a quarterly magazine on **concentrated solar heat**

SUN FOCUS

Volume 2 | Issue 1 | July–September 2014

INDIA'S QUEST FOR SOLAR STEAM AND PROCESS HEAT

Recent Developments

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Empowered lives.
Resilient nations.

UNDP–GEF Project on CSH
Ministry of New and Renewable Energy
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Learning by Sharing

Inviting authors to contribute to

SUN FOCUS

What we require

Feature Articles

Policies

Case Studies

Technology Focus

An honorarium will be paid for published articles.

For contributions and comments, please contact

Ms Sangeeta Paul at sangeeta.paul@teri.res.in or +91 11 24682100; Extn: 2734

Financial Support Available for CST Based Systems

MNRE

- 30% of system benchmark cost as capital subsidy in general category states. Higher subsidy (60%) in special category states, including hilly states, islands, and union territories except to commercial establishments.
- 80% accelerated depreciation benefit available to profit making bodies in the first year.

UNDP–GEF Project (Details available at MNRE website: http://www.mnre.gov.in/)

- 15% of the system benchmark cost to a maximum of Rs 30 lakh for demonstration projects of 250 sq. m and above mainly for online performance monitoring, O&M expenses, feasibility report/ DPR, etc. For dual axis tracked dishes, the support is available for project of 150 sq.m and above.
- Rs 5–10 lakh for replication projects of 250 sq.m and above mainly for providing performance/fuel saving data, O&M expenses, etc.
- Rs 2 lakh for projects below 250 sq.m but not less than 64 sq.m for Scheffler dishes and 45 sq.m for other concentrators mainly for meeting part O&M expenses.
- Additional 10 per cent of cost to a maximum of Rs 15 lakh for projects done in ESCO mode.
- 20% of the system cost to a maximum of Rs 15 lakh for 5-year-old systems for repair and renovation, subject to the condition that an equal amount is spent by the beneficiary.

Contact: Project Management Unit, UNDP–GEF CSHP, MNRE,
Ministry of New and Renewable Energy
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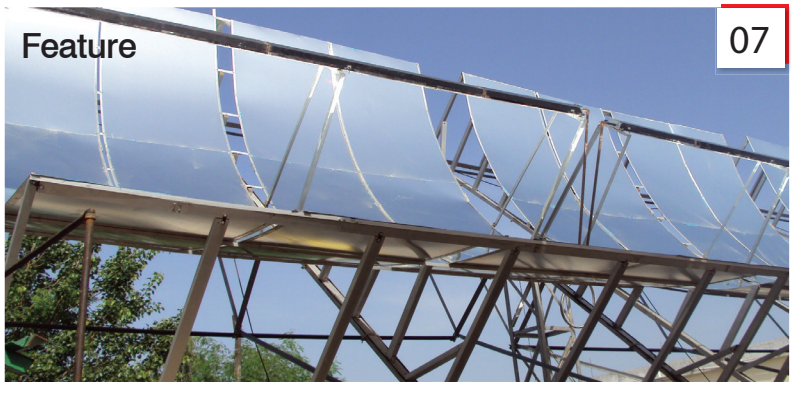
INside...



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India's First CST Test Setup at the University of Pune

On July 22, 2014, the University of Pune (UoP) dedicated a prestigious test facility in the service of the nation meant for testing Concentrated Solar Thermal (CST) technologies at the School of Energy Studies (SES), Pune. This India's first CST test setup was inaugurated by Prof. W N Gade, Vice Chancellor, University of Pune and Mr Tarun Kapoor (IAS), Joint Secretary, Ministry of New and Renewable Energy (MNRE). A similar test facility is also nearing completion at National Institute of Solar Energy, Gurgaon. These CST test facilities are designed to test and rate the performance of different types of solar thermal collectors to bring quality standards in Concentrated Solar Thermal (CST) technologies.

These test centres, funded under the UNDP–GEF CSH project, have come up at an installation cost of Rs 5 crore. The work at Pune centre began in February 2014 and was completed on July 22, 2014. Built with the assistance of Thermax Limited and conceptualized by School of Energy Studies, University of Pune, this facility is a classic example of the amalgamation of academia, industry, and the government sectors. The broad tests that would be carried out in the facility will be surface reflectivity test of reflectors, absorptivity and emissivity test of receivers, and optical and thermal efficiency test of the CST technology. The test output will help the user to estimate the performance of the technology in the local environment.

During the inauguration, Prof. Gade praised the UoP's efforts towards developing new renewable technologies for the benefit of all. Mr Tarun Kapoor lauded the effort by UoP in taking initiatives for establishing test and research centres. He thanked UoP for providing all the assistance in establishing CST test centre in record time. Dr Srinivas, Representative of UNDP appreciated the efforts by UoP and Thermax for establishing this important facility. Dr Singhal, National Project Manager, UNDP–GEF Project thanked UoP and assured that through this facility test procedures and protocols could be fine-tuned for standardization process. Dr R R Sonde, Executive Vice President, Thermax informed that this test facility is first-of-its-kind in Asia.

The CST technologies are looked upon as highly adaptable technologies for Indian environment. A large number of manufacturers are coming with various designs and concepts. It is important to verify their claims independently in the interest of the users. This test facility will surely serve this purpose.

From the editor's desk...

Dear Readers,

I am pleased to inform you that SUN FOCUS has completed its first year successfully and has now entered into the second year. From now on, outreach of the magazine is planned to be improved significantly with print circulation reaching 750 stakeholders in CST sector and a simultaneous increase in e-circulation of the magazine.

This issue focusses on the recent technology developments in the Indian CST sector. As we all know that indigenous research and development is crucial for further development and long-term sustainability of CST sector. This will ensure development of technology solutions that are both cost-effective and suitable to Indian conditions. Fortunately, CST sector is seeing tremendous interest and lot of activity in India with ongoing work on various technologies, such as two axes tracked paraboloid dishes, parabolic troughs, linear fresnel reflectors, and compound parabolic collectors. Some work is also going on for heliostats and central tower technologies. Lot of effort is going into performance improvement and cost reductions of these technologies, which enables CST to tap high temperature applications.

Keeping all this in mind, the current issue covers recent technology developments related to various major components of CST systems, such as development of new technologies of solar collector by Forbes Solar and Leverage Net Solutions. This issue includes a case study demonstrating the recent innovative application of thermal storage for storing steam at Ramakrishna Mission Student's Home, Chennai. Considering the fact that solar mirrors/reflectors are crucial for solar collector technology development, the issue also offers a review article on the topic. WRST, Mount Abu has also developed a fixed focus 60 sq.m automatically tracked paraboloid dish with heat storage, which you may find of good interest.

I hope you will find this issue quite interesting and informative as all previous issues. I look forward to your valuable comments, suggestions, and most importantly 'contributions' to further improve the quality of this magazine. I wish to thank our readers and supporters for their support and encouragement during last year and look forward for the same in future.

Sd/-
Tarun Kapoor
Joint Secretary, Ministry of New and Renewable Energy
&
National Project Director, UNDP–GEF CSH Project

UNIQUE COMBINED SOLAR HEAT AND POWER (CHP) STEAM GENERATING SYSTEMS

Rajesh Nair

For over half a century, Forbes Marshall has been providing steam engineering and control instrumentation solutions for process industry. Forbes Marshall's goal is to provide solutions in energy, efficiency, and process automation using world's best technology. In the last five decades, Forbes Marshall has grown to a multidivisional, ISO 9001 certified global company manufacturing advanced engineering products for process and power industries across the world. Forbes Marshall is probably the only company in the world to have extensive expertise in both steam and control instrumentation. The dual expertise has allowed us to engineer industry specific systems focusing on energy efficiency and utilities management for diverse sectors including textiles, food processing, paper, power, chemicals, etc. The company has always played a role in greenhouse gas (GHG) emission reduction. The Company's new division Forbes Solar, aims at taking the vast untapped solar energy to the industry in a climate friendly way.

Combined Solar Heat and Power (CHP) System

Forbes Solar has developed a unique Combined Solar Heat and Power (CHP) System wherein both electrical as well as thermal outputs are generated from a single solar collector. This system consists of a solar concentrating collector system that includes two parabolic dishes per system each of size 16 m^2 along with a thermo photovoltaic receiver.

A CHP System

The parabolic dishes are mounted on a common two axes tracking system with tracking accuracy of 0.2°, The collector is programmed to track the sun automatically based on the sun's path tracking algorithm. The thermo photovoltaic receiver consists of very high efficiency (35 per cent) Triple Junction GaAs Solar Cells that are actively cooled by water, thereby generating hot water as well. The system generates 7.5 kWp (DC) electricity and around 3.9 m^3/day of hot water. In this system, the high efficiency solar cells generate more power output over a much smaller area as compared to the conventional solar cells. The hot water generation is an additional output that captures the residual portion of the solar power captured by the cells that could not be converted into electricity, and makes it available for thermal applications.

The microcontroller operates the system in three modes—automatic, manual/service, and stow, which are used for operation and maintenance. The mode of selection depends on the wind speed. The system is tested for wind bearing capacity of 40 km/h. The reflectors used are mirrors, which are 3D bent solar glass-based mirrors imported from Flabeg, Germany. These mirrors are unique in a way that no hand alignment is required at site for them and they can be cleaned by normal water.

Integration with Industrial Processes

This system is a fine example of integration of renewable energy and energy efficiency. The system has been giving outstanding results (please refer Figure 1, for details at an engineering company near Pune).

