a quarterly magazine on **concentrated solar heat**

SUN FOCUS

FOURTEENTH ISSUE

CONCENTRATED SOLAR THERMAL USAGE IN INDIA

Volume 4
Issue 2
Oct–Dec 2016

UNDP–GEF CSH Project
Ministry of New and Renewable Energy
Government of India

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सत्यमेव जयते

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SUN FOCUS

Volume 4 • Issue 2
October–December 2016
a quarterly magazine on
concentrated solar heat

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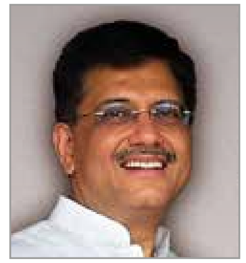

MESSAGE

India is a country with rich solar resources and Government of India has modified Jawaharlal Nehru National Solar Mission (JNNSM) target of 20 GW solar power to ambitious 100 GW solar power by 2022. Government's emphasis on solar energy is due to the fact that it produces clean and emission free energy while reducing country's dependence on fossil fuels. Apart from power generation, solar energy can also play an important role in saving fuel used for heating and cooling applications in industrial, institutional and residential sectors through Concentrated Solar Thermal (CST) technologies. The Ministry of New and Renewable Energy (MNRE) has initiated a couple of projects in association with UNDP and UNIDO to promote CST applications through financial and fiscal support to users and technology providers/ manufacturers. MNRE has also taken steps to develop Renewable Energy (RE) Policy in this regard.

CST technologies, both in India and on global scale, are in a nascent stage but have huge potential to impact carbon footprint of global industrial sector in a significant manner. For a developing country like India, CST technologies offer very attractive proposition. The clean and emission free source of energy will help reduce fossil fuel consumption significantly. This will also reduce carbon footprint of industrial sector, assisting India's commitment to reduce its greenhouse emissions. The Government of India (GoI) through Bureau of Energy Efficiency (BEE) has initiated a massive programme for energy conservation across all sectors and promotion of CST technologies to further reduce fossil fuel consumption is next logical step in this direction. These technologies offer opportunities for development of indigenous technologies which can create local jobs and take forward 'Make in India' initiative launched by the Hon'ble Prime Minister Shri Narendra Modi.

The MNRE has recognized this potential and has taken systematic efforts for development and support of CST sector. These efforts have culminated into installation of approximately 42,000 m^2 of aperture area of CST systems into community cooking, process heating and cooling applications. Publication of *SUN FOCUS* magazine is one of such initiatives by MNRE, which is spreading awareness about CST technology all over the country.

I wish *SUN FOCUS* well for its continued journey and further progress.

Goyal

Shri Piyush Goyal

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सत्यमेव जयते

राजीव कपूर
Rajeev Kapoor

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SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

MESSAGE

I am happy to note the progress made in CST technology implementation under the UNDP–GEF funded project.

CSTs have vast potential for community cooking in hostels, ashrams, para-military/defence units, prisons, hotels, hospitals, industrial canteens, etc which needs to be taped to save precious fuel oil and LPG. Among the industries, dairy, textile, pharmaceutical, chemical, metal treatment and food processing needs to be targeted first. Use of high grade fossil fuels especially the fuel oil & electricity for thermal applications needs to be minimized by using solar thermal devices/ systems in a country like ours where 80% of fuel oil is being imported and over 35% people in rural areas have little or no access to electricity.

India has signed the Paris Agreement on Climate Change and our commitment to International community is to reduce emissions intensity of GDP by 33 to 35% by 2030 over 2005 levels. This project and Ministries' another project with UNIDO on use of solar thermal energy in industrial process heating and cooling requirements are going to play an important role in achieving our emission reduction targets.

The Ministry of New and Renewable Energy is committed to grow and develop various technologies for utilization of solar energy in process heating and cooling applications through support to research and development and implementation. This Project has played an important role and has achieved now 50,000 m^2 of collector area installations.

Communication and outreach are important pathways for creating awareness and propagation of technology. The role played by SUN FOCUS in this regard is vital.

I wish all the best for the project and SUN FOCUS.

Rajeev Kapoor
Secretary

अक्षय ऊर्जा से देश विकास
सूरज एक रूप अनेक

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From the editor's desk...

Dear Readers,

The Jawaharlal Nehru National Solar Mission (JNNSM) marked a new era of solar-based technologies in India, which has provided an emphasis on concentrated solar thermal (CST) technologies. We also know that India holds ample solar resources and has a good potential for CSP technology.

The biggest advantage of installing a CSP plant is the opportunity of thermal storage capacity addition. Since a CSP plant primarily produces heat, the heat produced can be stored by using various technologies, and then can be released to produce electricity.

This 14th issue of *Sun Focus* presents you with a special feature on the Parabolic Trough CSP technology used by Godavari Green Energy Limited to generate electricity. The issue also covers an interesting write-up on thermal storage and its applications.

You will also find an article on the Integrated Solar Thermal Power Plant commissioned at NTPC Dadri. This project the solar field is going to supply heat to the existing power plant and deliver with an efficiency of the offset-steam is calculated to be 42%. The other articles covered in this issue are Solar dish collectors being used for cloth processing at Navkar Textiles and CST technology used for heating process at a Copper mine in Mexico.

The updates from the GEF-UNIDO-MNRE project on Concentrating Solar Technologies are captured in a brief write-up along with the details of the Loan Scheme recently announced by IREDA for this project.

I am sure you will find this issue interesting and informative similar to all previous issue of *Sun Focus* magazine and also thank all the readers and stakeholders for their support and look forward to their continued patronage for our future issues.

Sd/-
Santosh D. Vaidya
Joint Secretary, Ministry of New and Renewable Energy &
National Project Director, UNDP–GEF CSH Project

अक्षय ऊर्जा से देश विकास
सूरज एक रूप अनेक

GODAWARI CSP PLANT: AN OVERVIEW OF PERFORMANCE

J S Solanki*

Godawari Green Energy Ltd (GGEL), established in 2009, is a flagship company of the HIRA group in the renewable energy sector. The company was formed with an objective to tackle the growing energy requirement of the country in an ecologically sustainable manner. GGEL's focus area is power generation using renewable sources, such as solar energy, geothermal energy, wind energy, etc.

The Integrated Energy Policy Report, 2006, estimates that India will need to increase their electricity generation by five to six times to meet the per capita consumption needs of its citizens. Renewable energy will play an important role in filling the gap while addressing the environmental concerns as well. GGEL has taken the first step in this direction by taking up a project to construct and operate a 50 MW Solar Thermal Power Project at Village-Nokh, Tehsil-Pokhran, Dist-Jaisalmer, Rajasthan.

This Project is capable of lighting 2.5 million homes in India without adding harmful air pollutants and greenhouse gases into the atmosphere.

