a quarterly magazine on **concentrated solar heat**

SUN FOCUS

CST Case Studies

Volume 3
Issue 4
April–June 2016

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

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April –June 2016
a quarterly magazine on
concentrated solar heat

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पीयूष गोयल
PIYUSH GOYAL

विद्युत, कोयला एवं नवीन और नवीकरण ऊर्जा
राज्य मंत्री (स्वतंत्र प्रभार)
भारत सरकार
Minister of State (Independent Charge)
for Power, Coal and New & Renewable Energy
Government of India

MESSAGE

India is a country with rich solar resource 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
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

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From the editor's desk...

Dear Readers,

I am pleased to inform you that Sun Focus completes three years with this 12th issue. The last three years have been very eventful for Sun Focus with its gradual growth in print circulation reaching to 1000 stakeholders and the progress in CST sector in India. So far, Sun Focus has brought out exclusive information on various technologies, policy updates, applications in different sectors, beneficiary and manufacturer perspective and international development on CSTs.

The current issue has been designed to inform you on the various kinds of applications and uses of concentrated solar technologies in industries and institutions. Some selected installations are featured in this issue with comprehensive information on the technical details, requirement, performance and benefits.

The case studies covered in the issue are concentrating solar steam generating system for milk pasteurization at Salem Dairy in Tamil Nadu, A.T.E.'s solar concentrator for the community kitchen at Nareshwadi Learning Centre, in Dahanu, Maharashtra; pharmaceutical industry using CST for medicine preparation and sludge drying at Unique Biotech Ltd, Hyderabad; Solar-LPG hybrid smart kitchen at NTPC, Dadri, UP; steam cooking system at Dayalbhag Institution, Agra; CPC based system at tea plant of Goodricke for drying application in West Bengal and solar steam based 100 TR air conditioning system at Muni Seva Ashram near Vadodara, Gujarat. The magazine also features the National Workshop on CSTs cum Award Distribution Function held at Hotel Ashok, New Delhi on April 29, 2016.

I hope you will find this issue quite interesting and informative similar to all previous issue of Sun Focus magazine. I look forward to your valuable comments, suggestions, and most importantly 'contributions' to further improve the quality and impact of the magazine.

I thank all the readers and stakeholders for their support and look forward to their continued patronage for our future issues.

Sd/-

Tarun Kapoor

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

CONCENTRATING SOLAR STEAM GENERATING SYSTEM FOR MILK PASTEURIZATION AT SALEM DAIRY

K Santhi[1] and P ManiKannan[2]

The Salem District Co-operative milk producers union is located in Salem District in Tamil Nadu. Under the brand name of 'Aavin', the Salem Union is procuring around 5.25 lakh litres of milk per day from the milk producers in and around Salem and Namakkal districts in Tamil Nadu.

About the System

The milk being procured is pasteurized and processed in to various products, such as butter, ghee, skimmed milk powder, ***khoya***, flavoured milk, and milk shakes. The heat energy for above processes is supplied in the form of steam and hot water of various qualities.

Pasteurization is the main energy consuming process in which the milk is heated to 78°C by means of steam. The steam is generated through boiler using furnace oil as fuel. The dairy burns on an average of 6,000 litres of furnace oil per day to generate the required steam.

In order to reduce the burning of fossil fuel and to reduce the carbon footprints, the Salem union had installed two ARUN 160 dishes at a total cost of ₹101 lakh. The project was approved as a demonstration project under UNDP–GEF programme. The project received financial support of ₹10 lakh from UNDP–GEF, ₹20.28 lakh from MNRE and the remaining ₹79.90 lakh from the Tamil Nadu Government under Green Dairying initiatives in the Part II scheme 2013–14.

Picture 1: Two ARUN 160 dishes installed at Salem Dairy

Picture 2: Milk Pasteurizer Machine; Capacity: 20,000 litres/hour; Steam Requirement: 250 to 300 kg/hour

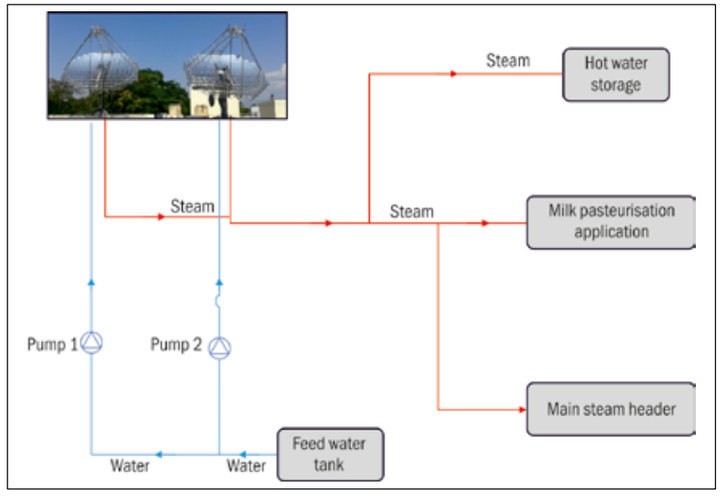

Figure 1: Schematic layout

The two ARUN 160 dishes generate steam at a pressure of 3 to 4.5 kg/cm^2. The steam generated by the two dishes meet the entire steam requirement for pasteurizing 20,000 litres of milk per hour.

The milk pasteurizer is connected with the steam line from conventional boiler and also from the solar dishes. During the day time, the steam generated from solar dishes is used for the pasteurizer and during night hours and cloudy days, the steam from the conventional boiler is used.

An automatic valve arrangement is made at the pasteurizer steam line so that whenever the steam pressure from solar concentrator reduces due to clouds below the required value, i.e., 2 kg/cm^2, the steam from the boiler will be fed into the pasteurizer automatically, so that the process does not get affected.

In addition to the above, a hot water storage silo of capacity 5,000 litres was also installed to store the heat energy from the solar dishes in the form of hot water when the entire processing plant is not in operation, thereby ensuring that the generated heat energy is not wasted.

Performance

These dishes were installed and put in operation from July 13, 2015. The steam generated through these dishes up to March 2016 is 155,880 kg. The savings in the usage of fossil fuel (furnace oil) is 14,845 kg. On an average, the Salem dairy has pasteurized 60,000 to 70,000 litres of milk per day through the above two ARUN 160 dishes.

Moreover the Salem Union has also proposed to install two more dishes exclusively for powder plant to generate hot air to dry the condensed milk into powder.

Daily Steam Requirements

The daily steam requirement for our plant is around 50,000–60,000 kg. The steam from the Concentrator contributes only 3–5 per cent of the total requirement. On an average, approximately 60,000–70,000 litres of milk is pasteurized using solar steam, which is 11.5-13.5 per cent of the daily milk collection.

