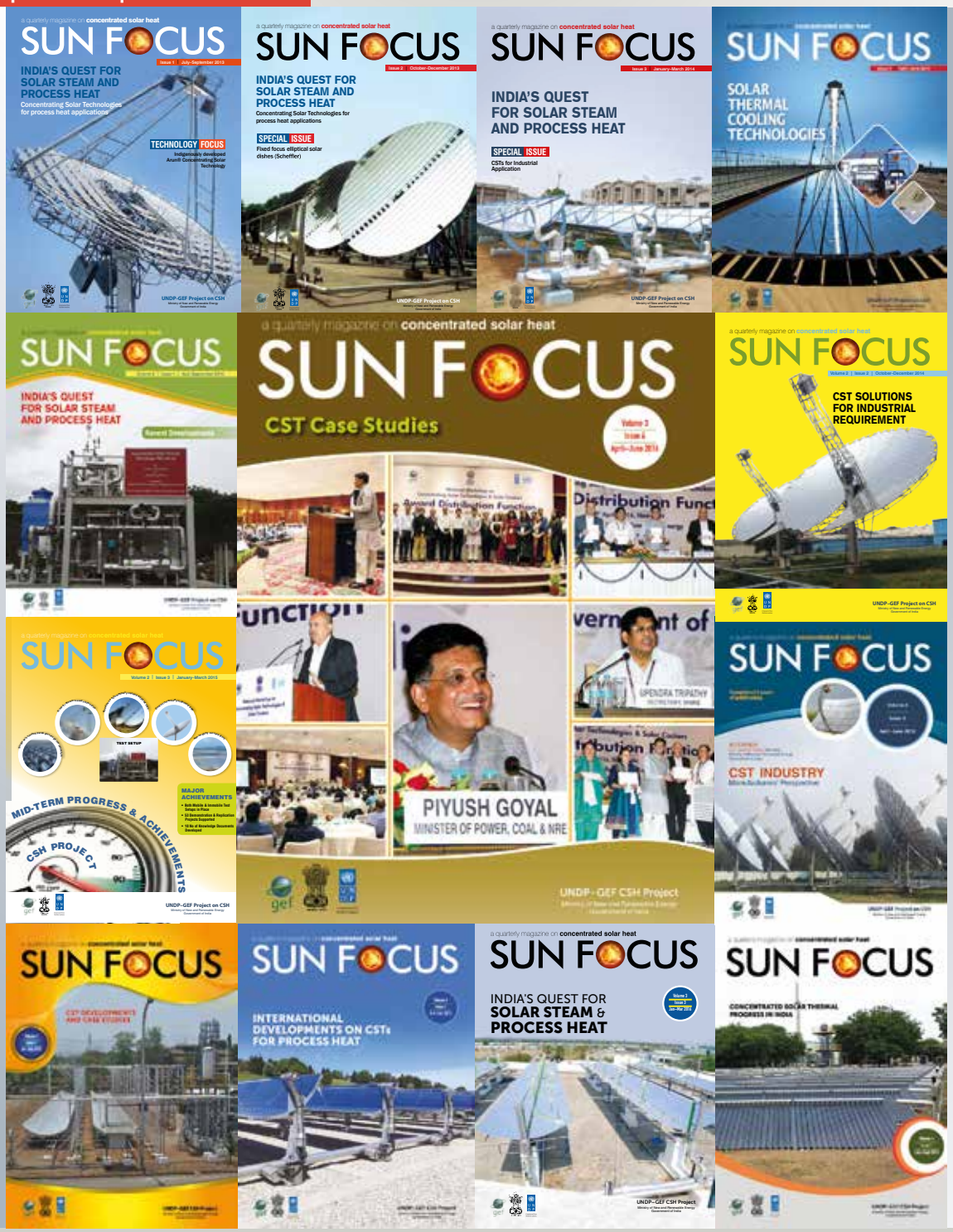
a quarterly magazine on **concentrated solar heat**

SUN FOCUS

Volume 4 | Issue 3 | Jan–Mar 2017

FIFTEENTH ISSUE



UNDP–GEF CSH Project

Ministry of New and Renewable Energy
Government of India

SUN FOCUS

Volume 4 • Issue 3
January–March 2017
a quarterly magazine on
concentrated solar heat

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Produced and Published by
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UNDP–GEF project on CSH
Ministry of New and Renewable Energy
Government of India, New Delhi
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&
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Lodhi Road, New Delhi – 110 003
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Printed at
SVS Press
116, Patparganj Industrial Estate,
New Delhi – 110 092, India

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PIYUSH GOYAL

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राज्य मंत्री (स्वतंत्र प्रभार)
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for Power, Coal, Mines and New & Renewable Energy
Government of India

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.

Shri Piyush Goyal

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सत्यमेव जयते
राजीव कपूर
Rajeev Kapoor

सचिव
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नवीन और नवीकरणीय ऊर्जा मंत्रालय
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 tapped 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 the 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

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From the editor's desk...

Dear Readers,

The Jawaharlal Nehru National Solar Mission (JNNSM) seeks to achieve a target of 20 sq. m. of solar thermal systems including CSTs by 2022. CST technologies have the potential to play a significant role in achieving this target.

The future of Concentrated Solar Thermal (CST) technology looks bright as the new UNIDO-GEF Programme has now successfully laid foundation for CST market development since 2015 through innovative financial mechanisms such as soft loans for CST projects. The current issue of *Sun Focus* magazine carries a very relevant article, "An Optimistic Growth of CSTs in India".

The UNDP-GEF CSH Project which is on the verge of completion has been able to create significant awareness of CSTs with newer and better technologies made available in the market, besides development of a large number of knowledge documents available on the CSH website. The impact of this project has been articulated in the article, "Impact of UNDP-GEF CSH Project in Addressing Barriers for Accelerating Growth of CSTs".

You would also find another article, "Information Awareness Proliferates Solar Thermal Market" useful and informative. Promisingly, various initiatives for information and awareness on solar thermal energy undertaken by Solar Thermal Federation of India (STFI) have so far been able to earn respect for solar thermal business development in India. Many other articles, such as "Highlights of CST Field Projects Supported under UNDP CSHP", "Online Performance Monitoring of CST Installations by APITCO Ltd", "Awareness-cum-Training Centres for CSTs at Brahma Kumaris, Abu Road", etc., are also featured in the issue.

I am delighted to share that *Sun Focus* has gradually gained popularity and has been admired by various stakeholders. The subscribers have found it very useful in their decision-making process for adopting CST technology. I am sure you will find this issue interesting and informative, similar to all previous issues of *Sun Focus* magazine and would like to thank all the readers and stakeholders for their interest and support and I look forward to their continued patronage for our future issues.

Sd/-

Anjani Nandan Sharan

Joint Secretary, Ministry of New and Renewable Energy &
National Project Director, UNDP–GEF CSH Project

AN OPTIMISTIC GROWTH OF CSTs IN INDIA

Dr R P Goswami*

Concentrated Solar Thermal (CST) technologies have wide range of applications across the various industrial sectors in India. These technologies have the potential to play a significant role in achieving India's solar mission target and also in achieving India's Nationally Determined Contributions (NDCs) of reducing GHG emissions as part of Paris Agreement on Climate Change Mitigation. MNRE has been promoting solar thermal technologies including CST technologies for the last few years and became a part of the first phase of National Solar Mission launched in 2010 wherein CST Technology based power plants with 500 MW capacity were tendered. Moreover, under the initial phase of NSM for implementation of "Off Grid applications" CST technology-based systems were promoted for industrial process heating, cooking and similar applications but in subsequent years these technologies became secondary to solar PV technologies due to market conditions. In the current climate, the solar thermal is gaining advantage again due to better efficiencies and smaller space requirements, which MNRE is keen to popularise not only power generation but also for heating, cooling and tri-generation applications.

MNRE and UNDP–GEF project on 'Concentrated Solar Heat' to promote concentrated solar heating applications since 2012 focused on developing markets for these technologies through development of test standards and facilities, new technologies, skilled manpower for design, development and installation, and commissioning of projects for innovative applications.

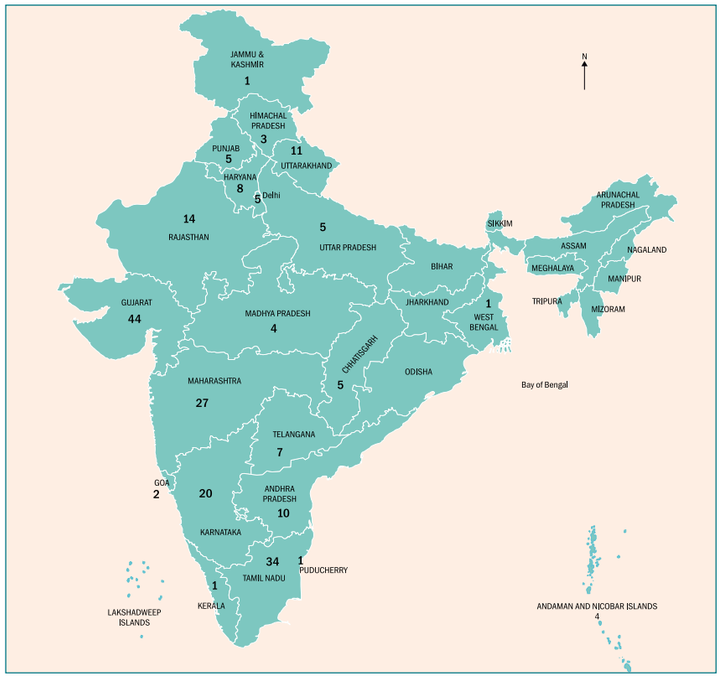

Figure 1: *State-wise CST systems installed as on March 2017*

S. No	Particulars	Total projects in numbers	Total Area (in sq. m)	Total in MW Equivalent
1.	Installed & Commissioned till March 2017	208	52448.4	35
2.	Projects Sanctioned & Under Installation till March 2017	110	28524.6	19
	Total	**318**	**80973**	**54**

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It will be appropriate to mention here that a CST based system having collector/reflector area 721 m² has recently been installed and commissioned for solar process heat application at M/s. Hatsun Agro Product Ltd., Salem. On an average, the solar system delivered about 190 KW per hour energy on sunny days and save about 635 kg or Litres of conventional fuel per day. Thus, the CST technology is directly contributing to meet the thermal energy requirement for production of more than 40 products at this site.