Godawari Green Energy Limited (GGEL) has started injecting power to the Grid on June 19, 2013, coinciding with World Environment Day. With this achievement, GGEL has become the nation's First Solar Thermal Power Plant under JNNSM, Phase – I.

Overview of Solar Thermal Plant

This unique Solar Thermal Power Plant has employed Parabolic Trough CSP Technology with state-of-the-art SKAL-ET 150 trough structure. India's first ever utility to generate electricity by using sophisticated CSP parabolic trough technology, the 50 MW project is contracted by Lauren Engineers & Constructors (I) Private Ltd (LECI). Upon reaching full capacity, the project featuring a solar field aperture area of almost 400,000 m², generates up to 118,000 MW hours of electricity per year.

Image 1: View of the Solar Field at Nokh, Rajasthan

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Aperture area	3,92,400 m²
No. of Loops	120
Surface area	2.4 m²
No. of Mirrors per Module	28
Total no. of Mirrors	1,61,280
Operating temperature	385 °C
Heat rate	2262.3 kcal/kwh

Image 2: Parabolic trough collectors at GGEL

GGEL had signed power purchase agreement (PPA) with NTPC Vidyut Vyapar Nigam (NVVN) for power evacuation.

According to the PPA, the tariff rate decided was ₹12.2/kWh for 25 years.

The Process

GGEL's CSP plant runs on Rankine cycle. The heat collected by trough is being transferred to water through thermic fluids (HTF) for steam generation. Temperature of fluid goes up to 380°C and fluid indirectly heat water to generate steam. Thus, generated steam goes to the turbine for power generation.

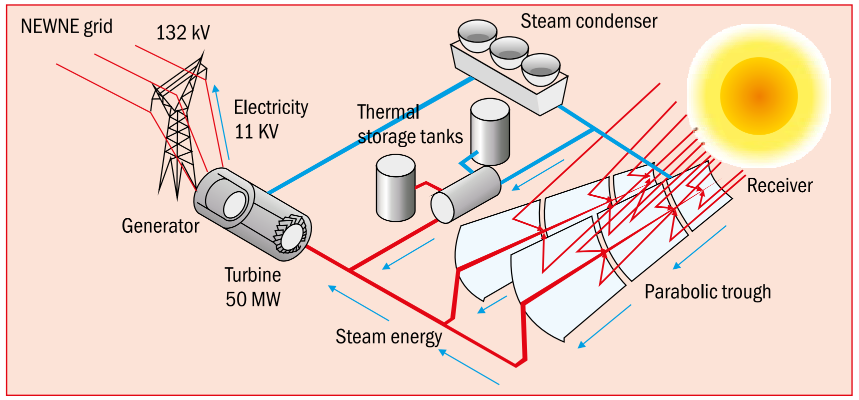

Figure 1: Technology and Project Boundary

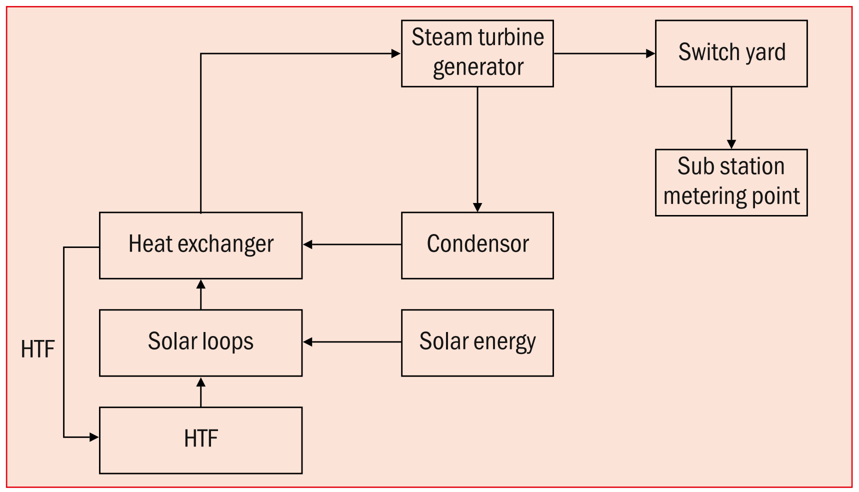

Figure 2: Schematic Diagram of Project

Performance and Monitoring

The plant is running successfully. In last financial year (2015–2016), it had generated 97 million units of electricity and net realization export was found to be around 84 million units.

Here are some instruments use for performance analysis:

- **System Advisory Model (SAM)** for plant performance analysis. SAM closely observes the real power output of the plant.
- Mirrors are the heart of system and observing its reflectance is an important parameter. To monitor reflectance, the Specular Reflect meter is deployed.
- Tracking is essential for getting maximum output. **Digital balancer** to get the accuracy of solar collector assemblies (SCA) tracking.
- **Thermal Imager** to analyse temperature profile.
- It is essential to analyse the hourly output and efficiency parameters with standard tools to enhance the plant performance.

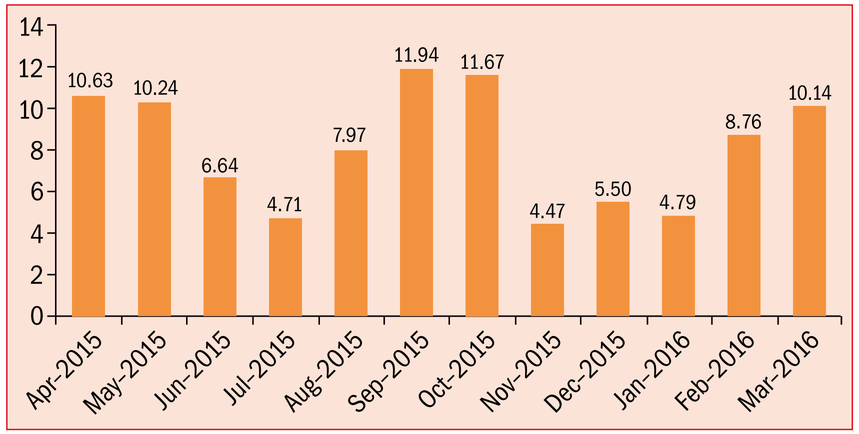

***Figure 3:** Monthly Electricity generation for 2015–2016 (In million units)*

***Image 3:** Top view of the Power Block*

***Image 4:** Pipe rack carrying Heat Thermic Fluids (HTF)*

Savings

During last financial year, around 82,228 t CO_2 was saved by the CSP plant.

Challenges

Like other CSP plants, it has some key challenges that play an important role in plant's functioning. Currently, the plant is facing some technical challenges such as auxiliary power reduction, power consumption during non-generating hours, etc.

