a quarterly magazine on **Concentrating Solar Thermal**

SUN FOCUS

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PROMOTING BUSINESS MODELS FOR INCREASING PENETRATION AND SCALING UP OF SOLAR ENERGY

Ministry of New and Renewable Energy
Government of India

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FROM THE EDITOR'S DESK

Dear Readers, I am pleased to share the latest issue of Sun Focus magazine, which is premised on the theme of the promotion of concentrating solar technologies in various industries, institutions, and organizations. Industrial sectors have been adopting energy-efficient ways to ensure sustainable development. Over the last couple of decades The Ministry of New and Renewable Energy has been implementing various schemes for the promotion of solar thermal heating, cooling, and other applications, and the growth of CST projects for off-grid solar thermal applications has gained currency. Adopting such applications can aid in the reduction of use of fossil fuels. The size of the industrial sector will not only provide long-term opportunities for CST sector, it can also rely on CST to reduce its ever-increasing fossil fuel bills.

Considering the promising prospects of CST in industrial sector, the current issue offers an eclectic mix of case studies and features. The feature 'Concentrating Solar Technology for Various Process Heat Applications and Power Generation with Thermal Energy Storage for Institutions and Industries' focuses on successful experiments on a large-scale through CST and CSP installations at Brahma Kumaris, which is a global organization with a presence in more than 130 countries. It is fascinating to note that besides cooking, the organization also uses CST technology for sterilization of medical instruments and laundry. The second feature – 'Sunrise CSP's Big Dish Solar Concentrator' delves into the possibility of revolutionizing the delivery of clean solar heat to Indian industry. Some selected installations are featured in this issue with comprehensive information on the technical details, requirement, performance and benefits. For instance, one of the case studies in this issue focuses on the installation of compound parabolic concentrators (CPCs) in the development of post cocoon activities at Uttarakhand Resham Federation Cooperation in Dehradun, Uttarakhand. Installed in May 2017 in Selaqui, Dehradun, the CST system is maintained by women workers and it is the first case in India under UNIDO–CST project.

I am sure you will find this issue as interesting and informative as all the previous issues. As always, we do look forward to your valuable comments, suggestions, and most importantly 'enthusiastic contributions' to further issues of the magazine.

Amitesh Kumar Sinha
Joint Secretary
Ministry of New and Renewable Energy
Government of India

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Regional Office in India

MESSAGE FROM UNIDO REPRESENTATIVE IN INDIA

Globally, heat production accounts for around one-half of energy demand. This demand is of utmost significance in tropical countries such as India, where cooking and heating applications are heavily dependent on heat. In India, heat accounts for two-thirds of total final energy consumption, and in the last decade, India's need for energy has amplified. With an increase in energy demand, the dependence on conventional fuels has consequently gone up. As a result, fuel prices have been impacted. Since the industrial sector meets most of its energy needs through use of fossil fuels, it is crucial to provide alternative and innovative solutions to meet the upward demands of the industrial sector. This is where the concentrating solar thermal (CST) technology comes to the fore as one of the most viable solutions to meet electricity and fuel oil demands of the country. Therefore, on-ground application of CST technologies in India must be evaluated so that the burden on fossil fuels is lessened considerably. Since India boasts of abundant sun energy, it is about time that this natural resource is harnessed through application of technologies such as CST.

India currently has about 64,000 m2 collector area under implementation for heating and cooling purposes with an installed capacity of 43.30 MW. While the government of India has been promoting CST technologies in the country recognizing their large-scale benefits, UNIDO's project specifically focuses on market mechanisms and financing to enhance the market size of the CST sector in India.

In August 2019, an agreement was signed between the National Institute of Solar Energy (NISE) and the United Nations Industrial Development Organization (UNIDO) to initiate a skill development programme for various levels of beneficiaries in the sector of solar thermal energy. This initiative was driven by the motive to support capacity building and skill development of technical expertise in the concentrated solar thermal (CST) energy technologies in an attempt to replace the use of conventional fossil fuels such coal, diesel, furnace oil, etc., and save costs and emissions in the industrial process heat applications. The need of the hour is that industrial emissions and fossil fuel consumption are minimized for sustainable development.

This edition of *Sun Focus* extensively covers the scientific and technical analysis, discussions, development and constant exchange of ideas among the industries, experts, policymakers, and governments. We hope the magazine opens dialogues and discussions to herald a wider acceptance of CST technologies.

Rene Van Berkel
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CONCENTRATING SOLAR THERMAL SYSTEM USING COCOON PROCESS AT UTTARAKHAND RESHAM FEDERATION COOPERATION IN DEHRADUN, UTTARAKHAND

Introduction

Uttarakhand boasts of a rich tradition of silk production. Legend has it, in 1858, Captain Hutton introduced sericulture in the hills of Mussoorie and gradually, Messers Lister & Company became instrumental in the commercial production of silk in a village on Dehradun–Haridwar Road, which later came to be known as 'Resham Majari'. In recent years, within the paradigm of soil conservation and livelihood development, the silk industry has achieved prominence in the state. Aptly known as the 'Bowl of Bivoltine Silk in India', Uttarakhand's history of sericulture has achieved a unique dimension ever since. This case study focuses on the installation of compound parabolic concentrators (CPCs) in the development of post cocoon activities in the state.

