

Tower Tech Beams Down in the Middle East

A concentrated solar power (CSP) generation project using unique Japanese technology is underway in Abu Dhabi in the United Arab Emirates. Project leader **Yutaka Tamaura**, a professor at the Tokyo Institute of Technology, explains how the technology works and its importance to the Middle East.

The basic mechanism of concentrated solar power (CSP) generation is to collect sunlight via mirrors and use it to heat a fluid that serves as the heating medium, and use the heat to operate the power generation device.

CSP systems are broadly categorized into the parabolic trough (**figure 1**), tower and dish systems. So far, the parabolic trough and tower systems have been put into practical application in a large capacity of 10-100MW. Both types can store solar heat with molten salt composed of sodium nitrate and potassium nitrate, and use the heat to generate steam for a turbine, generating electricity. With the parabolic trough system, sunlight col-

lected with curved mirrors is radiated onto a light-collecting pipe placed in front of the curved mirror surface to heat oil flowing through the pipe. The pipe is connected to a tank containing molten salt, so the molten salt is also heated. The tower system, on the other hand, collects sunlight using mirrors of heliostats, equipped with a function to adjust the direction of the mirrors in accordance with the sun's motion, and the concentrated lights are irradiated onto the tower-top receiver at the top of the tower in the center of the heliostat field (solar light collecting field) to heat the molten salt in the receiver.

One of the advantages of CSP over PV (photo voltaic) is that the solar energy can be stored using mol-

ten salt. With the heat stored, the CSP system can cope with fluctuations in the availability of sunlight on a cloudy day, and can also generate power during the night. In other words, electricity can be supplied steadily to the grid (power supply and distribution networks) from a CSP station. In contrast, PV systems for the stable power supply need to be equipped with storage batteries, which are more expensive than a molten salt heat storage system. Even if the plants are located in a desert, there are several cloudy days each year. The issue of the higher cost of the storage battery for the PV system obstructs large-scale solar power supply to the grid from a PV station in a desert.

There are so-called Sun Belt areas with thirty cloudy days or fewer per year and an annual rainfall of 100 mm or less located in California and Nevada in the United States, North Africa, the Middle East and Australia. These areas are ideal for generating electricity using PV and CSP systems in terms of efficiency and economy. They are more suited to CSP because the efficiency of PV systems decreases when the temperature is too high.

The cost of CSP generation is about half to one-third of that of solar power generation. However, the initial cost of constructing a CSP system is enormous due to the requirement for a large-capacity plant for high efficiency of 17-25% to reduce the electricity cost. If the electricity is generated using a steam turbine, it is not worthwhile unless at least 100MW of heat is obtained. It costs at least 30 billion yen (326 million dollars) to construct a CSP system that generates 100MW of heat or more. On the other hand, a PV system does not necessarily require a large initial investment.

The issue here is not that one system is good and the other is bad. The two can operate side by side to suit regional conditions, taking into account their respective advantages and disadvantages. In areas where both systems can be used, PV systems can be used to generate peak electricity during the day in combination with CSP systems that are used to supply the base load for stable power supply for twenty-four hours a day.