The plant itself takes around 9.30 per cent of total power (FY 2015–2016) for its captive consumptions. To reduce these auxiliary power reductions is still a big challenge for the management. On the quest to maximize plant efficiency, integrated process management across standardized plant designs promises to deliver cost efficiency, reduced risk, and to bring plants online, quicker. So power lost during mismatch with grid and reduction of non-generating hours are some of the issues with existing infrastructure. Accuracy of power output, sustaining turbine and generators efficiency are the key challenges for smooth function.

Conclusion

Godawari plant is one of the finest examples of successful CSP technology in India. Being a first ever CSP plant in India, it had created confidence among industries to adopt cleaner and highly efficient technology.

THERMAL ENERGY STORAGE AND APPLICATIONS

Abhinav Bhaskar*

Thermal energy storage (TES) systems allow the storage of heat or cold for later use. TES is useful for applications where there is a mismatch between supply and demand of energy. TES systems can be extremely useful for integration with renewable energy sources which are intermittent and whose availability is further reduced by weather perturbation. Solar thermal energy is available only during the day, and hence, its application requires efficient thermal energy storage so that the excess heat collected during sunshine hours can be stored for later use during the night. Similar problems occur in heat recovery systems and industrial processes where the waste heat availability and utilization periods are different, requiring some thermal energy storage. Electrical energy consumption varies significantly during the day and night, especially in extremely cold and hot climate countries where the major part of the variation is due to domestic space heating and air conditioning. Such variation leads to peak and off-peak period. Accordingly, power stations have to be designed for capacities sufficient to fulfill the peak load. This requires further investment in energy generation capacity. Otherwise, very efficient power distribution would be required. Better power generation management can be carried out if some of the peak load could be shifted to the off-peak load period, which can be achieved by energy storage.

Phase Change Materials and their Properties

In the recent times a lot of research is being conducted in high temperature thermal energy storage system. They can be primarily divided into three types namely; sensible, latent, and thermo-chemical energy storage system. The traditional two-tank sensible heat storage system (sensible heat storage), which uses molten salts are not as efficient as latent heat energy storage system (LHES), which store a greater amount of heat per unit volume. The materials used for LHES are called phase change materials (PCM). They store a large amount of heat as the heat of fusion and can provide the stored heat when required by the system. Figure 1 depicts the different properties of the phase change material, which are taken into consideration while designing a thermal energy storage system. The most important

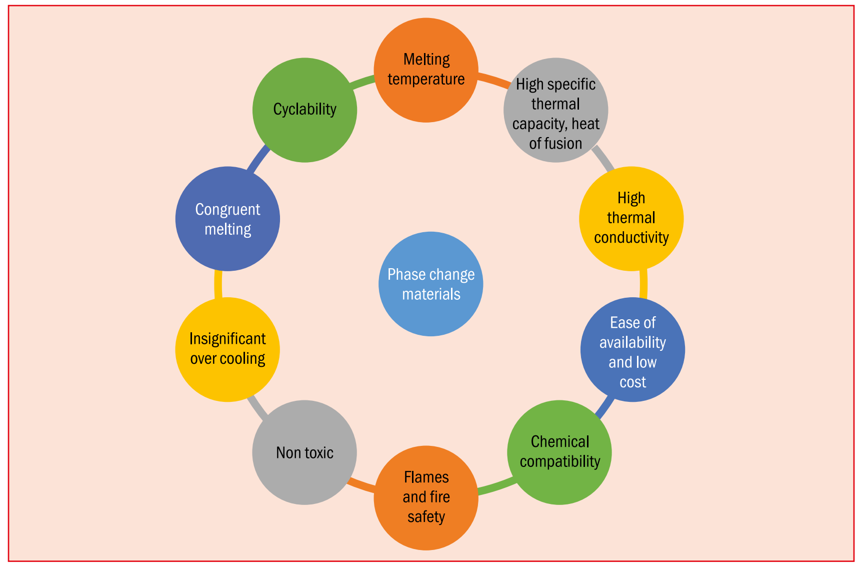

***Figure 1:** Properties of phase change materials*

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considerations are melting point, thermal conductivity, latent heat of fusion, cost and material compatibility.

Both organic and inorganic compounds can be used as phase change materials. Organic compounds include paraffin, fatty acids, esters, etc. Inorganic PCM includes salt hydrates, salts, metal hydrides, etc. Table 1 shows thermo-physical properties of salts which can be used as PCM.

Table 1: Melting temperature and heat of fusion of inorganic salts (˚C)

Melting temperature of inorganic salts (˚C)										
Metal	**Fluoride**	**Chloride**	**Bromide**	**Iodide**	**Sulphate**	**Nitrate**	**Carbonate**	**Chromate**	**Molybdate**	**Tungstate**
Lithium	849	610	550	469	858	253	732	485	703	740
Sodium	996	801	742	661	884	307	858	794	688	696
Potassium	858	771	734	681	1069	335	900	973	926	923
Rubidium	795	723	692	556	1070	312	873	994	955	952
Cesium	703	645	638	632	1015	409	793	975	935	953
Magnesium	1263	714	711	633	1137	426	990	-	1230	826
Calcium	1418	772	742	783	1460	560	1330	1000	1449	1580
Strontium	1477	875	657	538	1605	645	1490	1283	1457	1535
Barium	1368	961	857	711	1680	594	1555	1444	1458	1475
Heat of fusion (Joule/gram) of inorganic salts										
Metal	**Fluoride**	**Chloride**	**Bromide**	**Iodide**	**Sulphate**	**Nitrate**	**Carbonate**	**Chromate**	**Molybdate**	**Tungstate**
Lithium	1041	416	203		84	373	509	168	281	157
Sodium	794	482	255	158	165	177	165	146	109	107
Potassium	507	353	215	145	212	88	202	41	163	86
Rubidium	248	197	141	104	145	31	-	-	140	78
Cesium	143	121	111	96	101	71	-	94	75	63
Magnesium	938	454	214	93	122	-	698	-	-	-
Calcium	381	253	145	142	203	145	-	-	-	-
Strontium	226	103	41	57	196	231	-	-	-	-
Barium	105	76	108	68	175	209	-	-	-	-

Image 1: Cylindrical capsules filled with PCM integrated into a pressure vessel

Development of PCM-based Thermal Storage System

Large number of thermal energy storage projects are being carried out in Germany. These are either funded by the government or the industries. Extensive study on high temperature phase change materials has been conducted by national renewable energy laboratory (NREL). A thorough review of high temperature thermal energy storage system can be found here. The design on a latent heat storage system based on phase change material is composed of two important parts. The first step is the selection of an appropriate phase change material and the other is to design an optimized heat exchanger system.

Several researches on PCM-based thermal storage have been conducted and a prototype storage model with capacity of 200 kWh was installed at The Plataforma Solar de Almería (PSA).