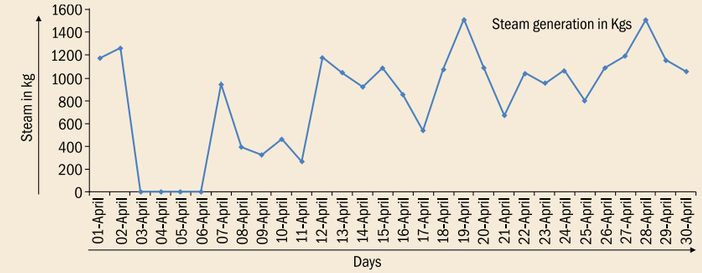

Figure 2: Solar steam generation details for the month of April 2016

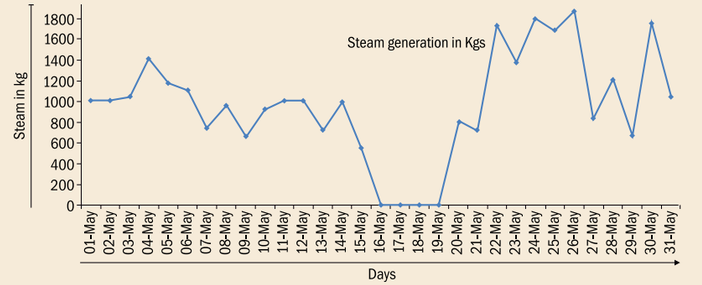

Figure 3: Solar steam generation details for the month of May 2016

Conclusion

The unit is working satisfactorily since commissioning and no major breakdowns have been observed till now. The only maintenance carried out is cleaning of mirrors once in three days which can be easily carried through the cleaning pump and hose available with the dish.

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A.T.E. SOLAR CONCENTRATOR BRINGS CHEERS TO THE COMMUNITY KITCHEN AT NLC DAHANU, MAHARASHTRA

Dadasaheb J Shendage[1], M Girish[2], and Vishal R Sardeshpande[3]

Background

The Girivanvasi Educational Trust (GVET) operates the Nareshwadi Learning Centre (NLC), an educational facility for children from underprivileged families of the Warli tribal community, at Dhundalwadi, Dahanu taluka (Maharashtra), about 130 km from Mumbai. The NLC campus hosts a primary school, a secondary school, a vocational education and training centre, general hostels for girls and boys, school health centre, school farm, and a dairy. Seven hundred and fifty students attend the school, of which 450 children use the boarding facility available on campus.

The management at NLC shifted to wood as a fuel for cooking in 2012 to reduce their dependence and expenses on LPG. Picture 1 shows photographs of the existing practices at NLC. The school kitchen prepares 1,200 meals per day in total (750 for lunch and 450 for dinner). The management wanted to reduce their expenditure on wood and LPG (and reduce concerns about the fuel availability, transportation, and storage throughout the year). According to Dr Gokhale, CEO, NLC, the management also wished to improve the working conditions for the women staff who operated the kitchen.

Resident tribal school for 450 children

Abandoned LPG cooking practices

Wood-stove for cooking

Kitchen operated by 6-8 ladies

Picture 1: The tribal school at NLC, Dahanu, and examples of cooking practices in their kitchen

Challenges Faced

The management at Nareshwadi Learning Centre (NLC) sought a complete cooking solution to cater to its requirement of 1,200 meals per day, throughout the year. Power supply to NLC was inconsistent with significant periods of low voltage that prohibited the use of an electric boiler. The tribal women, who operated the existing kitchen, would be responsible for operating the new kitchen too. The challenge faced was to customise the cooking solution within the existing infrastructure and resources with minimal disruption to the existing schedule.

CST Cooking Solution

The management at NLC invited A.T.E. to demonstrate their integrated solar-assisted steam cooking system. The A.T.E. team systematically addressed several requirements and offered a solution that integrated energy efficiency and renewable solar thermal energy. The CST-based steam cooking solution also include (i) A UPS backup system for the feed water pump and PLC operation; (ii) Simple-to-use water filter assembly; (iii) Insulated hot water storage system; and (iv) A wood-fired boiler for operation during monsoon period. The PLC interface was re-designed to improve user accessibility and the women staff in the kitchen were trained to operate the solar concentrator. Picture 2 shows photographs of the modified practices at NLC. Figure 1 is the schematic of the steam-based cooking system eventually implemented.

Performance

A.T.E. commissioned and handed-over the solar steam-based cooking system at the Nareshwadi Learning Centre in September 2014. NLC uses A.T.E. Solar's integrated steam-based cooking solution to cook 1,200 meals/day—750 students at lunch (12:30–1:30 p.m.) and 450 students at dinner (6:45–7:30 p.m.). The requirement mainly comprises boiling loads with 105 kg rice (on dry basis), 24 kg lentils (on dry basis), and about 33 kg vegetables. The staff has found that the steam-based system cooks food faster and has reduced the total cooking time by about 40 per cent from about 9 hours/day to about 5.5 hours/day. The cooking periods are usually

Picture 2: Concentrated solar thermal-based steam cooking system implemented by A.T.E. Enterprises Private Limited at NLC Dahanu

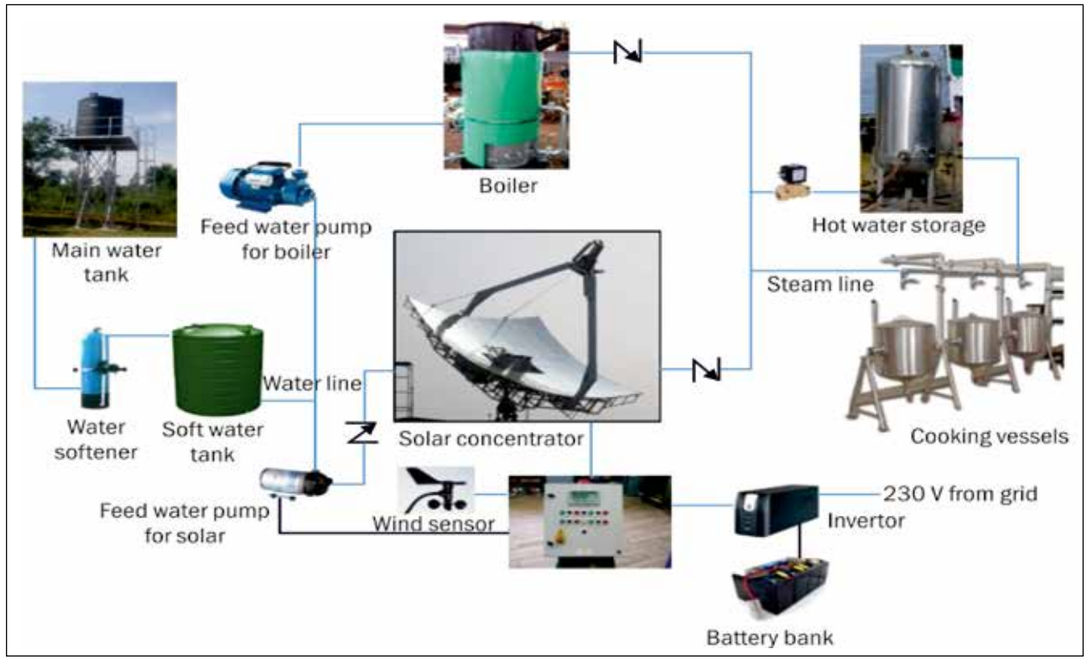

Figure 1: Schematic of the steam-based cooking system installed by A.T.E. Enterprises Private Limited at Nareshwadi Learning Centre, Dahanu.