Background

The Central Silk Board is a statutory body under the Ministry of Textiles, Government of India, which was established for the development of sericulture and silk industry in the country. There are four major types of silk of commercial importance, obtained from different species of silkworms, which in turn feed on a number of food plants. These are:

- Mulberry
- Oak Tasar and Tropical Tasar
- Muga
- Eri

The Uttarakhand Cooperative Resham Federation (UCRF) works under the aegis of the Department of Sericulture, Government of Uttarakhand. UCRF is engaged in the development of post cocoon activities in the state. Presently, 56 silkworm-rearing cooperative societies, 10 reeling cooperative societies, 124 self-help groups, and 4 non-governmental organizations are functioning under the umbrella cover of the Department of Sericulture.

Installed in May 2017 in Selaqui, Dehradun, CPCs were supplied by Ultra Conserve Pvt Ltd, Mumbai. A total of 90 CPCs with 295.50 m^2 of collector area were installed through application of pressurized hot water for cocoon processing in the region. It is important to note here that the installed CST system is maintained by women workers and it is the first case in India under UNIDO-CST project. The installed system is being used in its partial capacity for the processing of cocoon with a satisfactory performance. The UNIDO, MNRE, and UREDA teams visited the installation site on April 4, 2019.

System Details and Process

The CPC (see Figure 1) is a specific type of solar collector with a reflector fabricated in the shape of two meeting parabolas. It belongs to the non-imaging

Figure 1: *Compound parabolic concentrators (CPCs) were supplied by Ultra Conserve Pvt Ltd, Mumbai*

collector family and is considered to be the collector in this class with the highest possible concentrating ratio. The CPC collectors could operate up to 5 bar pressure with a maximum temperature of 140°C, but they are most efficient in the range of 80–120°C. This technology combines the high-efficiency evacuated system and the solar radiation concentrating system with copper U-tube aluminium fins for heat transfer.

Timings and system application details

The timing for operating the installed CST system starts at 8:00 a.m. and continues till 4:30 p.m., with an average operating time of 7-8 hours (during the sunshine hours).

A closed loop with the solar collector array consisting of series and parallel connections with an expansion tank, pump, and other accessories such as pressure and air release valve, pressure balancing valve, and so on, is formed with a plate heat exchanger (PHE). The cold water line passes through the PHE. The process of reeling converts the cocoon into raw silk, where the water at room temperature is heated up to 90°C through the CST system and further heated up to 120°C through a wood-fired boiler. The CST system saves more than 50% of wood, which is then used as a fuel in the boiler on a daily basis. The CPC with a PHE operating for 8 hours/day (during the sunny period) is a viable solution. Based on the actual data collected for 15 days in the month of May 2017, daily savings of 417 kg of wood were reported.

System Performance

Operating at a temperature of 90°C and pressure of 1 bar (see Figure 2), the total thermal output of the system was recorded to be 103,000 kcal/day. Firewood was the type of fuel saved and as a fuel, wood is considered carbon neutral. The total percentage of heat generated from ambient temperature to 90°C was through the CST system and further temperature rise up to 120°C was through firewood. The overall solar fraction was 75%. Through the usage of this system, an amount of 417 kg of wood was saved per day.

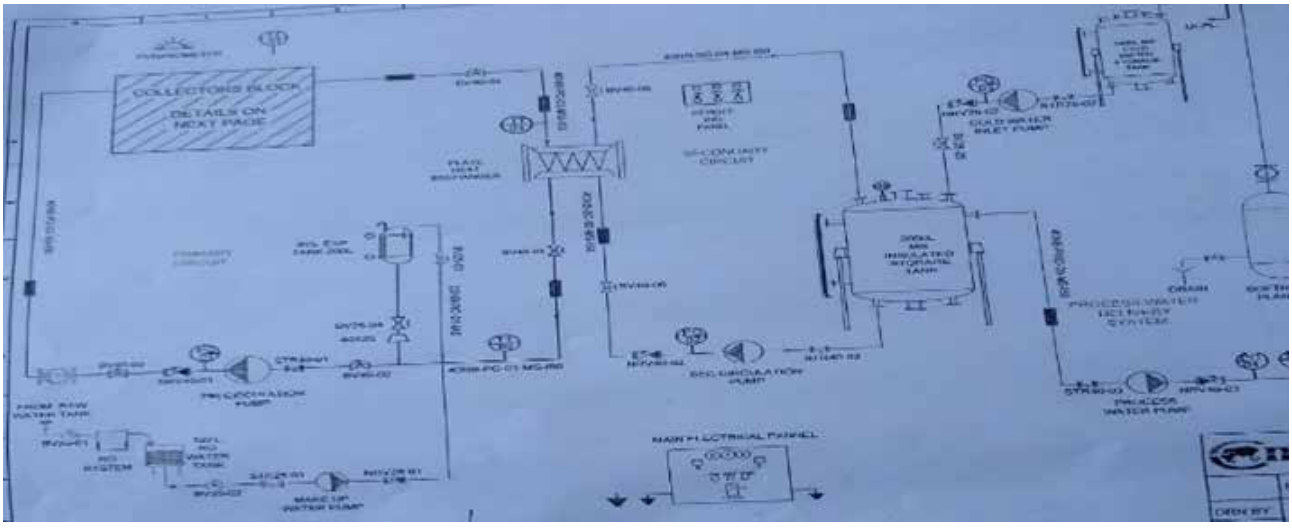


Figure 2: *A flow diagram explaining the structure of CPC*

Performance chart and comments

O & M Issues & Beneficiary Perception: Required training programme for operators

Financial Support: MNRE, UNDP, Government of Uttarakhand

Overall System Performance: Satisfactory

IRR & Payback with FA: 4.5 years

IRR & Payback without FA: 8.3 years

CONCENTRATING SOLAR TECHNOLOGY FOR VARIOUS PROCESS HEAT APPLICATIONS AND POWER GENERATION WITH THERMAL ENERGY STORAGE FOR INSTITUTIONS AND INDUSTRIES

Dr Jayasimha Rathod

Concentrating solar technologies (CST) provide an excellent solution for institutions and industries to fulfil their energy needs for steam, high temperature water, and hot air. Temperature ranges above 90oC can be only met by concentrating solar energy at the receiver by multiple orders of magnitude. In industries, the required temperature ranges vary from as low as 40oC to as high as 300oC or more. Looking at the practical aspects, concentrating solar technologies with moderate concentration ratio can easily provide forms of heat up to 250oC.