Conclusion

High temperature heat storage has a lot of benefits. The primary application is to solve the intermittent nature of solar radiation. Mobile heat storage systems are another application which can benefit residential owners as well as industries. Solar thermal concentrators, like parabolic trough collectors, require large areas for implementation. This acts as a deterrent for their implementation in industrial areas where land is an expensive commodity. Heat could be generated at the outskirts, where land prices are lower and then transported to the industrial hubs using mobile heat storage systems. This would make solar thermal competitive with fossil fuel powered boilers. Waste heat from one industry can be stored and transported cheaply to another industry hence increasing the overall efficiency of both the industries.

District heating networks can function more optimally with integrated storage system. There is ongoing research on the integration of storage to coal thermal power plants and combined heat power plants. Storage would ensure a smaller gap between peak supply and demand at the generation site itself. This will lead to size reduction of the power plants and make them more efficient.

There is a need for pushing the development of large-scale high temperature storage systems and evaluating their performance parameters. This would require collaborative effort from the industries, academia, and the government.

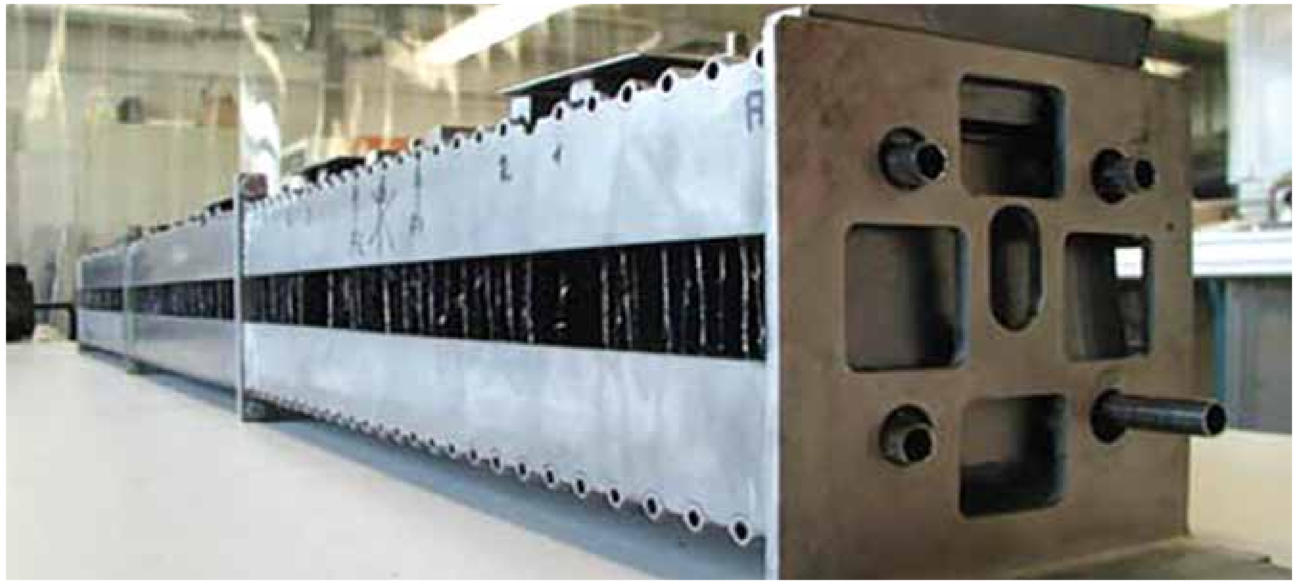

Image 2: Heat exchanger integrated with PCM

Image 3: System installed at PSA DISS (Direct Solar Steam) plant at Almeria, Spain, for PCM-based thermal storage

INTEGRATED SOLAR THERMAL POWER PLANT AT DADRI U.P.

Dr R R Sonde[1], S Shaswattam[2] and Thomaz Mehlitz[3]

About NCPS

National Capital Power Station (NCPS) or NTPC Dadri, is the power project to meet the power demand of National Capital Region (India). It has 1820 MW coal-fired thermal power plant and 817 MW gas-fired plants. It is located in Gautam Budh Nagar district of Uttar Pradesh, about 25 km from Ghaziabad and about 9 km from Dadri.

About the Project

The project at NTPC Dadri is the first Integrated Solar Thermal Power Plant Project in India. In this project, a solar field is going to supply heat to the existing power plant. The heat will be supplied to the High Pressure Heater (#6) which will offset the steam which is currently being used for this purpose. This steam which is saved will go through the High Pressure and the Low Pressure turbine and deliver work with a high efficiency of 42 per cent.

Solar Thermal Integration is one of the best methods of adding renewable energy to an existing fossil power plant. In this method, the cost of the power island which forms about 30 per cent of the cost of a solar power plant is completely avoided. Further, the existing high efficiency power cycle boosts the solar to electricity conversion efficiency which far exceeds the efficiency that can be obtained by other systems, such as Photovoltaic.

CST Technology

The Compact Linear Fresnel Reflector (CLFR)-based solar thermal technology being deployed in this project is being provided by Frenell GmbH, Germany, a leader in low-cost Concentrated Solar Power (CSP) Solutions.

The Frenell CLFR technology can be used for generating hot water, steam, and also for heating thermal oils or molten salts. Temperatures of upto 550°C can be achieved by focussing the sunlight on the absorber tubes.

Rows of mirrors are driven by east and west field motors which focus the sun on the vacuum tube mounted in the centre.

Figure 1: General layout of the proposed plant

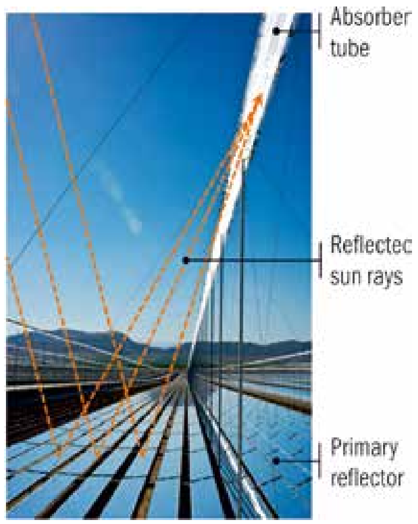

Figure 2: Working of the CLFR technology

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[2] *Asst. General Manager, NETRA, NTPC; Email: shaswattam@gmail.com*

[3] *Project Manager, Frenell GmbH; Email: thomas.mehlitz@frenell.de*

Some of the key features of the techology include:

- Use of flat mirrors with curvature being provided by mirror-box
- No ground clearance with low ground hugging structure
- Robotic factory made components wih high level of pre-fabrication
- Low cost and automatic cleaning machines to achieve high level of availability

The technology offers flexibility to be integrated as a part of :

a. Standalone solar thermal power plants based on steam and thermic fluid

b. Solar thermal power plants with inbuilt storage to offer 24x7 availability

c. Integrated solar thermal hybrid plants with existing fossil fuel-based plants

The uniqueness of the current configuration is the use of the Solar Field to generate hot water at 257°C which can be achieved at efficiencies as high as 64 per cent.