Image 1: *Hatsun Agro Product Ltd Plant Uses CPC for Hot Water Feed into Boilers*

Current Status

CST technologies and industries are flourishing in India. As on date, there are more than 203 numbers of systems having cumulative reflector area of 51,328 m². Apart from this, there are about 115 Nos. On-going projects having total collector/reflector area 30,000 m² area are under execution.

Future

CST technologies are becoming popular; however, the market penetration is still not up to the level where it can become self-sustaining. UNIDO–GEF programme has now successfully laid foundation for CST market development since 2015 through innovative financial mechanisms such as soft loans for CST projects.

The solar field can be used to produce process heat that can be used directly or for the steam production. For example, in the food and beverage industry, the solar generated steam can be used in almost all steps of the production as follows:

- Boiling
- Pasteurisation
- Sterilisation
- Drying
- Cooking/Evaporating

Table 1: Fourteen industry sectors

S.No.	Sectors
1	Textiles (Weaving, Finishing)
2	Pharmaceuticals
3	Tobacco
4	Breweries
5	Pulp & paper
6.	Electroplating
7	Food processing (including Dairy & Sugar)
8	Rubber
9	Chemical & Fertiliser
10	Petroleum Refineries
11	Desalination
12	Ceramic tile & pottery
13	Plaster of Paris, Steel re-rolling, Cement, Mining
14	Other industries including tertiary using steam or cooling

The true market potential of CST technologies in the industrial sectors has been assessed as 6.4 GW in India in a study recently commissioned by UNIDO. Fourteen industry sectors have been identified (Table 1) by UNIDO where CST technologies make economic and technical sense in terms of ready acceptability for their deployment for a variety of process heat applications in the temperature range up to 350°C.

IMPACT OF UNDP-GEF CSH PROJECT IN ADDRESSING BARRIERS FOR ACCELERATING THE GROWTH OF CSTs

Dr A K Singhal*

The UNDP-GEF Project on 'Market Development of Concentrating Solar Technologies for Process Heat Applications' initiated in April 2012 by signing the Project Document between MNRE and UNDP on 28 March, 2012, with inception workshop held on 18 May, 2012, in Delhi. The workshop, attended by over 200 stakeholders from various parts of the country, provided a platform to participants to discuss about barriers, limitations, opportunities, & potential for CSTs. It also helped the participants in understanding various components & activities planned in the Project.

Project Objective

The basic objective of the project was to accelerate activities of the MNRE programme on CSTs by removing barriers & developing the market through awareness generation, capacity building, & other required measures. It is a five-year project, scheduled to be completed on 31 March 2017, with GEF support of USD 4.40 million made available to MNRE through UNDP. The major outcomes expected from the project are enumerated further ahead, with baseline on CST installations taken as 85 systems having 25,000 sq. m. of concentrator area:

- Knowledge documents, test set ups & standards developed with barriers removed for large-scale promotion of CSTs
- 45,000 sq. m. of CST-based systems installed in 90 establishments through Demonstration & Replication projects resulting to 39,200 tonnes of CO_2 emission reduced & 3.15 million liters of fuel oil saved per year

Implementation set up

To implement the project, a Project Management Unit (PMU) was established in MNRE which comprises of National Project Manager (NPM), 2 Technical Officers & some support staff. A Project Executive Committee (PEC) chaired by Joint Secretary, MNRE, as National Project Director with Members from MNRE, NISE, IREDA, PMU & UNDP was also formed. Project Steering-cum-Advisory Committee (PSAC) chaired by Secretary, MNRE, with Senior Members from MoEF, DoE, UNDP, IREDA, NISE, SECI, Ministries of Textile, Food Processing, Medium & Small Scale Industries, BEE, BIS, CII, Central Boiler Board, IIT Bombay, etc., was also formed for the purpose of providing guidance & directions to PMU. While the PEC meets once in 2–3 months, the PSAC meets once in 6–12 months or as and when required.

Barriers in CSTs Growth

Major barriers listed in large-scale promotion of CSTs at the start of project were as follows:

- Lack of awareness about the technologies & their benefits. Information on successful projects not accessible to public.
- Lack of confidence on technologies. Lacking in trained manpower of technicians.
- No test standards & test set ups for measuring performance exists
- Space constraints for installations to beneficiaries
- Non-availability of solar grade mirrors in required sizes at reasonable prices.
- Non-availability of soft loans to beneficiaries & ESCOs
- Low returns on investments as compared to SWH. Requires higher support, especially for space cooling & standalone systems and also for non-profit making bodies
- Very few manufacturers. Not much competition. Finding difficult to control cost.

Activities Undertaken to Address Barriers

To address these barriers and achieve the set goal of installing 45,000 sq. m. of CST-based systems in 90 establishments, various activities were undertaken as per the project components outlined in the documents with outcomes given as per below:

Awareness generation & capacity building

Market Development Programmes were undertaken in industrial, commercial, and institutional sectors. Under the programme over 70 workshops/business meets were organized all over the country for various groups of participants amounting to around 3,000 in number. A number of video films on successful projects with case studies were also prepared and placed on the website. Monthly Electronic Newsletters were developed and made available at www.insolthermtimes.in. So far, 48 newsletters have been developed under the project. *Quarterly magazine* on CSTs was started.

Fifteen issues of the magazine 'SUNFOCUS' were published and distributed to over 500 to 100 stakeholders on quarterly basis. Advertisements on CSTs were released in national newspapers and industrial/commercial/ institutional magazines. So far, 7 ads, each in 3 national newspapers and 12 magazines were released. A National Toll free Helpline 1800 2 33 44 77 was also started which could be accessed during Monday to Friday between 9.30 am to 6.30 pm & on Saturday : 9.30 am to 1.30 pm. The Helpline is still in operation.

New website on CSH project www.cshindia.in was developed and is in place since last 3 years. The website has been found to be very useful to interested stakeholders as it contains all information related to CSTs and CST programmes/ activities. Over 6,000 people have visited the site so far.

Calendars for financial years 2014–15 & 2016–17 were prepared to highlight showcase CST installations and were distributed to various stakeholders to generate awareness about the technologies and their utility. A diary prepared for 2016–17 providing information related to CST projects and MNRE / UNDP programmes was also found to be useful. Exposure trips to showcase installations for potential beneficiaries were also organized through University of Pune.

A training-cum-awareness centre on CSTs has been established with Brahma Kumaris at Mount Abu for the purpose of creating awareness among various groups of stakeholders from industries, institutions & commercial establishments and also help in capacity building of manufacturers/ entrepreneurs on various aspects of technologies. The Centre keeps organizing awareness programmes and training programmes for respective group of participants, resulting in generating significant interest to go for installation of CST-based systems at their places and developing trained manpower of installers. Earlier under an assignment taken up, *Manuals on Operation, Maintenance & Troubleshooting on various types of CSTs* were also developed, both in Hindi and English, for the benefit of users and are available on CSH website besides organizing training programmes for ITI students/

Image 1: *Plant for making glass mirrors of solar grade quality at Vadodara*

Image 2: *State-of-art facility for PTC mirror manufacturing at Kuchch, Gujarat*

** National Project Manager, UNDP-GEF CSH Project, MNRE; Email: singhalak@nic.in*

operators of existing installations.

Test Set Ups and Standards

The important milestone of the project activities was establishment of test set ups for measuring the performance of various types of CSTs. So far, there were no such facilities in the country and manufacturers/beneficiaries of systems installed in the field were not sure of their actual performance on heat delivery. Under the project, first time in the country rather in Asia test facilities for CSTs both mobile and immobile have been established at two places; one at National Institute of Solar Energy (NISE), Gurugram, of the Ministry and the other at School of Energy of University of Pune (UoP). Whereas the immobile facilities at these places are taking care of testing of smaller CSTs and their components at respective centres, the mobile facilities are helping in testing the bigger systems installed in the field. These test set ups are also helping manufacturers and new entrepreneurs in improving quality of their products and getting certification for participation in Ministry 'programme. The test set ups are expected to help beneficiaries in raising their confidence in the technologies, thereby giving a big push to the CST programme in the country.

Development of Test Standards for CSTs was another important task to ensure quality in the field. An assignment on "Development of material and component specifications of various types of CSTs" was thus undertaken. Six such booklets on different CSTs have been prepared which act as reference document for maintaining quality of CST-based systems in the field by manufacturers. These booklets have also been used to develop BIS standards on CSTs by various Groups of Experts formed by MNRE. The draft standards developed were passed over to BIS for publication and are expected to be published very soon.

BIS Standard on CSTs under publication	
Part 1	Dish Technology-Requirements and Specification
Part 2	Scheffler Technology-Requirements and Specifications
Part 3	Parabolic Trough Concentrator-Requirements and Specifications
Part 4	Non Imaging Concentrator-Requirements and Specifications
Part 5	CSTs-Test Methods

Performance norms for various CSTs in terms of anticipated heat delivery in different regions were also finalized by a Group of Experts and are made available on the website for the knowledge of beneficiaries and manufacturers.

Online performance monitoring of field installations was made an important part of the project. To get that done an assignment on "Collection & Compilation of performance data of CST based system through remote monitoring" was taken up. Online performance data has started coming on the desktops of MNRE & UNDP-GEF officials with weblink details provided by the beneficiaries. It is expected to acquire data for atleast 40 systems by end of the Project. The data collected will help MNRE and the Project Unit in knowing heat delivery, fuel savings and GHG abatement from installed systems in the field. It will help beneficiaries and respective manufacturers also to improve upon their systems, if some shortcomings are observed.