There are various technologies in this field, for example, Scheffler paraboloid dish with fixed focus, linear focus design, such as parabolic trough, CFLR, and moving focus paraboloid dishes of various sizes. These are available and mature technologies that cater to such energy requirements.

Thermal Energy Storage

Thermal Energy Storage (TES) plays a vital role in concentrating solar technologies. Due to the uninterrupted requirement of thermal energy for process heat, TES acts as a buffer during peak sunny hours and non-sunny hours.

Thermal energy can be stored in various forms, depending on the temperature ranges and the applications. The different materials that can be used for thermal energy storage can be in liquid and solid forms, as well as phase change. In the lower temperature ranges, energy can be stored quite efficiently and cost-effectively in the form of hot water. But when it comes to higher temperature ranges (above 100°C), there are phase change materials available that store high density of energy in the form of sensible heat, and then release it at the phase change temperature point. In these cases, it is possible to use nitrate and high-tech salts, such as a combination of potassium nitrate and sodium nitrate, as they are phase change materials that carry high density energy in the phase change stage.

There have also been many experiments in latent heat storage, using solid materials of high density, such as concrete blocks, cast iron blocks, iron blocks, and others. One such successful experiment is the India One Solar Thermal Power Plant that uses cast iron as a storage material. Cast iron is characterized by a specific heat of 0.57 kJ/kg·K and density of 7500 kg/m^3.

Each and every thermal energy storage material offers its own advantages and challenges, so the most suitable one has to be selected by institutions carefully, according to the application's requirements.

Concentrating Solar Thermal Power Generation

Another major application of CST is in power generation on megawatt scale, which has been tested and tried worldwide. Concentrating solar power (CSP) offers the advantage that the heat can be stored in a cost-effective manner, for requirement of energy during non-sunny hours. One such successful experiment in India is the India One Solar Thermal Power Plant at the Brahma Kumaris' headquarters in Abu Road, Rajasthan.

CST and CSP installations at Brahma Kumaris – successful experiments on large scale

The Brahma Kumaris is a worldwide organization with a presence in more than 130 countries. Every year, more than 1 million people visit its centres for meditation,

Solar cooker at B K Gyan Sarovar, Mount Abu

residential retreats, and various conferences. As a consequence, the energy requirements of the organization are huge. As a socio-spiritual organization, its fundamental principles oblige it to use natural resources to fulfil these energy requirements, as much as possible. Brahma Kumaris started to experiment by using solar energy on a large-scale way back in the 1990s. One example is the first of its kind solar cooker which was installed in the Academy for a Better World, Gyan Sarovar in Mount Abu, Rajasthan, which provides 2000 meals a day and it was commissioned in 1996. It is the longest running working installation in the solar steam cooking systems, as even today, the system is fully operational and delivers the required output. Regarding the main technical specifications, it uses concentrating solar thermal technology with Scheffler paraboloid reflectors of 7.6 m^2 area each. There are 24 such dishes connected in a series, generating direct steam with the help of thermosyphon principle. While very simple, the design is robust and sturdy, and very effective with not much of auxiliary load and there is easy maintenance and operation. This project was a good showcase for the Indo-German cooperation, where GTZ now (GIZ) was involved in funding the project.

After the encouraging results and successful demonstration of this system, in 1999, the management decided to install a bigger system, to generate as many as 30,000 meals a day – 15,000 for lunch and 15,000 for dinner. This solar cooker was built at Brahma Kumaris' campus – Shantivan, in Talethi, Abu Road. The design was improved and it consisted of 84 in-house developed paraboloid dishes of 10 m^2 area each.

Both these systems have thermal energy storage for the non-sunny hours and early morning cooking. The storage is in the form of high pressure hot water, which is easy to install and maintain, while also being cheap and reliable. The energy is stored in water of temperature up to 200°C and pressure of 12 bar.

Apart from cooking, the organization also uses CST technology for sterilization of medical instruments and laundry at the Global Hospital and Research Centre, a hospital with 120 beds, located in Mount Abu. This hospital serves the tribal people in and around the area. Again, a similar CST technology system with storage in the form of high pressure hot water was installed and it has been working successfully ever since.

Several other projects have been replicated in other Brahma Kumaris' campuses, mostly for institutional cooking purposes. Meanwhile, the Brahma Kumaris encouraged the use of this kind of system by other religious organizations (such as Shirdi Sai Baba, Tirupati, and others) and NGOs, through free consultation and demonstrations of their plants.

India One Solar Thermal Power Plant with Energy Storage

Apart from the thermal requirement, there is a huge electrical need to cater the 25,000 people regularly visiting the Brahma Kumaris' Shantivan campus. A decision to design a very innovative solar thermal power plant was taken, with 16 hours storage for seamless operation. 'India One' is a 1 MW electrical solar thermal power plant and it was for the first time that a new design of 60 m^2 paraboloid reflector with static focus was created that concentrates sunlight in a small area of 400 mm diameter. The concentration ratio is more than 350 times. It is an indigenous innovation with everything being developed in-house and manufactured with the help of tribal people. This provides a good example of the involvement and capacity building potential of the local society.