Integration of Solar Heat with Existing Power Plant

The integration of solar heat with the existing power plant is being done by Thermax Ltd. The existing plant at NCPS is a 210 MW coal-fired power plant. It has 6 heaters out of which the HP#5 and HP#6 are the high pressure heaters which heat the water before the economizer of the boiler.

The current integration is to place a Solar Heat Exchanger in parallel to the HP#6 and bypass a part of the load on the heater & heat the water using the heat from the solar field. The extraction steam which is saved from the HP turbine will perform more work in the IP and the LP turbine and generate more electricity. This efficiency of the offset-steam is calculated to be 42 per cent.

Integrated Solar Hybrid System at NCPS

At NPCS, the system configuration consists of seven rows of CLFR collectors which heat the water from 210°C to 257°C. This heat is then transferred through the hot header to the Solar Heat Exchanger which is located at a distance of 1.5 km inside the turbine building. The heat is used to heat a part of the boiler feed water from 200°C to 247°C. The water circuit consists of water at high pressures in the range of 60 Bar to 80 Bar which is pumped through the circuit by 3 circulation pumps.

The system is designed to work at a range of DNI values as well as different plant operating conditions to deliver the maximum possible heat from the solar field to the heat exchanger. Based on previous experience and the solar data of the plant, the solar field is expected to deliver about 14 GWh of energy to the fossil-fired power plant.

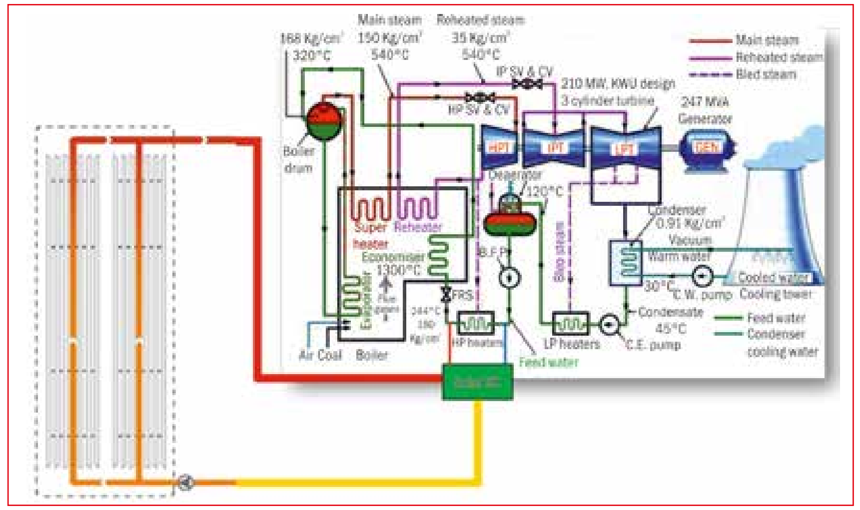

Figure 3: Detailed layout of the proposed plant

Current Status

The project is underway since September 2016. Site work and manufacturing of solar components and various work packages along with ground activity are also in process such as layout finalization, process finalization, and site levelling etc.

Benefits of Integrated Solar Thermal Plants

Some of the benefits of Solar Thermal Hybridization are indicated in the figure above.

Solar thermal hybridization provides one of the best opportunities of including an existing high efficiency system such as a high pressure power plant or a Super Critical Power plant with a green and renewable solar thermal system. This integration offers the best possible solar to power conversion of as high as 29 per cent when coupled with an existing high performance power island.

The cost of a hybrid solar thermal system is also lower than that of a standalone power plant. The power island is completely eliminated and the existing systems are used to full capacity which also increases the throughput of the plant.

In conclusion, Solar Thermal Hybridization offers unique and sustainable opportunities to fulfil the Jawaharlal Nehru National Solar Mission as well as India's commitment to prevent climate change and reduce the carbon footprint.

CST PLANT FOR CLOTH PROCESSING AT NAVKAR TEXTILES

Sanjeev Kachhwaha[1], Prakash Sancheti[2] and Kumar Abhishek[3]

Navkar Textiles, located in the heavy industrial area of Jodhpur, Rajasthan, manufactures and supplies cloth materials and fabrics for various weaving industries which, in turn design and develop various varieties of dress and other dress materials.

Navkar Textiles is a process industry, wherein they purchase grey material (cloths) prepared in various looms, the cloth is then stitched together and sent for bleaching and various chemical process so as to remove impurities during the cloth-making process. After various bleaching and chemical processes, the cloth is passed through a closed chamber where it is passed through the steam to clean various chemical agents during the bleaching process. Further, the cloth is coloured as per required order before dispatch.

Image 1: Scheffler dishes installed at Navkar Textile, Jodhpur

Technology

Navkar Textiles has installed solar dish concentrators (Scheffler type) for their steam utility purpose.

This recent installation comprises of 12 solar dish concentrators, each having an aperture area of 16 m². These dishes are connected in a series and parallel combination and generate steam at 150°C and three bar pressure. It is installed in an open area near the utility section of the factory. The total collector area for the dish assembly system is 192 m².

The solar parabolic dish from K energy are 16 m² solar dish concentrators (Scheffler type) which focus thermal energy from the sun onto a point receiver that concentrates heat. This heat converts the water, flowing through the receiver into steam in order to increase the efficiency of traversing water into steam. A high quality cavity receiver, specially designed by K energy, is being used apart from preparing special PU back coating for the mirrors for its long life.

The overall system assembly consists of the concentrator dish, receiver, tracking system, and supporting structure. It is capable of delivering temperatures up to 150°C and is equipped with a tracking mechanism for improved efficiency. The system is capable of tracking the movements of the sun automatically throughout the day with the help of automatic tracking system (i.e. east to west), focussing the sunlight exactly on the receivers which are connected to the header. The process of energy generation is natural, ecofriendly, and long lasting.

Each module of 16 m² has a total shadow free area requirement of 35 m² and a weight of 400 kg. A single module has an output capacity of up to 6 kWth.

