a quarterly magazine on **concentrated solar heat**

SUN FOCUS

CONCENTRATED SOLAR THERMAL PROGRESS IN INDIA

Volume 4
Issue 1
July–Sept 2016

gef

सत्यमेव जयते

UNDP
Empowered lives.
Resilient nations.

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

SUN FOCUS

Volume 4 • Issue 1
July–September 2016
a quarterly magazine on
concentrated solar heat

Chief Patron
Shri Upendra Tripathy, Secretary, MNRE

Editor-in-Chief
Shri Santosh D Vaidya, Joint Secretary, MNRE

Editorial Board
Mr S K Singh, Director, NISE
Dr R P Goswami, Director, MNRE
Dr S N Srinivas, PO, UNDP
Mr Abhilakh Singh, GM, IREDA
Dr A K Singhal, NPM-CSHP, MNRE
Mr Shirish Garud, Director, TERI

Content Coordinators
Mr Rahul Udawant, MNRE
Mr Kumar Abhishek, MNRE
Mr Chinmay Kinjavdekar, TERI
Mr Sarvesh Devraj, TERI

Production Team
Ms Anushree T Sharma, TERI
Mr R K Joshi, TERI
Mr Santosh Gautam, TERI
Mr Raman Kr Jha, TERI
Mr Aman Sachdeva, TERI

Produced and Published by
Project Management Unit
UNDP–GEF project on CSH
Ministry of New and Renewable Energy
Government of India, New Delhi
Web: www.mnre.gov.in
&
TERI Press
TERI, Darbari Seth Block, IHC Complex
Lodhi Road, New Delhi – 110 003
Tel: +91 11 2468 2100, 4150 4900
Fax: +91 2436 3035, 2436 2288
Email: teripress@teri.res.in

Printed at
SVS Press
116, Patparganj Industrial Estate,
New Delhi – 110 092, India

Cover image: CPC system installed at Kandla by VCare Global.

INside...

CONTENTS

पीयूष गोयल
PIYUSH GOYAL

विद्युत, कोयला एवं नवीन और नवीकरणीय ऊर्जा
राज्य मंत्री (स्वतंत्र प्रभार)
भारत सरकार
सत्यमेव जयते

Minister of State (Independent Charge)
for Power, Coal 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

Shram Shakti Bhawan, New Delhi-110 001 Phone : +91-11-23717474, 23710411, Fax : +91-11-23710065
E-mail : piyush.goyal@nic.in, Website : www.piyushgoyal.in

सत्यमेव जयते

उपेन्द्र त्रिपाठी
Upendra Tripathy

सचिव
भारत सरकार
नवीन और नवीकरणीय ऊर्जा मंत्रालय
SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

MESSAGE

Concentrated Solar Thermal (CST) sector is very promising for India; firstly, due to costly fossil fuels and increasing stress on fuel source, such as wood and secondly, due to adequate availability of solar resource potential (5–7 kWh/m^2/day) in the country. Food, beverage, dairy, textile, machinery, and pulp and paper industries, where predominant heat requirement is below 250°C, are most suitable for CST implementation.

CST sector in India has progressed well since the last few years, but is still far from commercial maturity. A lot of development is required in terms of technology reliability, awareness generation, and improvement in overall perception of the technology for user industries as well as financial institutes. It is also important to improve application of CST technologies to large, energy-intensive industries and smaller MSME industries. The MSME sector has tremendous potential for CST in India, provided customized technology solutions are available and industry-specific issues, such as shortage of space and lack of capital for high upfront costs are catered.

Ministry of New and Renewable Energy has made efforts to grow and develop the CST sector for a long time. It supports various initiatives covering all important aspects of the sector. There are efforts towards standardization and indigenization of important CST technologies, awareness generation of various stakeholders, such as user industries, financial institutions, and improvement in performance reliability of CST technologies and of course, financial incentives through various schemes.

To accelerate the growth of CST technology, the Ministry is also implementing a UNDP–GEF supported project on "Market Development and Promotion of Solar Concentrator based Process Heat Applications in India". The objective of the project is to promote and commercialize 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 replicated projects.

The publication of ***SUN FOCUS*** is part of MNRE–UNDP–GEF project, which is an initiative for reaching out to various stakeholders of CST sector.

Upendra Tripathy
Secretary

ब्लॉक नं. 14, केन्द्रीय कार्यालय परिसर, लोदी रोड, नई दिल्ली–110003
Block No. 14, CGO Complex, Lodi Road, New Delhi - 110 003
Tel. : 011-24361481, 24362772 • Facsimile : 011-24367329 • E-mail : sec-mnre@nic.in
website : www.mnre.gov.in

अक्षय ऊर्जा से देश विकास
सूरज एक रूप अनेक

From the editor's desk...

Dear Readers,

I am pleased to be part of clean technology such as concentrating solar thermal (CST) which plays an important role in power and heat generation in India to accelerate the decarbonisation in the commercial and industrial process heat generation. It is evident that rapid deployment of CST in India will contribute to enabling sustainable energy supply and environmental securities over the next decades. The success of deployment of CST technology will also allow Indian power and heat generators to strengthen their competitiveness in the context of intensified global constraint of carbon emissions.

I also glad to state that SUN FOCUS completes an important milestone with the completion of three years. Since 2013, SUN FOCUS has been providing potential information on CSTs such as policy, technology developments, new applications, and national & international scenario.

With the advent of fourth year, I present you the thirteenth issue of SUN FOCUS magazine with you all. This issue of SUN FOCUS is themed as "Concentrated Solar Thermal Progress in India" covering various recent and interesting developments.

The special feature of this issue covers a really promising technology–compound parabolic collectors (CPC) by SUNBEST. The article shares experiences on compound parabolic concentrators installed at manufacturing & diary units for process heat applications. Another interesting article "Solar Dish Cooker for Community Cooking", is about the concentrator developed by Dr Ajay Chandak for the community cooking purpose.

The magazine also features article on concentrated solar thermal based poly-generation system generating hot water and thermic fluid heating, and introduces CPC collector technology development undertaken by VCare Global. You will also find a brief write-up on the overall solar thermal sector developments in Leh area and an article from Concentrated Solar Power developer Atria, about the tracking and control system for parabolic trough collectors.

I believe that you will find this issue filled with very relevant and interesting information on CSTs and look forward to your valuable contribution or inputs for the magazine.

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

EXPERIENCES ON COMPOUND PARABOLIC CONCENTRATORS INSTALLED AT MANUFACTURING & DAIRY UNITS FOR PROCESS HEAT APPLICATIONS

C Palaniappan[1], H T Rajan[2] and **Muthuswami[3]**

Compound Parabolic Concentrator, also known as CPC solar collector, is a recent innovation in the solar field. This technology combines the high efficiency evacuated system plus solar radiation concentrating system with copper U-tube aluminium fins for heat transfer (Figure 1). Even in low radiation, it can generate pressurized hot water above 100°C. Unlike other evacuated tube systems, water passes through a copper-U tube with aluminium fins ensuring high heat transfer, ruggedness, and long life of the unit. CPC has an efficiency above 60 per cent. The system operates as follows:

- The solar panels will be mounted on the south-facing roofs of the factory.
- DM water in closed loop in these panels will be pressurized and circulated by this arrangement, even if low radiation heat from sun's heat could be tapped.
- A pump will be used to circulate the pressurized water around 90°C–120°C.