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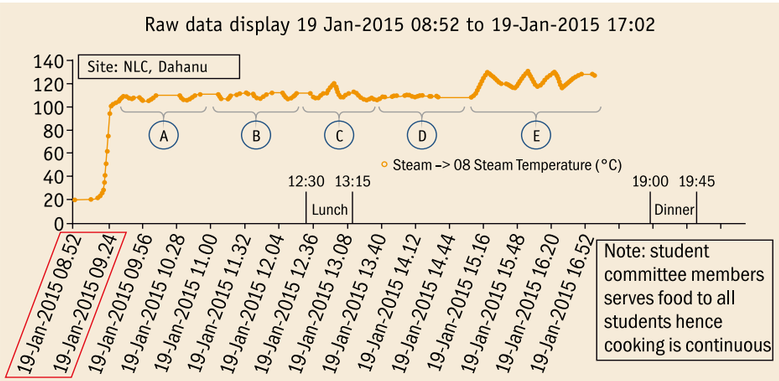

Figure 2: Variation in temperature of steam produced by the solar concentrator on a typical day (using remote monitoring data). A.T.E.'s innovative two-axis tracking system enables the concentrator to generate steam quickly on start-up. A–D denote the time intervals during which different food items are cooked. During period E, steam is not used for cooking, and is used to generate hot water that is stored.

Table 1: Details of the solar steam-based cooking installation at Nareshwadi Learning Centre, Dahanu

Customer	Girivanvasi Educational Trust (GVET), Dahanu, Maharashtra
Requirement	Cooking of 1200 meals per day
Thermal requirements **Hot water @ 60 °C** **Steam @ 2 bar**	 180 litres 100 kg
Fuel consumption	200 – 250 kg of wood/day
Solution provider	A.T.E. Enterprises Private Limited, Pune
Month and year of commissioning	September 2014
Solution provided	Steam and hot water generation using CST technology based dual axis tracking paraboloid solar concentrator – 25 m^2
Steam output	100 kg/day
Conventional system	Open flame cooking on wood fired stoves
Savings	200–250 kg wood/day
Average operation /day	6-8 hours
Daily heat delivery of installation	60,000 kcal/day
Payback period	4 years

between 9 a.m.–12:00 noon and 2:30–4 p.m., but can also be continuous. Figure 2 illustrates the performance of the solar concentrator in terms of steam temperature during a typical day. During the non-cooking periods, the produced steam is sparged into insulated, non-pressurized storage tanks to generate hot water that may be used for cleaning and soaking.

NLC operates the solar steam-based cooking system for about 260 days/year. The wood saved by operating the solar concentrator is about 220 kg/day. Thus, the solar steam-based cooking system saves about 57 tonnes of wood annually. (Assuming previous kitchen was operated on very low efficiency i.e. 10 per cent).

Feedback from the User

In the words of Dr Patricia Gokhale, CEO, NLC, Dahanu, "A.T.E. Solar's steam-based cooking solution reduced wood consumption notably and provided smoke-free environment to the cooking staff without reshuffling of food serving timings. It has improved the hygiene level during cooking. It has reduced drudgery, manual effort, time, and energy required during the cooking process."

PHARMACEUTICAL INDUSTRY USING CST FOR MEDICINE PREPARATION AND SLUDGE DRYING

Jawahar Babu[1], Siddharth Malik[2], and Anubhav Aggrawal[3]

Unique Biotech Ltd (UBL) is a world class, dedicated, and a well laid out large scale fermentation facility established in 2001 for probiotics, enzymes, and nutraceuticals with state-of-the-art equipment in Genome Valley, Hyderabad. Unique Biotech is an ISO 9000:2008 and a WHO–GMP certified company. Our Centre for Research and Development is recognized by the Department of Scientific and Industrial Research (DSIR), Government of India. Unique Biotech is working towards developing disease-specific probiotic solutions.

In UBL drug manufacturing process, heat energy is required for multiple applications like hot water, sludge drying, etc., and furnace oil-based boiler uses, for meeting the requirements. The fluctuating prices of furnace oil and willingness to adopt clean technology motivated the switch to renewable technology.

After a deep market research, UBL found that CST based system would be highly efficient and could be used for multiple heating applications in the company.

In the year 2014, Megawatt Solutions Pvt. Ltd—a channel partner of MNRE commissioned CST system for hot water generation.

System Details

Picture 1 shows paraboloid dishes used for hot water generation. The CST system uses thermic oil as a heating medium and transfers heat to water with the help of a shell tube type heat exchanger.

The system consists of automated dual axis tracking and is integrated with the existing system, without any undeterred impact on the process.

In Figure 1, which shows the schematic of CST system used for drug manufacturing, the

Picture 1: CST system installed at Unique Biotech Ltd, Hyderabad

Table 1: Features of the solar installations at Unique Biotech Ltd

Project Site	**UBL Hyderabad, Telangana**
Commissioning Date	August 2014
Requirement	30,000 litres of Hot water at 90°C
Application	Boiler feed water or process water
Solar Field Size	540 m^2
Solar Field Configuration	Six M90 dishes in parallel configuration
Solar Dishes Tracking	Automated 2 axis solar tracking
Integration Configuration	Thermic oil heating in solar field exchanging heat to water with heat exchanger
Average Solar Energy Yield Per Day	15 lakh kcal/day
Average FO Equivalent Solar Yield Per Day	200 kg/day
Payback Period	3 Years
Overall System Operations	Automated with remote access

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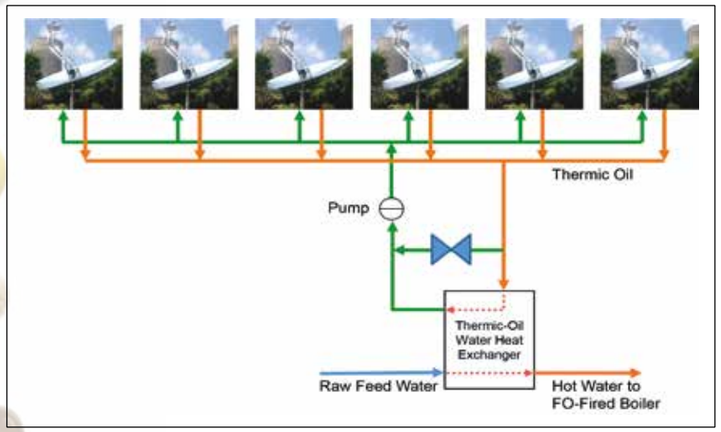

Figure 1: Schematic of CST system for drug manufacturing

dishes are connected in parallel configurations and thermic oil transfers heat to water with the help of heat exchanger.

Hot water (around 90°C) gets stored in insulated storage tanks of 30 kL which can be used either for boiler feed-water heating or directly into the process. Hot water requirement for drug manufacturing—around 30,000 litre/day—is being fulfilled by the CST system which is saving around 200 kg of furnace oil per day. In other words, 9,000 tonne CO_2 emission will be saved over the project lifetime.