Table 1: Parameters for Solar dish concentrators (Scheffler type)

Heat Delivery	30,000–35,000 kcal per day
Total aperture area	16 m²
Total shade free area	35 m²
Total weight	400 kg
Tracking	Single axis automatic tracking

[1] Chief Executive, K Energy; Email: info@kenergy.co.in
[2] Owner, Navkar Textiles; Email: prakashsancheti99@gmail.com
[3] Technical Officer, MNRE; Email:abhishek.mnre@gmail.com

System Details

No. of solar dish concentrators (Scheffler type)	12
Total aperture area	16*12 = 192 m²
Total shade free area	35*12 = 420 m²
Total weight	400*12 = 4.8 tonnes
Manufacturer	K Energy

Application

In total, 12 single axis tracked parabolic dishes (Scheffler type) were installed. The principle application of these dishes is to supply steam at a temperature of 150°C to the steam spraying section. The unit utilizes the steam generated from the solar collectors for their steam washing/cleaning needs during the day time or when sunlight can be captured.

CST—a good alternate

Prior to using solar concentrators for their washing/cleaning needs, Navkar Textiles had been using firewood. They used two tonnes of firewood on a daily basis and annually, 660 tonnes on a commercial basis which comes to ₹2,600,000.40 annual expenditure along with the resultant environmental pollution by emitting almost 1320 tonnes of carbon dioxide (CO_2). Due to these environmental hazards and under surveillance of the National Green Tribunal (NGT), nowadays it is not possible to run such units. At current firewood rates, Navkar Textiles will be saving close to ₹2,000,000 approx. per annum, by running solar concentrators and avoiding firewood usage for the cloth washing/cleaning needs.

Fuel savings and economics

The total cost of the system is ₹3,600,000 which includes balance of system cost such as piping, civil works, etc., which vary and are specific to every installation since this is a scheffler dish-based with single axis automatic tracking the subsidy on benchmark costs stands at ₹5400/m². The total subsidy applicable for the system based on MNRE benchmarks for 192 m² is ₹1,036,800 and an additional support from UNDP of ₹518,000.

Image 2: Cloth rolling process

Image 3: Furnace for cloth processing

The assumption of financial feasibility for the project site is as follows:

Project cost	₹3,600,000.00
MNRE CFA	₹1,036,800.00
UNDP support	₹518,000.00
Expected fuel saving per annum	₹2,000,000.00 per annum approx.

Thus, the overall project cost minus the subsidy available from MNRE is ₹2,045,200. The financial analysis also addresses the fact that an additional accelerated depreciation benefit of 80 per cent of the project cost is available for the unit owner. This accelerated depreciation is available under the IT Act and can be availed on 80 per cent of the cost incurred on solar concentrators.

GEF-UNIDO-MNRE PROJECT ON PROMOTING BUSINESS MODELS OF CONCENTRATING SOLAR TECHNOLOGIES

Dr Anil Misra*

A significant potential exists for solar heat for industrial processes. In this regard, the Concentrated Solar Thermal (CST) technologies have only recently started gaining confidence of the users. UNIDO has identified a total market potential of 6.45 GW for industrial applications in India during preparation of CST Roadmap 2020.

The CST technologies, due to efforts of the indigenous technology providers, are making technical and economic sense today in many applications, such as steam cooking, laundry services, dairy thermal applications, and the automotive sector. The factors that are scaling up the deployment of CST technologies are listed as follows:

- Increasing awareness of solar thermal technologies and acceptance of its use;
- Increasing number of participants entering the market with a larger share of private investment;
- Industry beginning to invest in market development and R&D initiatives; and
- Mass production and heightened levels of marketing, driving down costs of procurement and installation.

Solar heating and cooling applications for industrial processes represent a niche market. Analysis of solar sector in India and review of existing barriers to promote solar energy use in industrial sectors, carried out during the project preparation phase, display strong relevance of CST in India.

The Project

The MNRE-GEF-UNIDO project, driven by the solar support initiative under the Jawaharlal Nehru National Solar Mission (JNNSM), offers complementarity to the ongoing and planned national and international programmes to promote the CST technologies industrial thermal applications in India.

The project has been conceived aiming to contribute to the GEF Climate Change Strategic Objective namely, promoting investment in renewable energy (RE) technologies by transforming the market for solar energy for industrial heat applications in India through investment, market demonstration, development of appropriate financial instruments, development of technical specifications, capacity building, and contributions to establish a favourable policy and regulatory environment.

The project strategy builds on the existing favourable framework for solar thermal in India aiming to overcome the barriers, and is driven by high commitment by the government to the development of its solar thermal industry, and significant interest by the industrial sector to reduce its reliance on fossil fuels.

The primary stakeholders of the project are energy policy-making and implementing institutions, primarily Ministry of New and Renewable Energy (MNRE), Government of India; Micro, Small and Medium Enterprises (MSMEs), Indian Renewable Energy Development Agency (IREDA), industrial unit owners (end beneficiaries), CST manufacturers, designers, installers, training institutes, energy professionals, and service providers.

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Innovative Loan Scheme

The United Nations Industrial Development Organization (UNIDO) has partnered with IREDA to develop and implement an innovative finance/loan scheme to further promote the deployment of CST projects in India for heating and cooling applications in selected industrial sectors to reduce energy consumption and greenhouse gas (GHG) emissions. The highlights of the currently available financial incentives are as follows:

- The beneficiary's or project developer's contribution would be 25 per cent of the project benchmark cost.
- The financial incentives provided for CST installation include CFA (Central Financial Assistance) from MNRE at 30 per cent of the benchmark solar project cost and tax benefit from the Government of India (80 per cent depreciation benefit).
- Additional support is available from UNIDO project in terms of technical feasibility and loan from IREDA as follows:
- Bridge loan against subsidy and at normal interest rate would be available.
- Loan for the remaining amount would be provided at an interest subvention of 5 per cent. The funds under the UNIDO project would be used for subvention of the interest rate. Both the loan and MNRE subsidy would be bundled in the form of a financial package by IREDA.

Image 2: Workshop chaired by Secretary, MNRE at New Delhi on 12 October 2015

National-level Workshops on Application of CST Technologies in the Dairy Sector

Addressing the need to create more awareness about the CST technologies, UNIDO initiated a series of national workshops, as highly interactive sessions, with the senior representatives of various industry sectors. UNIDO organized a series of awareness generation and interactive workshops to sensitize the industry representatives about the large potential of CSTs for heating and cooling applications. Starting with the first workshop on July 1, 2015, chaired by the Joint Secretary, MNRE, the workshops followed in Uttarakhand, Himachal Pradesh, Gujarat, Karnataka, Madhya Pradesh, Tamil Nadu, Maharashtra, West Bengal, Uttar Pradesh, Rajasthan, and Telangana (Hyderabad) between January and September 2016.

The project developers and beneficiaries may contact UNIDO for further information on the loan scheme and the technical support available from UNIDO for CST projects for industry process heat applications.