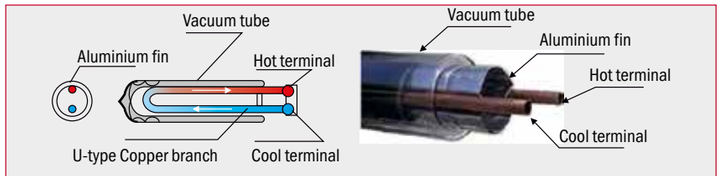


***Figure 1:** Components of CPC Technology*

CPC at TTK Prestige Roorkee Manufacturing Unit

TTK Prestige Ltd, part of the TTK Group, has emerged as India's largest kitchen and consumer appliances and healthcare company, catering to the needs of homemakers in India and abroad. Today, the TTK group spans 30 product categories, across 7 group companies, and a turnover that crosses ₹30 billion. TTK Prestige had set up a manufacturing unit at Roorkee in Uttarakhand for manufacturing of kitchen electrical appliances and pressure cookers.

Overview

The manufactured pressure cookers are to be cleaned for oil and other impurities in specialized different baths (Picture 1). The hot water at 90°C–95°C is used for the process and diesel-fired thermal oil heats water indirectly, using a heat exchanger in a 5 kl insulated water tank at 90°C–95°C. To reduce the fuel consumption, the factory had installed around 200 m^2 CPC system to meet the process heat. The 60 special types of CPC-18 solar collectors are mounted on

***Picture 1:** CPC Solar Collectors Installed at TTK Prestige for Hot Water Generation Required for Cleaning Impurities*

[1] *CEO, Sun Best (P) Ltd, Theni, Tamil Nadu; Email: info@sunbest.in*

[2] *Chief Manufacturing Officer, TTK Prestige Ltd, Bangalore; Email: htr@ttkprestige.com*

[3] *Joint General Manager, Hatsun Agro Product Ltd, Chennai; Email: muthuswami@hatsun.com*

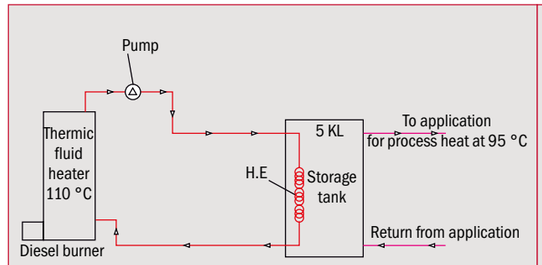


***Figure 2a:** Before Solar Intervention*

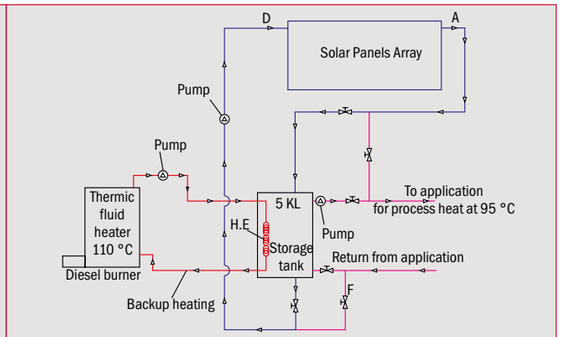


***Figure 2b:** After Solar Intervention*

the factory's open flat terrace. The system is expected to save around 18,000 litres of diesel/year and 48 tonnes of CO_2. CPC collectors can be effectively used for 7–8 hours/day which almost covers entire sunny period.

System Description

Around 60 CPCs, each with 18 tubes and reflectors, are installed on the factory open terrace. A closed loop with solar collector array, consisting of series and parallel connections of CPC with an expansion tank, pump, and other accessories like pressure and air release valve, pressure balancing valve, etc., are formed in a closed loop with a 5 kl tank (Figures 2a & 2b). The hot water from the 5 kl tank is taken to the process. During non-sunny period, the 5 kl tank could be heated by diesel-fired thermic oil heating system. Based on the actual data collected from November 2015 to September 2016, the system saved 16,740 litres of diesel.

The performance of the new concentrating technology has been proved at Roorkee, which typically has very low radiation levels in winter. Consequently, the company has applied for another CPC project of 262 m^2 for the Roorkee factory.

Challenges

The company preferred to go for CPC collectors mainly to overcome fog in winter and the low radiations in winter. The system has so far saved 16,740 litres of diesel. The 5 kl storage helps the operation hours of factory to go beyond sunny hours.

CPC at Hatsun Agro Product Ltd Salem Dairy Unit

Hatsun Agro Product Ltd is one of India's largest private sector company in the dairy industry. Milk from select fine quality cows is collected from over 3 lakh+ farmers across 8,500 villages. The company has set up dairies in 10 locations, possessing state-of-the-art facilities and international know-how to enable creation of excellent quality products meeting highest norms of hygiene and health. These dairy ingredients are being exported to 38 countries in the US, Middle East, and South-East Asian markets. The company, producing and marketing a wide range of dairy products, holds various quality standard certifications, including the prestigious ISO 9001 and ISO 22000. Arun Ice creams, the largest-selling ice cream seller in south India, and Arokya Milk are immensely popular across millions of households in south India.

Overview

The Salem plant at Hatsun Agro Product Ltd requires 35 kl hot water at a temperature of 90°C–95°C for process heat in the ice cream plant and around 40 to 50 kl for the boiler feed water (Picture 2). Presently, hot water for processing is produced using steam with a plate heat exchanger (PHE). The average coal consumption/day is 11.3 tonnes in the 8 tonne boiler. The site at Salem, Tamil Nadu, receives annual average of 5.19 kWh/m^2/day of solar radiation (as per NASA). Based on the energy demand, 220 CPC-18 collectors of 3.28 m^2 area are installed to provide around 25,000 litres hot water around 90°C–95°C to reduce coal consumption around 194 tonne/per year. Solar CPC system to provide hot water of capacity 25,000 litre/day at a temperature of 90°C during sunny period to bring down the coal consumption and pollution; better pollution control; and reduction in CO_2 emission along with better efficiency in avoiding water to steam in boiler and again steam to 90°C water by PHE.

