Central Receiver Solar Power Plants – The Future of Renewable Energy

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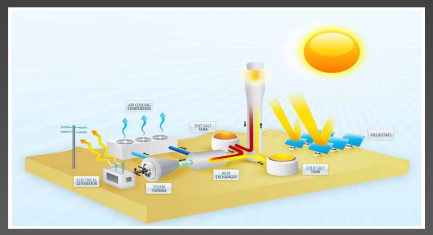
Renewable energy sources are growing both in capacity and popularity due to growing environmental concerns and scarcity of fossil fuel oriented energy sources. All clean or renewable energies are not made the same, they exhibit their own environmental impacts and overall suitability based on the environment they are in. Of all current renewable energy sources central receiver solar power plants are relatively unknown to the general public but are considered among the top contender for the next major source of clean energy in the future[1].

Central Receiver Power Plant Electricity Production



Source: http://www.skepticalscience.com/print.php?n=647

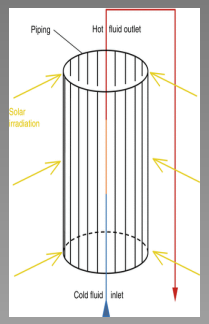
Thousands of sun-tracking mirrors known as heliostats, reflect sunlight cast onto the surface of the Earth up to the central receiver. The concentration of the solar energy heats up the receiver to roughly 550°C [2]

Source: http://terrainforma.ca/2010/09/20/

The electrical-thermal energy cycle begins and continues with "cold" molten salt being circulated into the central receiver

Source: www.bine.info/en/publications/

The heated molten salts are pumped into a "hot salt tank" at about 500°C. When electricity is required the molten salt is circulated through a heat exchanger to produce a typical Rankine steam cycle. The returning molten salts are returned to a "cold salt tank" at about 290°C



Source: Concentrating Receiver Systems Fig.17

The central receiver uses a heat transfer fluid (HTF) to absorb and transfer the concentrated solar thermal energy. Currently, the best HTF is a sodium ($NaNO_3$) and potassium nitrate (KNO_3) salt compound[3]

Advantages in Central Receiver Power Plants

The $NaNO_3$ and KNO_3 solid compound melts at 220°C, well below the 550°C operating temperature of the central receiver plant. In molten form, these salts have a higher heat capacity and thermal transfer coefficient than water or oil (traditional HTFs) while retaining the ability to be circulated and stored like a fluid[3].

The salt compound is non-toxic, environmental safe, readily available and relatively inexpensive.

With the ability to store large quantities of molten salt at high temperatures, production of electricity can be ramped up during peak hours and continue when the sun sets for up to 15 hours[4]. This capability is a major advantage over other solar power plants, namely photovoltaics[5].

Overall Comparison of Renewable Energy Sources

Renewable Energy Sectors	Land Usage [ha/MWh/yr]	Water Consumption[6] [m^3/MWh/yr]	Capital Investment[7] [$/kW]	Levelized Cost of Electricity [7][$/kWh]
Biomass	Neg	2.1	1880-6820	0.03-0.14
Hydroelectric	0.008	17.0	1000-3500	0.04-0.14
Geothermal	Neg	6.8	1850-5100	0.04-0.14
Solar - Photovoltaic	0.020	0.1	1570-4340	0.06-0.08
Solar - Thermal	0.014	3.0	3550-8760	0.075-0.18
Wind	0.005	0	1280-5070	0.06-0.21

Solar Power Plant Gemasolar – Case Study[8]

The 'Gemasolar' project near Seville Spain began in 2006 by the company SENER. This system utilizes molten salts as the heat transfer fluid and is capable of producing electricity for 15 hours without the presence of the Sun.

In order to produce a more efficient heat transfer mechanism SENER explored a new heat exchanger tubing for the receiver panels. They came up with a seamless stretch of 15 kilometres of 25mm outer diamter nickel-chromium tubing. This tubing is corrosion-resistant and capable of handling the 565°C molten salt used in the thermal solar power plant.

Further innovations in the receiver technology and HTF chemistry will allow for more of the concentrated solar power to be captured by the central receiver power plant. New receivers are being proposed which utilize ambient air as the HTF or a mixed gas, where thermal energy is used to execute a reversible chemical reaction where energy would be stored in the chemical bonds then released when required.

Central receiver solar power plants, also known as power towers, have a limited impact on the surrounding environment and can store thermal energy for specified usage, and is highly reliable within certain regions on the Earth.

Amongst the the more mature and developed renewable energy sources including hydroelectric, geothermal, solar photovoltaics (PV) and wind; solar thermal can compete with many of these energy sources from different aspects[9].

Environmental: Hydroelectric can involve drastically changing aquatic ecosystems, terrestrial wildlife habitats and geographical landscapes. Geothermal can involve extensive drilling of the Earth's crust with release of toxic gases and major water consumption. Solar thermal minimally changes desert ecosystems, exists above ground and releases no toxic gases.

Reliability: Wind and PV are intermittent by the fact that they are dependent on the weather and Sun. Coastal , marine and some inland locations have well established wind patterns. Winds are directly related to temperature and pressure changes which are dependent on weather conditions. PV are highly effective during daylight hours but can be active less than 50% of each day[10]. In regions within the "sun belt", solar thermal plants are exposed to sunlight nearly 95% of the year. With excess thermal energy, purposefully being stored in tanks, for use in electrical production during peak demand hours, changing weather and at nighttime. This feature temporarily circumvents the dependency on the presence of the Sun.

Currently, thermal energy storage (TES), heat transfer fluid (HTF) and receiver technologies require more development in order to make solar thermal a strong option for electrical production in the future. TES systems require further abilities to economically store a HTF which may involve preserving chemical or physical changes[11]. New HTFs are vital in economically storing and distributing thermal energy captured by receivers. New phase change materials and chemical processes are being explored as mediums for enhanced energy storage. Finally, new receivers are being developed to more efficiently absorb the thermal energy from concentrated solar power. With development in all these fields, central receiver solar power plants will begin to surpass other, more popular, renewable energy sources.

References

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