Other Activities

Organization of Training Programmes for the senior officials of banks/FIs were taken up for the purpose of educating them to provide loans to the manufacturers and beneficiaries of CST-based systems. This resulted in developing schemes/issuing circulars by 4 banks namely; Syndicate bank, United Bank of India, State Bank of Bikaner & Jaipur and State Bank of Patiala on providing loans at priority interest rates for CSTs. State-of-art facility for PTC mirror manufacturing has been developed by M/s Thermo Glass Company of Cargo Power Ahmedabad at Kuchch district of Gujarat. A visit made by the senior officials of MNRE and UNDP project noted that it is a fully automatic solar grade parabolic trough mirror plant established first time in the country which will prove to be a landmark.

To highlight the achievements made in UNDP-GEF CSH project so far and also recognize the efforts made by various stakeholders in the field of CSTs, a National Workshop on CSTs & Solar Cookers-cum-Award Distribution Function was organized on 29 April 2016 in Delhi. The workshop was attended by over 300 CST stakeholders from all over the country wherein over 102 awards were given away by Shri Piyush Goyal, Hon'ble Minister of Power, Coal & New and Renewable Energy, and Secretary, MNRE, besides releasing various knowledge documents developed under UNDP-GEF CSH project. A ½ day international workshop was also organized on 19 November, 2015, as part of Intersolar India 2015. The workshop was attended by over 100 delegates with two international speakers from abroad. In addition to this, many more activities were undertaken which are not highlighted in this article.

Impact on CST Growth

It has been noted that the project activities has made a good impact in accelerating the growth of CSTs in country. Level of awareness & interest on CSTs has been found to be increased significantly. While earlier people were aware of solar water heaters, solar cookers and solar photovoltaic only, now there is widespread awareness among potential beneficiaries on concentrating solar technologies for medium and high temperature applications. This has resulted in increased number of installations & CST area which almost doubled in last 4 years (50,000 sq. m. as compared to 25,000 sq. m. before start of project). A total of 154 projects with 44,950 sq. m. area have been supported so far in the project. This includes 33 projects with 11,479 sq. m. which were either dropped or did not avail UNDP support. Out of these, 69 projects with 16,177 sq. m. have been commissioned. Another 52 with 17,294 sq.m. are under implementation.

The installations have spread to industrial & commercial establishments which was earlier seen in institutions only and that too for cooking (around 50% as compared to 20% in 2012). The applications have now spread to milk pasteurization, medicine preparation, metal phosphating, flavouring of tobacco leaves, component washing, ironing in laundry, waste water evaporation etc. Newer & better technologies have been introduced with systems having heat storage also for use on non-sunshine hours etc. Cooking of food at 4 a.m. in R K Mission School, Chennai, is an example. Dish technology installed on pillars have addressed the barrier of space constraint as the space below dishes installed could be used for parking of vehicles or some other use. First time the project proposals have also started coming for implementation in ESCo mode. Five projects are under implementation. Loans at lower interest are now available from some banks and IREDA which has addressed the issue of high investment in the beginning.

Image 3: *Release of CST Knowledge Documents during the award function*

To address the issue of quality of systems in field, for the first time in the country, National & Regional Test Centers (Mobile & Immobile) have been established at NISE, Gurugram & UoP, Pune. Booklets on component & material specifications of 6 CSTs are in place for guidance to suppliers & beneficiaries. BIS standards on various CSTs and test methods are under publication. Making the online performance monitoring arrangement mandatory has helped in developing the confidence of beneficiaries and keeping a check on the manufacturers. A plant for edge sealing & back coating of solar grade cut mirrors established by ARS, Vadodara, with 5 years guarantee on mirrors has further enhanced the confidence of manufacturers and beneficiaries. Another plant established for making state-of-the-art parabolic trough mirrors established by M/s Thermosol Glass (P) Ltd, A'bad at Kuchch, Gujarat, is going to be a landmark and unique in the country as the company provides 25 years guarantee for their mirrors with much higher heat delivery as compared to other existing technologies.

Conclusion

In all, it could be said that the project has been able to create greater awareness on CSTs with newer and better technologies introduced, test set ups and BIS standards established, besides developing a large number of knowledge documents available on CSH website. This has resulted in accelerating the growth of CSTs significantly in the country with over 150 projects of 50,000 sq. m. supported during the project period as compared to 85 with 25,000 sq. m. at the start of the project. Most of the barriers mentioned in the article for accelerating the growth of CSTs have been addressed.

HIGHLIGHTS OF CST FIELD PROJECTS SUPPORTED UNDER UNDP CSHP

Kumar Abhishek[1] and Rahul Udawant[2]

The UNDP-GEF Project on 'Market Development of Concentrating Solar Technologies for Process Heat Applications' initiated in April 2012. One of the objectives of the project is to promote the Concentrating Solar Technologies for industrial process heat applications in India and facilitating the installation of 45,000 m^2 of installed solar collector area by March 2017 through Demonstration and Replication Projects. Direct emission reduction from these projects during its 5 years period is expected to be 39,200 tonne of CO_2.

Background

The industrial sector is the second-largest energy-using sector in India after the residential sector. Key energy using industries (such as, pharmaceuticals, chemicals, metal treatment, textiles, and food and dairy processing) have a significant requirement for low medium temperature heat (up to 250oC) as steam, pressurised hot water, hot air, and hot oil. Significant quantities of low-medium temperature process heat are also required in the commercial sector in hotels, hospitals, and other institutional buildings for space cooling, cooking and space heating. This low-medium temperature heat is primarily provided by fuel oil, coal, biomass, and electricity for cooling. CSH for process heat applications is at an early development stage- with less than 250 known working examples worldwide. India is leading the world with around 200 CSH applications.

Installations During Project Period

The PMU under the UNDP-GEF CSH project took a large number of initiatives during the last 4 years as regards to awareness generation, capacity & market development programmes, including advertisements in newspapers, industrial and commercial magazines, development of case studies and video films, etc. This led to an increased awareness among beneficairies about the use of CSTs. New and better technologies were also introduced by the manufacturers which increased installations in the industrial and commercial sectors where the potential is very high.

A total of 154 projects have been sanctioned so far with CSH projects. Out of these, 70 are commissioned, 45 are under implementation, 23 are not taken up (this included the projects which were either dropped or did not take support from UNDP GEF CSH project), and 16 have been supported for repair and renovation. The technology- and application-wise details of these projects are shown in Table 1.

Table 1: Technology- and application-wise status

Technology - wise Status on Field Projects								
Technology	**Commissioned**		**Not taken up/support not availed**		**Under implementation**		**Total**	
	No.	Area	No.	Area	No.	Area	No.	Area
Paraboloid	11	3606	7	4680	9	2464	27	10750
Arun	8	1295	3	442	0	0	11	1737
PTC/CLFR	16	3764	6	1475	3	800	25	6039
Scheffler	28	3712	5	1472	17	2992	50	8176
CPC	7	3154	2	1296	16	10070	25	14520
Grand Total	**70**	**15531**	**23**	**9365**	**45**	**16326**	**138**	**41222**

[1] *Technical Officer, MNRE; Email: abhishek.mnre@gmail.com*
[2] *Technical Officer, MNRE; Email: rahulgiri.ru@gmail.com*

Application- wise Status on Field Projects								
Application	**Commissioned**		**Not taken up/support not availed**		**Under implementation**		**Total**	
	No.	Area	No.	Area	No.	Area	No.	Area
Process heating	34	10027	15	7539	20	10622	69	28188
Cooking	34	4042	8	1826	22	3340	64	9208
Space cooling	2	1462	0	0	3	2364	5	3826
Total	**70**	**15531**	**23**	**9365**	**45**	**16326**	**138**	**41222**
Repair Projects	12	3394	0	0	4	333	16	3727
Grand Total	**82**	**18925**	**23**	**9365**	**49**	**16659**	**154**	**44949**

Highlights of some projects

Mother Dairy, Delhi	
Technology	**Paraboloid Dishes each of 95 sq.m.**
System Size	1,520 sq. m. (16 nos. of Dishes)
Application	Cleaning in Place (CIP) process
Manufacturer	Megawatt Solutions, Noida
Sanction Date	MNRE & UNDP : February 2016
Commissioning	November 2016
Cost & Support	Project Cost: ₹345 lakhs ; MNRE Support: ₹91.20 lakhs ; UNDP Support: ₹42.75 lakhs.
Process	Paraboloid dishes which heat water at 70°–90°C being used for CIP process after mixing caustic soda (lye) and dilute nitric acid.
Savings & Other benefits	235 SCM of PNG being saved on daily basis. Pay back period estimated as 6.5 years @ ₹40
On line data accessible on MNRE desktops	

PSG Hospitals, Coimbatore	
Technology	**Parabolic Trough**
Systems (2Nos.)	50 m^2 each at 2 blocks
Application	Laundry and sterilization
Manufacturer	Greenera Energy Pvt. Ltd
Sanction Date	MNRE : September 2014 UNDP : March 2015
Commissioning	September 2014
Cost & Support	₹25 lakhs ; MNRE : ₹5.40 lakhs ; UNDP : ₹4.00 lakhs
Process	Steam produced at 150 C & 3 bar being used for drying & sterilization purpose. System is hybridized with electrical heaters at one block & boiler at other block.
Savings	On a average, each system delivers steam at @ 16kg/hr and saves 12 litres of fuel per day. Expected Payback:3.5 years

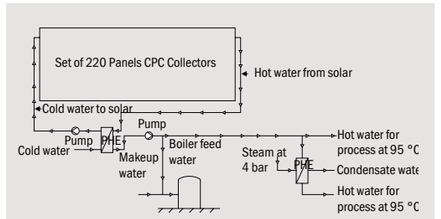
Tamil Nadu Agricultural University	
Technology	**Paraboloid Dishes each of 25 sqm.**
System Size	250 sq.m (10 nos. of Dishes)
Application	Steam Cooking
Manufacturer	A.T.E. Enterprises, Pune
Sanction Date	MNRE: February 2016 / UNDP: February 2016
Commissioning	January 2016
Cost & Support	Project Cost: ₹82.00 lakh; MNRE: ₹15.00 lakh; UNDP: ₹7.50 lakh
Process	Dishes with heat storage & integrated to boilers are able to cook food for 1,000 students even during non sunshine hours.
Savings & Other benefits	About 130 kg of LPG to be saved per day. Pay back:3 years @ ₹60
Online data accessible at MNRE desktops	

Rainbow Dry-cleaning Industries, Aurangabad	
Technology	**Paraboloid dual axis tracking**
Systems (2Nos.)	25 sq. m.
Application	Steam Ironing in Laundry
Manufacturer	A.T.E. Enterprises, Pune
Sanction Date	MNRE: 21 September 2014 / UNDP: 17 November 2015
Commissioning	19/10/2015
Cost & Support	₹10.00 lakh; MNRE: ₹1.50 lakh; UNDP: ₹1.50 lakh
Process	Steam generated is being directly used for ironing. Earlier beneficiry was using electricity for this purpose.
Savings	Savings: ₹700 per day on electricity. Payback expected is 3.5 years.
Online data accessible on MNRE desktops	

The figures cited Table 1 clearly indicate that utilization of solar concentrating technology is crucial, specifically for cooking and process heating applications, in India. Many Scheffler dishes have been used so far for cooking application. Use of parabolic trough collectors and paraboloid dishes has been consistently growing in last five years.