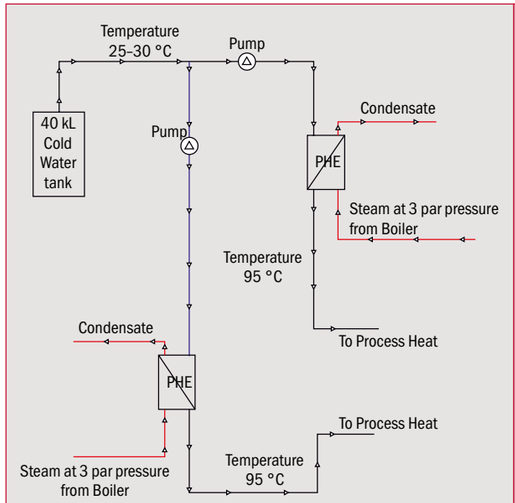


Figure 3a: Before Solar Intervention

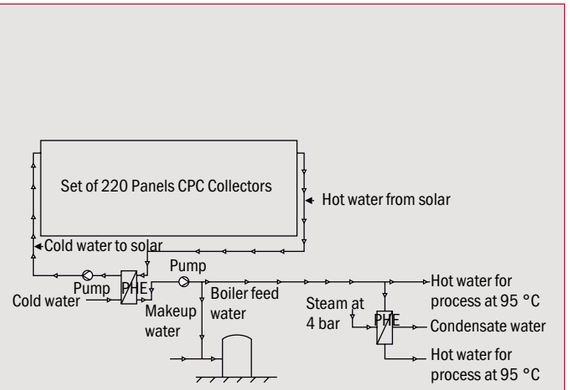


Figure 3b: After Solar Intervention

System Description

The factory has a large south-facing metal roof over the ice cream storage facility. The 220 CPCs are divided into 110 each as a one full system and fixed on the roof of the factory with metal support. A primary closed loop is formed with solar collector array consisting of series and parallel connections with an expansion tank, pump, plate heat exchanger (PHE), and other accessories like pressure and air release valve, sensors, and others (Figures 3a & 3b). The cold water passes through the PHE in the secondary loop and get heated up to a temperature of around 90°C to 95°C and it is taken to the process. Based on the actual data collected for 15 days in the month of September 2016, a savings of 672 kg/day of coal was observed (some of the days are cloudy, rainy, and partly sunny).

The company has been taking major initiatives in renewable energy by installing 22MW wind mill and 1,500 kWth/day solar CPC heating system and includes future plans of introducing more solar, thermal as well as large megawatt SPV projects for captive power needs.

***Picture 2:** Hatsun Agro Product Ltd Plant Uses CPC for Hot Water Feed into Boilers*

Hatsun Agro Product Ltd is the first CPC unit for dairy industries in the country.

Challenges

The requirement of hot water for processing starts early morning at 4 a.m. and continues for a few times during the day and in the night. Hence, a 21 kl insulated storage has been incorporated to hold the hot water. The other challenge is the distance of process application from the hot water generation point which is 300 m and drop of 3°C–50°C was observed during this transfer. Due to the 15 m height of the roof, the installation team had to face major hardships during installation.

SOLAR DISH COOKER FOR COMMUNITY COOKING

Dr Ajay Chandak[1] and **Gulu Advani**[2]

Identified as the world's biggest and most successful effort, the Mid Day Meal Scheme is operational in 1.2 m rural schools in India. Fuel used in these schools is mostly firewood or LPG. However, providing LPG to most of remotely located schools is a huge task. The Asian and African countries are blessed with ample sun and so, switching over to 'solar cooking' is a viable option. In this regard, the Ministry of Human Resource Development, Government of India, has budgeted Rs. 3000 crore for provision of community solar cookers for 5 lakh schools in the Twelfth Five Year Plan.

The use of individual or family-sized cookers is restricted due to limitations of space and cooking timings, but community cooking does have a huge market potential, especially in India. Temples, old age homes, residential schools, hotels, public health centres, *aanganwadis*, mid day meal schemes in schools, and the border security forces, are the primary areas where community cooking is practiced on a large scale and many million meals are prepared on a daily basis. In recent years, development of community dish cookers such as SK-23 and PRINCE-40 have shown great potential in energy saving and mass deployment of technology.

SK-23 Community Dish Cookers: Review of Installation

SK-23 is a simple dish cooker of 2.30 m diameter with 4 m^2 aperture area. Cooking tests, conducted on these cookers, by the regional test center of the Government of India at the University of Pune showed that the cookers are capable of cooking a mid day meal for 50 students in just 1 hour. More than 500 community dish cookers were installed for private users as well as government organizations through various manufactures. These included the world's largest installation with 360 dish cookers, consisting of a total aperture area of 1,440 m^2, installed at 160 tribal residential schools in Maharashtra (Picture 1). At present, these systems are cooking meals for more than 25,000 students, saving 54 tonnes of LPG equivalent, i.e., around 150 tonnes of carbon emission reduction per year. Despite the success of the SK-23 community dish cookers, large-scale dissemination was difficult, as the dish of 2.3 m diameter was fabricated in single piece, was difficult to transport and required an expert installation team.

***Picture 1:** SK-23 Installations at Hotel Emerald Park, Nasik (Left), and at a Tribal School in Nandurbar District (Right)*

[1] *SSVPS BSD College of Engineering, Deopur, Dhule; Email: renewable.consultant@gmail.com*

[2] *Director, Elektromag Group of Industries, Unique, Mumbai; Email: lighting@elektromag.com*

Development of PRINCE-40 Concentrator

In order to overcome the limitations of SK-23 concentrator dish, a new compact design, PRINCE-40, was developed. Herein, all construction members of the dish are of same geometry and hence, it is possible to design the dish as knock down assembly which can be assembled onsite. Although this design, a square paraboloidal dish, also required an expert team for installation, it did resolve the transportability issue of SK-23. The cooking test showed that PRINCE-40 solar concentrators are better in terms of performance than SK-23.

Adoption of PRINCE-40 Concentrators for Community Cooking

After successful laboratory and field tests, PRINCE-40 technology was disseminated to a few prospective entrepreneurs. The first sizable project came up at Madhya Pradesh Samaj Seva Samiti (MPSSS), a residential facility for tribal students at more than 200 locations. Initially, two installations were made and reviewed by cooks from different schools (Picture 2). On recommendations of the cooks, a total of 42 PRINCE-40 community cookers were installed to serve more than 2,500 children. The feedback received from end users showed a high level of satisfaction.

The WOTR (Watershed Organisation TRust) which expanded its scope of work beyond watershed development to rural energy needs approached the PRINCE Group for appropriate technology options. Encouraged by the experience of MPSSS, WOTR initially placed an order for four

Picture 2: *PRINCE-40 Solar Cookers Adoption by Coimbatore Corporation for Mid Day Meals in Schools*

systems and meticulously exposed their prospective users to these systems. Post positive response from the user community, WOTR also installed 23 systems, catering to more than 1,300 children in Sangamner tehsil of Maharashtra, later, 10 PRINCE-40 solar cookers were installed by WOTR in Madhya Pradesh and Chhattisgarh (Picture 3). The projects by MPSSS and WOTR have shown the possibility of adoption of this technology on a large scale for community cooking applications.

Experimenting with PRINCE-40 Concentrators beyond Cooking

Use of solar concentrator for sterlisation can prove to be very useful, especially in rural public health centres where availability of the power is very uncertain. It is possible to sterilize the autoclave with contents, when sun is available, and store the ready autoclave for 2–3 days. Such successful tests have opened doors for deployment of solar concentrators in medical applications.