Operation & Maintenance (O&M) and Safety

- The Unique Biotech staff has undergone extensive training by Megawatt Solutions for the best O&M practices of the system. The automated system and robust tracking system reduces the O&M expenses significantly.
- The fully automated system is working efficiently and its performance is regularly monitored with the help of PLC monitors. Problems can be remotely monitored for quick action.
- The bright mirrors are the heart of CST technology, so it has to be cleaned on a regular basis. UBL deploys sophisticated cleaning methods which are motorized, to clean unreachable parts of the mirrors.

All safety measures have been considered in the system. In case of a severe problem, or failure of any component, the system automatically goes into safety mode and generates an alarm to alert the operator. The system is working at atmospheric pressure and hence there is no pressure-related risk for the operator.

User Feedback

Dr Ratna Sudha, Managing Director of Unique Biotech said, "CST system has seamlessly and successfully integrated with our existing process, which has set a benchmark for other pharmaceutical companies to adopt CST systems and reduce their dependence on fossil fuels."

Unique Biotech solar installation has set a classic example of success implementation of CST for industrial scale process heating application.

About system performance, she added that they were satisfied with the system's performance and are truly thankful to MNRE and Project Developer, Megawatt Solutions. This project has created awareness, reliability, and goodwill in the market for CST technology in the customer's mind.

Picture 2: Cleaning of mirrors by motorized brushes

Picture 3: Weather Monitoring station to evaluate performance of CST Dishes

NATIONAL WORKSHOP ON CSTS CUM AWARD DISTRIBUTION FUNCTION

The National Workshop on Concentrated Solar Thermal (CST) technologies and Solar Cookers cum Award Distribution Function was organized by the Ministry of New and Renewable Energy (MNRE) in New Delhi on April 29, 2016. Shri Piyush Goyal, Minister of State (IC) for Power, Coal and New and Renewable Energy inaugurated the workshop, felicitated 102 awardees at the "CST & Solar Cooker Excellence Awards 2016" and also released nine knowledge documents collated by several experts to provide information on CST Technology. The Ministry organized the solar thermal excellence awards to recognize and encourage notable achievements in offgrid and decentralized solar thermal applications. The function was attended by Shri Upendra Tripathy, Secretary, MNRE; Mr Jaco Cilliers, Country Director, The United Nations Development Programme (UNDP); Ms Ayumi Fujino, The United Nations Industrial Development Organization (UNIDO) Representative & Regional Director; and senior officers of the Ministry. Among the awardees were the state nodal agencies (SNAs), channel partners of MNRE, and benefitted beneficiaries. First time awardees, such as R K Ashram, Chhattisgarh, and Goodricke were extremely delighted on their recognitions. Encouraging and appreciating the awardees Shri Goyal said that such individual projects have a vital role to play in achieving holistic solar targets. Shri Upendra Tripathy, Secretary, MNRE added, "Next time we are planning to give more numbers of awards and our target will be to give around 800 awards."

Picture 1: Release of knowledge documents

Case studies on successful CSTs installation were presented at the award function. Emphasizing on India's crucial role in solar energy Shri Piyush Goyal said, "With 21 GW offgrid-connected new solar projects out in the market, India has signaled to the world that we're ready to lead."

While speaking on solar energy he said, "Solar programme will not only ensure energy security of our country but also provide power to the last person at the bottom of the pyramid." Also commenting on India's ambitious solar targets he said "India's solar targets are achievable, we have exceeded our solar target by 116 per cent this year as compared to last year and already had awarded projects of 11,000 MW."

MNRE appreciated support provided by UNIDO and UNDP for overall promotion of solar thermal technology in industries and hasten the applications by removing technical and financial barriers in the next five years. The Ministry is also preparing a roadmap to install 100 MW of CSTs by the year 2022. Total 45,000 m^2 collector area have been already installed so far and the Ministry plans to install 45,000 m^2 in the next 5 years.

Picture 2: Shri Piyush Goyal addressing the audience

SOLAR–LPG HYBRID SMART KITCHEN AT NTPC

Siddharth Malik[1] and Anubhav Aggrawal[2]

National Thermal Power Corporation (NTPC), the biggest energy sector company under the Government of India and NTPC Dadri located in Uttar Pradesh, delivers electricity mostly to National Capital Region (NCR). NTPC has a staff canteen to serve for 350 people (Breakfast, Lunch, Dinner), where significant amount of LPG is consumed. In current cooking method around 50 per cent of the heat is lost to surrounding atmosphere from open flame burners and due to radiating cooking vessels. It is realized that improving efficiency of the LPG burners can also help in lot of savings. To overcome this, NTPC wanted a more efficient and safer solution to meet energy needs of cooking. After sufficient market research, NTPC realized that only thermic oil heating based CST system is pertinent for baking, cooking, and frying. In the year 2014, Megawatt Solutions proposed and installed a hybrid solution for kitchen.

Operation Philosophy

Kitchen at NTPC Dadri has been hybridized with two Concentrating Solar Thermal M90 dishes having total collector area of 180 m^2 by Megawatt Solutions. The CST system is a dual axis automated system. Solar thermal paraboloid dishes heats thermic oil at 220°C and this heated oil transfers heat to cooking items through jacketed vessels. In the morning, during lower solar radiation hours, LPG is used to attain the required cooking temperature i.e. 220°C. Afterwards, it switches automatically to solar and all the required cooking

Picture 1: Dishes installed at NTPC Dadri

operations, i.e., baking, boiling, and frying can be done at this temperature. Around 350 meals are prepared in each shift. Generally cooking preparations start at 6 a.m. and continue till 10 p.m. Meals are served thrice in a day.

It can be seen in Picture 2 that there are two highly efficient double jacketed cooking vessels for cooking rice and dal, besides two frying vessels, and two chapati maker.

Picture 2: View of smart kitchen at NTPC

Features of System and Monitoring

This Solar Thermal Cooking System at the staff kitchen of NTPC, Dadri is the most advanced, fully automated CST cooking system in India.

- System works automatically Programmable Logic Controllers (PLC) and manually (in emergency)
- System is completely automated and controlled by a PLC. User can start system, stop the system, and monitor all system parameters directly on the Human Machine Interface (HMI) screen
- During non-solar or low sun-light period, PLC automatically fires LPG burner to deliver uniform heat required in kitchen for cooking
- System has thermal storage tank to store solar energy when cooking is not being done.