It would be worth stating that by the efforts made in this project, approximately 35,000 m^2 of collector area of CST systems has been added for various applications. Sanctioning of projects under ESCO mode and recommissioning of more than 5 year old systems are other remarkable achievements under the project. In total, 5 projects under ESCO mode are under implementation, besides 16 supported for repair and renovation.

Abbott Healthcare Pvt. Ltd	
Technology	**Parabolic Twin dishes each of 31 Sq.m.**
System Size	186 (6 modules of twin dishes)
Application	Process heat applications
Manufacturer	Forbes Solar Pvt. Ltd
Sanction Date	MNRE: 4 March 2014 UNDP: 26 March 2014
Commissioning	June 2014
Cost & Support	₹69.16 lakh; MNRE Support: ₹11.16 lakh; UNDP Support : ₹2.00 lakh
Process	Hot water generated from dishes is fed to boiler which produces steam for preparing drugs.
Savings	Expected saving 122926 kg of fuel per year and annual reduction of 25 tonnes of CO_2. Around 337 kg of furnace oil being saved daily. Payback is high due to cost of state-of-art dishes.
Online data accessible on MNRE desktops	



After Solar Intervention

Ultramarine Pigments, Vellore	
Technology	**Paraboloid Dishes each of 95 sqm.**
Systems (2Nos.)	570 sq. m. (6 nos.)
Application	Drying of pigments
Manufacturer	Megawatt Solutions, Noida
Sanction Date	MNRE: February 2016 / UNDP: February 2016
Commissioning	June 2016
Cost & Support	Project Cost: ₹145 lakh; MNRE Support: ₹34.20 lakh; UNDP Support: ₹17.10 lakh
Process	Paraboloid dishes which heats thermic oil up to 200°C generates hot air at 140°C for pigment drying.
Savings	Expected saving: 120 kg of superior kerosene per day. Drying time which was earlier 2–3 days reduced to 6 hours. Shifted to close drying from open field drying, leading to improved products
Online data accessible on MNRE desktops	

Conclusion

It may be noted that with the efforts of PMU, under UNDP-GEF CSH project, the CST sector has attained significant growth with installations spread in industrial and commercial sectors. The major factors that have scaled up the deployment of CST technologies are:

a. Increasing awareness and acceptance of CST;
b. Increased number of participants entering the market with larger share of private investment;
c. Investment in market development and R&D initiatives related to solar energy; and
d. Mass production and heightened levels of marketing, driving down costs of procurement, and installation.

ONLINE PERFORMANCE MONITORING OF CST INSTALLATIONS BY APITCO

Mr Srinivas Rao*

In the first two years of 'MNRE-UNDP-GEF project on Concentrated Solar Heat' programme, EcoAxis conducted the study of establishment of online monitoring systems in demonstration mode in fifteen systems across various applications, technology types, and geographical regions. EcoAxis has successfully implemented remote monitoring solution for CST-based steam generation system, thermic fluid, and pressurized hot water system at 15 different site locations under the project. The remote monitoring solution is designed to capture data from the multiple locations and produce reports on overall system performance. The monitoring of CST systems benefited the users of CST system, manufacturers and policy makers with essential information for continuous development and promotion of such systems.

In December 2014, the activity was proposed to scale-up online installations for systems further sanctioned until March 2017 and the assignment was given to APITCO Ltd, Hyderabad, with the following objectives.

Objectives

- Facilitate the implementation of online monitoring systems in CST systems either by consulting agency themselves or through linking suppliers based on category of projects
- Visiting the site and collection of CST plant details, and reporting its performance
- Compilation of online data on thermal / heat (viz. inlet and outlet temperature, flow, pressure) and meteorological parameters (wherever applicable), and
- Estimation of reduction in carbon emissions CO_2. The data has to be tabulated on monthly basis and presented on quarterly basis. In addition, based on the performance data the study comprises a two-page brief of each of the commissioned plants.

Collection of Baseline Information

The study done by APITCO establishes baseline information of each plant with details of earlier arrangement, reason for installation, type of system installed, standalone or integrated set up, operational & maintenance issues, system's performance since installation and the status on installation of dishes, quality of mirrors and other components. The study covered operational parameters to know the operating temperature, pressure of steam/fuel, type and amount of fuel being saved in a year and verify maintenance of any manual systems for such data. A broad view of the beneficiary on system's performance since installation is accounted for further improvements in the programme.

Growth of CST Installation

Until December 2016, 136 plants have been sanctioned, comprising of 43 demonstration plants, 56 replication plants, and 37 other projects. So far, 71 plants have been implemented and remaining are under tendering or commissioning stages. Out of 71 plants, 42 plants have been set up with online monitoring instrumentation.

The pace of implementation of CST plants has been slow as compared to the plants sanctioned. Only 17 plants were installed in December 2014. By December 2015, the installations reached to 38 plants. Only 59 plants were implemented by October 2016 and 71 plants by February 2017.

Instruments for Online Performance Monitoring

The performance of CST systems is based on the energy input and output parameters. Input parameters being, the solar radiation, ambient temperature, and wind speed. The output parameters on which the performance depends are inlet water/thermic fluid temperature, outlet hot water/steam/heated fluid temperature, pressure in system, and flow rate of steam/hot water/thermic fluid. The online performance monitoring system comprises of three aspects.

- Weather instruments: pyranometer for measurement of global radiation, pyranometer with shaded ring for measurement of diffused radiation, continuous weather station fitted with anemometer to measure wind speed, and sensor for recording ambient temperature.
- Thermal output instruments: temperature sensors, pressure transmitters, vortex flow meter for steam flow measurement, and electromagnetic flow meter for measuring hot water flow.
- Data acquisition and management system: This includes data acquisition from the weather and thermal instruments and data transmission through a sim-based data logger system.

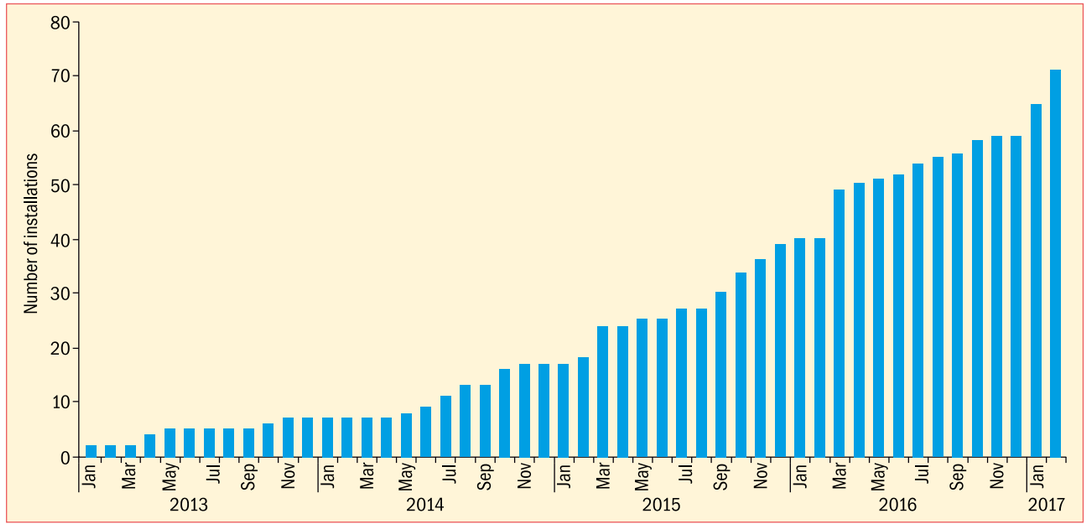


Figure 1: *Growth of CST Installations (2013–17)*

Data Collection Through SIM-Based Online Arrangement

So far, online performance arrangement has been done on 40 CST installations which include 15 by EcoAxis, Pune prior to the assignment with APITCO. The online arrangement provides web link details to MNRE/PMU with password and user ID. A sample of data collected on one of the systems is as below.

M/s Zytex Biotech, Mumbai: Zytex Biotech uses Parabolic Trough Collector (PTC), manufactured by Ultraconserve, with an area of 136 sq. m. for process heating. The monthly savings in fuel recorded at Zytex are depicted in Table 1.

Table 1: Monthly fuel savings at M/s Zytex Biotech in 2016

Month	Days Operated	Average inlet temp (Ti)	Average outlet temp (To)	Diff. in Average outlet & inlet temp (To-Ti)	Total Fuel Flow (M) (in KL)	Total Heat Delivered (in Lakhs of Kcals)	Fuel Saved (in Liters)	GHG Abated (in Tonnes)
January	11	78	84	6	24,328	563	5362	14
February	2	36	40	4	2,101	337	322	1
March	27	71	78	7	44,146	1252	11924	32
April	24	76	81	5	17,360	519	4948	13
May	24	76	80	4	20,704	628	5981	16
June	26	67	74	7	39,788	1106	10541	28
July	25	45	49	4	12,637	183	1745	5
August	23	43	46	3	9,728	127	1214	3
September	28	56	59	3	44,201	765	7292	20

* *Chief Consultant, APITCO Ltd, Hyderabad; Email: srineev@yahoo.com*

Image 1: *UCPL Parabolic Trough installed at Zytex Biotech*

Key Benefits of Online Monitoring

The online monitoring of systems enables to understand the performance of various plants across geographical regions, applications, and technologies. It creates a database of meteorological parameters useful in research for solar energy development and deployment at a large scale. This also helps to understand the cost benefit of system more appropriately based on actual data and provides a scope for verification in design and quality of material for improvements by manufacturers.