Development of Segmented Dish Version of PRINCE-40

Fabricated version of PRINCE-40 solar cooker has 42 structural strip members, bolted together to form structure of the dish to which the reflectors are tied. The geometry in which the fabricated dish is kept was replaced by sheet metal panels. These 8 panels form the same geometry of fabricated dish keeping center open. The open centre allows passage for the wind and prevents toppling of the solar cooker. In the new design, reflectors are factory-fitted and this makes the design a truly DIY (Do It Yourself) kit. As the dish segments are manufactured on dies, the geometry is consistent and production time is low; process of assembly takes only two hours for two people.

The new design of paneled PRINCE-40 concentrator was also tested at the regional test center and at 10 different engineering institutes. The results of these tests are visible in the figure below.

Cooking time	
5 kg rice	60 minutes
100 eggs	80 minutes
5 kg potatoes	60 minutes
3 kg pulses	60 minutes

Picture 3: *Tribal Workers Installing PRINCE-40 Concentrators and Cooking in Action*

PRINCE-15 and PRINCE-40 solar cookers were also used by a Dutch team in the world's first ever solar trek in Nepal (Picture 4). All food, for the trekkers, at all the trekking sites, was cooked on these solar cookers. These solar cookers proved their worth even at elevation of 4000 masl and also established the fact that they are easy to transport and assemble even in the hilly terrain of Himalayas.

Conclusion

The new DIY kit design of PRINCE-40 paneled solar concentrator has the potential to create wonders in community cooking in terms of being one of the cleanest cooking methods, reducing emissions to large extent, and hygienic.

Trials also show suitability of the technology for applications like autoclaving at rural public health centres. Applications like water distillation and bakery can be practiced as micro enterprise to generate revenue for rural folks and improve utilization of the concentrator.

One small version of the square dish, already available as PRINCE-15, as domestic dish cooker of 1.5 m^2 can be promoted in rural areas for cooking for families, especially in areas where cooking fuel like firewood, LPG, kerosene, etc., is scarce. In the deserts of Rajasthan, Kutch, and Ladakh, these domestic as well as community solar cookers are blessings in disguise.

Technology requires financial support from the government and by other means such as carbon funding in order to improve viability of the projects. Widespread demonstrations and pilot projects are also needed for the prospective users to acquire a first hand feel of the system. A wider network of manufacturers, dealers, and entrepreneurs to improve availability of the new designs needs to be developed.

Picture 4: *PRINCE-15 and PRINCE-40 Solar Cookers in First Ever Solar Trek in Nepal*

INDIA'S FIRST POLY-GENERATION CONCENTRATED SOLAR THERMAL SYSTEM FOR INDUSTRIAL HEATING

Tara Parthasarathy[1], Indira Sudararajan[2] and **Siddharth Malik[3]**

Ultramarine & Pigments Ltd (UPL) is one of the largest pigment and surfactant manufacturing companies of Indian origin. At the factory located in Ranipet, Tamil Nadu, the industrial process requires Special Kerosene Oil (SKO)-based thermic oil heating system for drying of the product pigment. The company first explored hot air-based natural drying to reduce load on SKO dryer and reduce SKO consumption. Although SKO consumption was reduced to some extent, the drying rates were too slow and led to a large inventory of pigments and loss of productivity. The company then decided to explore technologies which will enable saving SKO consumption and enhancing the production efficiency and productivity.

Post market research, UPL decided to adopt solar-based thermic oil heating. The technology was two-axis tracking paraboloid dish concentrator system (Picture 1), developed by Megawatt Solutions (MWS), an MNRE-channel partner for turnkey delivery of CST technologies and solutions to reduce fossil consumption in process and thermal applications in industries. MWS studied customer's drying requirement and designed a solution for enhancing their drying with minimum fuel consumption. The solution consisted of six dual-axis tracking based completely on automated Solar Paraboloid Concentrators that concentrate incoming solar radiation to heat up thermic oil up to 200°C which generates hot air at up to 140°C through radiator.

Picture 1: *CST System for Pigment Drying Application*

[1] *Joint Managing Director, Ultramarine & Pigments Ltd., Chennai; Email: syndet@ultramarinepigments.net*

[2] *VC & Managing Director, Ultramarine & Pigments Ltd., Chennai; Email: syndet@ultramarinepigments.net*

[3] *Managing Director, Megawatt Solutions Pvt. Ltd., New Delhi; Email: smalik@megawattsolutions.in*

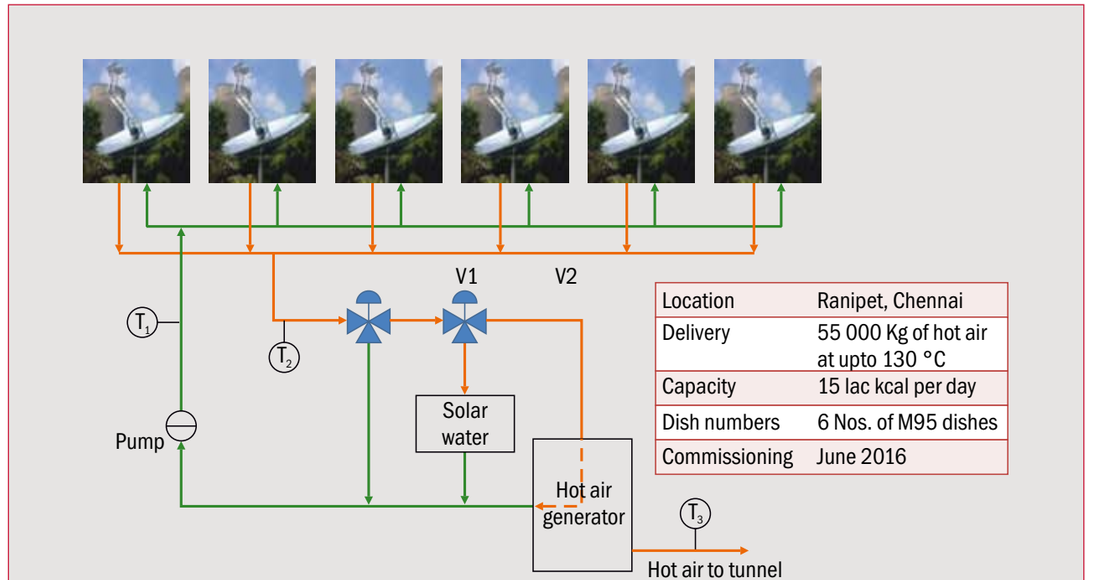


Figure 1: *Schematic Diagram of Hot Air Generation Using CST System*

CST-Based System

The CST system is based on state-of-the-art high efficiency paraboloid dish concentrator based system, the MWS Solar Field™. The MWS Solar field™ has been designed, engineered, and commissioned by Megawatt Solutions Pvt Ltd, an MNRE-channel partner for CST industrial process heating solutions. The system is based on fully two-axis tracking paraboloid dish concentrators with high concentration ratios and low ground foot print. The system was commissioned in June 2016 and is operational since July 1, 2016.