The author is Manager in Forbes Solar Pvt. Ltd, Pune; E-mail: rrnair@forbesmarshall.com

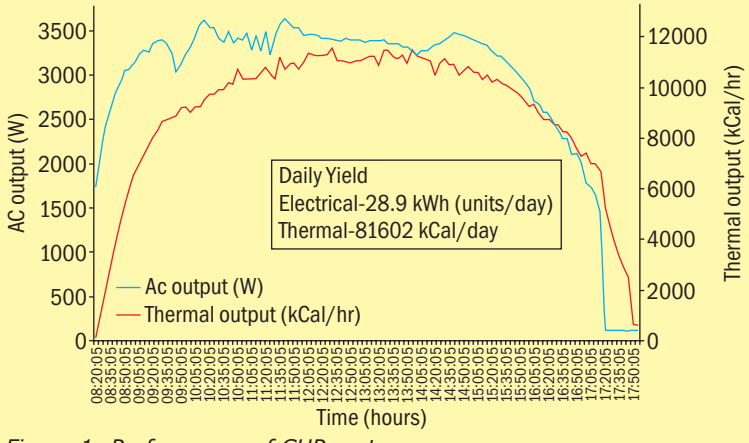


Figure 1: Performance of CHP system

Primarily the electricity generated from the system is connected to one phase of the already existing electrical supply line of the factory with an energy meter fitted giving the outputs from the solar system. The additional hot water received from the solar system is fed into the boiler feed water tank. The system is giving satisfactory results for more than six months.

We have such systems installed in different sectors, such as in a pharmaceutical company, hotels and clubs where both the outputs are effectively used.

Solar Steam Generating System

The same collector can be used to deliver only thermal energy in the form of hot water or steam simply by replacing the electrical generating receiver with a thermal receiver. The extraction in form of only thermal energy enables the system of delivering high temperatures up to 180 °C. This modular system can be configured easily according to the process requirement and can easily be integrated into the existing system, where Forbes Marshall has an experience of over 60 decades. These systems which can be easily installed on roofs have applications in process industries where heat in the form of hot water/steam is required.

Working and Operation

It is a fully automated system with no manual intervention except cleaning of mirrors. The integration has been done in such a way that the process is not at all affected. One example of its application is in a pharmaceutical plant for HVAC process where six such systems are seamlessly integrated with their existing process to deliver hot water for dehumidification. The CST system through a common control for all the systems starts in the morning automatically and instantaneously delivers hot water, thereby reducing the steam consumption which is generated by fossil fuel (P&ID of the integration scheme is Figure 2).

Another advantage of CST systems is that they are light in weight. Due to this they can be installed on the roof top with minimum civil works as seen in photo below. They just stand on a RCC pillar.

The numerous advantages of this system have enabled us to install several systems in industries in last two years. The system has a pre-defined geometry created from a jig, which means no focus alignment at site. The solar grade 3D curved mirrors and precise tracking delivers a very high optical efficiency. All the structural elements are galvanized and all the moving components are

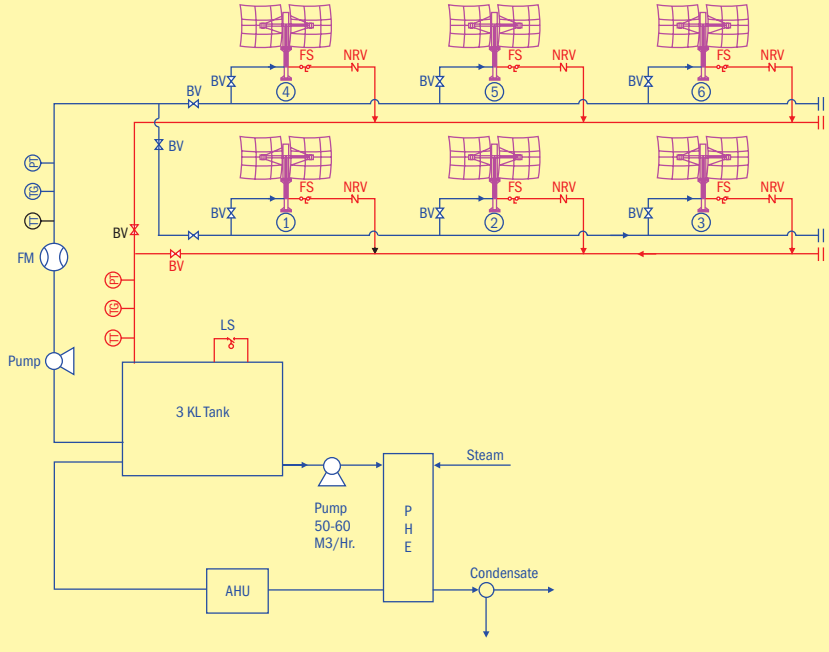


Figure 2: Typical P&ID for integration of CST with existing system in a pharma company

enclosed, thus improving the reliability of the system with very minimal maintenance requirement.

The system has been developed after years of R&D activities on international standards. Currently, more than 10 highly experienced and technical professionals are involved in optimizing the system on daily basis. The analysis of the output behaviour is being done continuously through simulation tools, controllers, and through other equipment. The modular nature of the system enables a trouble free installation and use at the site.

Multiple system installation on rooftop of a pharma company for HVAC application in Baddi, Himachal Pradesh

Applications

These systems can be used to deliver hot water for applications like boiler feed water heating, de-greasing application, HVAC — for dehumidification, process water, etc. It can also deliver medium pressure steam into a common process header. Typically collector system (with aperture area of 16 m²) generates around 100,000 kcal per day of average DNI location of 5 kWh/m²/ day.

One of the installations of this system is in Baddi, Himachal Pradesh (refer image above). This application is in a pharmaceutical plant for HVAC process where six such systems with a total aperture area of 186 m² delivering 700,000 kCal/day (annual average) are seamlessly integrated with their existing process to deliver hot water for dehumidification. Common control system is provided for all collectors. Figure 3 shows the daily energy generation in the month of June 2014.

The collectors start in the morning automatically and instantaneously deliver hot water when sun is available.

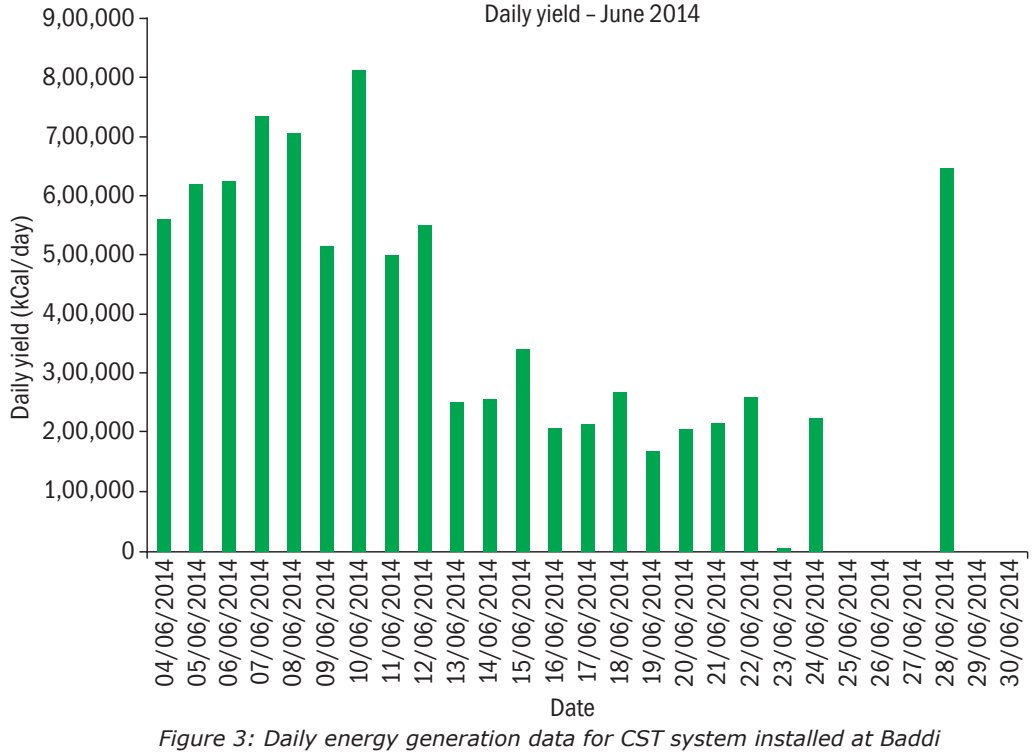
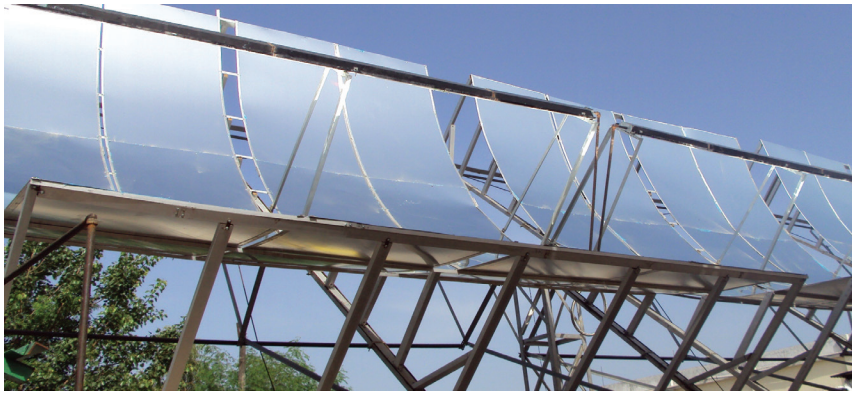


Figure 3: Daily energy generation data for CST system installed at Baddi

AN INNOVATIVE PARABOLIC TROUGH CONCENTRATOR BORN OUT OF CSP FOR PROCESS HEAT APPLICATIONS

Geetanjali Patil Choori

Energy-Guru ® SharperSun introduced by LeverageNet Solutions, has opened up immense possibilities of saving significant proportion of fossil fuels used in industrial process heat applications in economically viable manner. The team while assisting a few of CSP power plants in India with international financing and global technology collaborations and advisory, found that there is a need for scalable CST technology that can fulfil various industrial needs. It designed **SharperSun**, the largest aperture parabolic trough in the world used in process heat applications having a high performance parabolic trough concentrating solar thermal collector with a simple and innovative design that significantly reduces capital, installation, and operating costs (Table 1).