Limitations of Online Monitoring in CSTs

The lack of standardization of online monitoring systems is a limitation, resulting in non-uniform approaches of data acquisition, data transmission, and data analytics. Limitation in data parameters and data retrieval features, confines the strength of online monitoring technologies available in the market. There is lack of understanding and interpretation of hourly-data, daily-data vis-à-vis throughput of CST systems which may result in erroneous results. The absence of information sharing amongst stakeholders decelerates the process of establishing online systems and understanding the performance. Finally, an effective after sales service in online monitoring systems is essential to help users for affective use of the system.

Interventions for Growth of Online Monitoring in CSTs

The standardization of online monitoring systems is essential with a full-fledged system, which is now limited to daily data retrieval. The manufacturers should provide total standardized solutions, while MNRE should integrate the online component in the subsidy/CFA for CST systems. After sales services of online systems should be made compulsory and more startup companies should be brought in online monitoring as it involves major IT and communication technology component. Areas which are remote and distant may be provided total cost of establishing online systems due to higher lead time and access to location for completion of tasks. It is beneficial to conduct capacity-building workshops and training in this segment which will strengthen manpower in this segment.

INFORMATION AWARENESS PROLIFERATES SOLAR THERMAL MARKET

Jaideep N Malaviya*

Providing effective information and reaching out to people is the key for any business to proliferate and with the rapid technological advancements with it is essential to keep oneself updated with the events around. The GEF-UNDP programme on concentrated solar thermal systems was to be a major revolution for market development of solar thermal business in India. In order to create tools for awareness and sharing the developments in solar thermal, the Solar Thermal Federation of India (STFI) developed three vital initiatives:

a. National Toll free Solar Energy Helpline (1800 2334477)
b. Solar Thermal e-Newsletter (www.insolthermtimes.in)
c. Concentrated Solar Thermal Heating website (www.cshindia.in)

These activities are proving constructive to the masses and aptly fulfill the goals of GEF-UNDP programme. It is, in fact, one of the success case stories under the GEF-UNDP programme and validates the support.

National Toll-Free Solar Energy Helpline

Since the toll free National Solar Energy Helpline (1800 234477) started in July 2011 under the GEF-UNDP solar water heater project, it has received over 5,00,000 calls and presently caters to all forms of solar energy. It is perhaps the first such global Helpline on Solar Energy supported by a federal government. The objectives are to guide the user with its requirements and address callers' requirements and complaints. The operational timings are from 0930 to 1830 hours, Monday–Friday and 0930 to 1330 hours on Saturdays. The medium of language for communication presently is Hindi and English. Callers are from all walks to life, i.e. commercial organizations, experts, consultants, government officials, academicians, students, and above all the common man.

Image 1: *Solar Energy Helpline*

Whenever a caller wants in-depth understanding of any technology the Helpline directs them to visit the Frequently Asked Questions (FAQs) available on MNRE and Solar Thermal Federation of India websites. The FAQs cover all forms of solar energy technologies, i.e. Concentrated Solar Thermal, Solar Water Heater, and PV. They are periodically updated with latest information and helped the masses to resolve their queries.

The initial year's lack of effective publicity resulted in fewer call and mostly originated as complaints of end-users and their word of mouth publicity to their close accomplices for general information. In order to increase its far reach to the masses as on a pilot basis, Short Messaging Service (SMS) publicity was undertaken in late 2013 and 2014 informing about the Helpline service and to call to take advantage. India has the world's second largest mobile phone density (84%) and taking advantage of this fact it was found to be the most cost-effective tool for publicizing the Helpline to the masses. The SMS's were sent to 20 lakh mobile users in 25 major cities of India targeting architects, hotel owners, salaried people, builders, real estate developers, industry owners, high net worth individuals, doctors, and chartered accountants. This resulted in almost 300% rise in call traffic during that year. Subsequently Ministry of New and Renewable Energy (MNRE) and some of the state nodal agencies (SNAs) prominently displayed this number in all their print and electronic communications. Thus, the Helpline receives widespread

** Secretary General, Solar Thermal Federation of India, Pune; Email: info@stfi.org.in*

publicity and today it has very well penetrated almost all the social media.

Another advantage the Helpline has offered is that the publicity about SNA has also increased as select calls share the phone number of SNA from the state they call resulting in a closer interaction between the SNA and the beneficiary. Complaints for non-performance of systems also benefitted some of the large manufacturers and proved useful to resolve the complaints. Using the MNRE email database of manufacturers, the complaints received are forwarded to the respective manufacturer.

A quick glance at the number of callers during the period 2012–16 (Figure 1) reveals the accomplishment of this creativity.

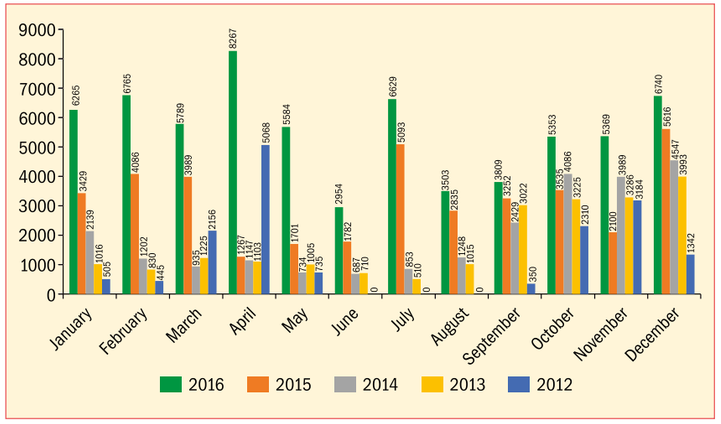


Figure 1: *Number of Callers on Solar Energy Helpline during 2012–16*

Interestingly, calls from students of technical institutions and entrepreneurs are on the rise seeking more information about solar energy and the desire to get trained. This has benefitted National Institute of Solar Energy to receive applications for their capacity building workshops and helping the government fulfil its objectives of generating skilled employment.

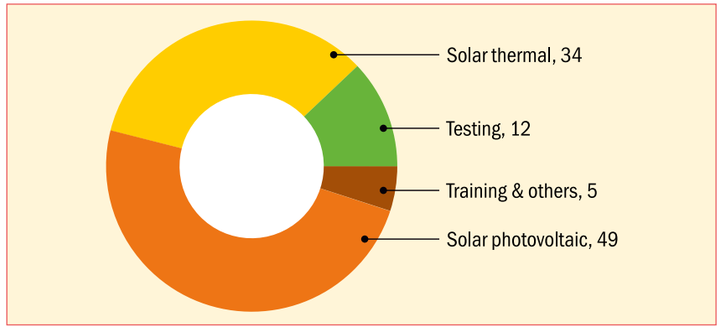


Figure 2: *Breakup of calls received sector-wise in 2014*

Solar Thermal e-Newsletter

The wonderful projects developed by manufacturers and developers needed to be recognized globally and the only way was to publish them in form of newsletter that would reach the desk of an avid reader. Keeping this fact in mind, STFI started a monthly e-Newsletter "InSolTherm Times" (www.insolthermtimes.in) in August 2011 focused on solar thermal. Perhaps it the only dedicated solar thermal e-Newsletter published by any country. In the initial three months, it already had over 1,000 subscribers. Over the years, the word spread around about this publication at various events in India and globally and the curiosity increased. Until December 2016 when the last edition under GEF-UNDP was published, the subscriber base was 5,249 and this number is sufficient to speak its popularity.

The newsletter covered all forms of solar thermal developments in India, be it water heating, steam cooking, process heating, cooling, and drying. On an average, six to eight news per month would appear including interviews of prominent personalities and end users. Prominent events happening in the country also received attention. Although the newsletter focused on current happenings, however, to make it more interesting to the reader it also included other sections like feature stories, R&D activity by industries, policy announcements by Central or State governments & other agencies, noticeable international projects, and personality interviews. During the period, August 2011–December 2016 a total of 426 news

Image 2: *The InSolTherm Times masthead*

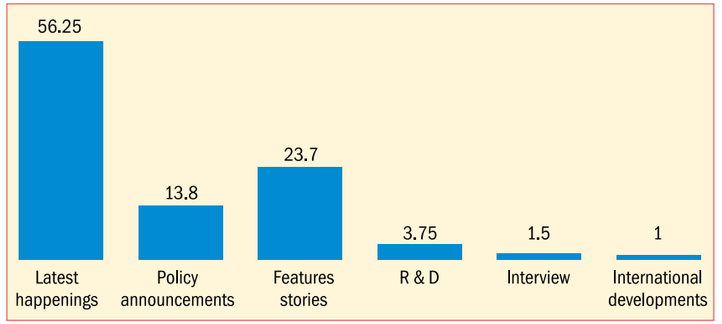


Figure 3: *Breakup of news covered sector-wise in InSolTherm Times during 2011–16*

and the other stories were published. A feature to search a particular news was also provided on the website. Figure 3 depicts the news covered category-wise.

The e-newsletter attracted several international manufacturers to consider doing business in India with their developments. Christoph Klein-Schmeink of Magontec, Germany, one of the leading manufacturers of magnesium and magnesium products informs "the admirable solar thermal market development shared in the newsletter attracted me to explore my business in India".

The success of the newsletter can also be attributed to the positive anticipation by manufacturers who would willingly share the information. While due care was taken to acquire first-hand information, personal visits were made at sites of installations and for interviews to ascertain the claims.