The MWS Solar Field™ is engineered to provide hot air indirectly by heating thermic oil in the solar field, which exchanges energy with the air circuit in which air is fed at ambient temperature and raised to a temperature of 130°C for feeding into tunnels (Picture 2) to displace SKO conventionally used for drying. The operation of the system is shown in Figure 1.

Along with heating thermic oil to 200°C for hot air generation, the system is also configured to generate hot water at 90°C for boiler feed water heating. This secondary application is designed so that solar energy is completely utilized and there is no wastage even during peak sunny hours. The salient features of the project are enumerated in Table 1.

Table 1: Salient features of the project

Parameter	Description
Solar Field Configuration	6 M95 paraboloid Dish Concentrators total of 570m^2 of concentrator area
Solar Tracking Arrangements	Fully automated 2-axis tracking with tracking receiver
Solar Field Working Fluid	Thermic Oil
Heat Transfer Equipment	Thermic Oil-to-Air Heat Exchanger
Inlet Temperature of Air	25°C–30°C
Outlet Temperature of Air	Peak 120°C
Air Flow Rate	Fixed at 55,000 kg/day
Average Daily Energy Yield	Upto 15 lakh kcal/day

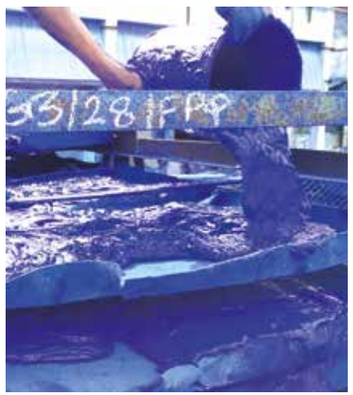
Performance

The complete system logs the daily temperature of the thermic oil and air circuits and can also be remotely monitored. The installed CST system can deliver up to 15 lakh kcal/day on a clear sunny day and is able to save up to 150 kg SKO on a daily basis. The CST system is also equipped with various safety features for automatic handling of contingencies as listed in Table 2.

Picture 2: Pigment Drying Tunnel

Table 2: Safety Features of MWS Solar Field™

Condition	Solar Field Auto Action
High Wind Conditions	Dishes in safety position by anemometer signal
Low Oil Flow	Alarm indicators and defocusing of dishes
Low Oil Level	Triple contingency design including automatic top up by drawing oil from overflow and expansion tanks; reverse flow condition prevention, U-loop configuration
High Temperature Conditions	Thermal storage or defocus of solar field as per equipment schedule
Low pressure	Pump and circuit pressures linked by pressure switches to provide alarm
Intermittent Cloudy Conditions	Temporary defocus and refocus routines
Permanent Cloudy Conditions	Defocus and safety positions, Alarm indicators
Process Condition	Auto detection of process status
Remote Monitoring	Via GSM/GPRS
Emergency Condition	Master Shutdown



Picture 3a: Initial Pigment Fed to Dryer

Picture 3b: Final Pigment After Drying

Impact

A one of its kind project, MWS Solar Dish Concentrators has been successfully integrated for generating hot air through heat exchanger. The system is a classic example of successful integration of Concentrated Solar Thermal with fossil-fuel based industrial heating systems. The subsidy and support from the MNRE ensures that the system pays back within 4 years, thus, guaranteeing more than 20 years of emission free, zero-fuel process heating.

COMPOUND PARABOLIC CONCENTRATORS USED FOR INDUSTRIAL PROCESS HEATING IN KANDLA

Jatin Joshi[1], Satish Shah[2] and **Deepak Gadhia[3]**

VCare Global is a Vadodara-based engineering company which aims to utilize solar energy for industrial, commercial, and residential applications to provide sustainable and enviro-friendly solutions.

VCare Global is committed to promote renewable technologies in industries. Traditionally, the industrial sectors are largely dependent on conventional fuels to meet their heating applications. Since its establishment in 2005, VCare Global has been researching, developing, and implementing affordable novel solutions of renewable and clean energy for providing process heat and air-conditioning for the industrial, commercial, residential, and hospitality sector. One of such proven, highly efficient, and economical solar thermal technology is Compound Parabolic Concentrator (CPC). CPC is suitable for generating hot water up to 90°C–100°C. VCare Global has applied and commissioned CPC technology for hot water generation at Kandla free trade plant for a leading FMCG company—Hindustan Unilever Ltd.

Picture 1: CPC Collectors Installed at Hindustan Unilever, Kandla, Gujarat

Need for CPC System

Earlier the process heating requirement at Hindustan Unilever's Kandla plant (Picture 1) was met by diesel. The key concerns—the costing of diesel, its contribution to environmental pollution, including global warming—were the key drivers that led the company to consider alternative cleaner solutions. Hindustan Unilever decided to switch over to solar technology for heating 20 kl of process water during one shift operation. The water is heated from 30°C to 85°C, accounting for 11 lakh Kcal.

To meet the heating requirements, VCare Global proposed a comprehensive solution, based on Compound Parabolic Concentrator technology. The solution comprised of 160 collectors providing a total aperture area of 480 m^2.

The system has a primary circuit consisting of cold water storage, cold water pumping to the CPC in series and parallel laid on three arrays and collecting the generated hot water in the hot water tank (Figure 1). The CPC was designed to give 11 lakh kcal per shift operation on an average basis. To achieve the desired temperature of 85°C on the secondary side, it was designed to raise the temperature of hot water up to 92°C in the primary circuit, using solar energy generated from CPC.

Objective

While India has abundant coal, it is of poor quality causing substantial harm to the environment. India has meagre clean fossil fuels like oil and natural gas. The country has no option except to adopt renewable forms of energy, such as solar, hydro, wind, and biogas/biomass.

[1] *MD, VCare Global, Vadodara; Email: jatin@vcare-global.com*

[2] *Technical Adviser, VCare Global, Vadodara; Email: satish.shah@vcare-global.com*

[3] *Trustee & Director-MSA Renewtech Foundation & Mentor to VCare Global, Vadodara; Email: deepak.gadhia@greenashram.org*