Large aperture parabolic trough concentrator

Table 1: Salient Features of SharperSun collector

Innovations		Salient Features
• Large aperture parabolic trough design using aluminium and silver solar mirror film	Heavy glass and steel structure	Lighter weight, easy to transport modular structure
• Multi-pass receiver tube	Single pass	Multi-pass to get more heat and coverage on the rays captured
• Modular and rectangular solar block to suit industrial spaces	One long assembly of solar collectors	Modular and configurable block design based on the availability of free space in the industrial plant
• Energy efficient cradle like sun-tracking solution	The trough is moved from axis of rotation, so energy required is extremely high	Uses a baby's cradle philosophy and pulley like system to track sun. This reduces one-third of the energy requirement as compared to conventional tracking. This is the biggest innovation by SharperSun.

Brief Description of Components

A. Large Aperture Parabolic Trough Collector

The SharperSun collector has been designed indigenously and has the following advantages:

- Largest aperture trough for CST in the world,
- Simple light weight structure, easy to manufacture, and assemble, and
- Uses high quality mirror film lamination.

B. Multi-pass Tube Receiver

The SharperSun collector utilizes indigenously developed multi-pass tube receiver. The receiver is designed so as to be able to capture maximum amount of radiation reflected from the parabolic collector. The main features of the receiver are as follows:

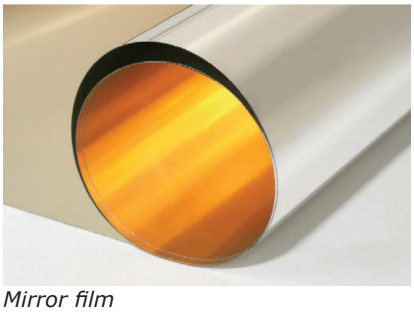
Multi-pass receiver tube used in SharperSun collector

- It is a low cost design. No use of vacuum tube, so does not require absolute precision like the conventional single receiver tube,
- Tubes made up of stainless steel, and
- High quality expensive solar grade selective coating.

The author is CEO and Co-founder of LeverageNet Solutions Pvt. Ltd ; E-mail: contact@energy-guru.com

C. Solar Mirrors

SharperSun collector utilizes high reflectivity solar mirror film mounted on aluminium substrate. This combination is selected considering the suitability to Indian conditions. The physical and optical properties of the mirror film are mentioned in Table 2.



Mirror film

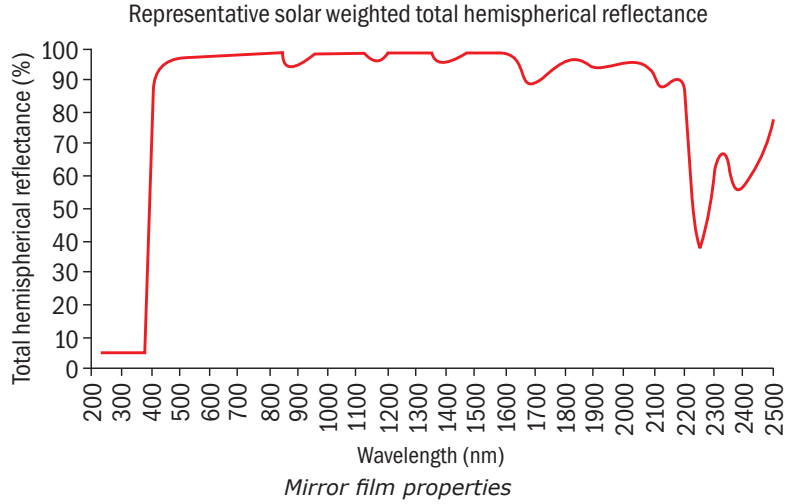
Optical Properties

- Specular reflectance vs angular resolution property value,
- Target 97% at 25 mrad (1.4°) cone angle,
- Solar weighted total hemispherical reflectance, and
- Target 94% per ASTM E 903, ASTM G173.

Table 2: Physical Properties

Properties	Typical Values
Thickness (without liner) mils (microns)	5.0 (127)
Maximum width inches (m)	49.25 (1.25)
Total solar reflectance (Air Mass 1.5) percentage	94%
Specularity percentage	>95%
Minimum reflective area/sq.m	99.8%
Operating temperature range °F	–40 °F to 149 °F

Source: EnergyGuru



Mirror film properties

D. Cradle-like Sun Tracking System

SharperSun collector utilizes a cradle like sun tracking system, which is simple and hence cost effective. Tracking of collector by moving frame's end like a cradle and not at the axis of rotation leads to both efficient and accurate tracking mechanism. Some of its advantages are as follows:

- Energy consumption is only one-third of the regular sun tracking system, and
- Simple and cost-effective tracking mechanism.

Cradle-like sun tracking system

Commercially Viability and Scalability

Indigenously developed SharperSun technology is scalable to various sizes as per project need and is commercially viable due to its cost effectiveness and innovative design. The technology has following advantages over its competitors:

- Cost effective design leads to less capital and O&M expenses,
- Strong modular structure leads to ease of installation and less transportation costs,
- Overall design flexibility leads to ability to utilize most industrial spaces,
- Less auxiliary power for tracking system due to light weight troughs and innovative tracking, and
- Energy Guru is empanelled manufacturer and channel partner by MNRE and is eligible for MNRE subsidy and UNDP grants. When the installation of SharperSun technology is utilized to displace costly fossil fuels, the system gives payback period of about 3–4 years. Energy Guru has setup a factory in Alandi's industrial area, near Pune.

Applications

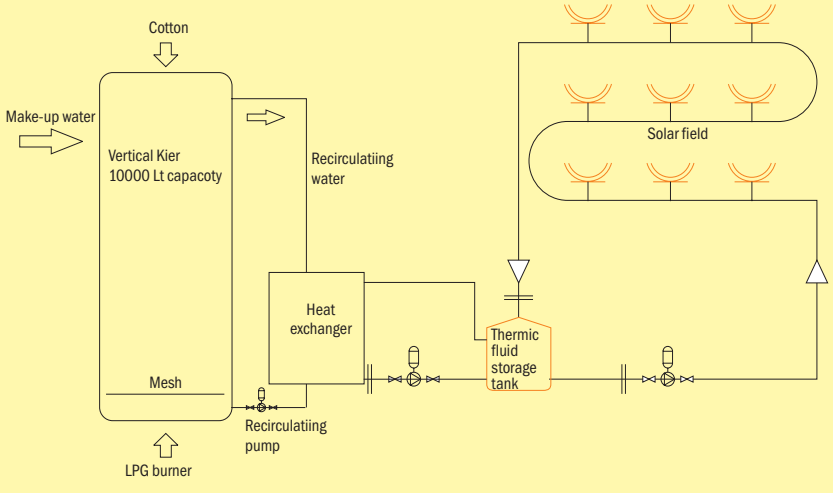
SharperSun collector is able to handle various heat transfer fluids, such as pressurized hot water, hot air and is also able to directly generate steam. Due to this flexibility, SharperSun is suitable for various applications and industries. Some of the applicable examples are given below:

- Process heating and cooling
- Hybrid solar thermal power plants
- Steam augmentation
- Solar desalination
- Enhanced oil recovery.
- Power generation with ORC turbine

Case Study

Solar Heat Intervention in Siddharth Surgical Process

Siddharth Surgicals at Valsad, Gujarat, have commissioned 263 m^2 accumulated area of concentrated solar at an estimated investment of Rs 45 lakh. The solar field will produce 4.02 lakh kcal/day of energy displacing an average 40 kg of LPG on a normal sunny day. It is in hybrid mode with the existing LPG burner (Table 3).



Schematic diagram of solar heat intervention in Siddharth Surgical Process

Table 3: Siddharth Surgicals Solar Heat Parameters

Solar Thermal Input		
Solar Radiation	750	Watt/m^2
Max Temp	140	°C
Solar Field Aperture Area	263	sq.m
Solar Field Surface Area	293	sq.m
Thermal Heat Generated	450000	kcal/Day
Kier Process Fluid Heating		
Process Fluid Quantity	10000	Litre
Temperature Increase	Ambient to 100	°C
Energy Savings		
LPG Savings Per Year	40	Kg/Day
Cost Savings Per Day	3,600	Rs/Day
CO_2 Emission Reduction	100	Tonnes/ Year
Payback	2	Years

"The company is manufacturing surgical cotton, absorbent cotton wool, and soft cotton roll for use in pharmaceutical industry. SharperSun installation by Energy Guru uses a closed loop system to deliver heat to the process application. The hot water is allowed to pass through a heat exchanger tank containing the synthetic heat transfer fluid 'HTF Therminol 55'. This is then stored for short period until the surgical plant starts its operations at noon. Majority of thermal energy is consumed in the process of making surgical cotton. A brick type wide mouthed vertical kier is used at high pressure in the process. About 10,000 litres of water is heated from ambient temperature to 110 °C for six hours at 10 pounds per square inch gauge (psig) pressure in 30 mm thick tank by direct firing at the bottom. This water is withdrawn from the tank and again pumped back to the tank to achieve homogenous heating. Thus, the entire process operates on zero discharge water. The project has qualified for 30 per cent capital subsidy under MNRE scheme and 15 per cent under the UNDP–GEF project on concentrated solar thermal.

FIXED FOCUS FULLY TRACKED 60 sq.m PARABOLOID DISH WITH HEAT STORAGE

B K Jayasimha

India is a country blessed with ample of sun light. It is also a homeland of many great saints and spiritual organizations. Sun connects people with spirituality as they worship him as Surya Devataynamaha.

Brahmakumaris, a socio-spiritual organization with international foot prints over 135 countries all over the world teaches Meditation and Moral, Spiritual Values in day today life for all. The Organization headquarters is situated in the lush green laps of Aravali hills, Mount Abu Rajasthan.