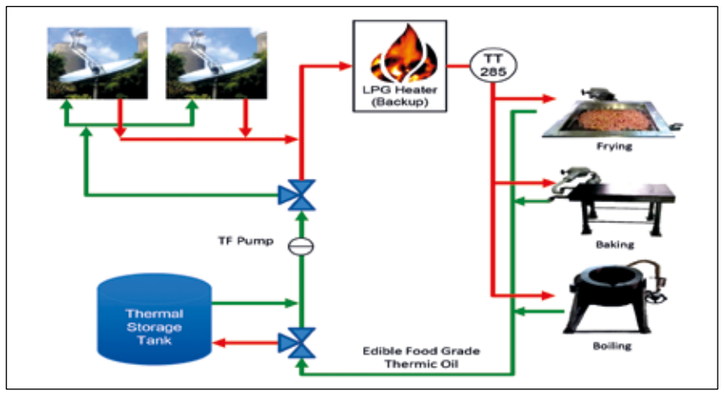

Figure 1: Solar- LPG hybrid system

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[2] *Project Engineer, Megawatt Solutions Pvt. Ltd, New Delhi; Email: aaggarwal@megawattsolutions.in*

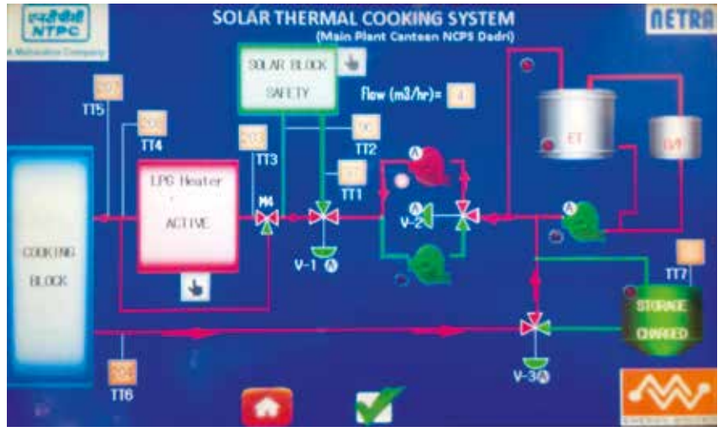

Figure 2: HMI screen to monitor system parameters

Table 1: Project Highlights

Application	Baking, Boiling, and Frying (Cooking)
Heat Source	Food Grade Thermic Oil at 220°C
Integration Methodology	Hybridized with LPG Thermic Oil Heater
Solar Dish Configuration	Two M90 Paraboloid Solar Concentrators (CST)
Solar Field Size	180 m^2
Solar Dish Tracking	Automated Double Axis Solar Tracking
Peak Capacity at Standard Test Conditions (STC)	80,000 kcal/hr.
Backup System	LPG Gas-Fired Thermic Fluid Heater
Backup Net Heat Output	100,000 kcal/hr

Safety Features

- Since thermic oil in the system is always at atmospheric pressure, there is no risk for the cook
- All vessels have been insulated to protect cooks from hand-burns
- Thermic oil used is food grade and safe even in the case of any accidental leakage
- There is no LPG cylinder, smoke, or flame in the kitchen. Hence the kitchen is now safer, cleaner, and more hygienic than before
- PLC has protection from major possible problems in the system and generates an alarm.

Operation & Maintenance (O&M)

NTPC staff has undergone extensive training by the Manufacturer, Megawatt Solutions for best O&M practices of the system. Mirrors are the heart of the CST system, so the dishes are cleaned on a regular basis. CST system is designed for automatic protection from wind storms. In case of an emergency, an automatic alarm is activated and the system is shut. Megawatt Solutions (MWS) has been providing all the support in Training, O&M for keeping the system in running condition.

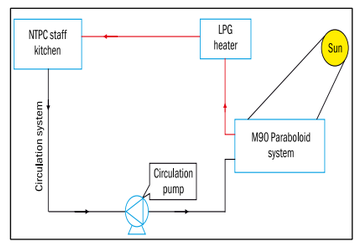

Figure 3: Schematic of Solar–LPG hybrid system

Observations

MWS Smart Kitchen is a flameless modern cooking kitchen, free from the problems of conventional kitchens. Smart kitchen gives customers multiple fuel options for cooking, based on cost and local fuel availability. Food is cooked in a scientific manner while maintaining its calorific value and reducing cooking time period. Cooking temperature is monitored, resulting in fewer food overcooking problems. Smart Kitchens deploy insulated cooking vessel and centralized controlled high efficiency kitchens to reduce fuel consumption.

- Solar Field and LPG heater at NTPC can provide hot thermic oil at up to 300°C to the kitchen at which all cooking configurations, i.e., baking, boiling, and frying can be easily performed
- Boiling time for rice on solar thermal system has reduced by 67 per cent from 60 minutes to 20 minutes, when compared to open flame cooking. Now it takes lesser time for food to boil/fry on solar, as compared to earlier conventional methods.
- On shifting to CST system, LPG consumption has drastically reduced.
- Ambient kitchen temperature has reduced on using solar system because no fuel is burnt in the kitchen.

STEAM COOKING SYSTEM AT DAYALBAGH INSTITUTE IN AGRA, UP

A. K. Saxena[1], Saurabh Motiwala[2], and Sarvesh Devraj[3]

Dayalbagh is a holy place of devotees of Radha Soami faith and has its headquarters at Dayalbagh. The ***bhandar ghar*** at Dayalbagh is a community kitchen of Radha Soami Satsang Sabha and provides food to all devotees residing within the Dayalbagh premises as well as to all pilgrims visiting Dayalbagh on different religious occasions.

To meet the huge demand of fuel for cooking purpose, a solar biomass hybrid cooking system has been installed at ***bhandar ghar.***

The cooking system comprises Scheffler dishes (Picture 1) with total collector area of 128 m^2 making it capable of serving on average 1,000 people/day. The operation and maintenance of the dishes is carried out by a local team of trained personnel.

Picture 1: Concentrated solar cooking system installed at Bhandar Ghar

System Details

The system is equipped with specially designed receivers, with manual tracking which are connected to a common steam header through which steam is fed to the cooking vessels (Figure 1). The cooking utensils include four pickling vessels, each with 200 litres capacity along with one double jacketed vessel of 200 litres for the purpose of boiling milk and water.

During low radiation hours or on cloudy/rainy days, the steam requirement is met up by a wood-based downdraft gasifier. This hybrid system is highly efficient and can serve up to 5,000 people during special gatherings.

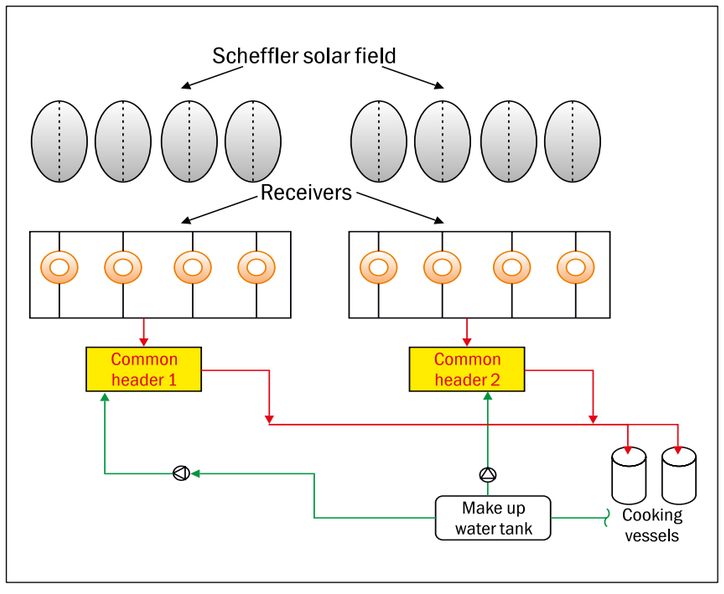

Figure 1: Schematic of solar system

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[2] *Student, M.Tech, Renewable Energy Engineering and Management, TERI University, New Delhi*