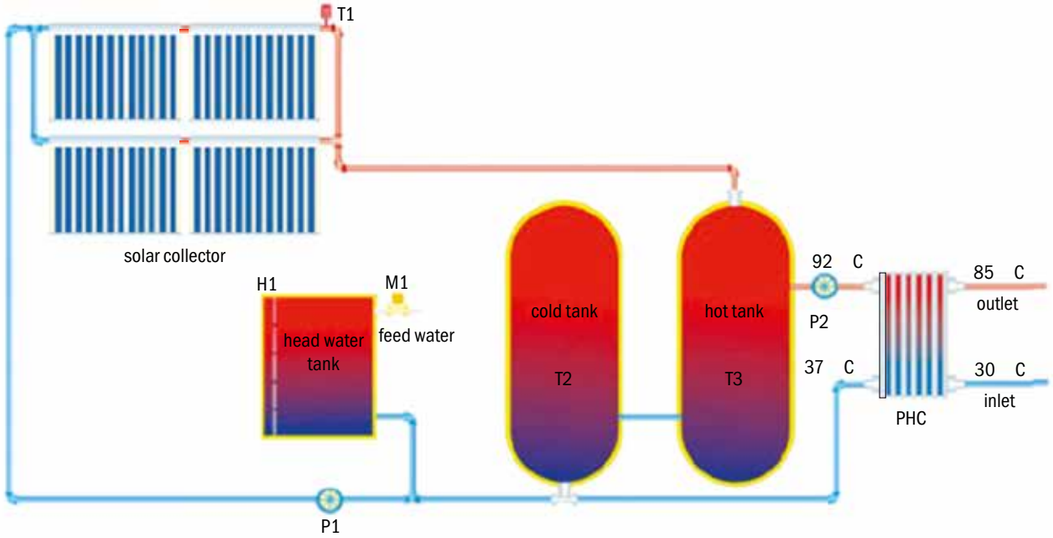


Figure 1: System Schematic Diagram

On a micro level, industries across the country face the problem of rising fuel costs compounded by regulatory edicts from the state environmental boards that are becoming stricter by the day. Cost reduction was certainly an objective for Hindustan Unilever and at the same time, being a steward of a clean environment.

Challenges

Unilever, the client of VCare requested them to offer a sustainable solution to offer the fuel savings and reduce its carbon-footprint. After exploring various technologies for solar process heating which included Flat Plate Collectors, Evacuated Tube Collectors, Parabolic dishes, Parabolic Trough Concentrators and Fresnel Linear Concentrator. VCare zoomed in on CPC as it was most suited of the technology for such application.

Space is a challenge for any Solar Thermal Heating system. The Kandla project was no exception. VCare Global mitigated the challenge by designing the layout of CPC panels in a most space-minimizing way.

The challenge was installation of system at site as soil conditions had to be analysed to determine type of civil foundation and work could be decided.

Another challenge was limited working time that was allowed at plant (only during daytime) and of course being monsoon many days of site work was delayed as civil work and insulation work could not be undertaken during that period but still the timeline had to be maintained.

User Feedback

The Unilever team is satisfied with the system performance and the user-friendly control system provided with the PLC panel, and SCADA. With this, they can measure, control, monitor, and analyse the system performance.

Savings

The client has started taking benefits by using the Solar Thermal Hot Water System of saving in daily diesel consumption at about 127 ltr/day and also reduction in CO_2 emission of about 126 Ton CO_2 per annum of 300 days operation.

SOLAR THERMAL TECHNOLOGIES FLOURISHING AT LEH

Kumar Abhishek[1] and **Abhilakh Singh**[2]

Leh-Ladakh, recognized as the Land of High Passes, is a high-altitude cold desert region of Jammu and Kashmir that extends from Kunlun mountain range to the main great Himalayas to the south. A solar rich region, with an average Direct Normal irradiance (DNI) of 5.43 kWh/m^2/day, Ladakh is a favourite place for solar thermal applications. There are some places in Leh-Ladakh, that are blessed with solar insolation of around 1,200 W/m^2. Along with the Ladakh Renewable Energy Development Agency (LREDA), the Ministry of New and Renewable Energy (MNRE), Government of India, has implemented many solar projects for process heating, cooking, and water heating. Due to the elevated geography, maintenance and monitoring of such solar systems becomes essential. To address this issue, a team of MNRE, led by Mr Abhilakh Singh, General Manager, IREDA, visited Ladakh.

The delegation visited various solar thermal components, including the Greenhouses & CST-based systems in the district of Leh during 20–24, August 2016. During this visit, around 30 solar thermal installations were covered (Table 1).

Table 1: Total number of solar thermal components inspected, during the site visit in Leh region

System/Devices	Allocated target (m^2)	Target Achieved (m^2)	System Inspected (nos)
Steam Cooking System	10	1	7
Domestic Green House (DGH)	2,500	2,500	01
Commercial Green Houses (CGH)	750	300	11
Solar Water Heaters (SWH)	17,384	14,584	10
Dish Solar Cooker	4,500	2,250	20
Solar Dryers	500	Nil	Nil
Ground Source Heat Pumps (GSHPs)	2 Demo Units	Nil	Nil

***Picture 1:** Scheffler Dishes Installed at Lamdon Higher Secondary School (Girls Hostel)*

***Picture 2:** Scheffler Dish Installed at Jamyang School*

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

[2] *General Manager, IREDA; Email: abhilakh@ireda.gov.in*

Steam Cooking System

Recently, MNRE has sanctioned 9 steam cooking systems, each with an aperture area of 64 m^2 (Pictures 1 & 2). It was found that six out of these nine sites are either in the phase of completion or are under developed. These projects can be summed up in Table 2.

Table 2: Steam cooking system visited in Leh

Beneficiary Details	CST Technology	Collector area(m^2)	Project Status
Lamdon Boys Higher Secondary School, Leh	Scheffler	64	Under Implementation
Lamdon Girls Higher Secondary School, Leh	Scheffler	64	Complete
Druk Padma Karpo Residential School through LAREDA	Scheffler	64	Under Implementation
Jamyang School	Scheffler	64	Completed
Central Institute of Buddhist Studies	Scheffler	64	Under Implementation
Govt. Residential School, Tharuk	Scheffler	64	Completed
Govt. Residential School, Nayoma/Diskit	Scheffler	64	Completed
Govt. Residential School, Khaltsi	Scheffler	64	Completed
Lamdon School, Shrey	Scheffler	64	Completed

Solar Water Heating Systems

Solar water heaters are the most popular thermal equipment in Leh and generally are the highest in terms of solar installations.

The LREDA–LAHDC (Ladakh Autonomous Hill Development Council) has set an installation target of around 17,584 m^2 solar water heating systems for the financial year 2015–16. Till date, LREDA has successfully achieved and installed 14,584 m^2 for this current financial year.

The team inspected 10 solar water heating systems and interacted with the beneficiaries, following which the performance of existing installations was found satisfactory (Table 3).

Although some of the systems were 4–5 years old performance of existing installations found satisfactory. The demand of solar water heaters is very high in Leh region, now MNRE has revised its target for current financial year. A proposal for installation of solar water heater of 15,600 sq. m is under consideration.