Brahmakumaris, together with its daughter organization the World Renewal Spiritual Trust (WRST), have been actively involved in the research and demonstration of alternative renewable energy concepts for more than 18 years. Since early 1990's, the WRST developed and successfully demonstrated various applications in the field of solar energy for institutional use, like Solar steam cooking systems, Solar Sterilization, and laundry system, which were further widely replicated by other organizations in India. So far, across India, the WRST has installed 6 large steam cooking systems, more than 1.2 MW peak stand-alone solar PV power systems and approx. 50,000 litres/day solar hot water systems at the headquarters. With the help of wide firsthand experience & applied research in the field of Concentrating Solar heat technologies, presently WRST is executing "India One" Solar Thermal Power Plant with various Innovative features. This R&D project is supported by MNRE, Government of India and BMU Government of Germany through GIZ.

Paraboloid Dish

Key Features

Static focus

The Paraboloid reflector is a lateral section of bigger parabola and designed in such a way that it rotates along with polar axis and maintains the focus in a static position. This key feature of the reflector enables to integrate a decentralized storage at focus and avoids high pressure moving joints.

Space frame design for optimum steel usage/sq.m

The 60 sq.m Paraboloid Reflector is structurally designed based on light weight space frame analysis. This structurally optimized design requires steel material of about 50 kg/m² of reflector area. The Reflector is designed taking into consideration the local availability of the material and the ease of fabrication for large scale manufacturing. Currently, 770 such reflectors are being manufactured at the "India One" Solar thermal power plant at Abu road, Rajasthan, with the optimum productivity and highest quality.

Fully automatic dual axis tracking mechanism

In order to synchronize the Reflector rotation with the sun (Daily Tracking) and to achieve various shapes in the same structure in an accurate manner (Seasonal Tracking and shape change Tracking), automatic dual axis tracking is achieved with the help of optical camera for sensing the bright pixels at focus, sensors, microprocessor and electromechanical actuators. The tracking is developed in such a way that it considers real focus position as a result of reflection rather than calculated or measured sun position. The tracking mechanism is network enabled, can be remotely monitored and has communication capabilities. The details are as follows:

Daily tracking

The Reflector automatically tracks the sun from morning 8.00 am to evening 5.00 pm from East to West direction with accuracy of 0.1 degree maintaining sharp static focus at the focal point. This is achieved with the help of camera installed at the centre of Reflector parallel to the axis of rotation of the Reflector. The camera generates the image of the focus which then sends to the processor for image processing for the position of the focus. Mechanically it is run with rack and pinion arrangement powered by DC motor.

Seasonal and shape change tracking

In order to achieve flexible parabolas for each day of the year, the Reflector has to perform inclinations with respect to the sun position in the north-south plane, we call it seasonal tracking. Also, the reflector has to undergo deformation in shape like deeper parabola for winter and flatter parabola for summer in order to maintain the static focus, we call it shape change tracking. This is achieved with the help of electromechanical actuators powered by DC motors (Figure1).

The author is CEO of India One Solar Power Plant at Brahmakumaris Ashram in Mount Abu, Rajasthan; E-mail: bkjsimha@yahoo.co.uk

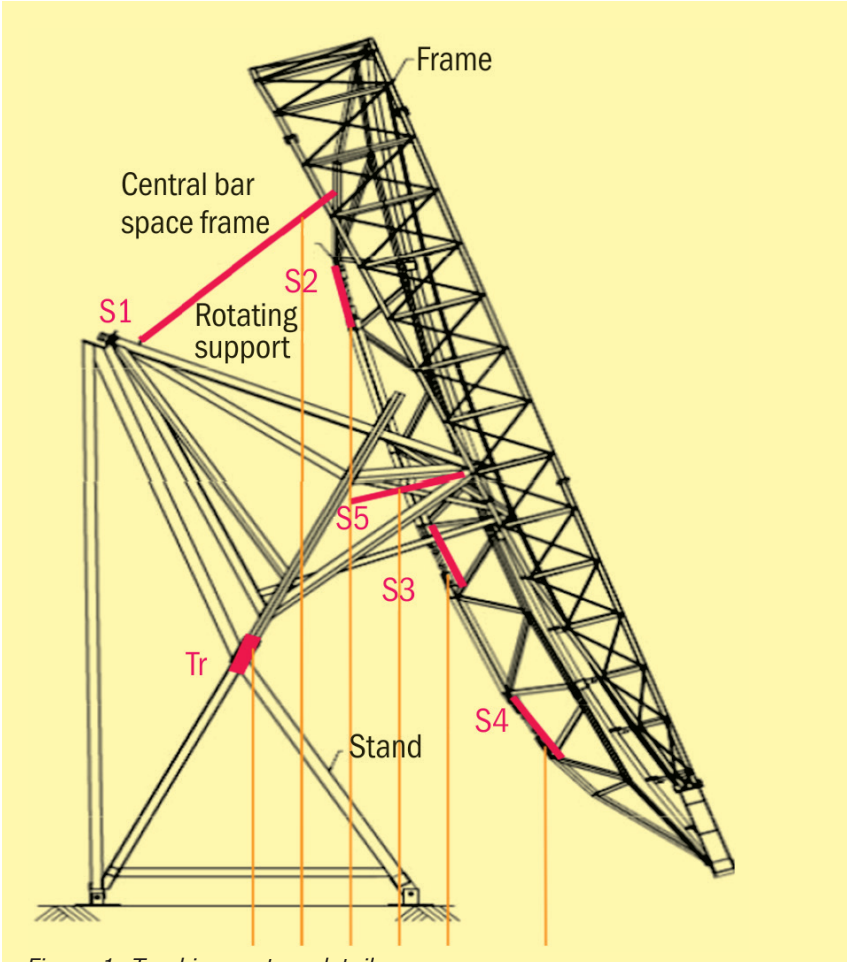


Figure 1: Tracking system details

Tr: Daily tracking (rack and pinion)
S1: Seasonal tracking (electromechanical actuators)
S2, S3, S4, S5: Shape Change tracking (electromechanical actuators)

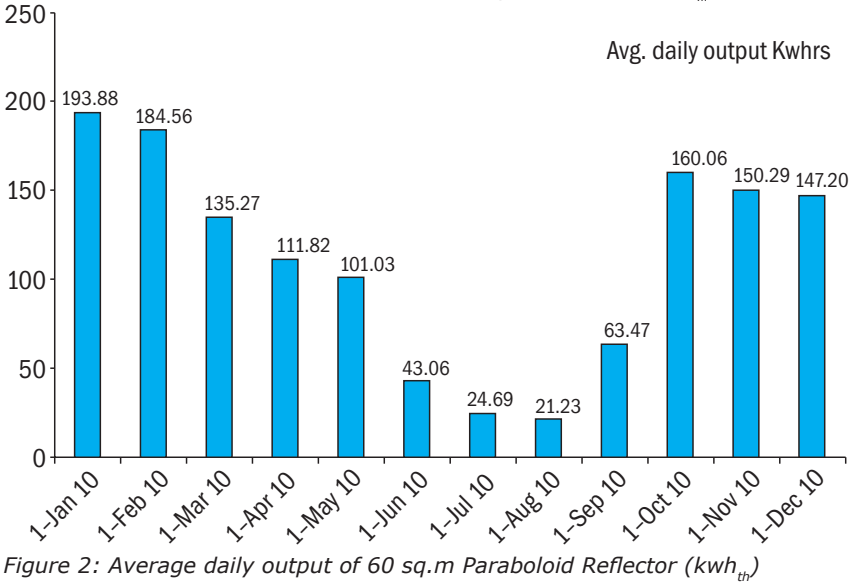


Figure 2: Average daily output of 60 sq.m Paraboloid Reflector (kwh_{th})

Reflective surface area

The 60 sq.m reflective surface is the result of in-house developed curved mirrors. Special Solar grade mirrors with 93 per cent reflectivity are used as reflectors. The curvature of the mirrors is achieved through sandwich process by using special low viscous, fast curing two component silicon glue that is also UV resistant and is suitable for external weather conditions. Each 60 sq.m reflector accommodates around 750 curved mirror pieces and have 16 number of different curvatures that makes perfect parabola shape of the reflector.

Reflector thermal output

Each 60 sq.m Paraboloid Reflector with automatic dual axis tracking mechanism delivers Peak thermal output of about 3.25 kWh/m²/day at focal point. Thus the Reflector efficiency under ideal conditions reaches up to 60 per cent at focal point. The concentration ratio with respect to the reflector area is 1:350 and the stagnation temperature at the focal point reaches up to 1200 °C (Refer Graph in Figure 2).

Decentralized Thermal Storage for Round the Clock Operation

Thermal energy storage plays a vital role into harnessing the solar energy effectively. As the DNI peaks up at noon hours, thermal energy storage acts as a buffer between production and consumption. Moving forward from this basic requirement WRST developed a unique thermal storage that can cater the user round the clock by using cast iron cavity receiver that has high energy density and high specific heat and long lifecycle.

Design

The indigenous static cast iron cavity Receiver is placed at the focal point of the Paraboloid Reflector in line with the axis of rotation of the Reflector (Figure 3). The conical cavity is designed for perfect black body absorption.