Image 1: First interactive workshop in New Delhi on 1 July 2015

IREDA'S LOAN SCHEME FOR CSTs UNDER UNIDO-GEF-MNRE PROJECT

Objective

The Ministry of New & Renewable Energy (MNRE) in partnership with United Nations Industrial Development Organization (UNIDO) and IREDA (Indian Renewable Energy Development Agency) under the GEF-UNIDO-MNRE project launches an innovative financing scheme to promote adoption of the Concentrated Solar Thermal (CST) Technologies for process heat applications in the industrial sectors. It aims to create the necessary enabling environment for increasing penetration and scaling up of CST Technology in India through this innovative financing mechanism.

Benefits of Loan Scheme

- Soft Loan: Soft loan available at a low rate of interest for 7 years inclusive of 1 year moratorium.
- Single Window for multiple funding: Single application to IREDA for MNRE subsidy, IREDA Soft Loan and Bridge Loan.
- Simpler processing and documentation: Composite loan application form for Soft Loan and Bridge Loan.

Scheme Highlights

The scheme provides an indicative cost structure of minimum 25% as promoter's contribution, 45% as soft loan (Part A) and Bridge Loan against sanctioned 30% MNRE subsidy on benchmark costs (Part B).

Part A: Soft Loan from IREDA

Rate of Interest	7%	After considering UNIDO interest subvention
Repayment Period	7 years	1 year moratorium + 6 years repayment

Part B: Bridge Loan against MNRE subsidy

Rate of Interest	12%	The rate is applicable till the project is commissioned. On commissioning, the MNRE subsidy will be passed to the project and the bridge loan will be closed

Notes:

- The Project would be eligible for interest rebate of 1% in the event of Borrower furnishing security of Bank Guarantee/Pledge of FDRs as the primary security, equivalent to the amount sanctioned by IREDA for both soft loan and bridge loan.
- Quantum of soft loan will depend on the MNRE subsidy and approval by UNIDO-PMU.
- The Project would be eligible for interest rebate of 1% in the event of Borrower furnishing security of Bank Guarantee/Pledge of FDRs as the primary security, equivalent to the amount sanctioned by IREDA from Scheduled Commercial Banks as described in RBI Act or Unconditional or Irrevocable guarantee from All India Public Financial Institutions with "AAA" or equivalent rating.

Eligibility

Any entity as per IREDA guidelines setting up a solar thermal heating/ cooling/ tri-generation project is eligible to apply under this scheme.

General Applicant Eligibility norms

Eligible Entities/Categories as per IREDA norms shall include the following. • Private Sector Companies/firms • Central Public Sector Undertakings (CPSUs) • State Utilities/Discoms/Transcos/Gencos/Corporations • Joint Sector Companies

Applicants, registered in India, falling under any of the above categories, with borrowing powers and powers to take up new and renewable energy and energy efficiency projects as per their Charter, are only eligible to apply for financial assistance from IREDA except for the following:

a. Trusts, Societies, Individuals, Proprietary concerns and Partnership firms (other than Limited Liability Partnerships, LLPs). However, they can be considered for financing only if they provide Bank Guarantee/ Pledge of FDR issued by Scheduled Commercial Banks as described in RBI Act for the entire loan.

b. Loss making applicants and/or, Applicants with accumulated losses (without taking in to account effect of revaluation of asset, if any) as per audited Annual Accounts of the immediate preceding financial year of operation. However, they can be considered for financing only if they provide security of Bank Guarantee/ Pledge of Fixed Deposit Receipt (FDR) issued by Scheduled Commercial Bank as described in RBI Act for the entire loan.

c. Applicants who are in default in payment of dues to Financial Institutions, Banks, NBFCs and/or IREDA.

d. Applicants/ Group Companies and/or Core promoters of the applicant company who,
   - » Default in payment of IREDA dues and/ or defaults of other banks/FI.
   - » Classified as wilful defaulters as defined by RBI/ classified by other FIs and/or,
   - » Had availed OTS from IREDA and/or, from other Banks/FI.
   - » Convicted by court for criminal/economic offences or under national security laws

e. Greenfield Projects involving second-hand equipment and machinery.

Minimum Loan Amount:

The minimum loan eligibility from IREDA will be ₹50 lakhs.

Disbursement Schedule

The following disbursement schedule is applicable for both Part A (Soft Loan) and Part B (Bridge Loan).

Instalment	Percentage	Terms
1st instalment	30 % of loan amount	On signing of the loan agreement and inflow of minimum 30 % share of promoters contribution
2nd instalment	30 % of loan amount	Inflow of additional 60% share of promoter's contribution and after delivery of all equipment at site
3rd instalment	30 % of loan amount	Inflow of minimum 90% share of promoter's contribution, On final installation of CST equipment at location
4th instalment	10 % of loan amount	On completion, commissioning, testing and inspection and utilization of 100% of the promoter's contribution.

Note: Main loan and bridge loan will be disbursed proportionately as indicated in the table above.

Guarantee & Security

- As per IREDA's norms (Please see IREDA guidelines)
- Additionally performance guarantee from supplier for a period of 7 years or until complete repayment of loan and payment guarantee from the beneficiary
- The promoter shall give an undertaking that in case non-release of Capital Subsidy, the company will bring in equity to repay IREDA Loan.

Fees & Charges

The fees and charges applicable for this loan scheme are mentioned as below. A rebate of 20% is available to the beneficiary if the loan agreement is signed within 60 days of the sanction of loan.

Processing Fee

Loan Applied	Registration Fee per application
Up to 1 crore	₹10,000 (plus service tax and education cess as applicable)
Above 1 crore	₹30,000 (plus service tax and education cess as applicable)

Front-end Fees

The borrowers will have to pay front-end fee as below after issuance of loan sanction letter and before signing of the loan agreement.

Loan slab	Front-end Fee (% of loan amount)
Up to 5 crores	0.50 % of the loan amount
Above 5 crores	1.0 % of the loan amount

Other Guidelines

Insurance

The borrower will ensure insurance coverage of all works and equipments during construction and also during operation. The cover should remain operative till the loan is fully repaid.

Others

For all other terms not specifically mentioned in this document (please refer to the FINANCING NORMS AND SCHEMES (Doc no. IREDA / FG / Part 1 / Issue No. 2 / updated 29.06.2016, www.ireda.gov.in – Financing Norms). The terms and conditions specifically enumerated in this document will override the terms mentioned in the Financing Norms and Schemes mentioned which are in variance.

For further details please write to:
Chairman & Managing Director
Indian Renewable Energy Development
Agency (IREDA) Core 4-A, India Habitat Centre Lodhi Road, New Delhi 110003, Tel.: +91.11.2468 2201;
Fax: +91.11.2468 2202; Email: cmd@ireda.in, Kpphilip@ireda.in
Kindly visit the IREDA website **http://www.ireda.in/.**
The CST Loan Scheme and Application Form can be downloaded at the link: **http://www.ireda.in/forms/contentpage.aspx?lid=740**

SOLAR HEATING SYSTEM FOR MEXICAN COPPER MINE

Baerbel Epp*

Peñoles, founded in 1887, is a mining group with integrated operations in smelting and refining non-ferrous metals and producing chemicals. Peñoles is the world's top producer of refined silver and the leader in metallic bismuth in the Americas; the leading Latin American producer of refined gold and lead, and among the main refined zinc and sodium sulfate producers worldwide. Peñoles group has a copper mine in La Parrena at Mexico, which requires huge amount of heat for various processes involved in copper mining.