The key features of the research and development achievements at the India One Solar Thermal Power Plant are as follows:

- A total of 770 parabolic reflectors of 60 m^2 with unique static focus design, using special solar grade mirrors with 93% reflectivity and equipped with fully automatic dual axis tracking mechanism to adjust daily and seasonally, to the position of the sun.

CST training at Brahma Kumaris

- A total of 770 indigenously designed cast iron cavity receivers, generating directly superheated steam (up to 420°C temperature and 42 bar pressure). Due to the static design, receivers are cost-effective and last long with minimum required maintenance. The solid mass of 3 tonnes of cast iron acts as a medium to store thermal energy, thanks to its good properties of specific heat and density.

The 60 m^2 parabolic reflector tracks the sun, concentrating the solar rays in the static cast iron receiver. Each receiver acts as a thermal energy storage system during the night or amid partial cloudy conditions. The cast iron core is surrounded by a steam coil, which acts as a steam generator by exchanging the heat from iron core to water. The high

Solar cooker at B K Shantivan, Abu Road

temperature steam runs through a turbine connected to a generator that produces electricity. 'India One' is a captive, off-grid power plant providing power for Shantivan Complex at Abu Road.

The India One Solar Thermal Power Plant was successfully commissioned in the beginning of 2017. It is a good showcase for solar thermal power plants with storage and is also an example of the 'Make in India' initiative.

One of the aims of the India One Solar Thermal Power Plant has been to build capacity and contribute to the creation of sustainable local communities. This is being achieved by creating employment for 300 local tribal people for 3 years, encouraging skill development of neighbourhood inhabitants, and overall improvement in their well-being with health check-ups, de-addiction camps, provision of clean drinking water, and meditation courses.

Apart from the solar installation, the organization also planted more than 5000 trees and has organic and yogic farming in the open space, which creates good synergy within the plant.

Many experts and well-wishers from India, Germany, and other countries contributed significantly to the overall success of the project.

Due to cutting-edge research, a substantial part of the project funding was provided by the Ministry of New and Renewable Energy, Government of India under R&D Scheme and also by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), Government of Germany within the bilateral ComSolar initiative, executed for them through the German development agency, GIZ.

The Ministry of New and Renewable Energy, Government of India under the UNDP—GEF-assisted Concentrated Solar Heat Project awarded Brahma Kumaris' World Renewal Spiritual Trust with the assignment of Awareness-Cum-Training Centre on Concentrating Solar Thermal Technologies. From 2014 to 2017, more than 500 entrepreneurs, industrialists, institutions, manufacturers, academicians, and government officials took part and benefited from the programmes organized by the CST Center.

Brahma Kumaris is an international non-governmental organization of the United Nations accredited with General Consultative Status with the Economic and Social Council; Associate Status with the Department of Public Information. Brahma Kumaris plays an active role as an accredited member, observer organization to all UN Conventions related to environmental protection, such as United Nations Environment Assembly of UNEP; UN Framework Convention on Climate Change; UN Convention on Biological Diversity and UN Convention to Combat Desertification. At the core of Brahma Kumaris' work is the understanding of the connection between our consciousness, thoughts, and actions, and their impact on the world. It has been seen that long-lasting change in any social or environmental system starts with a profound shift in the minds and hearts of people. The current environmental crisis is therefore a clear call to transform our lifestyle and be more aware. Brahma Kumaris participates in international conferences to sensitize and inspire all for personal change and to demonstrate practical application of solar energy on an institutional level.

CST TECHNOLOGY: 'COLLABORATIONS BETWEEN AUSTRALIA AND INDIA COULD BE VALUABLE'

The scaling up of solar energy and the efforts by consumers and manufacturers to adopt and implement concentrating solar thermal (CST) technologies as viable energy sources could ensure sustainable development in India's industrial sectors. In an interview with Shirish S Garud, Associate Director–EETD, TERI, Dr Keith Lovegrove, Managing Director, ITP Thermal Pty Ltd, with 30 years' experience in solar energy shares his insights on solar CST or CST for cooling applications. Currently a member of the University of Adelaide's Centre for Energy Technology advisory board, the Australian Renewable Energy Agency's Advisory Panel, the Australian Solar Thermal Energy Association board and the Australian Solar Thermal Research Institute steering committee, Dr Lovegrove discusses the importance of indigenous manufacture, extensive performance monitoring of CSP plants, and more.

Could you tell us what you are currently doing?

I am no longer connected to Australian National University. Since 2011, I am working full-time with ITP (ITPEnergised Group). In regards to solar thermal, I am also on the steering committee of an organization called the Australian Solar Thermal Research Institute, which is the home of all the concentrating solar thermal research and development (R&D) in Australia. It is a big centre to which many of the research institutions belong, and receives funding from the government, so it is actively funding projects in the field. I am also on the board of the Australian Solar Thermal Energy Association.

Could you tell us a bit about current R&D programmes in improving the performance of CST – particularly the thermal systems?