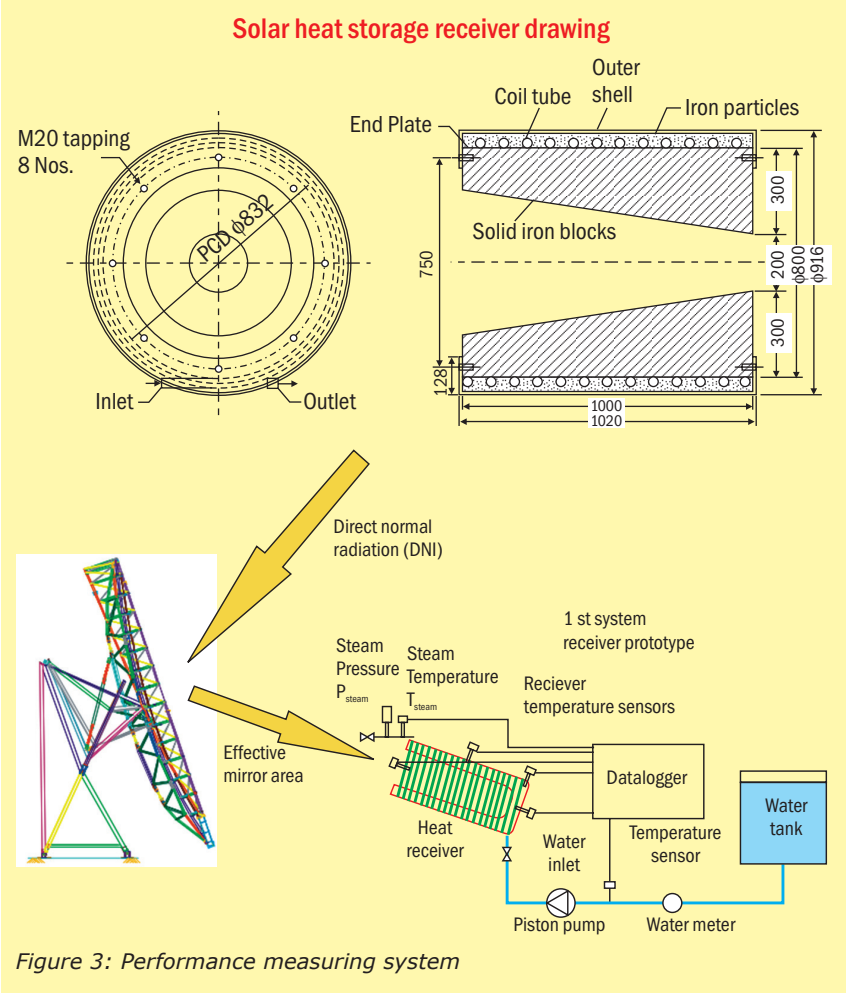


Figure 3: Performance measuring system

Figure 4: Fixed focus fully tracked paraboloid dish with heat storage

Thermal energy delivered by the Reflector is absorbed by the solid cast Iron metal around the cavity, thus provides excellent thermal storage. The heat exchanger coil is tightly wound around the solid cast Iron body that improves heat transfer through surface contact. This mechanism allows direct steam generation when water is pumped into the coil. The result is superheated steam of range up to 400 °C round the clock.

Insulation

The cavity opening of the Receiver is sealed with clear quartz glass to avoid convective losses through the cavity during the day. Automatic front door is designed in such a way that it closes the cavity opening in the evening and night to avoid overnight thermal losses. The rest of the Receiver body is insulated with high density ceramic fibre and glass wool layers to further reduce the thermal losses.

Receiver Output

The static cast iron cavity Receiver deliver peak output of @150 kWhrs/ day of thermal energy. The peak temperature of steam generated is 400 °C at 42 bar pressure under ideal sunny day thus delivering superheated steam as well as saturated steam. The receiver is designed for 25 years lifespan and has high residual value even after the lifecycle.

Applications

The Reflector and the Receiver storage can be used in various industries for wide range of applications. The storage enables the system to cater load energy requirements during non-solar hours. The use of reliable and high temperature storages expands the applicability of solar thermal systems to the critical applications which run round the clock. The 60 sq.m dish can deliver steam in temperature range from 100 °C to 400 °C, in both saturated and superheated conditions.

COMPREHENSIVE REVIEW OF SOLAR REFLECTORS TECHNOLOGIES

Deepak Gadhia and Chinmay Kinjavedkar

It is commonly observed that for a developing country like India, ~15-20 per cent of the total energy requirement is in the form of heat. Most of this energy is required in a temperature range of 50 °C – 250 °C that can be easily catered by solar thermal systems.

Most commonly used solar thermal systems are flat plate water heaters and evacuated tubular collectors which can be used for low temperature applications. However, for higher temperature applications concentrated solar systems are used. In solar concentrators, incident solar radiation is concentrated over a smaller absorber area, unlike flat plate collectors, leading to higher radiation flux density on the absorber and lower heat losses. Due to this solar concentrators are able to go to higher temperatures. Some of examples of concentrator technologies are given in Table 1.

Reflectors: Vital Component of Solar Concentrators

In all solar concentrator technologies, the main components are:

- Reflectors
- Receiver
- Tracking system
- Reflector supporting structure

Out of these, reflectors are very important for overall performance of solar thermal systems. For use of solar concentrators in medium and high temperature applications such as institutional cooking and industrial process heat, the concentrators need to be efficient and effective in terms of generating heat at required temperatures. The overall performance of solar concentrator is given by following equation:

$$\eta = \eta_o - U_L \times \frac{(T_{abs} - T_{amb})}{I}$$

Where,

η Overall thermal efficiency
η_o Optical efficiency
U_L Overall heat loss coefficient (W/m²-k)
T_{abs} Average absorber temperature (°C)
T_{amb} Ambient temperature (°C)
I Beam radiation (W/m²)

It can be seen clearly that the overall performance of the concentrator is limited by the optical efficiency of the concentrator. The optical efficiency of the collector is directly dependent on the reflector performance, i.e., its specular reflectivity. The mirrors or reflectors with very high specular reflectivity (>0.95) are therefore required and it is necessary to maintain this high reflectivity throughout the life of solar concentrator. The mirrors with high reflectivity (>0.95) and relatively low degradation during operations under outdoor conditions are known as solar grade mirrors.

Table 1: Examples of concentrator technologies

S No.	Tracking Type	Collector Type	Concentration Ratio (CR)	Operating Temperature (°C)
1.	Non-Tracking	Flat Plate Collector	1	30–80
		Evacuated Tube Collector	1	50–150
		Compound Parabolic Collector	1.5	60–200
2.	Single Axis	CLFR	10–50	60–250
		Parabolic Trough	10–50	60–300
3.	Two Axis	Parabolic Dish	100–500	100–500
		Heliostat Field	100–1,500	150–2,000

Types of Reflectors

A typical reflector or mirror consists of two main components namely: substrate material and coating material. Substrate material forms the backbone on which reflective coating is applied. Generally used substrate materials are glass, metal, plastics, or polymers. The coating material is typically silver or aluminium which are highly reflective materials. The classification of the solar grade mirrors is done based on the substrate and coating material as shown in the Figure 1.

Glass mirrors

There are two types of glass mirrors based on the surface used for reflective coating. Front surface mirrors use reflective material deposited on a substrate (glass or plastic) and coated with a protective, transparent film to eliminate abrasion and corrosion. In back surface mirrors, silver or aluminium is deposited on the back of the transparent substrate. In this case, glass itself provides protection against abrasion and corrosion. In both these types special protection is needed for the mirror edges as they are the most exposed parts to outside environment.

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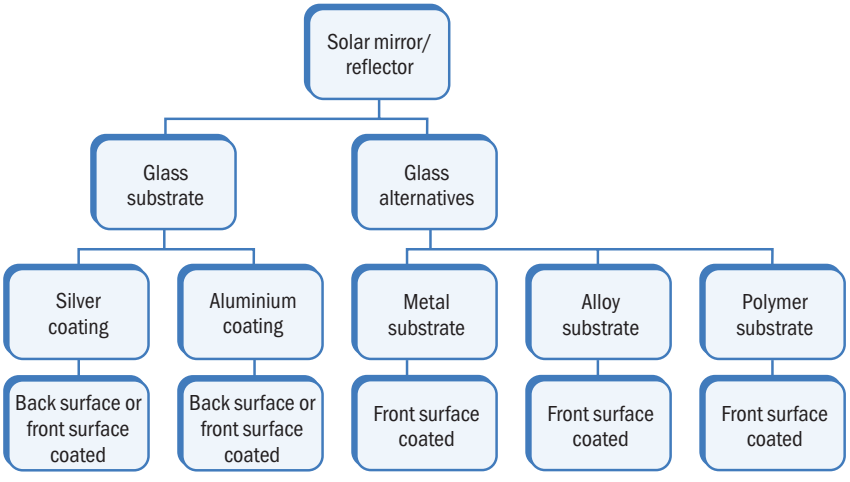


Figure 1: Classification of solar reflectors/mirrors

Glass has various advantages as substrate material as listed below:

- Readily available
- Can be shaped easily
- Potentially very inexpensive when mass produced in high volume
- Mechanical and chemical stability

Due to these obvious advantages glass along with silver coating material (on back surface) have been used as solar grade mirrors since long time.The glass provides good protection of the silver from environmental attack. And this combination is proven to retain initial high reflectance for many years in the field. However, there are two main drawbacks of this combination which prompted research work in search of better alternatives, they are as follows:

- Reflectance of silver, though extremely high at visible and infrared wavelengths, drops off in violet and ultraviolet range, and
- Even small impurities in glass cause radiation absorption in red and infrared wavelength.

Aluminium, as a coating material

Compared to silver, though aluminium has less reflectance (~ 0.85–0.91) it is comparatively cheap and abundant metal, making it good alternative. It also exhibits good mechanical properties and is easy to recycle.

However, aluminium has one major drawback that exposure to air causes serious degradation of the optical properties of unprotected aluminium surfaces. This is catered by use of anodized aluminium which has very less degradation due to the Al_2O_3 layer. The Alanod MIRO® brand manufactures this type of aluminium mirror utilizing highly reflective aluminium foil. It uses SiO_2 layer which protects against abrasion and improves corrosion resistance. The use of polished aluminium sheet has also been tried. In this case, separate substrate material for support is not required due to mechanical properties of aluminium.[1]

Front surface coating

The main advantages of front surface coating over back surface coating are:

- No glass transmissivity losses (incident ray has to cross glass two times in case of back surface coating), and
- High transmissivity and low iron glass is not required, and therefore cheap glass can be utilized.

Along with these advantages, front surface coating has one crucial disadvantage that separate protection is to be provided for corrosion and abrasion resistance. Research is going on mainly in inorganic materials that can be used as protective layer. The long term performance of front surface mirrors has not been thoroughly investigated yet.