Concentrating Solar Thermal Heating Website

With the objective of providing single window for information dissemination about medium to high temperature project developments through concentrated solar and the periodic policy announcements encouraging concentrated solar thermal systems, a dedicated and comprehensive website www.cshindia.in was developed in November 2013. The website gives basic information about the various concentrating technologies and their advantages, list of successful projects, database of manufacturers of cooking and hot water processing and cooling, channel partners of MNRE and consultants. The incentives available from MNRE and GEF-UNDP project were revised from time to time. The six types of solar thermal technologies listed include Fresnel Reflector, Linear Fresnel Reflector, parabolic trough, paraboloid dish, Fixed Focus Elliptical and non-imaging. A detailed description of each of these technologies is listed out. Any potential customer get a clear picture of the technology and enables making a faster decision while considering implementation. Since its launch, the website receives global visitors more than 400 daily. The Google analytics report until December 2016 indicates the global number of visitors as 28,539 visitors. Besides India, visitors frequenting are from Russia, European Union countries and USA. The high volume itself speaks of the importance of the sector and studies the exciting progress happening. The most promising feedback received are the variety of videos available on successful case studies of concentrating solar thermal projects considering the fact 'seeing is believing'.

Looking at the popularity of the various medium-high temperature solar thermal technologies, the website will prove a blessing for business development in future.

Image 3: *Snapshot of www.cshindiain website*

Conclusions

The various initiatives for information and awareness on solar thermal energy undertaken by STFI have successfully delivered its importance and so have been able to earn respect for solar thermal business development. Most essential it has raised the confidence bar of an Indian investor and will be remembered in the long term as a worthwhile idea. These initiatives have also set global benchmarks and influence any country while planning solar thermal market strategy.

The Solar Energy Helpline is becoming a one stop window for all needs concerning solar energy and it won't be a wonder if it gets tagged as "Solar Energy Hotline" in the future.

AWARENESS-CUM-TRAINING CENTRE FOR CST TECHNOLOGIES AT BRAHMA KUMARIS, ABU ROAD

B K Jayasimha*

Realizing the importance of knowledge dissemination on Concentrating Solar Heat (CSH) technologies, the Project Management Unit (PMU) of UNDP-GEF assisted CSH Project of MNRE, awarded an assignment to World Renewal Spiritual Trust (WRST) for conducting awareness seminars and trainings on CST technologies in May 2014.

WRST has gained substantial knowledge and expertise in this field by developing and demonstrating various CSH projects for more than 20 years. Additionally, there are many CSH demonstration units working successfully for nearly two decades in Mt Abu and Abu Road. This provides an excellent opportunity for participants to learn and explore existing functional systems. The international headquarters of Brahma Kumaris at Mt Abu and Abu Road (Rajasthan) hosts about 1 million people every year from all over the world. To fulfill the energy requirements of the large campuses, various CSH-based systems were developed in house.

About the Programmes

CST Awareness Seminars and Technology Trainings are conducted at "India One" Solar Thermal Power Plant (www.india-one.net), a prestigious R&D project on Concentrating Solar Power (CSP) and has all CSH demonstration units developed and installed under UNDP-GEF assisted CSH Project of MNRE.

The CST Technology Trainings aim at supporting the capacity building of CST manufacturers and entrepreneurs in the area of CST quality, especially in the field of mirror reliability, durability, performance improvements, manufacturing skills, customization of end user products/systems, etc. During the training programme, participants explored and gained practical experience on the concept, design, fabrication, and installation features of 16 sq. m Scheffler paraboloid reflector.

Image 1: *Two 16 sq.m Scheffler Reflectors for demonstration and training*

Objectives

The objectives of the Awareness-cum-Training Center are to provide:

- Insights of various CSH technologies available in India and the world;
- Knowledge on geometrical aspects, manufacturing considerations, installation and maintenance of CSH-based systems;
- Techno-economic analysis of various CSH-based systems;
- The procedure for output measurement and determination of the efficiencies;
- Guidance in adopting suitable CSH technology on the basis of the temperature requirements, DNI data, location, etc.;
- Training on design, installation, manufacturing and O&M of 16 sq. m Scheffler reflector.

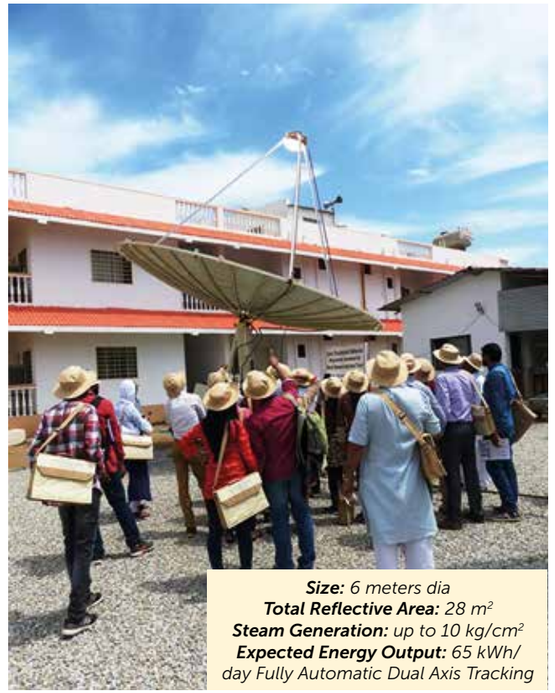


Image 2: *8 sq.m Moving Focus Paraboloid Dish*

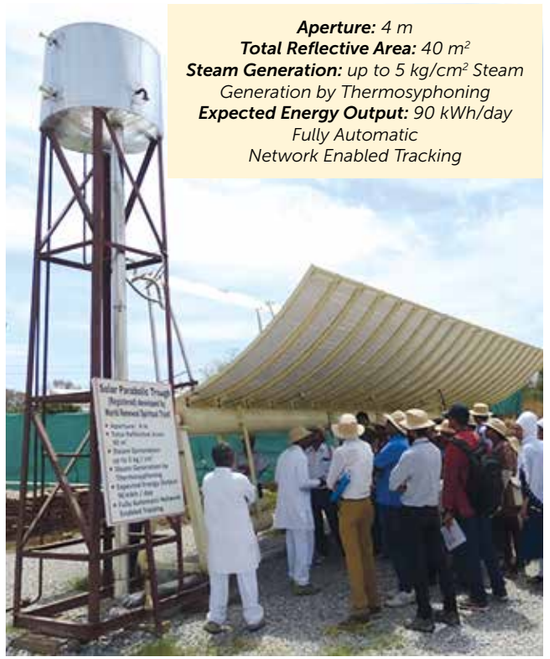


Image 3: *40 m² Parabolic Trough Concentrator*

Achievements

- So far, a total of 8 awareness programmes and 6 training programmes have been organized by the Centre.

	No. conducted	No. of participants
Awareness Seminars	8	180
Technology Trainings	6	150
Workshops for SNAs	1	37
Total	**15**	**367**

- To demonstrate the various types of CSTs, the Centre has developed the following 4 cost-effective CSTs:

a. 16 sq. m Scheffler Reflectors (2 nos.)
b. 8 sq. m Moving Focus Paraboloid Dish
c. 40 m² Parabolic Trough Concentrator
d. 12 sq. m Compound Parabolic Collectors

Highlights of the Centre

- The Centre has developed an edge sealing mirror technology which increases the life of the mirror from 5 to 15 years. The technique can be used by various manufacturers in the country.
- Cost-effective CSTs have been developed and demonstrated by the Centre for the benefit of potential users and manufacturers.
- Training manuals/capsules on various CSTs have been developed which could be useful to entrepreneurs and manufacturers.
- Development of 60 sq. m size Scheffler dish with dual axis trading and heat storage which could act as a standalone system for various applications. These dishes have been used for the 'India One' programme to generate 1 MW power on a 24-hour basis.

* *CEO, "India One"Solar Thermal Plant, Brahma Kumaris Ashram, Mount Abu; E-mail: bkjsimha@yahoo.co.uk*

CST TEST CENTRES–SUPPORTING CSH PROGRAMME OF MNRE

Mr S K Singh[1], Mr Kiran Deshpande[2], and Dr Anagha Pathak[3]

National Institute of Solar Energy (NISE) and Savitribai Phule Pune University (SPPU) has state-of-art test laboratories for testing and certification of Concentrated Solar thermal (CST) technologies. The test laboratories were developed under UNDP-GEF Project "Market Development and Promotion of Solar Concentrated based Process Heat Application in India (India CSH)". The test laboratories are first of its kind laboratories for testing of Concentrated Solar Thermal (CST) technologies in Asia. The testing laboratories have their own weather station and have the following facilities for testing of CST technologies:

- Test facility for testing of hot water/steam-based CST systems.
- Test facility for testing of thermal oil-based CST systems.
- Mobile test facility for on-site performance evaluation of CST systems.
- Concentrated Solar Thermal (CST) component test facility.

Importance of Testing

Concentrated Solar Thermal (CST) technologies are new and emerging technologies in Indian market. The Ministry of New and Renewable Energy (MNRE) has made it mandatory for manufacturers/ supplier to test their CST system to get empanelled as a channel partners.

Testing of CST technologies is aiding in creating standardization among products, systems, and components manufactured by various manufacturers across India. This ensures that only quality products, system and components are being manufactured and supplied to customer. Also, the test datas collected during testing is helping in implementation of performance benchmark of all CST systems and is also assisting in research and development purposes. The standardization and performance benchmarking is creating healthy competition among supplier/manufacturers and will help in bringing down the cost of CST technologies.

Testing Carried out at CST Test Centres

Various manufacturers/suppliers across India are approaching the test centres to get their system tested & certified. Till date, 17 CST systems have been tested at National Institute of Solar Energy and Savitribai Phule Pune University using water/steam-based test facility, thermic oil-based test facility and mobile test facility. Apart from this, testing of components of CSTs like reflectivity of reflectors and heat loss in receiver tube has been done.The list and test results of CST systems tested by NISE and SPPU are given in Tables 1 and 2.