Picture 3: *The 3,000 LPD System Installed at Alpine Villa, Leh*

Picture 4: *500 LPD System in Pangong Lake at 3500 ft. above sea level*

Table 3: Status of the Solar Water Heating Systems

Location	Capacity in LPD	Status
Installation at Stock Palace, Leh	100	Working
Druk Padma Karpo Residential (Rancho School) Shey by (LREDA)	100	Working
Lamdom Higher Secondary School in Shey by (LREDA)	200	Working
Linshed Residential hostel Shey by (LREDA)	300	Working
Lamdom Higher Secondary School in Shey, donated by SOTRA nasa	1,000	
Rest Point Tent, near Pangong Lake in Leh at 3500 ft.	1,000	Working
Lamdom Boys Higher Secondary School in Leh by LREDA	1,400	Working
Jamyang School in Leh by LREDA	2,000	Working
Alpine Villa in Leh by LREDA	3,000	Working
Food Point Tent near Pangong Lake in Leh at 3500 ft.	3,500	Working

Table 4: Details of Greenhouses Covered

Year of Installation	Type of Greenhouse	Location and Name of Owner
2011	Commercial	Village: Tikse; Owner: Lobzang
2012	Commercial	Village: Tikse; Owner: Phuntsog
2012	Commercial	Village: Shey; Owner: Padma
2015	Commercial	Village: Tikse; Owner: Thinles
2015	Domestic	Location: Lamdon Model School, Shey, Leh, Ladakh
2015	Commercial	Location: Druk Padma Karpo, Residential School (Rancho School)
2016	Commercial	Village: Shey; Owner: Tsetan
2016	Commercial	Village: Shey; Owner: Stanzen
2016	Commercial	Village: Shey; Owner: Zangmo
2016	Commercial	Location: Lamdon Boys High School
2016	Commercial	Location: Lamdon Girls High School
2016	Commercial	Village: Stok; Owner: Dokpa

Greenhouses

Located at an altitude of around 11,000 ft. above sea level, the temperature in Leh varies from 30°C–30°C and is extremely difficult to cultivate vegetation. So, greenhouses plays crucial role in the process of cultivation. The LREDA LAHDC has, so far, constructed 2,900 greenhouses in Leh. The demand for greenhouses (Pictures 5 & 6), especially the commercial greenhouses, in Leh is so high that the sanctioned 500 greenhouses as per the demand in 2016–17 is already completed, and the agency is planning to submit a new proposal for greenhouses to MNRE. During the visit, a total of 12 greenhouses were covered (Table 4) and their condition and performance was found satisfactory.

Picture 5: *Outside View of Commercial Greenhouse Village; Tikse, Owner; Phuntsog*

Picture 6: *Inside View of the Commercial Greenhouse Village, Tikse; Owner, Phuntsog*

OPEN-LOOP TRACKING FOR PARABOLIC TROUGH COLLECTORS

Carlos Tejada[1]

Concentrated Solar Power, especially with high concentration ratios on small receivers, requires a good solar tracking. Combine it with a large mirroring area and you need an automated system to overcome the tedious and error-prone task of managing a hand-operated sun tracking. This automation control can be performed on either opened or closed loop.

Open-Loop Tracking

An open-loop controller (also called non-feedback) is a type of controller that computes its input into a system using only the current state and its mathematical model of the system.

In terms of sun tracking for concentrated thermal heat, the mathematical model is the solar equation, the inputs are mechanical actuators (one or two axis), and output is the concentrated beam into the receiver, as can be seen in Figure 1.

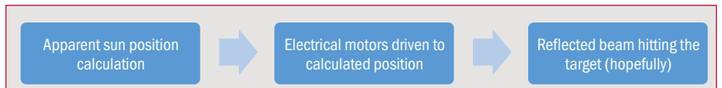


Figure 1: *Open-loop Control*

The solar equations are mathematical formulas that take the geographical position (latitude and longitude) and the current date/time of day as inputs, and gives the elevation and azimuth solar angles as output. These two values are further processed with a rotation matrix to obtain the single axis angle position for a parabolic trough collector.

The mathematical formulas are computing-intensive, with many trigonometrical double-precision calculations and large look-up tables. The Global Positioning System is used which provides this information in real time with excellent accuracy and relatively cheap receivers. The air pressure and temperature also need to be accounted for sun's refraction in the atmosphere, at low elevations.

The computing power required is very challenging for real-time applications. Earlier personal computers were used for this task despite the high cost, power consumption, and space required.

However, the development of powerful yet small and cheap microcontrollers changed the game. They can be programmed using high level compilers, with lots of memory, integrated peripherals, and computing power exceeding 40 MIPS (millions of instructions per second).

Simply connecting a GPS receiver to a microcontroller will help us in open-loop tracking with high accuracy at a low cost.

Comparison with Alternative Tracking Methods

A closed-loop controller provides feedback on the output status, and uses the difference between the desired set-point and the actual position (also known as the 'error') to change the output in order to reduce this error (see Figure 2).

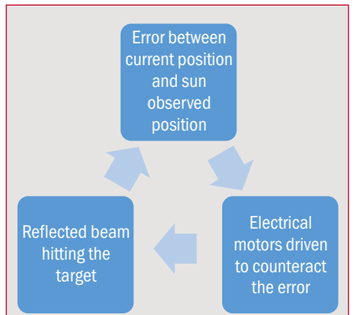


Figure 2: *Closed-loop Control*

The easiest way of automated sun tracking can be performed by closing the control loop with a sun sensor. This method is simple, relatively cheap, and allows some margin for construction misalignment and drive tolerances. It can be implemented using only analog electronics, eliminating the need of programming algorithms.

However, the most obvious drawback to this system is how to track the sun during cloud transients. The system either stops tracking or starts moving back and forth.

[1] *Head of Instrumentation and Controls, Atria Smart Energy Solutions S.L.U., Spain; Email: carlos.tejada@atriapower.es*

Another inconvenience of the open loop control is the sun sensor: as an optical element, it is subject to dust soiling and reflections from external elements that would induce errors. Careful adjustment is required so that the reflected beam hits properly the receiver.

In contrast, other advantages of the open loop control (besides the ability to accurately track the sun during cloudy transients) are its capability of upgrading the program to include compensation of the structural bending as a function of the angle, or implementing a power ramp-up and ramp-down to avoid thermal stress of the receiver, or implementing a partial defocus tracking to avoid heat dumping, or an anti-freezing mode.

Atria Local Controller

Atria Smart Energy Solutions has designed and tested an open-loop local controller (Atria LOC) with two objectives in mind: (i) low cost and (ii) flexibility, enough to suit any need (current or future) of the parabolic trough collector

The computing hardware of the LOC is based on Microchip PIC24H series microcontrollers, with added peripheral to support RS232 and RS485 communications, thermocouple temperature reading, pulse width modulation for motor control, quadrature encoders from the slew drive sensors and other auxiliary devices such as DIP switches for selecting the MODBUS slave ID. The Printed Circuit Board (PCB) (see Picture 1) measures only 8x6 cm, and can be easily installed inside a common junction box For testing purposes an LCD screen and small joystick has been added for local control (see Picture 2).

Picture 1: *Atria LOC Prototype, PCB Side*

Picture 2: *Atria LOC in a Junction Box w/LCD Screen Driving a Small Parabolic Trough Simulator*

The software programmed in the LOC is based on Finite State Machines, therefore no operating system is needed while achieving a true cooperative multitasking.