Alternatives to glass mirrors

In front surface mirrors, the functionality of glass substrate is limited only to give mechanical support and stability to the mirror. Due to this, various other materials have also been explored to replace glass. The main alternatives considered are metals and polymers due high strength and low weight. Abengoa Solar also is developing its own alternative to glass mirrors. Meanwhile, some companies already have already launched commercial products. Alanod Solar, for example, has an aluminium reflector that has been used by customers such as Sopogy in Hawaii. Pennsylvania-based Alcoa, meanwhile, recently announced a field trial of a parabolic trough system at NREL using Alanod's mirrors. Startup SkyFuel in Colorado also sells parabolic trough aluminium reflectors, which are lined with a silver film developed by NREL and commercialized by ReflecTech.[2]

The manufacturing simplicity and flexibility provided by metal and polymer substrates have lead to important development of solar grade mirrors, i.e., decoupling of reflecting material and substrate. Various companies are now manufacturing mirror films with adhesive on backside. The pasting of these films can be done on substrates of user's choice (generally using machine pasting), for example, 3M working on solar mirror film and

[1] InTech article on solar mirrors, http://cdn.intechopen.com/pdfs-wm/28480.pdf
[2] *CSP Today* Article: http://social.csptoday.com/technology/parabolic-trough-reflectors-does-glass-still-have-cutting-edge, 2010

is planning for a full commercial launch shortly.[3]

Reflectors: The 'Gadhia Solar' Experience

Gadhia Solar has commercialized several types of solar cookers in India and has done pioneering work in this field. It is a prime manufacturer of SK 10 and SK 14 domestic parabolic solar cookers, scheffler community solar cookers, and scheffler solar concentrators. It has done numerous scheffler installations mainly for mass cooking systems at religious and institutional places. It has to its credit the World's largest solar cooker that cooks 30,000 meals per day at a temple in South India and has received many awards and recognition for its work. Mr Deepak Gadhia was instrumental in all this work and while working on various concentrators, he made lot of experiments and trials to work out the best reflector alternative. His experience with reflectors is mentioned in Table 2.

It may be seen that glass is one of better alternatives considering performance, cost and availability in India. Glass has considerably a longer life and is more suitable to cleaning operation. Following points may be noted for reflectors for solar thermal concentrators:

- Use of high performance solar grade mirrors is advisable. These mirrors are not manufactured in India (as of now) and therefore are needed to be imported. Use of these high cost mirrors makes sense due to considerable improvement in collector energy output,
- Imported solar grade mirrors have high reflectivity (~0.93–0.95), but performance guarantee is not yet available for Indian conditions. With proper installation and maintenance care, these mirrors usually last from 5–7 years, and
- For both local and imported mirrors, proper care is needed to maximize the life of the mirror. One of the methods is to provide protection on backside of the coating and use of proper sealant to protect edges.

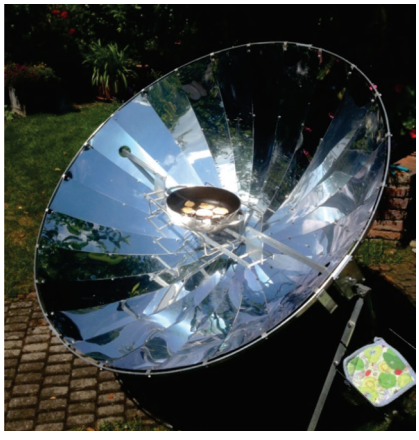
Helping hand by MNRE

The Ministry of New and Renewable Energy (MNRE) has come out with a scheme where it supports the User by bearing upto 50 per cent of the mirror replacement cost with maximum amount upto Rs 15 lakh depending on the Area of mirrors and size of the system. The main purpose of this scheme is to protect users interest and stop this chronic issue from affecting the entire solar thermal sector.

Table 2: Gadhia's experience with reflectors

S. No.	Concentrator Type	Description	Issues	Learning
1	SK 10/14 parabolic solar cookers	Highly polished anodized aluminium sheet of 0.5 mm thickness are used. They are mostly imported material which can be brought locally from dealers of the companies. Two major suppliers were "Alanod" and "Alkan" of Germany. The cost of Reflector on the Domestic Parabolic Solar Cooker is more than 50 % of the cost of cooker	High cost since no Indian major aluminium sheet manufacturer is working in this area mainly due to limited demand from the sector	High performance of reflectors is essential for good performance of cooker. Aluminium sheet is recommended for its small size solar cooker, since operation and maintenance is easy
2	Scheffler: Mylar aluminium foil	Scheffler concentrators are stationary and outdoor installations unlike solar cookers. So imported aluminium foils were not used initially. The foil was stretched and stuck on GI Sheet segments was used the segments as reflective mirrors	Scratching and peeking by birds on foil was main issue. Also cleaning and maintenance also lead to scratching of mirrors and hence rapid deterioration of optical performance	Mylar aluminium foil was not found suitable for outdoor installations
3	Scheffler: Acrylic/ Polycarbonate mirrors	This alternative was explored since polycarbonate mirrors were easily available in India in open market	There were no guarantees on the optical performance. Also, supply was not available round the year	Since it is imported mainly as scrap, there are no guarantees over the optical performance. Therefore, this alternative also is not suitable for commercial solar installations
4	Scheffler: Glass mirrors	The advantage of glass mirrors was that they were cheaper than acrylic. The solar grade mirrors which have low iron content and high reflectivity were manufactured only by foreign manufacturers	Mirror deterioration and degradation after 3 to 5 years. Less number of vendors	It was observed that glass had more stable and reliable optical performance than others. Also glass is much more suitable to cleaning and maintenance activities

[3] RenewableEnergyWorld.com article: http://www.renewableenergyworld.com/rea/news/article/2010/08/should-csp-mirrors-be-glass-or-metal, 2012



Sk-14 solar cooker with aluminium foil

Mirror degradation observed in Scheffler concentrator

Scheffler installation at Muni Seva Ashram is one of such project, where glass mirrors of 100 Scheffler dishes of 12.5 m^2 each are being replaced.

Research and Development

There has been a lot of activity in solar thermal sector and a number of solar concentrator technologies have been developed indigenously namely Arun Dish from Clique, Mega Watt Solution Parabolic dishes of 50 m^2 and 90 m^2, Trough Parabolic Solar Concentrators from Thermax and others. The R&D is also going on for Heliostats, Linear Fresnel Reflectors and footprint and outreach is only set to be increased rapidly.

The key prerequisite for this growth would be availability of reliable and high performance reflectors. Therefore finding a sustainable, cost-effective, and indigenous solution to the reflectors is now highly essential for India. The key is to develop high performance and long life solution without increasing the cost. Some efforts are already going on in India at few academic institutions and private companies. The efforts are sporadic though and coherent national strategy is not yet formulated.

Use of slide sections in mirror arrangement

One such effort is being carried out by Mr Deepak Gadhia at Muni Seva Ashram who has collaborated with Gujarat Energy Research Management Institute of Gandhinagar. Research is going on various possible solutions and performance analysis and testing of following alternatives in process:

- Foil imported from France
- Solar Mirrors imported from Germany
- Various Acrylic Mirrors available in market
- Locally available anodized Aluminium sheet

The important aspect of this work is involving Vendors, Processors and Scientific and academic community by assigning MTech Projects and PhD work to students. This effort invites both, manufacturers and users of solar concentrators to share experiences and issues faced. Also glass vendors, manufacturers are also invited to join this research effort.

International efforts

The US Department of Energy and NREL are one of the active agencies which is working with the industry consortium for research and development of solar mirrors. There are also number of industries (mainly in the USA and Europe) in solar mirror manufacturing such as 3 M, Abengoa, Alanod, Evonik, Flabeg, Guardian, JDSU, ReflecTech, RioGlass, Saint Gobain, SkyFuel. Extensive research is going on these organizations aiming at performance and reliability improvement and cost reduction of solar mirrors.

The long term research activities are directed to:

- Develop Service Lifetime Prediction (SLP) methodology and acceleration factors for basic families of solar mirrors:
  - Metalized (Ag & Al) polymer
  - Silvered glass
  - Anodized aluminium (enhanced reflectance)
  - Front surface mirrors
  - Multi-layer all-polymeric
- Develop advanced reflector coatings using lessons learned and technology improvements
- Develop antisoiling coatings and low-to-no H_2O cleaning methods
- Support development of qualification tests and standards on solar mirror reflectance measurements and durability testing.

SOLAR STEAM COOKING SYSTEM WITH HEAT STORAGE FOR NON-SOLAR HOURS: A CASE STUDY

Brother Chandrasekaran

Ramakrishna Mission Students Home, Chennai, serves around 700 orphan and poor students with free education, food, and accommodation every year. A residential High School and a residential Polytechnic College are educating the students from school to diploma level.

Why We Wanted Low Cost Fuel?

When LPG prices were increased by the Government last year, Students Home authorities were facing a dilemma. Earlier LPG was available to the Home at subsidized rates. A sudden increase in commercial rates forced the Home to spend Rs 80,000 more for the use of 80 LPG cylinders every month. This steep increase in fuel expenses led the Home to think of alternative energy sources.

LPG was used to fire a conventional boiler to produce steam to cook food for children staying in the Students Home.

> "We cook four times a day for 700 students: breakfast (early morning 4.30 am to 6.30 am), lunch (morning–10.00 am to 11.30 am), evening tiffin, and dinner (afternoon–2.30 pm to 5.30 pm)"

Concentrated solar thermal dish with steam storage

The author is Project-in-charge in Ramakrishna Mission School, Chennai; E-mail: office@rkmshome.org

Storage tank

Approximately 3,000 meals are cooked at different hours per day. After increase in LPG prices, wood gas stove was used to generate steam for some days.

Renewable energy—Concentrated Solar Thermal (CST) energy—was thought of as a permanent solution to our cooking needs.

How We Decided to Go Solar?

When we explored various Concentrated Solar Thermal (CST) technologies, we came across many options, such as parabolic troughs and various types of parabolic dishes. We studied and evaluated each of them against our requirements. Uninterrupted steam supply, quick steam generation in the mornings, and automated operations were our major requirements.