Well, for thermal systems in particular, I would actually say that there is not much R&D in that space. This is mainly because the technologies for industrial process heat using solar are pretty well established. So there are mostly incremental improvements. The one initiative that is actually worth mentioning is the development of evacuated systems that are non-tracking. They might still be concentrators, but of a non-tracking sort, because the aim is to get process heat temperatures at around 150°C. I find this a very interesting development because there is a lot of process heat that you can

access with those temperatures. Since I am of the view that solar rooftop systems for industries need to be very simple in their operation, I have reservations about using tracking concentrators for that. And there is another aspect as well, particularly for India in situations where the diffuse radiation is pretty high even when the direct radiation is quite low (basically due to dust and particles in the air), a process heat system that collects all the diffuse radiation as well as brings a lot of advantages.

I think the large concentrators are really for power generation and they need to be put in locations where the DNI is basically as good as it can possibly be, which basically means, for India, I suppose Rajasthan or northern Gujarat. Although I am very intrigued by the idea that something could be done in Kashmir. That seems to be a serious possibility. There is a plethora of R&D globally around large CSP for power generation. One of the dominant themes is the potential for improving efficiency by using new supercritical CO_2 power cycles.

So, how is it moving in CST or CSP in the global market?

Well, it is progressing quite strongly. While I will not say it is spectacular, CSP is certainly managing to add a gigawatt electrical each year for the last year or so, and is now up to around 6 GW in electrical equivalent. In actual fact, if you look at solar thermal in general, including all the process heat in the hot water, it is a very huge sector globally, and is collecting almost as much energy in a year as PV does. However, most of that is for water heating.

Do you think there is any possibility of having a hybrid system with flat plate or vacuum tube plus concentrator, which can give better utilization of whatever radiation is available?

Do you mean for a process heat application? Yes, that could be interesting. Just last week in fact, I visited a large factory in the textile industry and looked at their needs. And what I saw was that, at the moment, they are using a coal-fired boiler and distributing steam around the plant. But when you look at it, a lot of the usage is actually below 100°C, and only a few bits of the usage were hotter. So you could actually consider having a large amount of collection using non-tracking absorbers and storing the heat simply as hot water at say 95°C in insulated tanks. A small subset of that could be taken in small concentrator systems to produce steam, with the steam only being used where the higher temperatures are absolutely needed.

You have had some exposure to the Indian industry – based on your experience and your interactions with the Indian users of CST technologies, would you have any message? Also, could you comment on collaborative efforts that Australian manufacturers or research institutes can have with the Indian industry?

My main message to the people of the industry in India would be to be very careful of quality control. The solar thermal technology does lend itself to indigenous manufacture, but one of the challenges with solar technologies is that it is very easy to make a bad one and it is a bit harder to make a good one. While India has the manufacturing skill to make any high-quality product, the danger can be when very small companies start up – they may promise more than they can deliver and their quality control may not be sufficient. So while I am all in favour of encouraging indigenous manufacture, like any other industry, one should treat it like a global venture and capture the best global practices. As to collaborations – it is a global sector. So certainly, collaborations between Australia and India could be valuable, but then indeed, so would a collaboration with any other country as well, and I would encourage people to be open to that.

Is there anything specific you would like to mention about ITP?

ITP is quite an interesting company. We do work across all renewable energies, including solar thermal, with a total of 150 people, globally. We actually have quite a large global footprint, because of course we have ITP India, based out of Delhi, and ourselves in Australia, plus a big office in the UK, and a small presence in China. So we are actually in quite a good position to look at the development of things globally and may be help other companies – for example, we can help Indian companies to consider exporting. That should definitely be considered.

Could you talk a bit about analyzing the performance of the existing large-scale solar thermal plants?

Well, every large CSP plant has extensive performance monitoring. One interesting point though is that while every plant has extensive performance monitoring, the information is not readily available, and I think the industry does itself a disservice by being a bit secretive. In some countries such as in Australia and the USA,

if there is power generation going on, then each individual power station's monthly output is publicly known, in fact, sometimes even their daily output. But in many countries, that is not the case. So when a new plant is built, it is not immediately apparent how well it is working, and I think that is a shame because if the industry wants to gain credibility, it has to be very transparent about when there is a problem and when the problem has been solved.

But as a country, do you have the required experts, skills, and tools for doing such kind of performance monitoring and performance analysis?

Well, certainly we do. But in that way, we are not unique. All plants have that sort of thing – they are just not sharing the data. For example, ITP would take on jobs like independent-due-diligence assessments, particularly where investors might want such independent performance analysis.

Organization like NREL and CSP services in DLR in Germany have tools and software that can do performance assessment – they are doing this in some of the large plants, which already exist on the ground. They have systems using either LIDAR systems or photometric systems, which are drone based. Are there such services coming from Australia?

Yes, there are some very interesting drone approaches being developed, and I know that DLR has recently developed such a tool. I think the Australian research groups have done their share of the development of such techniques. So I would say, yes. See, a lot of the techniques are well-known and well-published in the scientific literature and so it is simply often a matter of buying the instrument and developing the capability with any given organization.

What is your view on solar CST or CST for cooling applications? In terms of technology, is CST a mature solution for space cooling or other cooling applications?

It is quite interesting. The mainstream absorption chiller technology, which is not solar specific, is clearly quite mature. So if one applies a concentrator system to develop low temperature steam to drive an absorption chiller, it is pretty mature. There are other ideas that are still in the research phase. The question of course is – can you actually beat PV panels plus conventional vapour compression heat pump chillers? That gets a bit harder as the cost of PVs comes down. I think where thermal chilling comes into its own is when you could find a very large load and you build a CSP power plant as a combined heat and power operation. Because if you take the heat as waste heat after expansion through a back pressure turbine, the two revenue streams really help the economics.