[3] *Research Associate, Renewable Energy Technology Applications, TERI, New Delhi; Email: sarvesh.devraj@teri.res.in*

Picture 2: Community kitchen at Dayalbagh

Type of food cooked daily	Quantity (in kg)
Dal	40
Rice	40
Vegetables	30

Details of solar cooking system	
Project Developers	**Flareum Solar Technologies Private Limited**
Year of commissioning	2013
Operating temperature and pressure	170°C, 8 bar
Project cost	₹3,040,000
Daily steam generation	300 kg
No. of dishes	8 (each 16 m^2)
Total collector area	128 m^2
Annual savings	₹208,000
Daily heat delivery	200,000 Kcal/day
Payback period	3 years (with subsidy) 5 years (without subsidy)

Working Schedule

Steam generation starts at 11 a.m. and attains the temperature of 150°C at around 2:00 p.m. daily. After achieving the standard quality of steam, valves are opened to utilize it for cooking. Use of solar cooking system saves approximately 200 kg fuel every day, which accounts for annual savings of around ₹208,000. The solar cooking system functions for around 240–260 days in a year.

Key Issues and Challenges Faced

Initially, operation and maintenance was a key issue of the system, but now local staff consisting of two operators and one supervisor are being trained to tackle such issues.

Maintenance of mirrors is an important aspect of any CST system. In order to ensure consistency of their performance, mirrors have to be cleaned with RO water every few days or fortnightly.

A storage system could be integrated with the existing system to utilize the surplus steam for later use. However, techno-economic viability of the system is arguable.

Manual tracking of the dishes often increases radiation losses, and it also involves lot of physical effort.

Conclusion

Prof. A K Saxena, Head, Electrical Department, Dayalbagh Educational Institute (DEI) and a devotee of Radha Soami faith says "Since the system was installed, we made huge savings on the amount of fuel wood as well as considerable savings on cooking time. This system provides an opportunity to the students at the DEI campus to perform experiments and suggests measures to improve the efficiency of the system."

A committee is being formed to regularly monitor the performance of the system. DEI aspires to motivate other institutions for installing such systems by forming a knowledge and experience sharing platform.

Prof. D Bhagwan Das, Electrical Department, DEI, discussed the importance of replicating similar projects in the tribal areas of Madhya Pradesh, which would not only serve energy access issues but also improve lives of people by providing them a source of income.

CPC BASED SYSTEM AT TEA PLANT OF GOODRICKE FOR PROCESSING APPLICATION IN WEST BENGAL

Atul Asthana[1] and C Palaniappan[2]

Picture 1: Goodricke factory in Jalpaiguri, West Bengal

Goodricke Group, a major constituent of Camellia Plc., UK, is one of India's leading producers of premium teas. The Group's core business is the cultivation and production of tea. The Group has 27 estates in the eastern part of India, spread across 15,803 ha in the three main tea growing regions of Dooars, Assam, and Darjeeling. It produces 30 million kg of tea annually and directly provides employment to 36,000 people. The annual export of the Group is 5.60 million kg. The Group also owns the world's first integrated, state-of-the-art, Instant Tea Plant situated at Aibheel Tea Garden in the Dooars. The Group also has an R&D Centre at Danguajhar Tea Garden in Dooars which is certified by DSIR (Department of Scientific and Industrial Research), Government of India.

Compound Parabolic Concentrator (CPC) Solar Collector – Technology in Goodricke

Compound parabolic concentrator have efficiency of above 60 per cent. CPC collectors could operate up to 6 bar pressure and temperature maximum 160°C, but efficiently in the range of 90–120°C.

Compound Parabolic Concentrator (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 aluminum fins for heat transfer.

Even in low radiation, it could generate pressurized hot water above 100°C, informs Mr. C Palaniappan, CEO, SunBest, a channel partner of MNRE under CST Programme. Unlike other evacuated tube systems, water passes through a U copper tube with aluminum fins ensuring high heat transfer, ruggedness, and long life of the unit.

- The solar panels will be mounted on the south facing roofs of the factory.
- Demineralised 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 90–160°C.

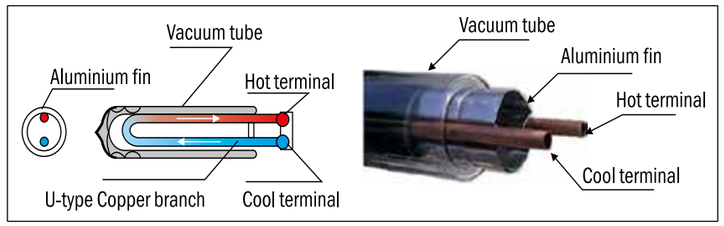

Figure 1: Working of CPC technology

[1] *Vice President, Goodricke Group Limited, Kolkata; Email: atul@goodricke.com*

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

Need for Solar Solution

Instant Tea Plant of Goodricke Group Ltd, Aibheel, Jalpaiguri, West Bengal, manufactures instant tea powder, using black tea as the raw material. The factory has two plate heat exchangers (PHE) of capacity 2,500 + 2,500 litres where ambient water is raised to 75–95°C (depending upon process requirements) on all working days, 24 hrs, using steam obtained by burning coal in a steam boiler. The factory spends 2,400 tonnes of coal/ annum at a cost of ₹ 2.2 crores/annum. The CO_2 emission accounts 5,784 tonnes/year leading to global warming.

Objectives

The basic objective of the project is to bring down the coal consumption and pollution; better pollution control; and reduction in CO_2 emission. The Solar CPC for the plate heat exchanger (PHE) operating for 6 hours/day (during sunny period) was a viable solution.

System Description and Savings

A 107 and 105 CPCs are placed on two different roofs. A closed loop with solar collector array consisting of series and parallel connections with an expansion tank, pump, and other accessories like pressure and air release valve, pressure balancing valve, etc., are formed closed loop with a plate heat exchanger (PHE). The cold water line passes through the PHE and then if needed again, through the conventional PHE.

Based on the actual data collected for 15 days in the month of October, a total savings of 7,627 kg of coal was observed (some of the days are cloudy, rainy, and partly sunny).