Some systems use single axis tracking method, i.e., tracking the sun by east-west direction, which results in decreased efficiency of the solar steam cooking systems. Automatic dual axis tracking systems, i.e., tracking the sun by east-west and north-west directions, help to harvest solar energy to a maximum possible extent.

We cook four times a day for 700 students—breakfast (early morning–4.30 am to 6.30 am), lunch (morning–10 am to 11.30 am), evening tiffin, and dinner (afternoon–2.30 pm to 5.30 pm). So we need steam at various hours of the day. This can be achieved only by storing steam in a storage tank. Without storage the steam produced throughout the day cannot be utilized fully.

For example, we start cooking breakfast by early morning 4.30 am, which is a non-solar hour and steam

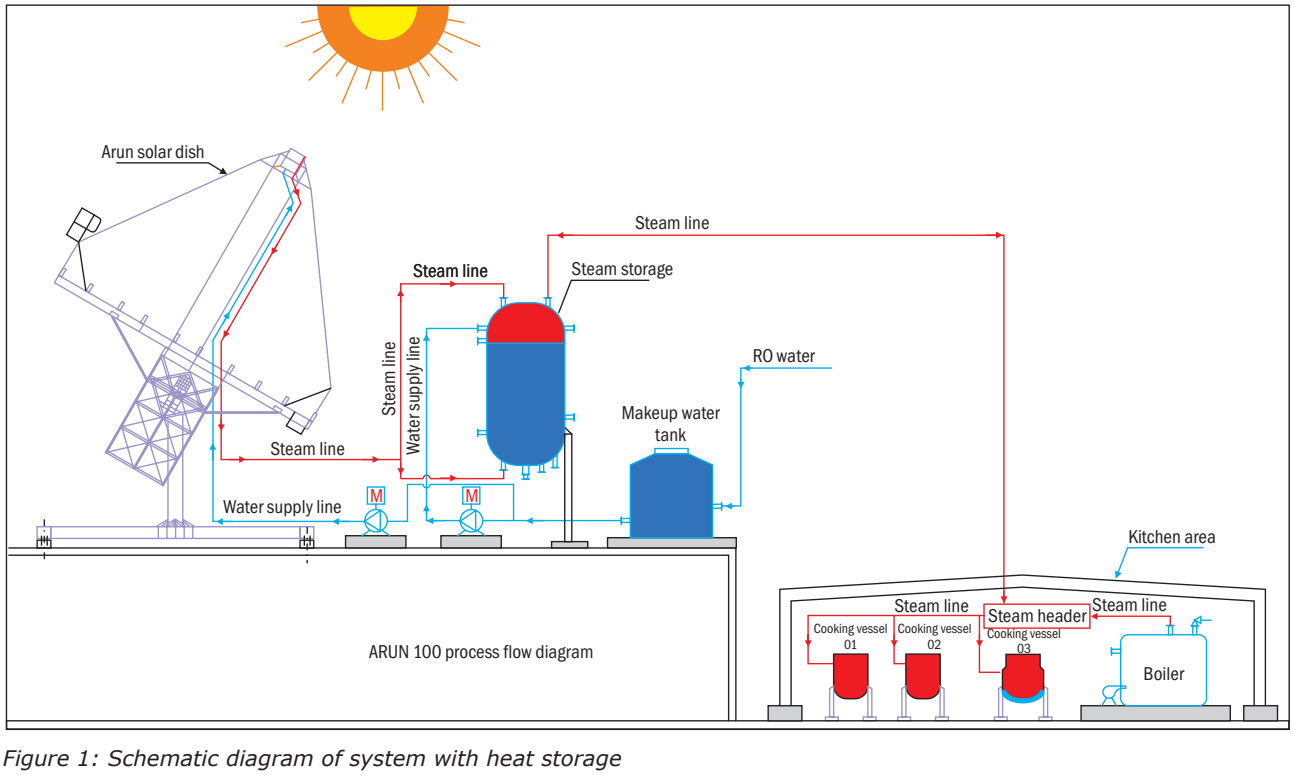


Figure 1: Schematic diagram of system with heat storage

storage is absolutely necessary. Similarly, 11.30 am to 2.30 pm is the prime time when we get maximum solar energy and steam. But we are not cooking at that period. Cooking for evening tiffin and dinner starts by 2.30 pm when the solar energy and steam production starts declining from maximum levels.

Arun®100—Concentrated Solar Thermal (CST) Dish with Steam Storage

Solar Steam Cooking system consists of ARUN®100 dish, pressurized energy storage tank (steam accumulator), feed water tank, pumps, valves, sensors, control panel, and others. The system is installed on the roof top of an existing building. It is integrated with existing steam boiler with LPG/wood stove, which acts as a backup.

Innovative design of ARUN®100 dish and the automatic two-axis tracking system guarantee the highest thermal energy output per sq.m of the collector area when compared to any other solar concentrators in India. ARUN®100 dish is an indigenously developed Fresnel Paraboloid Solar Concentrator Dish system based on an assembly of reflectors with a focal point.

No Focus Misalignment between Reflectors and Receiver

ARUN®100 uses solar grade mirrors as reflectors. They are arranged in such a way that their focal point is always fixed on a receiver (solar boiler). The receiver also moves with the dish. Reflectors in the dish are permanently fixed so that there is no chance of focus misalignment between the mirrors and receiver. This helps to harvest maximum amount of solar energy without human intervention.

Automated Operations

ARUN®dish automatically tracks the sun from morning to evening. Most of the operations are automated, such as pumping of feed water into the receiver and storing the steam in the steam accumulator with the help of sensors.

Quick Steam Generation

One of the notable characteristics of the ARUN®100 dish is that it generates steam very quickly. Our experience is that the steam flow started within 20–25 minutes of dish operation in the morning on a clear sunny day.

The solar radiation falling on the reflecting collector surface is concentrated on the receiver. The receiver coil at the focus of the dish transfers the heat of the sun to the heat transfer medium, i.e., water. As soon as the steam is generated, it is sent to a steam accumulator.

The ARUN®100 dish is capable of producing 540 kg of steam on a clear sunny day and up to seven bar pressure is generated due to this steam. It has built in safety provisions. Frequent cleaning of the reflector mirrors increases the steam output.

Technical Specifications	
Parameters	ARUN® 100
Aperture area	104 m²
Thermal medium	Steam
Operating wind speed	10 m/s or 36 km/hr
Survival wind speed	47 m/s or 170 km/hr
Weight	Moving weight: 9 tonnes, Total weight: 12 tonnes
Height	11.5 m from top to bottom
Tracking energy	~ 0.5kWh$_e$/day
Control system	Micro controller or PLC based
Tracking system	Two axis automatic tracking
Reflectors	Solar grade flat float glass mirrors
Temperature rating	Peak delivery of 350 °C
Thermal output rating	Peak delivery of 350,000 kcal/day
Estimated life of system	20 years +

Inputs Required

a) **Water for steam generation**: 600 litres/day at atmospheric pressure; softened water with hardness <5 ppm and TDS <500 ppm.

b) **Water for washing reflectors**: Potable water at ambient temp; 150 litres/cleaning.

c) **Power supply**: Voltage-3Ph, 415 V, 50 Hz TPN with UPS of 1Ph, 1.0 KVA.

Steam cooking vessels inside the kitchen

Uninterrupted Steam Supply—Steam Accumulator

Steam generated by the dish is sent to the steam accumulator. It is an insulated steel pressure tank with a capacity of 2.5 m^3 where pressurized hot water and steam are stored. It has two steam inlets, one on top and the other at the bottom of the tank. Steam outlet is on top of the tank.

Charging the Accumulator

Initially, the accumulator contains cold water of up to 50 per cent capacity. Steam enters the accumulator from the inlet present at the top and is stored as pressurized steam. Once the pressure reaches a predetermined level, the bottom inlet opens up and the top inlet shuts down. On entering through the bottom inlet of the accumulator, some of the steam condenses and heats the water. Condensed steam raises the water level in the accumulator to about three-quarters full, thereby increasing the temperature and pressure of the water. The remaining steam fills the space above the water level. Thus, hot water temperature, pressure, and water level are increased when the steam is stored in the accumulator.

When the steam pressure in the top portion of the storage decreases, the top inlet opens and bottom inlet closes. This inlet switchover is automatic for easy operation. When cooking is not done, the generated steam is stored in the accumulator for later use during non-solar hours, i.e., early morning use in our case.

Discharging

Steam pressure is reduced to one bar by a Pressure Reducing Valve (PRV) before the steam reaches to cooking vessels in the kitchen. Pressure in the accumulator gradually falls but the reduced pressure causes some of the hot water flashes to steam and the accumulator can go on supplying steam (while gradually reducing pressure and temperature) for some time before getting recharged.

Uninterrupted Steam Supply

Steam is used during non-solar hours from the storage. Also, during daytime when the sun is not available, the system will draw steam from the pressurized storage tank. Even one hour of cloudy sky condition will not affect the cooking when enough steam is stored in the accumulator. Thus, the accumulator helps to supply steady uninterrupted flow of steam for cooking during non-solar hours and intermittent cloudy conditions during solar hours.