SUNRISE CSP'S BIG DISH SOLAR CONCENTRATOR SET TO REVOLUTIONIZE THE DELIVERY OF CLEAN SOLAR HEAT TO THE INDIAN INDUSTRY

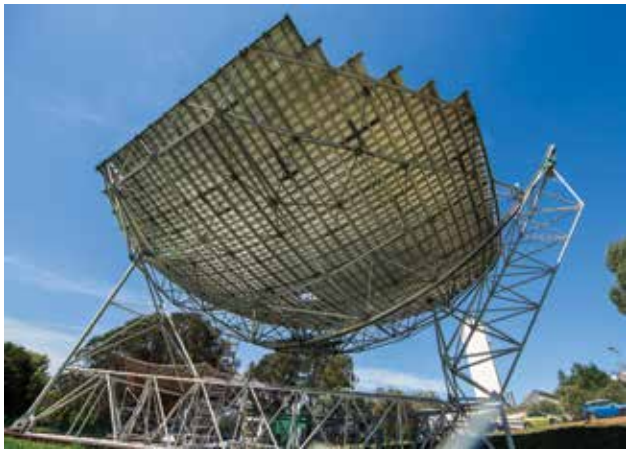
Deepak Gadhia

The Australian National University (ANU) is a leading research university in Australia, and has had a strong focus on solar thermal research. ANU had been the first to develop and run a commercial solar thermal power plant, which was installed in White Cliffs, Australia and had 14 parabolic dishes of 20 m2 each. Over the course of their five decades of research in solar thermal applications, they have developed increasingly sophisticated technologies, with the SG4 Big Dish representing their latest innovation.

The SG4 Solar Concentrator – the BIG DISH

Built on the design of the prototype SG3 (which is a 400 m^2 dish), the SG4 solar concentrator was developed as a collaboration between ANU and Canberra-based company Wizard Power, with support from an AusIndustry Renewable Energy Development Initiative (REDI) grant. It is a 520 m^2 parabolic dish, making it the world's largest paraboloidal dish solar concentrator. The concentrator is a dual-axis tracking parabolic dish with a receiver that can be installed on parcel of land of 25 m x 25 m. The thermal receiver, designed and tested by ANU, provides record performance at >97% solar to thermal energy efficiency, with an accurate tracking algorithm ensuring efficient tracking of the sun to capture all the incident radiation.

At the focal plane, the concentration at the receiver is 2100x, allowing it to generate temperatures ranging from 150°C to over 1700°C. For steam applications, the SG4 receiver is designed to provide steam of temperatures up to 600°C, and at pressures of up to 160 bar. This can support the heat requirements for industrial-scale air-conditioning, desalination, water purification, waste processing, and electricity generation. Higher temperatures, super-heated air, steam, and thermochemical applications for industrial sectors such as steel-making and chemical production will be developed based on industries' demands over time.



Sunrise CSP Pty Ltd acquired the intellectual property for the Big Dish and its complementary technology in 2013. Apart from this, it also holds a patent on molten salt thermal storage technology, which enables continuous high-temperature steam delivery even when the sun has set or is obscured by clouds. The receiver is also designed for extremely high pressures, of up to 160 bar. The high performance allows the expansion of applications of solar thermal technologies, with the potential for use in the pharmaceutical industry, chemical industry, steel forming mills, etc., in ways which were earlier not possible.

Another benefit is that the technology is designed for local manufacture using Sunrise CSP's Factory-in-the-Field (FiF) – this means that all Big Dish installations will be made in India, on the project site, thereby maximizing local content, employment, and supply chains.

The FiF is a modular, scalable, reusable, and relocatable facility for the low-cost manufacture and assembly of the Big Dish space frame. It is designed according to the principles of waste elimination, repeatable quality, adaptability to local circumstances, rapid deployment, and continuous improvement. By adding modules, the

FiF can be scaled from single dish industrial heat plants to hundreds of dish solar power plants, with the quality assured, using automated measurement processes at every stage of frame component manufacture and dish assembly. The quality and production metrics gathered for every dish and project enables Sunrise CSP's commitment to local adaptability and continuous improvement.

Sunrise CSP (India) Pvt Ltd

Sunrise CSP (India) Pvt Ltd, the Indian subsidiary of Sunrise CSP, was incorporated in July 2018 with Deepak Gadhia as the appointed Chairman and Pranav Gadhia as the CEO. In India, the company is engaging with customers from the textile, water treatment, waste management, and healthcare industries to meet its needs for industrial-scale steam and electricity. The projects under development include integrating solar steam with the steam output of coal-fired boilers (reducing coal consumption), large-scale air-conditioning, sludge drying, and desalination systems.

In India, Sunrise CSP's first project has been to deliver solar air-conditioning services for the Kailash Cancer Hospital and Research Centre, a leading cancer hospital based in Vadodra, Gujarat. Air-conditioned environments are critical to the operation of the hospital and patients' welfare. In order to address their requirements, Sunrise CSP will deliver air-conditioning using VAM chillers, whose steam will be supplied from Sunrise CSP's Big Dish.

The project will be developed in the following two stages:

1. A single 520 m^2 Big Dish will replace the existing array of 100 Scheffler dishes, providing steam for a 100 TR air-conditioning system.
2. The project will be expanded to a 600 TR air-conditioning system with additional steam for the hospital laundry, kitchen, and high-temperature autoclave sterilizers. The dishes will be integrated with chilled water storage and a biomass boiler for 24 x 7 operation, even in the monsoon period.

