bright that it illuminates water vapour and dust that is in the air; with the light beam focusing at one point you can actually see flashes and little puffs of smoke from specks of drifting dust being vaporised – an area where you need to wear sunglasses!

The heliostats move automatically by means of a mechanism programmed with the function of the solar calendar moving like plants tracking the sun on its axis.

The Tower

PS10 took more than four years to build from 1 July 2001 until 31 December 2005 and is a concrete tower over 100 metres or 35 storeys in height.

The question is at what cost it is viable to harness CSP energy, using current technologies – aesthetics?

The issue with aesthetics has been dealt with in the tall structure's ambitious design. The architectural design has reduced the visual impact on its surrounding environment, as it is 8m in width from the side and 18m wide from the front to accommodate the 14m wide receiver at the top. Incorporated into the design 30 metres up the tower is a viewing platform to allow school groups and visitors to view the Heliostat field.

The tower was painted a soft clay colour to help it merge into its backdrop. PS10 is aesthetically pleasing to the surrounding environment; however, this issue shouldn't be of significance when considering the enormous outcome from the plant.

The Receiver

Working by focusing reflected rays on one location the receiver (the target) is made up of a collection of water pipes to take the concentrated solar power, working like a traditional coal-fired power plant.

The solar energy concentrated at the top of the tower could easily melt metal; the water being pumped through the pipes stops it and

turns the water into steam through the solar receptor.

The steam generated from the receiver is put under pressure and blasted to turn turbines which in turn generate power. The chamber that houses the noisy turbines is located at the base of the tower. The steam sent to the turbines expands, producing mechanical work and electricity. It produces 250 degrees Celsius saturated steam from thermal energy supplied by the concentrating solar radiation flux which has a cavity design to reduce radiation and convector losses. The steam goes through pressurised condensers and pre-heaters fed with steam coming from the receiver, increasing the temperatures then mixing the water from the flow returning from the tanks. Generating temperatures of up to 250 degrees Celsius, the heat is held in thermal clad tanks that reach temperatures of 250-255 degrees Celsius (instead of around 600 degrees Celsius for systems using salt) as mentioned previously providing an hour at half load after dark. However, most heat and solar power is used during the summer when air-conditioning is used. The system has four tanks operated in order of their charge status.

Statistics

Current figures of electricity being produced from PS10 show it is enough to power up to 6,000 homes. Ultimately, it should generate enough for 600,000 people. In 2013, when complete, the plant is to produce enough energy to cover the consumption of 180,000 homes, equivalent to the entire city of Seville.

Unfortunately, the power is three times more expensive than power from conventional sources. Adding the current power to the grid has other disadvantages as the current generated has to be converted to alternating current losing around 7-12% in energy, but prices will fall and productivity will increase like wind power as the technologies develop.

Estimating a 20-year life for the plant it will in total prevent a colossal amount of emissions. When complete in 2013 the plant will prevent the emission of more than 600,000 metric tons of greenhouse gas carbon dioxide into the atmosphere each year, which would otherwise have resulted from the burning of fossil fuels to supply electricity to the 180,000 homes which are forecast to be served from the tower.

Conclusion

In conclusion, given CSP produces carbon-free energy, it is remarkable that CSPs haven't been developed further.

2004 saw Spain become the first country in the world to establish a dedicated feed-in-tariff for CSP and was described by Greenpeace as the hottest place in the world for CSP. This has boosted the Spanish economy into providing further legislation to allow operations to use natural gas as back-up to keep the CSP plants primed.

The Seville project is writing the first standards from the information, being compiled in view of the fact that the plant is based on the sale of electricity; technology on a purely commercial approach.

With the main project goal leading itself towards design, construction and commercial operation these have been achieved and the technology is already getting cheaper.

Spain is also to host a large number of parabolic troughs in a string of nine or ten developments by Acs Cobra and Solar Millennium in Andalusia totalling 100MW and several hours of storage, the first of which is due to be finished by the end of 2007.

The future should see solar towers dotted across southern Spain powering rainy northern Europe. Other plants are currently under construction in Morocco and Algeria with negotiations to build in California, Nevada and New Mexico.

Every day almost 6,000 times more potential energy than we need reaches the earth surface at no cost to us. If this energy was harvested we would find ourselves worrying less about issues such as global warming and the harvesting of the planet's fossil fuels.

The bottom line is that more solar towers should be built before global warming worsens.