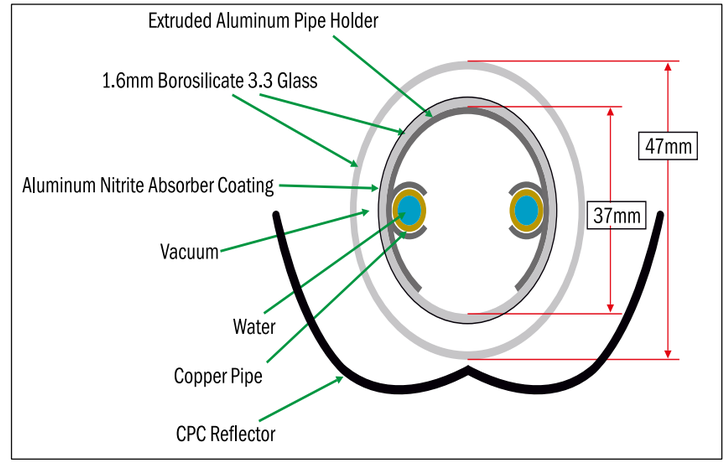

Figure 2: Compound Parabolic Concentrator (CPC) technology

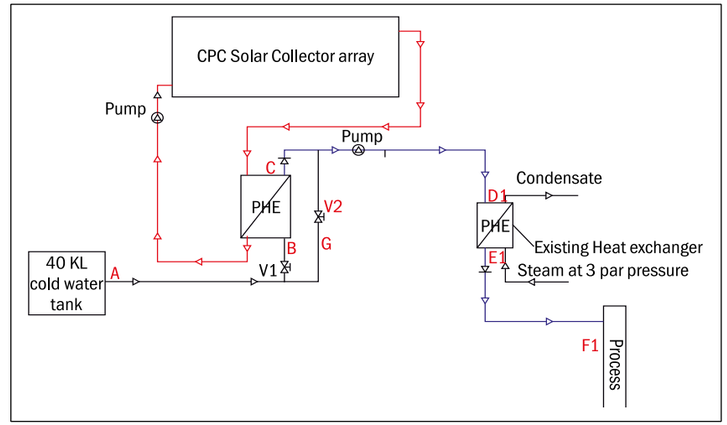

Figure 3: Working model of Solar system at Goodricke

Picture 2: A view of Solar collectors installed at Goodricke.

Challenges and their Solutions

The site has a unique solar radiation which on many days fluctuates between 400 W to 850 W but due to the conventional back up the issue is resolved. Weekly cleaning of the mirror has to be carried out for good performance.

SOLAR STEAM BASED 100 TR AIR CONDITIONING SYSTEM AT MUNI SEVA ASHRAM, VADODARA

Deepak Gadhia[1], Vikram Patel[2], Jayant Thadani[3], and Ankush Dharkar[4]

Late Ms Anuben Thakker with a vision to serve the needy and deprived people laid the foundation of Muni Seva Ashram (MSA) in Gujarat 35 years back. The Ashram's Kailash Cancer Hospital, serves the people with all modern and hi-tech equipment's and amenities which require air conditioned environment.

Earlier the air conditioning was done by steam generated with boiler fed from biomass. MSA had 600 TR Vapour Absorption Chiller (VAC) from a Pune based company namely, Thermax, that used to run with steam.

In the year 2000, Gadhia Solar installed a Solar Steam Cooking system for 500 students and once they were satisfied with the performance, Dr Vikram Patel enquired for possibilities to run the air conditioning system on solar energy. Thus, a feasibility study was conducted and it was concluded that it could be done! They also decided to go ahead with a small pilot in converting the existing 100 TR double effect evaporator-based vapour absorption chiller to run through Concentrating Solar Thermal energy.

Solar-Biomass Hybrid Cooling System

The system installed at Kailash hospital is a solar biomass hybrid cooling system. During the day time, solar provides heat for six hours and the rest of the time, it is run by biomass fired boiler.

CST System Installed

The solar concentrator system consists of 3.5 rows with total 50 pairs of Scheffler dishes and total collector area of 1,250 m^2 with automatic East–West tracking and manual North–South tracking (done every two days). This traps the solar radiation and incidents it on the receiver tank to heat the water, thus producing 400 kg of steam per hour at 167°C.

The configuration was such that the dishes were placed in pair, with the standing dish reflecting the sun rays on the one side of the receiver placed in its focus and the sleeping dish deflecting the sun rays on to the other side of the receiver.

Steam header pipes are placed above the receiver and the header pipe is filled till half. Water flows into the receiver below due to gravity. Due to thermo-siphon effect, the heated water from the receiver is pushed back into the header pipe and the circulation continues till the water comes to boiling point. The temperature in focus due to high concentration is about 55°C and thus on reaching 100°C, the water in steam header starts boiling and gets converted to steam. The pressure of steam is allowed to rise to 7.5 bar, i.e., 167°C and is then drawn and supplied to VAC. To ensure that the required temperature and pressure of steam is maintained, the steam is first sent through back-up boiler, which supplies meeting heat if needed, ensuring that VAS always gets the steam at

Picture 1: A view of Scheffler dishes forming an array

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[3] *M.Tech Student, G H Raisoni College of Engineering, Nagpur, Maharashtra; Email: jathdn@gmail.com*

[4] *M Tech Student, G H Raisoni College of Engineering, Nagpur, Maharashtra; Email: ankushdharkar01451@gmail.com*

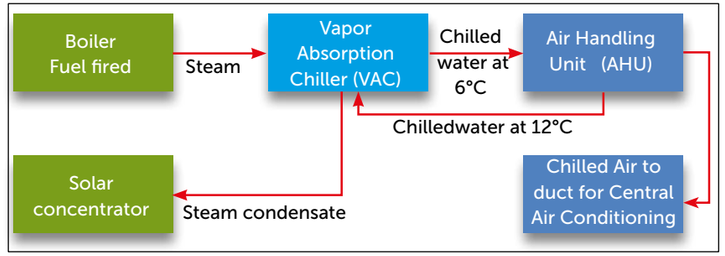

Figure 1: Design schematics of solar cooling system

desired temperature and pressure. If needed, it can also be operated to run air-conditioning during night hours and also during monsoon and non-sunshine hours.

Biomass Back-up System

As the system is operated on solar energy, the output (steam produced) always varies due to continuously varying weather and geographical aspects. Hence the boiler, fired by wood, supplies the shortage in steam produced. There is an automatic controller equipped with boiler, which controls the steam quantity and biomass feeds.

- The steam after giving away the heat to LiBr solution on VAC condenses and is pumped back to the solar receiver tanks for reheating and converting into steam, thus, forming a closed loop system. The steam at 167°C is fed into double effect evaporator based VAC, having COP: 1.12–1.14, Lithium Bromide Solution (LiBr), and generating chilled water at 6°C.
- Chilled water at 6°C is fed to Air Handling Unit (AHU). The fin coil exchanger in AHU chills the air, which is used for central air conditioning in the Ashram. The 6°C chilled water gets heated to 12°C due to it giving away chillness to air and is pumped back to VAC for re-chilling and thus building another closed loop.
- The cooling load supplied by the system is 100 TR per hour equivalent to 350kW thermal per hour.

Picture 2: Boiler producing steam and vapour absorption chiller used for cooling

Economics

The cost of 100 TR Solar Steam Generating System was ₹1.25 cr, out of which MNRE gave subsidy of ₹50 lakh, and the rest ₹62.5 lakh was borne by the Ashram. The cost does not include the cost of back-up boiler and VAC.

