Solar Thermal Electricity

Solar Thermal Electricity (STE) is produced as follows:

- Sunrays are concentrated towards a solar receiver by means of various kinds of mirrors: parabolic trough mirrors or Fresnel reflectors concentrating the solar energy to a longitudinal receiver, or a field of flat mirrors (heliostats) concentrating the energy to the top of a tower.

- The solar receiver absorbs the concentrated solar energy and transfers it to a fluid, either boiling water and superheated steam (direct steam generation), or to another heat transport fluid (thermal oil or molten salts).

- The energy accumulated in the heat transfer fluid is used to generate superheated steam to feed a steam turbine that drives a generator as in the classic process of most power plants.

This thermodynamic process is totally different from that of photovoltaic plants, where the electricity is directly produced in photovoltaic panels.

SUNRAYS, GREEN ENERGY

- 3% of the sunshine in the Sahara desert could cover 100% of the current worldwide electricity consumption.
- More than 30,000 MW will be installed by 2020 across the world.
- 20% of the European electricity could come from solar energy by 2050.
Central Tower Solar Thermal Electricity (STE)

On this type of plant, the sun’s rays are concentrated by thousands of mirrors, the heliostats, which are located on the ground. The heliostats direct the rays to a receiver located at the top of a tall tower.

The heat flux reaching the receiver easily exceeds 1000 kW/m², which represents more than 1000 times the natural solar flux at the most exposed places on the earth!

The receiver consists of tube panels through which a heat transfer fluid is sent to absorb the energy collected by the receiver.

A Central Tower STE offers substantial advantages compared with other STE technologies:

- Higher concentration ratios allows higher temperatures, and thus better efficiencies.
- Receiver is capable of withstanding high pressures. This allows direct production of high pressure superheated steam (up to 185 bars) and avoids the need for dangerously flammable and polluting thermal oils, widely used in parabolic trough plants, in which the pressure is limited due to the presence of swivel joints.
- A short and mostly vertical piping layout allows fast and easy drainage of the heat transfer fluid and makes the receiver the safest arrangement for molten salts plants.

Central tower thermosolar plants.
Abengoa’s PS10 and PS20 plants, Seville, Spain.
Direct Steam Generation

In a direct steam generation thermal solar plant, the solar receiver directly generates steam for the turbine, without resorting to other heat transport fluids.

As they do not require separated steam generators, such plants are economical and allow the highest efficiency. However, given the necessarily high pressures involved, steam storage tanks are thick, heavy and expensive. Direct steam generation is, therefore, not the best adapted technology for a large energy storage. In this case, a molten salts plant will be more storage efficient.
Molten Salts Plants

The best way to insure dispatchability or overnight electricity production is to store the absorbed solar energy in molten salts, a low-cost, flame-proof and non-polluting fluid.

The solar receiver first converts the absorbed solar energy into thermal energy by heating molten salts, which are stored in a hot molten salts storage tank. Steam can then be produced on demand by pumping the hot molten salts through a steam generator. Cold molten salts are returned to a cold molten salts tank, from which they are sent to the solar receiver to be heated again.

Thanks to their short and vertical piping layout, allowing fast and easy natural drainage, central towers are the safest solution for direct heating of the molten salts in the receiver. Indeed, in case of circulation system failure, the risks of having a molten salts solidification in the kilometer-long horizontal tubes, as it is the case with parabolic trough receivers, is very high. Parabolic trough plants therefore use thermal oil as primary transfer fluid circulating in the receiver, which requires a supplementary heat exchanger to heat the molten salts for energy storage.
Dispatchability and Energy Storage: the major advantages of STE

Wind and sun energies are uncontrolled, fluctuating energy sources whose electricity production may strongly vary. The network must adapt to this fact, and traditional power plants must immediately compensate for any power drop. This is why dispatchable electricity, i.e. electricity that can feed the network at any time, is much more valuable.

Solar Thermal Energy is a major asset thanks to its ability to dissociate steam production from solar energy absorption.

The heat storage process is divided into three phases:

1. Solar energy is first absorbed and transferred into a fluid, usually molten salts, by a solar receiver located at the top of the tower.
2. The absorbed energy is stored in the form of hot molten salts.
3. The stored energy can then be used to produce steam on demand in the steam generator. The steam is then sent to a steam turbine to generate electricity.

Dispatchability is a key advantage of STE over cheaper photovoltaic plants, which directly convert the sun’s energy into electricity. Indeed, as electricity cannot efficiently be stored at an industrial scale, the photovoltaic plants production necessarily follows sunshine fluctuation.

Erection on site of the CMI central tower direct steam generator at Khi Solar One, South Africa.
CMI’s Solar Receivers

Direct Steam Generation

In 2008, CMI Energy launched its first development upon a request from Abengoa Solar to develop a cavity type solar receiver producing superheated steam (530°C, 130 bars) directly usable by conventional steam turbines. This CMI receiver absorbs 250 MW of thermal power.

KEY FEATURES:
- Patented superheater design, allowing free tube expansion and minimal thermal stress.

In 2010, CMI was awarded a contract for the design and delivery of a solar receiver for the 50 MWe Khi Solar One CSP plant near Upington (South Africa).

CMI Energy also developed a receiver that increases the competitiveness of direct steam generation with 3 factors:
- Scale effect: using a 250 MW steam turbine instead of 50 MW
- Improving the steam cycle efficiency by increasing the steam parameters up to 180 barA and 590°C
- Reducing the receiver’s area by increasing the acceptable solar flux on the panels thanks to a cylindrical design of the receiver.

KEY FEATURES:
- Patented design of superheater panels
- Double drum
- Rifled tubes
- Designed to be erected on the ground and lifted in one piece to the top of the tower

Molten Salts

In 2014, CMI Energy developed a central tower molten salts receiver capable of absorbing thermal power of about 750 MWth, to equip molten salts Solar Thermal Electricity plants between 100 and 150 MWe, depending upon the heat storage capacity. This CMI receiver will equip Abengoa Solar’s power plants at Atacama I, Atacama II and Atacama III (5 CMI receivers) in Chile. Each of these plants has a capacity of 110 MWe and has an energy storage capability of 17.5 hours.

KEY FEATURES:
- Patented insulated airtight casing
- Designed to be erected on the ground and lifted in one piece to the top of the tower
- Allowing energy storage, enabling an electricity production 24h/7
CMI Solar, Optimized Solar Thermal Electricity Solutions Backed by 200 Years of Business Success

CMI was founded in 1817 by John Cockerill, an industrial genius who established his business activities in Seraing (Belgium) and sparked off the remarkable economic future of Wallonia. CMI Group has been specializing in steam generation for almost 200 years.

For more than 45 years, CMI Energy has been a leader in the development of Heat Recovery Steam Generators behind gas turbines, mainly for combined cycle applications.

CMI Solar was created in 2011 based upon CMI’s long-lasting experience and know-how in steam generation. Since then, CMI Solar has kept alive the tradition of John Cockerill.

CMI Solar develops steam generators for high power concentrated solar power stations and in particular in:

- Generation and management of steam
- Heat exchanges, thermal processes and fluid mechanics
- Management of high temperatures, thermal stresses in material.