Stage 1 of the project will involve the replacement of the hospital's existing array of 100 Scheffler dishes of 12.5 m^2 each (1250 m^2 reflecting area) that generate 400 kg/h steam at 7 kg/cm^2 pressure to run a 100 TR air-conditioning system. The 1250 m^2 of Scheffler dishes will be replaced with a single Big Dish of 520 m^2, which will provide the same thermal output as the 100 Scheffler dishes, but with only 42% of the mirror area and while occupying only 33% of the land. The Scheffler dishes were installed on 2735 m^2 of land, while the Big Dish will occupy just 900 m^2 of land. The Scheffler dishes are being replaced with SG4 BIG Dish as the Scheffler dishes need glass replacement every 5 years and they had reached the end of their life.

Stage 2 of the project will be delivered on a Build–Own–Operate–Transfer (BOOT) basis, which means that Sunrise CSP would fund the entire capital investment and the hospital would pay for the chilled water produced by solar steam generated by running

the vapour absorption chiller. This approach ensures the hospital has no capital costs and the price it pays for steam is lower than what they would otherwise pay if they used electricity from the grid for air-conditioning, creating a win–win for both the hospital and Sunrise CSP.

Many of Sunrise CSP's projects under development in India will be on a similar BOOT basis delivering reduced energy costs for the customer over the life of the service.

The Future

India has one of the world's largest and most successful concentrated solar programmes and with support from the Ministry of New and Renewable Energy and UNIDO, many industries have installed such systems. A study published by UNIDO in October 2018 showed that India has a 6.5 GW market of concentrated solar technology applied to industrial heat applications. This fits well with the Indian government's programme to install 100 GW solar by 2022. The concentrated solar thermal (CST) technology is complementary to the solar photovoltaics (PVs) and wind used for electricity generation because it fills a gap that PV and wind cannot, through low-cost generation, storage, and delivery of pure, clean heat to industry. The low-cost thermal storage that CST offers provides a perfect complement to the gigawatts of PV and wind being installed, by enabling the delivery of renewable power on-demand, at any time of day and in any weather, to reliably meet the on-demand energy requirements of the nation.

Sunrise CSP's primary goal is to make a major contribution to the successful achievement of India's renewable energy vision by delivering cost-competitive, high-value concentrated solar thermal energy as a complement to both traditional and new energy sources. By providing industries with the opportunity to use both solar thermal energy and solar electricity, the company believes that it can revolutionize clean and green industrial production and lower the long-term cost of energy by reducing, and eventually eliminating, reliance on polluting fuels, many of which must be imported.

NATIONAL WORKSHOP ON SCALING UP SOLAR THERMAL APPLICATIONS IN INDIA

August 23, 2019 at Hotel The Ashok, New Delhi

The United Nations Industrial Development Organization (UNIDO), in collaboration with the Ministry of New and Renewable Energy (MNRE), Government of India (GoI); and the National Institute of Solar Energy (NISE), organized a workshop on Scaling Up Solar Thermal Applications in India, under the ongoing MNRE-GEF-UNIDO project on Promoting Business Models for Increasing, Penetration and Scaling Up of Solar Energy at The Ashok Hotel in New Delhi on August 23, 2019.

The event was attended by senior Indian government officials from different ministries, the UNIDO representative in India, officials from State Nodal Agencies of MNRE, academic and research and development (R&D) institutions, manufacturers, channel partners and project developers from industry and beneficiaries.

The full day event constituted of the following four sessions:

Session I: Inaugural

The session began with a brief presentation by MNRE's Director on the status of concentrated solar thermal (CST) technologies in India, and the ongoing promotional schemes by the GoI including the complimentary role of the UNIDO project, followed by a brief address by the UNIDO representative on UNIDO's activities in India relating to national priorities and the Sustainable Development Goals. The inaugural address by the Joint Secretary of MNRE provided a forward outlook for the CST sector.

A vision document incorporating the road map of the CST sector in India for 2022 (prepared by UNIDO) was launched by the Joint Secretary of MNRE. *Sun Focus*, a quarterly magazine dedicated to ongoing projects and the CST sector in India, along with the CST newsletter were also launched.

The project website (www.setiaindia.in), with its map showing the geographical distribution of CST projects in the country with details of installed capacity, solar collector technology used, solar field area, year of installations, etc., was also launched.

Session II: Panel Discussion

The second session was conducted in the form of a panel discussion, where key officials from different ministries of the government (such as food processing, rubber, micro, small and medium enterprises, and petroleum) participated and interacted with the audience to get suggestions on how to further scale up and increase penetration of the use of CSTs in industries where thermal energy is needed for various applications.

At the end of the session, it was decided that the participating ministries will facilitate interactions among the entities and industrial units falling under their administrations with the other stakeholders such as UNIDO, manufacturers, vendors, suppliers and project developers of these technologies to increase the large-scale diffusion and adoption of CST.

The MNRE also announced that financial support on their behalf for CST installations was limited till the end of that financial year, that is, March 31, 2020, and solicited proposals to make it more effective in the future.

Session III: Presentation by NISE

The third session was allotted to the NISE. NISE has presented solar energy-based innovations, which had been developed with industrial collaboration for various applications including solar drying, cooling, cooking, etc.

Session IV: Experience Sharing

Session four was dedicated to experience sharing by the manufacturers, channel partners, project developers, and beneficiaries of CSTs in India.

PwC provided insight on the quality of infrastructure required for scaling up the solar sector in general and the CST sector in particular.

As a result of the discussions, UNIDO was requested to carry out a detailed assessment of existing CST projects

installed across the country. UNIDO announced that skill development activities would begin soon in partnership with the National Institute of Solar Energy.