The saving due to installation of solar system is approx. 1,000 kg/day of wood. At that time, the cost of wood was ₹2/kg, but now it has risen to ₹6/kg and its availability is also an issue. For Ashram 'Social Return' (benefit to society and environment) was more important than Internal Rate of Return (IRR) and Return on Investments (ROI), which are normally the parameters the Industry looks at before making a decision.

Operation and Maintenance

The system needs about 2–3 people to operate the system. Every day, the operators fill the steam header with make up-water which evaporates and thus needs be continually supplied with fresh water. They then set the focus manually by flexing the dish and turn on the switch for automatic East–West tracking system.

After five years of successful operation, mirrors have been changed under UNDP–MNRE repair and renovation project. Ashram has received support of ₹15 lakh for this scheme. The total cost incurred was ₹33 lakh and due to MNRE's support, the cost incurred by Ashram was ₹18 lakh only. To reduce the dependency on imported mirrors, Ashram has worked with local glass experts of Messer's ARS Gastec and they have developed a coating and side coating and sealing of edges which gives them a longer life.

GUIDELINES FOR SEEKING UNDP SUPPORT FOR INSTALLATION OF CST BASED SYSTEMS

In addition to MNRE subsidy, 20% of benchmark cost from UNDP–GEF project is available for installation of CST based system. More support is there for space cooling projects with new VAM and projects in ESCO mode. Details of support available under UNDP–GEF project for different types and sizes of CST-based systems is as follows:

Category	Type and applications of CSTs	Support under CSHP
Demonstration	All types and applications with sizes 500 sq. m & above	20% of MNRE benchmark cost to a maximum of ₹75 lakh
Replication	All types & applications with sizes below 500 sq. m (excluding Scheffler dishes for direct cooking)	20% of MNRE benchmark cost but not less than ₹2 lakh for projects of sizes 45 sq. m & above on dish and 64 sq. m & above on other CSTs. For projects below that ₹1.5 lakh will be available.
Space cooling where new VAM is installed (Max. 5 projects)	All types of CSTs with minimum 30 tonne capacity of VAM	10% of MNRE benchmark cost in addition to above
Projects in ESCO mode	All types and applications of CSTs	10% more of MNRE benchmark cost to a maximum of ₹15 lakh in addition to above only for systems availing 30% MNRE subsidy and not higher in special areas

Sanctioning of UNDP–GEF Support

A copy of proposal prepared in prescribed format (available on www.cshindia.in) and submitted to MNRE for subsidy simultaneously to Project Management Unit (PMU), also of UNDP-GEF CSH project. The proposals received will be examined by the PMU and if found complete in all respect will be placed before the Project Executive Committee on bimonthly basis for approval. Approved proposals will then be processed for the approval of competent authority based on which sanctions for providing additional support from UNDP–GEF project will be issued to the beneficiaries.

Release of UNDP–GEF Support

Sanctioned support will be available on reimbursement basis after third party inspection on completion and commissioning of the system subject to submission of the following.

i Third party inspection report along with 15 days performance data in prescribed format.
ii 5 year warranty for solar mirror/reflectors given by Supplier
iii 5/3 years Annual/Operation Maintenance Contract as applicable, including 1 year warranty taken by the beneficiary or an assurance given by him that they themselves will take care of the system without any complaint to MNRE/PMU and keep the system functional.
iv The system is installed as per MNRE specifications available on its website.
v Online performance monitoring established by installing the instruments, such as 2 pyranometers; with and without shading ring for measuring DNI, flow meter, temperature and pressure sensors, and sim-based data logger as the case will, e.g., Demonstration/Replication projects.

Online performance establishment for providing data in prescribed format with web link, providing user ID and password to the PMU will be necessary and if not done at the time of third party inspection, 50%-70% support may be released with balance to be released on completion of online establishment.

Fifty per cent of the support could be released in advance, based on the bank guarantee submitted from any scheduled commercial bank within 6 months, having validity for at least one year, subject to placement of the order to supplier or issuing of MNRE sanction. This could also be released to the supplier, subject to having no objection from the beneficiary. Final installment will, however, be released to the beneficiary only.

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Note: The above support is available till 31.3.2017 only, the complition date of the project.

FORTHCOMING EVENTS

NATIONAL

Ninth Annual Conference Solar Power in India
July 4–5, 2016
New Delhi, India
Website: http://indiainfrastructure.com/conference/conference-solar power-in-india-july2016.htm

Workshop on Concentrated Solar Thermal by UNIDO
July 14–15, 2016
Kolkata, West Bengal
July 21–22, 2016
Lucknow, Uttar Pradesh
July 28–29, 2016
Jaipur, Rajasthan
Website: www.cshindia.in/

India Oil, Gas & Renewable Energy Summit and International Exhibition (IORS 2016)
August 10–11, 2016
Mumbai, Maharashtra
Website: www.oilasia.com/IORS/index.php

7th World Renewable Energy Technology Congress
August 21–23, 2016
New Delhi, India
Website: http://wretc.in

Renewable Energy India Expo 2016
September 07–09, 2016
Greater Noida, India
Website: www.renewableenergyindiaexpo.com

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

INTERNATIONAL

Intersolar Europe 2016
June 21–24, 2016
Munich, Germany
Website: www.intersolar.de/en/home.html

Intersolar North America 2016
July 12–14, 2016
San Francisco, CA, United States
Website: www.intersolar.us/en/home.html

Solar Power International
September 12-15, 2016
Las Vegas, NV, United States
Website: www.solarpowerinternational.com/

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

सत्यमेव जयते
Government of India


Paraboloid Dishes

Make your Establishment green by reducing the carbon foot print

CONCENTRATING SOLAR TECHNOLOGIES

can meet a significant amount of your heat requirement for community cooking & Industrial process applications

SALIENT FEATURES

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

FINANCIAL SUPPORT

- 30% of benchmark cost as government subsidy
- Higher subsidy in special category states
- 80% accelerated depreciation to profit making bodies
- 20% of cost limited to Rs. 75 lakhs from UNDP-GEF project for specific activities.
- Additional 10% is available for new space cooling projects and projects in ESCO mode.


Scheffler Dishes


Parabolic Trough Concentrators


Arun Dish

Interested Organizations may contact our Channel Partners (**Clique Solar, Mumbai:** 09665055059 / adb@cliquesolar.com; **LeverageNet Solutions, Pune:** 09970319054 / contact@energy-guru.com; **Megawatt Solutions, New Delhi:** 09654451401 / smalik@megawattsolutions.in; **Taylormade Solutions, Ahmedabad:** 09712933390 / dharam@tss-india.com; **Thermax, Pune:** 020-67308880 or 8885 / kdeshpan@thermaxindia.com; **Ultra Conserve, Mumbai:** 09004445530 / vivek@conserve.co.in; **Unisun, Bangalore:** 09880022272 / shivanand.nashi@unisun.net;) and **Consultant- PwC, Gurgaon:** 08130322334 / vibhash.garg@in.pwc.com) For more details, visit our website **www.cshindia.in** or contact at **011- 24363638 / singhalak@nic.in**

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