Image 1: *CST Test Facility*

Image 2: *CST under testing by NISE*

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[2] *Thermax Limited, Pune; Email: kdeshpan@thermaxindia.com*
[3] *Solar Thermal Programme Coordinator, School of Energy Studies, Savitribai Phule Pune University; Email: drpathakam@gmail.com*

Table 1: List of products' performance evaluated by National Institute of Solar Energy

S. No.	Company/ manufacturer	Technology	Size	Test Results		
				Optical Efficiency (ηo) (%)	Conductive & convective heat loss coefficient (a1) (W/m2K)	Radiative heat loss coefficient (a2) (W/m2K2)
1.	Quadsun Solar Solution, Gurgaon	Dual axis tracked paraboloid dish	4 m^2	79.62	0.253	0.001
2.	SunBest, Tamil Nadu	Non-Imaging concentrators	1 m^2	61.2	1.15	.011
3.	Quadsun Solar Solution, Gurgaon	Dual axis tracking paraboloid dish	4.4 m^2	Under Testing		
4.	Softtech Renewables Energies, Ludhiana	Single axis tracking Scheffler Dish	16 m^2	59	1.2	0.01
5.	Vcare Global, Vadodara, Gujarat	Non-Imaging concentrators	3 m^2	61.74	1.1	0.001
6.	PAPL, Chennai, Tamil Nadu	Dual axis tracking paraboloid dish	108 m^2	67.0	0.24	0.001

Table 2: List of products' performance evaluated by University of Pune

S. No.	Company/manufacturer	Technology	Working Fluid	Optical Efficiency (ηo) (%)
1.	Thermax Ltd, Solar Division Pune, Maharashtra	Parabolic Trough Collector	Water	0.64
2.	Green Life Solutions Pvt. Ltd Nagpur, Maharashtra	Dish Type Solar Concentrator	Thermic Fluid	0.64
3.	Suntrak Synergy Chennai, Tamil Nadu	Parabolic Trough Collector	Water	0.69
4.	Enersun Power Tech Pvt. Ltd Mumbai, Maharashtra	Compact Linear Fresnel Reflector	Water	0.53
5.	Solwedish Solar Pvt. Ltd, Hyderabad, Telangana	Dish Type Solar Concentrator	Thermic Fluid	0.68
6.	A.T.E. Enterprises Pvt. Ltd, Pune, Maharashtra	Dish Type Solar Concentrator	Water	0.69
7.	Sahajanand Laser Technology Ltd, Gandhinagar, Gujarat	Parabolic Trough Collector	Water	0.67
8.	A.J.Nutraceuticals Pvt. Ltd, Mumbai, Maharashtra	Parabolic Trough Collector	Thermic Fluid	0.6
9.	A.T.E. Enterprises Pune, Maharashtra	Compound Parabolic Concentrator	Thermic Fluid	0.69
10.	Akson's Solar Equipment Pvt. Ltd, Pune	Single Axis Tracking Scheffler Dish Collector	Thermic Fluid	Report in preparation
11	Akson's Solar Equipment Pvt. Ltd, Pune	Double Axis Tracking Scheffler Dish Collector	Thermic Fluid	Report in preparation

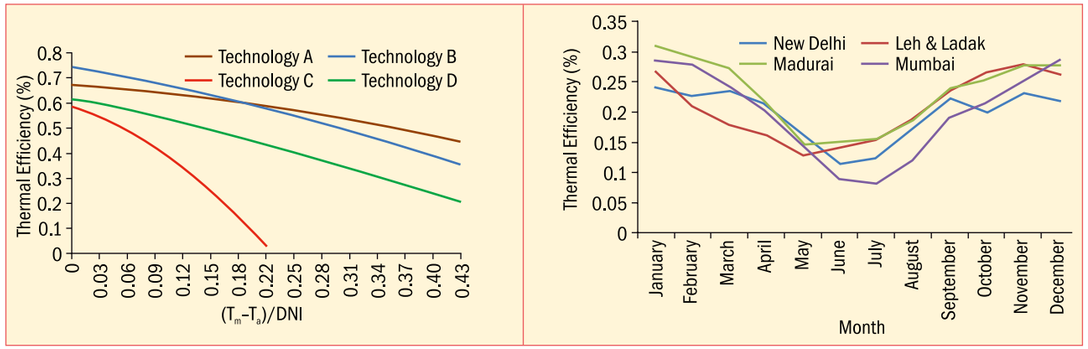

Figure 1: *Performance Map*

Figure 2: *Performance simulation of a CST system*

Research and Development Activities at Test Laboratories

The test report provided by test centres contains the performance results of CST system, such as optical efficiency, first order heat loss (a1) and second order heat loss (a2). These performance parameters assist the end-users to select suitable technologies for the required applications as well as to evaluate the performance of CST in actual field condition. The test data also helps the manufacturer to improvise the quality and performance of their system.

In research centres, the data and the results generated are used for characterization of performance of CST technologies. Performance mapping tools (Figure 1) are developed using the test results of various CST technologies. These performance mapping tools can be understood by a common person and he/she can make a comparison between performances of different CST technologies for different application requirements and at different climatic conditions. Performance maps are also used in simulating the yearly performance/ output from a CST technology for different applications and at various locations (Figure 2). Two research articles have also been prepared and sent to reputed journals for publication. The test data and results are also used for benchmarking the performance parameters of CST technologies and their components. Benchmarking will ensure quality and uniformity among the products/ system manufactured/supplied in the country.

Conclusion

From the experience of testing of CST technologies and after analysing international standards, the Indian standards for various types of CST technologies and test methods have been developed under UNDP-MNRE initiative. These standards have been passed over to BIS for publication and are expected to be completed very soon. The support from UNDP-GEF and Ministry of New and Renewable Energy (MNRE) has helped the CST test centres to strengthen the technical capacity of NISE and SPPU in field of solar thermal.

CST QUICK FACTS

Solar Steam cooking is clean, efficient, and hygienic. The system can be designed to cook food for thousands of people in an hour's time.

Solar Steam Cooking system for 10,000 people using Scheffler Dishes at Shantivan, Brahma Kumaris, Mount Abu.

SUN FOCUS–AN EXCLUSIVE MAGAZINE ON CST TECHNOLOGIES

Mr Shirish Garud*

Sun Focus, a quarterly magazine focused on solar concentrated thermal (CST) technologies, was initiated under the MNRE-UNDP-GEF project on 'Market Development & Promotion of Solar Concentrator Based Process Heat Applications in India'. This magazine was aimed to create awareness and promote solar concentrating technology usage in various industry applications. Sun Focus began its journey in 2013 and has so far released 14 issues. It has covered industry applications, space cooling, and community cooking in varied sectors.The magazine has covered details on various technologies in use, such as fixed focus automatically tracked paraboloid dishes, parabolic trough collectors and dishes with moving focus, dual axis tracking paraboloid dish concentrators, non-imaging concentrators, linear fresnel reflector, compound parabolic concentrators and other technologies – solar thermal biomass hybrid system, and solar dish cookers. The print copies are circulated amongst, state nodal agencies, industry associations, educational and research institutions, and major stakeholders. The subscription has significantly increased, starting with 500 subscribers in 2013–14 to 1000 subscribers in 2015–16. The magazine is also disseminated through email and is also, and CSH India websites. Sun Focus has featured many case studies to equip the readers to understand the benefits, how to overcome the adversities and incur paramount outcome from the use of CST technologies. It has also covered many international articles with existing and emerging CST technologies. Sun Focus has always provided balanced information from manufacturers, beneficiaries, consultants, and researchers.The magazine has gained popularity and has been admired by many stakeholders. The recipients have found it very useful in their decision-making process for adopting CST technology.

A compendium comprising 10 issues of Sun Focus was unveiled by Shri Piyush Goyal, Hon'ble Minister of Power, Coal, New and Renewable Energy, Government of India, at the National Workshop and Award distribution function.

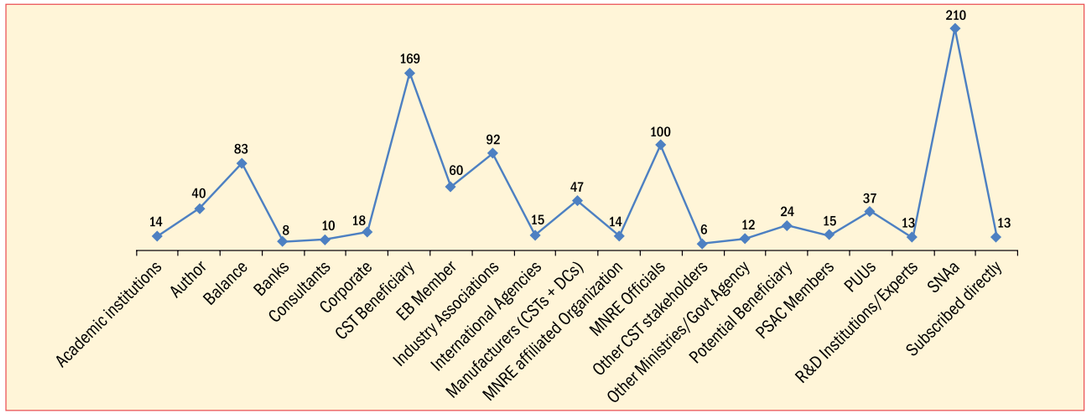

Figure 1: *Bifurcation of Recipients of Sun Focus Magazine*

A compendium comprising 10 issues of Sun Focus was unveiled by Shri Piyush Goyal, Hon'ble Minister of Power, Coal, New and Renewable Energy, Government of India, at the National Workshop and Award distribution function.

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UNDP'S PERSPECTIVE ON IMPLEMENTATION OF CSH PROJECT

Dr S N Srinivas*

Solar Energy to Meet Energy Requirements

Nearly 50% of total energy, 700 Mtoe[1] used in India is for heat applications. They include cooking for the community and family, hospitals & hospitality, religious and institutional premises, and the industrial sector. There are over 30 million enterprises in India, one-third of them require energy either for process heat or in the form of electricity. As per estimates, nearly 15 million tonnes of oil and 50 million tonnes of biomass fuels are used to meet the process heat applications. This is in addition to about 400 million tonnes of biomass and other fuels used to meet the household cooking energy needs. In 2014, National Institute of Solar Energy estimated that India has a potential of generating 749 GW from solar.[2] The estimate assumes that only 3% of the total wasteland available in a state is used for development of solar power projects. Thus, India can harness solar energy in a significant way both for electricity and heat applications.