To meet its large energy demand, the company started exploring the environment friendly alternatives. Success of the Gabriela Mistral project in Chile helped Peñoles to understand the technology and adopt this technology for its mining plant.

Arcon-Sunmark, a top energy solution provider from Denmark was selected for implementing the project at the copper mine of La Parreña. In September 2016, the solar thermal project has been completed.

The System Details

This turnkey solution by Arcon-Sunmark is one of the biggest projects in term of large scale solar heating applications.

The new solar heating solution at La Parreña copper mine has a collector field of 6,270 m^2 with a total of 456 collectors. The size of each collector is around 14 m^2. A 660 m^3 storage tank is part of the system enabling surplus heat to be stored so it can be used at another point of time *(Image 1)*.

Table 1: Salient features of solar heating facility at La Parreña copper mine

Project Developer	Arcon-Sunmark , Denmark
Year of Commissioning	September 2016
No. of collectors	456 (~14 m^2 each)
Total collector area	6,270 m^2
Total heat produced at peak	5.1 MW
Heating demand met by solar	58%
Storage tank capacity	660 m^3
Annual energy cost reduction	58%
Estimated system life	25 years
Payback period	4 years (approx.)

Benefits

From now on, the copper mine will get up to 58 per cent of its annual heating demand covered by solar energy and over time leading up to a 58 per cent reduction in energy costs and also a significant reduction in CO_2 emissions. In addition to benefits, Mr Hans Grydehoej, International Sales Director of Arcon-Sunmark explains, "We are very proud to have been selected as partners for this project by a company such as Peñoles. Solar heating as an energy source within the mining industry has a great future due to both economic and environmental benefits. The La Parreña copper mine will become an example for others to follow".

The initial investment in the solar heating solution has a payback time of only four years, and with a system life span of at least 25 years, the mine will be supplied with free energy for more than two decades.

Image 1: Solar Collectors and Storage Tank installed at La Parreña Copper Mine

Calculations made prior to the construction show that up to 58 per cent of the heating demand can be covered by solar thermal energy which over time will result in annual reduction in energy costs of no less than 58 per cent.

[Source of original article http://www.solarthermalworld.org/content/mexico-second-solar-process-heat-case-study-copper-mining]

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AWARENESS SEMINARS ON CST AT MOUNT ABU

In order to create awareness amongst stakeholders from industries, institutions, and commercial establishments, two Concentrating Solar Technologies (CST) seminars, focussed on the presentation of UNDP-GEF policies, case studies, and available CST solutions, were held on 1 and 2 October 2016 and 5 and 6 October 2016, respectively.

The main objective behind this was the generation of proposals for installation of CST-based systems through seminars/ workshops/ demonstrations. The participants also visited numerous CST-based applications where solar heat is being generated and used for various institutional applications, such as cooking, laundry, sterilization of instruments in the hospital, and water pasteurization. The participants who attended the workshops included entrepreneurs, consultants, academician, scholars, and industrialists interested in applying CST solutions in their field.

Workshop conducted on October 1–2, at Mount Abu, Rajasthan

Workshop conducted on October 5–6, at Mount Abu, Rajasthan

AWARENESS WORKSHOP ON CST AT BHILWARA

Mewar Chamber of Commerce & Industry (MCCI) and Rajasthan Renewable Energy Corporation Ltd jointly organized a workshop on concentrated solar technology (CST) on November 25, 2016, at Mewar Chamber in Bhilwara, Rajasthan. The workshop was organized with a view to do a first-hand sharing of the technical and financial aspects and utility of CST-based systems with industries. Addressing the participants, Mr Sunit Mathur, GM (RE&O), Rajasthan Renewable Energy Corporation Ltd, showed huge confidence in CST plants and felt that these could have a major role to play in Bhilwara textile industry. He also said that these CST plants could be established wherever there were large-sized shades or roofs in the textile industry. Financial grants could also be provided by the Ministry of New and Renewable Energy (MNRE), Government of India, for this purpose.

Mr Mathur also highlighted that Rajasthan is a leading state in the country in the field of utilization of renewable energy. Blessed with abundant sunlight throughout the year and a huge land area, Rajasthan is a land of infinite possibilities in solar energy. So far, solar plants of the capacity of 1,295 MW have been established in the state. Of these, 152 MW are CST plants.

FORTHCOMING EVENTS

NATIONAL

- **Energy Storage India 2017**
  January 11–13, 2017 Mumbai, Maharashtra
  Website: http://www.esiexpo.in/
- **India Rooftop Solar Congress 2017**
  January 17–18, 2017
  New Delhi
  Website: www.rooftopsolarcongress.com
- **Pro Solar 2017**
  January 23–24, 2017
  Hyderabad, Telangana
  Website: www.prosolarindia.com
- **North India Solar Summit 2017**
  February 17–19, 2017
  Lucknow, Uttar Pradesh
  Website: www.niss.org.in
- **RenewX 2017**
  April 7–8, 2017
  Hyderabad, Telangana
  Website: www.renewx.in
- **Renewable Energy World India 2017**
  May 17–19, 2017
  Pragati Maidan, New Delhi
  Website:
  http://www.renewableenergyworldindia.com/index.html

INTERNATIONAL

- **ITA-IEL-ICC Joint Conference on International Energy Arbitration**
  January 12–13, 2017
  Houston, USA
  Website: http://www.cailaw.org/Institute-for-Transnational-Arbitration/Events/2017/ita-iel-icc-conference.html
- **International Energy Week**
  January 17–19, 2017
  Kuching, Malaysia
  Website: http://www.expodetail.com/iew-international-energy-week-2017
- **The World Future Energy Summit**
  January 16–19, 2017
  Abu Dhabi, UAE
  Website: http://www.orldfutureenergysummit.com/#/
- **International Conference on Renewable Energy Technologies**
  January 22–24, 2017
  Bangkok, Thailand
  Website: http://icret.org/
- **38th Annual Energy Generation Conference**
  January 24–26, 2017
  Bismarck, USA
  Website: https://bismarckstate.edu/continuingeducation/professional/Conferences/EGC/
- **Annual Handelsblatt Conference Renewables Energy**
  January 24–26, 2017
  Berlin, Germany
  Website: http://veranstaltungen.handelsblatt.com/energy-industry/

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