Testing

A small Parabolic Trough Collector testing platform has been built and installed on the roof at Atria Smart Energy Solutions office for monitoring the operation (see Picture 3). 3D printed gears and a brushed 12 V DC motor with reduction gearbox are being used to measure the performance of the Atria LOC and the accuracy of the sun tracking. The DC motor is run using a full H-bridge MOSFETS which receives the PWM sent by the LOC and translates into a variable voltage power output. An digital inclinometer has been attached to the driven gear to communicate with the LOC via RS232 bus, and it gives an accuracy of 0.1°.

The testing platform includes a rod, parallel to the rotation axis, at a distance of 0.57 m, which projects a shadow on a scale so that angular deviations can be measured. A laptop with a small SCADA programmed for this application reads the position of the PTC and other parameters, such as the circuit temperature, time, and date with an internet time server (no GPS required).

Picture 3: *General view of the Testing Platform, Prior to Relocating the LOC in a Junction Box*

Results and Future Deployment

The tracking has been very good, with an accuracy of about ± 0.1° despite some backlash of the gears.

The industrial version of the LOC will consist of more than 1000 units for the 10 MW CSP plant being developed by Atria Power in Karnataka. The complete LOC will include a switched power supply to get 24 Vdc from the 415 Vac network, and a power H-bridge driver.

With the flexibility that a custom LOC gives, Atria Smart Energy Solutions will be glad to study any automated sun tracking need in order to provide the best, cost-effective solution for Concentrated Solar Power systems.

BANKERS' MEET ON LOAN PROVISION FOR CONCENTRATING SOLAR TECHNOLOGIES

On the issue of providing loans to development of Concentrating Solar Technologies (CST), the senior public sector bank officials confirmed that better knowledge about CST technology and its various applications via trainings is the need of the hour. The scope of asset-based financing especially in the case of capital subsidy availability from MNRE and UNDP/GEF was also discussed. The need of manufacturers to reach out to banks and help build capacity on CSTs was also discussed. Insight from bank officials was also sought to have better understanding on designing business models that would covered most risks judiciously.

WORKSHOPS ON CONCENTRATING SOLAR THERMAL TECHNOLOGIES IN INDUSTRIES

July 14-15, Kolkata

July 28-29, Jaipur

September 14-15, Hyderabad

July 21-22, Lucknow

GEF and UNIDO in partnership with the MNRE are implementing a project on 'Promoting business models for increasing penetrations and scaling up of solar energy' under which a series of workshops and site visits are being organized. Four such workshops were organized in Hyderabad, Kolkata, Jaipur, and Lucknow, to create awareness about the technology and its potential for application in the industrial sector. Wide participation and support from industry has been ensured through close cooperation with the State Nodal Agency Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA) and Confederation of Indian Industries (CII) for the workshop. The workshop saw presentations from CST manufacturers showcasing technologies available in the market and their application, technical specifications of their system and some case studies based on their installations in the country. The workshops also saw huge participation and active interactive dialogue with the industry representatives across different sectors, giving tremendous boost to the possibilities of implementing CST projects in eastern India.

FORTHCOMING EVENTS

NATIONAL

Seminar on Concentrating Solar Thermal (CST) Technologies
October 1–2, 2016
Abu Road, Rajasthan
Website: http://www.india-one.net/index.html;
Registration: infocshcenter@gmail.com

Intersolar India 2016
October 19–21, 2016
Mumbai, Maharashtra
Website: www.intersolar.in/en/home.html

3rd EnviroTech Asia 2016
December 2–4, 2016
Gandhinagar, Gujarat
Website: http://www.envirotechasia.com/

2nd International Conference on Solar Energy Photovoltaic
December 17–19, 2016
Bhubaneswar, Odisha
Website: http://www.kiit.ac.in/icsep2016/

Energy Storage India 2017
January 12–13, 2017
Mumbai, Maharashtra
Website: http://www.esiexpo.in/

RE-INVEST 2017
February 15–17, 2017
Gandhinagar, Gujarat
Website: http://re-invest.in

INTERNATIONAL

11th ISES EuroSun Conference 2016
October 11–14, 2016
Palma de Mallorca, Spain
Website: www.eurosun2016.org/

SolarPACES 2016
October 11–14, 2016
Abu Dhabi, UAE
Website: www.solarpaces-conference.org/home.html

Solar Asset Management Europe
November 9–10, 2016
Milan, Italy
Website: www.solarassetmanagementeu.com/home/#solar-asset-management-europe

10th International Concentrated Solar Thermal Power Summit
November 9–10, 2016
Seville, Spain
Website: http://www.csptoday.com/csp/

Solar Finance & Investment Southeast Asia
November 29–December 1, 2016
Bangkok, Thailand
Website: http://seasia.solarenergyevents.com/

ASEAN Energy Storage Congress & Expo 2016
December 5–6, 2016
Kuala Lumpur, Malaysia
Website: http://www.aseanenergystorage.com/

CONCENTRATING SOLAR TECHNOLOGIES

सत्यमेव जयते
Government of India

An emerging technology to meet your heat requirement for Community Cooking, Space Cooling & Industrial Process Applications

MAKE YOUR ESTABLISHMENT GREEN BY REDUCING THE CARBON FOOT PRINT

SALIENT FEATURES

- Can provide steam/hot oil/ pressurized water at 90° C - 350° C
- Integrated with boiler provides trouble free operations during non-sunshine hours. Systems with heat storage available
- Gives economic return in **3-5** years besides getting a green tag
- Over **200** systems of various capacities installed in the country

FINANCIAL SUPPORT

- **30%** of benchmark cost as government subsidy
- Higher subsidy in special category states
- **80%** accelerated depreciation to profit making bodies

Scheffler Dishes

Paraboloid Dish

Parabolic Trough Concentrators

gef

UNDP
Empowered lives.
Resilient nations.

National Project Director
UNDP-GEF Project on Concentrated Solar Heat
Ministry of New & Renewable Energy
Block-3, CGO Complex, Lodhi Road, New Delhi-110003.
Telefax: 011- 24363638, E-mail:singhalak@nic.in

Toll Free Helpline No. 1800 2 33 44 77

Interested Organizations may contact our Suppliers / Channel Partners :- A. T. E. (Pune) : 09880821732, **Clique Solar** (Mumbai) : 09096180000, **Green Life Solutions** (Nagpur) : 07507500122, **Greenera Energy** (Coimbatore) : 09600855443, **K Energy** (Jodhpur) : 09829022899, **Leveragenet Solutions** (Pune) : 09975591062, **Megawatt Solutions** (Delhi) : 09654451401, **Oorja Energy** (Hyderabad) : 09000332828, **Sunbest** (Tamil Nadu) : 04546-255272, **Taylormade Solutions** (Ahmedabad) : 09712933390, **Thermax** (Pune) : 020-67308991 or 67308880, **Ultra Conserve** (Mumbai) : 09004445530, **Unisun Technologies** (Bangalore) : 09880022272, **VSM Solar** (Bangalore) : 09886726565 or **our State Nodal Agencies**. For details, visit our websites **www.mnre.gov.in / www.cshindia.in.**