Heat Applications and Solar Concentrators

Heat applications can be broadly categorized as—upto 80°C as low temperature heat applications; 80°C to 300°C medium temperature applications, and above 300°C as high temperature applications. Solar water heaters/dryers are the most common solar products used for low temperature applications, while solar concentrators are used for medium and high temperature applications. This article presents the baseline on solar concentrators and the progress achieved till 28 February 2017.

Baseline and End of Project Situation

The project could overcome barriers, such as lack of awareness, limited capacity of CSH technology supply chain, non-availability of performance standards of CSH, limited skilled manpower, and technology providers. The recommendations of the mid-term review of the project (conducted by an external team in March 2015) were incorporated during the remainder period of the project. The project is almost nearing EOP, with a small extension of 6 months by 30 September 2017.

Key Results

✓ The project set out to develop a solar concentrator market for heat applications and was fairly successful in meeting this objective:

✓ Increased the annual rate of solar concentrator market by over five times. In baseline year 2012, it was 3,000 m^2 per year while in 2016, the sanctioned projects stood at nearly 20,000 m^2. The baseline installation in 2011 at 20,000 m^2 of collector area (about 71 installations) has now reached 64,950 m^2 (with 225 installations), including some still under implementation.

✓ Initially, two types of solar concentrator technology packages—Scheffler and ARUN Solar—were popular for heat applications. The project facilitated addition of Paraboloid, PTC/CLFR (Parabolic Trough Collectors/ Compact Linear Fresnel Reflector), CPC (Compound Parabolic Concentrator), and Non-imaging Concentrator.

✓ Leveraged private investments of about $20 million. The total outlay of the project was about $23.75 million which includes, 4.4 M from GEF, 6 M from MNRE [subsidy], 1.35 M [in kind], 6 M from loans from financing Institutions, and 6 M equity from the industries. As of now, 3.4 M of GEF funds are

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Table 1: Summarizes the progress under different outcomes

Intended output (baseline year 2012)	Main achievements
Objective: To Increase use and promotion of CSH systems for low and medium temperature process heat applications	
• To add 90 CSH installations CST cumulative area of 45,000 m^2 [Baseline: 20,000 m^2 and 71 CSH installations]	• 154 installations were sanctioned under the project covering a cumulative area of 44,950 m^2 and 82 commissioned, covering an area of 18,925 sq.m
Outcome 1: Identification of viable technology options & establishment of testing centres	
• Increase number of technology package suppliers available to market CSH technologies in India by EOP [Baseline 18] • Establishment of 2 testing facilities for CSH systems [Baseline 0] • Performance and system standards developed and published	• The project identified about 18 additional technology package suppliers • Establishment of one national testing facility at National Institute of Solar Energy and regional testing facility at University of Pune • Performance norms for various CSTs in terms of anticipated heat delivery in different regions • BIS Standards on various CSTs and test procedures (under publication by BIS)
Outcome 2: Capacity building, awareness generation & training	
• Train 300 persons on various aspects of CSH systems at technician and consultant levels • Fellowship support to 10 scholars (M.E./M. Tech/Ph.D.) • Website, newsletter, magazine, audio-visuals published	• About 470 persons were trained • Supported 16 scholars for their academic degrees • Website http://www.cshindia.in/ launched and periodically updated. 48 Monthly e-newsletters published www.insolthermtimes.in, 14 Sun Focus magazine issues published • 15 audio-visuals published and Solar Energy Toll Free Helpline (1800 2 33 44 77) launched
Outcome 3: Feasibility studies, documentation, ESCO model	
• Increase number of CSH installations by 90 during the project period [Baseline 71] • Online performance details for learning and future action plan • Implement CSH installations on market-based instruments such as ESCO	• Increased number of CSH installations by 154 • Online performance underway in 23 CSH sites and another 30 plus will be covered by end of the project • Sanctioned 4 ESCO-based CSH installations
Outcome 4: To enhance understanding of the financial viability of CSH technologies and measures to mitigate investment risks	
• To identify potential and feasible financial options for CSH technologies • To engage financial institutes/banks to agree to provide finances to CSH projects	• 2 options were identified – ESCO and regular channel of financing • 4 nationalized banks have agreed to provide financial support (loans) for CSH projects

spent and nearly 20 M from all other sources nationally. Thus, presenting a ratio of 1:6, that is, for every dollar of GEF grants, $6 of national investment.

- ✓ The project could add significantly to collector area of 44,950 m^2, thus, contributing to at least 13,000 tonnes of annual CO_2 reduction. In energy terms, it would translate to a reduction of 2205 tonnes of oil equivalent.

Conclusions and Way Forward

The UNDP-GEF-MNRE project, "Market Development and Promotion of Solar Concentrators based Process Heat Applications in India (India CSH)" increased the scope of the market by five times for medium temperature applications (80°C to 300°C), increased options of solar concentrator technology packages, and increased the number of solar concentrator package suppliers. Conventionally, solar concentrators were only used to generate steam for cooking applications for community kitchens. But the project demonstrated CSH applications for several different end uses in industries, namely spray drying, chemical drying, boiler feed water, and heating oil (which acts as a medium for further heating), calendaring in textile mills, component washing, painting applications, etc. The biggest system installed under the project was at Mother Dairy, Patparganj, New Delhi, with 1,520 sq. m of collector area. Specifications were developed and Bureau of Indian Standards is set to notify them soon. The establishment of online performance monitoring of 14 already established systems and 23+ CSH installed systems is another significant input to the project. This can provide immense learning and develop future performance standards.

Despite substantial progress under the UNDP-GEF [2012–17] and UNIDO-GEF [2016–20] projects, significant traction is required to exploit the potential. The payback on investment on full cost basis is still in the range of 5 to 9 years which needs to be reduced through a range of interventions like large scale production and deployment, local production of mirrors, etc. The potential for heat application exceeds 50% of total energy use in India. More conducive policies/ regulation is the need of the hour to fast track use of renewable energy sources like solar, such as RPO (Renewable Energy Purchase Obligation) can be extended to include heat. Continued awareness, sensitisation, training and capacity building is required to transfer the knowledge and make many more stakeholders amalgamate them as one of their key options in their planning process for meeting their energy requirements.

[1] https://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2016/bp-statistical-review-of-world-energy-2016-full-report.pdf

[2] http://mnre.gov.in/file-manager/UserFiles/Statewise-Solar-Potential-NISE.pdf

FORTHCOMING EVENTS

RenewX 2017
Hyderabad, India; April 7–8, 2017
www.renewx.in

India's Renewable Energy Congress
New Delhi, India; April 26–27, 2017
www.inreccongress.com

2nd Solar India 2017 Expo
New Delhi, India; May 10–12 2017
www.solarindiaexpo.com

Trade Fair for Renewable Energy Sources and Energy Efficiency
Wrocław, Poland; April 19–21, 2017
www.inenerg.com

Clean Energy Summit 2017
London, UK; April 24–26, 2017
summit.solarenergyevents.com

SolarPACES 2017
Santiago, Chile, September 26–29, 2017
http://www.solarpaces.org/events

STATE-WISE & APPLICATION-WISE FIELD PROJECTS SUPPORTED UNDER UNDP-GEF CSH PROJECT

State	Cooking		Process Heat		Space Cooling		Total	
Andhra Pradesh & Telangana	03	307	05	1731	01	821	9	2859
Chhattisgarh	06	676	-	-	01	768	7	1444
Goa	05	297	-	-	-	-	5	297
Gujarat	07	2190	04	1612	01	1333	12	5135
Haryana	01	96	02	887	01	264	4	1247
Himachal Pradesh	02	992	04	1034	-	-	6	2026
Karnataka	05	400	08	4088	-	-	13	4488
Kerala	01	32	01	32	-	-	2	64
Madhya Pradesh	04	286	01	263	-	-	5	549
Maharashtra	09	1646	16	5911	-	-	25	7557
Punjab	04	960	05	2862	-	-	9	3822
Rajasthan	-	-	02	448	01	641	3	1089
Tamil Nadu	13	3205	13	4895	-	-	26	8100
Uttar Pradesh	04	720	02	1140	-	-	6	1860
Uttarakhand	01	160	03	1132	-	-	4	1292
W.B., Bihar & Delhi (1 each)	-	-	3	2160	-	-	3	2160
Kargil & Ladakh	15	960	-	-	-	-	15	960
Total	**80***	**12,927**	**69**	**28,195**	**5**	**3,827**	**154**	**44,949**
	53%	29%	44%	63%	3%	8%		
	* Includes 16 projects for repair & renovation							

PROJECTS UNDER IMPLEMENTATION IN ESCO MODE

S.No.	Beneficiary	Technology/CST area	Application	Supplier
1.	Indian Ordnance Factories, Ministry of Defence, Nagpur	Dish/180 sq. m.	Cooking for 600 people	Green life Energy(P) Ltd.
2.	Velammal College of Engineering, Madurai	Dish/250 sq. m.	Cooking for 1000 people	-Do-
3.	Perumal College of Engineering, Hosur	Dish/250 sq. m.	-do-	-Do-
4.	Hatsun Agro Ltd., Chennai	PTC/550 sq. m.	Process heating of dairy products	Luit Renewable (P) Ltd

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- Gives economic return in **3-5** years besides getting a green tag
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- Higher subsidy in special category states
- **80%** accelerated depreciation to profit making bodies

Scheffler Dishes

Paraboloid Dish

Parabolic Trough Concentrators

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National Project Director
UNDP-GEF Project on Concentrated Solar Heat
Ministry of New & Renewable Energy
Block-3, CGO Complex, Lodhi Road, New Delhi-110003.
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