Figure 1: Parabolic trough collector and the sun



Tokyo Tech CSP Project in Abu Dhabi

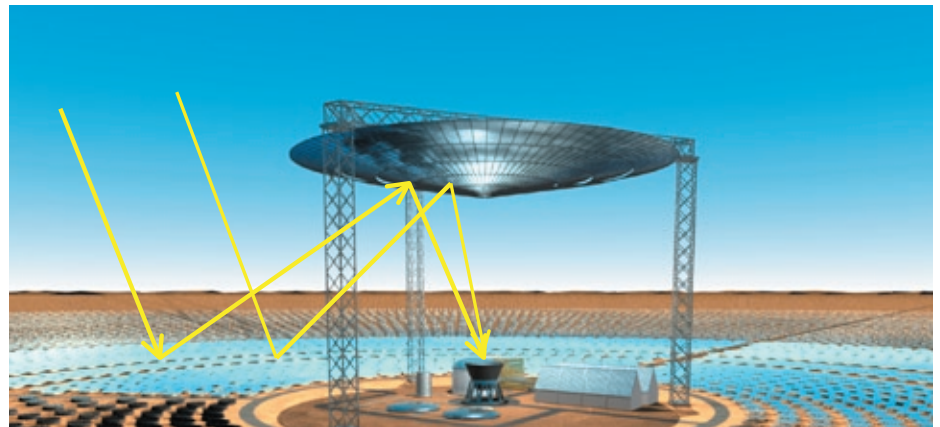
With CSP systems, development work has progressed further for parabolic trough systems than it has for tower systems. This is because the parabolic trough system is already proven technology, a mass production system is already in place and construction of commercial parabolic trough CSP stations is already underway in the United States and Spain. On the other hand, tower systems are not yet proven technology. However, there is no doubt that CSP systems will shift from the parabolic trough type to the tower type in the future. This is because tower systems have a higher power generation efficiency (20–25%), as the fluid (molten salt) heat obtained with tower systems is 600°C, while that (synthetic oil) for parabolic trough systems is 380°C at the most. Also, tower systems require only one-third of the amount of molten salt of trough systems to store the same amount of heat. As the amount of electricity generated by CSP systems increases in the future, a number of molten salt tanks will be constructed, just as petroleum store tanks are being used for petroleum-fired power stations. In other words, efficient power generation will be demanded using as little molten salt as possible. As such, demand for tower systems will certainly continue to grow.

The Abu Dhabi Project that we are implementing is a forerunner in the shift to tower systems. The Tokyo Tech Project in Abu Dhabi involves constructing a test plant (100kW) in the special economic zone of Masdar City near Abu Dhabi Airport, where an attempt is being made to move away from fossil fuels. The Project is being undertaken jointly by the Tokyo Institute of Technology, the Japanese petroleum company Cosmo Oil Co., and the Abu Dhabi government agency Abu Dhabi Masdar of the United Arab Emirates. The first phase has commenced with the construction of the test plant that gathers 100kW of heat from sunlight, and it is anticipated that it will be completed by year-end. The test plant utilizes the Tokyo Institute of Technology's beam-down

solar concentrating technology (figure 2). With a conventional tower system, the light is reflected from the heliostat onto a tower top receiver that contains molten salt, located at a height of around 130 meters. With the Tokyo Institute of Technology method, in contrast, the light is reflected from the heliostat onto a central reflecting mirror placed on the tower in the center of the heliostat field, and it is then reflected again and collected by a receiver located on the ground to heat the molten salt inside. Advantages of the Tokyo Institute of Technology

rely on solar energy after petroleum reserves are depleted. Desalination plants are currently operated using petroleum, so these countries will not even have access to fresh water once petroleum is depleted. As such, solar energy development is extremely important for the Middle East. Fortunately, the Middle East's location in the Sun Belt is an optimum area for utilizing solar energy, and oil money is available for research and development. One of the merits of CSP plants is that they can operate twenty-four hours a day. Since desalination plants

Figure 2: Beam-down solar concentration system and solar thermal power plant by Tokyo Tech




method include the simple heliostat operation and easier construction and maintenance of the receiver, as it is located on the ground. It is also worth mentioning that the central reflecting mirror is not a single gigantic mirror, but instead comprises small mirrors arranged in a ring, almost on a single plane. This cuts down the costs to about one-third of those needed to build a single gigantic central reflecting mirror.

The second phase will involve the construction of a 20MW demonstration plant with a cavity molten salt receiver that heats the molten salt very efficiently, and the third phase will involve the construction of commercial plants with a total heat collection capacity of 120MW, comprising either four 30MW plants or three 40MW plants.

Oil-producing countries in the Middle East will have no choice but to

also need to be operated twenty-four hours a day, CSP will be in higher demand in the Middle East than PV that cannot function during the night.

In Asia, Mongolia, Australia and northwestern India also offer promising prospects for CSP. After oil reserves are depleted, CSP undertaken in these areas will prove to be important for Japan as well. Unfortunately, Japan is not a suitable location in which to build CSP plants, owing to its high rainfall. However, Japan can contribute to the development of CSP generation with its technology. If a large number of Japanese companies participate, they will be able to create innovations in CSP. I believe that now is the time for Japan to take the initiative in developing solar thermal power generation in Asia. 

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