Participants

The workshop was jointly organized by UNIDO, MNRE, and NISE, and was attended by around 125 participants from the following:

- MNRE, GoI
- United Nations Industrial Development Organization
- State Nodal Agencies of MNRE
- NISE
- Ministry of Micro Small and Medium Enterprises, GoI
- Ministry of Food Processing Industries, GoI
- Ministry of Petroleum and Natural Gas, GoI
- Rubber Board, GoI
- Manufacturer, channel partners, vendors, of MNRE on CST, project developers and beneficiaries
- Academic and R&D institutions

The workshop agenda and photos are given below.

FORTHCOMING EVENTS

NATIONAL

India Smart Utility Week 2020
3–7 March | New Delhi

International Conference on Renewable, Environment and Agriculture
22 March | New Delhi

6th Solar India 2020 Expo
20 May | New Delhi

Solar Rooftop Summit
20–22 May | Pragati Maidan

INTERNATIONAL

The Future of Energy Summit
20–21 April, 2020 | NY, USA

Energy 2020 (14th International Conference on Renewable and Non-Renewable Energy)
16–17 April, 2020 | Singapore

Intersolar Europe
17–19 June, 2020 | Germany

सत्यमेव जयते
Ministry of New & Renewable Energy
Government of India

The Ministry of New and Renewable Energy (MNRE) is the nodal Ministry of the Government of India for all matters relating to new and renewable energy. The broad aim of the Ministry is to develop and deploy new and renewable energy for supplementing the energy requirements of the country. The role of the Ministry has assumed increasing significance with the growing concern for the country's energy security. With energy self-sufficiency identified as the major driver for renewable energy in the wake of the two oil shocks of the 1970s, the Government of India established the Commission for Additional Sources of Energy in the Department of Science & Technology in March 1981, which was incorporated in 1982 in the Department of Non-conventional Energy Sources in the then Ministry of Energy; and which became the Ministry of Non-conventional Energy Sources in 1982. The Ministry was re-christened as the Ministry of New and Renewable Energy in 2006.

gef

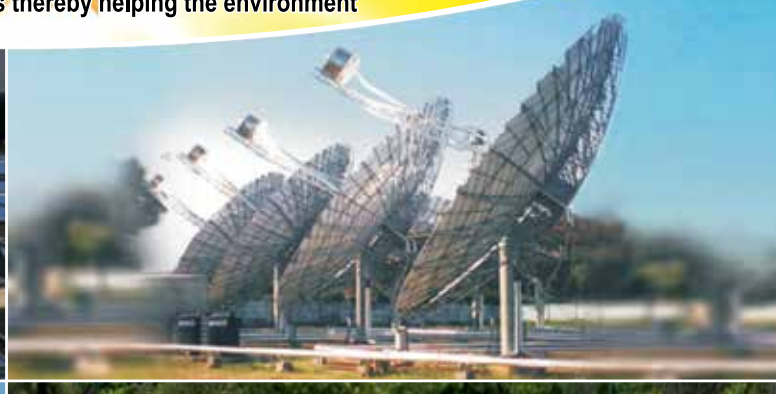
Global Environment Facility (GEF) is an international partnership of 183 countries, international institutions, civil society organizations and the private sector that addresses global environmental issues. It was established on the eve of the 1992 Rio Earth Summit to help tackle our planet's most pressing environmental problems. It serves as a financial mechanism for several environmental conventions.

UNIDO

The United Nations Industrial Development Organization (UNIDO) headquartered in Vienna, Austria is a specialized agency of the United Nations to promote industrial development for poverty reduction, inclusive globalization and environmental sustainability. The UNIDO Regional Office in New Delhi covers seven countries including Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal and Sri Lanka, and acts as a focal point to promote UNIDO's mandate of inclusive and sustainable industrial development. The core elements of UNIDO's technical cooperation services in India are to implement its activities in harmony with national policy priorities and development strategies; to build strong and long-term partnerships with donors; to increase UNIDO's visibility; and to focus its assistance in a manner that addresses international development goals, especially the Sustainable Development Goals.

Concentrating SOLAR Thermal Technologies

Proven technologies to save fossil fuels in industries for process heating and cooling needs to reduce reliance on fossil fuels thereby helping the environment



Salient Features

- Can provide steam / hot oil / pressurized water at 90 - 400 ˚C. Design and size of the system can be optimized based on requirements and site conditions.
- A typical system of 100 m^2 reflector area can save 5,000 to 10,000 litres of fuel oil per year depending on technology used and available solar radiation.
- Can be easily integrated with conventional boiler providing trouble free operations even during non-sunshine hours (heat storage is available).
- Around 200 systems of various capacities already installed in the country for different applications.

Financial Support for Installations

- The financial incentives provided for CST installation include CFA (Central Financial Assistance) from MNRE at 30% of the benchmark solar project cost, and depreciation benefit for profit-making companies. Higher subsidy for systems in special category states.
- Additional support is available from **MNRE-GEF-UNIDO project:**
  a) Technical Feasibility by UNIDO and soft loan from Indian Renewable Energy Development Agency (IREDA)
  b) Bridge loan against subsidy at normal interest rate.
  c) Support for improving the manufacturing of CST system / components.

Interested Organizations may send their Expression of Interest before 30th September 2019.

For more details please visit the following websites:-

MNRE (https://mnre.gov.in/concentrating-solar-system-solar-cookers-steam-generating-systems)

UNIDO (https://open.unido.org/projects/IN/projects/130149)

National Project Manager

MNRE-GEF-UNIDO Project on Concentrating Solar Thermal Technologies

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