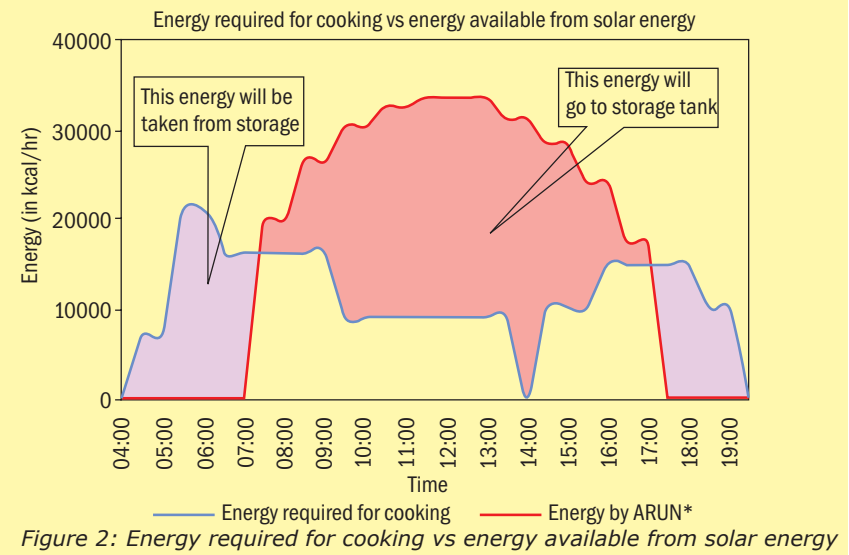


Figure 2: Energy required for cooking vs energy available from solar energy

Parameters	Steam Accumulator
Area	2.5 m^3
Storage	Pressurized hot water and steam
Pressure	Up to 7 bar pressure
Temperature	Up to 180 °C
Storage capacity	165 kg of steam

We have stored pressurized steam and hot water in the accumulator at 165 °C temperature and 6 bar pressure. We can store up to 165 kg steam in the accumulator.

In three direct injection type vessels we cook rice, *dal*, *sambar*, and vegetables. A jacketed vessel is used to boil milk and cook *rasam*, etc. An *idli* box cooks 400 *idlis* at a time. An average fuel saving of 25 to 30 kg of LPG on a clear sunny day is achieved.

Government Subsidy

Ministry of New and Renewable Energy had provided support by granting 30 per cent capital subsidy for ARUN®100 installation. Rs 200, 000 will be provided by UNDP as additional subsidy.

Under UNDP–GEF project, various data logging equipment were installed, such as:

1. Pyranometer for global radiation
2. Pyranometer with shading ring for diffuse radiation
3. Anemometer for wind speed
4. Ambient temperature sensor
5. Feed water temperature sensor
6. Pressure Transmitter (PT)
7. Steam temperature sensor

Conclusion

Quick steam generation at the initial stage leads to uninterrupted steam supply during non-solar hours and cloudy solar hours. Our cooking requirements are met with the use of ARUN®100 solar steam cooking system with steam storage—an enhancement of CST technology.

INTERNATIONAL DEVELOPMENTS IN CST

An Efficient Solar Thermal-Powered Evaporation System for Salt Harvesting and Wastewater Treatment (2014)

The system is based on an External Compound Parabolic Concentrator (XCPC) technology that researchers from the University of California in Merced (UC Merced) have developed. The XCPC is a non-tracking solar thermal collector for industrial process heat and has showed an efficient performance as tracking solar thermal collectors. It is also very competitive financially as compared to similar technologies. UC Merced's researchers are currently working on a 12-month research project aiming at analysing the economic and environmental positive impacts of a solar thermal-powered evaporation system using the XCPC technology. This presentation was given by the University of California Advanced Solar Technologies Institute (UC Solar) during a conference on "Sustainable Solutions in an Era of Climate Variability", organized by the Multi-State Salinity Coalition, in Las Vegas in February 2014.

Solar Thermal Cooling: Technology, Cost and Case Study (2014)

IRENA, the International Renewable Energy Agency, together with the Government of the Republic of Cyprus, organized an event on renewable energy applications for island tourism. Detailed study on solar thermal cooling focussing on the applications in tourism industry was presented in this event. The study shows that the use of solar thermal energy for cooling system helps saving money, reducing the electricity use by 87 per cent, and is a big step towards green tourism. The study provides extensive technical information on basic thermal cooling methods and on the functioning of absorption chillers. It also shares data on capacity and costs. About 3–6 m² of solar collector area will generate 1 kW of chiller cooling capacity. The price of a solar collector varies between 100 and 200 Euro/m². The cost of an absorption chiller very much depends on the cooling capacity; the higher the capacity, the lower the cost. The study was presented by Mr Panagiotis Tsekouras, Mechanical Engineer at CRES, the Greek Center for Renewable Energy Sources and Savings.

Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2012 (2014)

This report gives a detailed overview of the solar thermal market evolution by the end of 2012 in 58 countries, representing 95 per cent of the overall market worldwide. It reports on the total capacity in operation and on the newly installed systems, covering unglazed collectors, glazed flat-plate collectors, evacuated tube collectors as well as glazed and unglazed air collectors. Data shows that China and Europe are the major markets; together 83 per cent of their systems are already in operations and 92 per cent are newly installed systems.

In most countries, solar thermal systems are still being used mainly for domestic hot water in single family houses, representing 78 per cent of all usage. This is followed by domestic hot water usage (9 per cent) and swimming pool heating (8 per cent). District heating or industrial processes only count for 1 per cent. In terms of employment, it is estimated that the solar thermal energy sector has employed about 460,000 people worldwide in the areas of production, installation, and maintenance. It is to be noted that the use of solar thermal concentrators for medium and high temperature applications are still at very small level in terms of energy contribution at worldwide level. The report was prepared by Franz Mauthner and Werner Weiss of AEE INTEC in the framework of the Solar Heating and Cooling Programme (SHC) of the International Energy Agency (IEA).

Experimental Analysis on Performance of Solar Cooling System in UAE conditions (2014)

The study presents the conclusions and results of experimental and simulation studies carried out by CSEM at SOLAB (Solar Outdoor LABoratory) for solar cooling systems in the UAE. The study presents validation of simulation studies with live experiments. The study analysed the effect of temperatures and storage volume on overall system performances. This simulation model has also been used in South Africa and has shown better results due to more favourable environmental parameters. This presentation on the experimental analysis on the performance of a solar cooling system in United Arab Emirates' (UAE) conditions was given by CSEM UAE Innovation Center at the second Southern African Solar Energy Conference (SASEC) that took place on January 28, 2014.

Source: http://solarthermalworld.org/

RFP ON DEVELOPMENT OF CST BASED PROJECTS TO BE IMPLEMENTED IN ESCO MODE

Objective

To develop Concentrated Solar Technology (CST) based projects for implementation in ESCO mode by identifying the beneficiaries, manufacturer, and financial institutions and have agreement among them on recovery of investment based on savings made on conventional fuel in installments to be paid during a minimum period of five years.

Scope of Work

1. To identify the beneficiary, manufacturer, and financial institutions and develop Detailed Project Report (DPR) for generating ready to sanction proposal for submission to MNRE and PMU, CSHP for availing subsidy and UNDP–GEF support. 80% accelerated depreciation benefit available to profit making organizations may also be considered while calculating the cost economics and preparing the DPR.

2. To work out the details of financial mechanism and arrange signing of MoU covering the following :
   - Performance guaranty, performance measuring, and fuel saving techniques
   - Details of investment to be made by ESCO, beneficiary/any other in beginning
   - Whether equity of various parties or availing loans. If loans, details to be provided with name of FIs providing loans
   - Monthly/ quarterly installment to be paid by beneficiary on savings (minimum five years)
   - Time period of agreement with beneficiary
   - Beneficiary's commitment to bear minimum 20 per cent of project cost in beginning
   - An Affidavit that system installed will not be dismantled without permission

3. Submission of ready to sanction proposal to PMU for consideration of providing subsidy and UNDP–GEF support to Project Executer as per below:

   MNRE Subsidy

   30% of bench mark cost (Amount as applicable at the time of sanctioning project)

   Release : On commissioning of the system with sanction issued in the beginning. It could be adjusted with loan amount also if availed from IREDA.

   UNDP–GEF Support

   It will be either the direct support from Project Management Unit, UNDP–GEF project or in the form of interest subsidy to provide soft loan from IREDA as per below:

Direct Support

15% of MNRE benchmark cost to a maximum of Rs 75 lakhs as demonstration project for technologies other than 16 sq.m Scheffler dishes. (For 16 sq.m Scheffler dishes, it will be Rs 5 lakh for projects up 500 sq.m and Rs 10 lakhs above that)

10% of MNRE benchmark cost to a maximum of Rs 15 lakhs as project to be done in ESCO mode in addition *Release*: 50% of the sanctioned/ approved UNDP–GEF support in advance based on BG of same amount received for a period of one year atleast. Balance in 2–3 yearly installments.

Soft Loans from IREDA

80% of the project cost at an interest calculated after adjusting the available UNDP–GEF support as above on the basis of DPR approved by MNRE repayable to IREDA as per their existing scheme.

4. The DPR submitted to PMU along with ready to sanction proposal will contain the instruments and equipment to be installed at site for the purpose of web based on-line performance monitoring

Maximum projects to be considered for UNDP–GEF support

5. Nos on first cum first cum basis

Approval of Proposals Received

Proposals received will be presented by applicants before technical committee of the UNDP–GEF project for approval of MNRE and UNDP support. Approved projects will be then be processed for sanctioning of MNRE subsidy/UNDP support/ IREDA loan as applicable. The applicants of approved projects will also be eligible to get an amount of Rs 50,000/- towards preparation of DPR and generation of proposal which will be released within 15 days of time.

Last date of submission of proposals (the date of UNDP support available)

October 30, 2014. Applicants will, however, be required to confirm their interest in advance to Project Management Unit as early as possible.

Submission of Proposals

5 copies of DPR prepared along with ready to sanction Proposal will be submitted to PMU at following address. The applicant must have experience either in implementing/preparing report on the CST based projects or executing some ESCO projects.

Project Management Unit (PMU)
UNDP–GEF Concentrated Solar Heat Project
Ministry of New and Renewable Energy
Block 3, CGO Complex, Lodhi Road, New Delhi-110003
Telefax: +91 11 24363638; Website: www.mnre.gov.in; www.cshindia.in

BUSINESS MEET AT GOA ON MAY 8, 2014

The Goa Energy Development Agency (GEDA) and Ministry of New and Renewable Energy (MNRE), Government of India jointly organized a business meet on "Concentrating Solar Technologies for Community Cooking, Space Cooling, and Process Heat Applications" under UNDP–GEF Concentrated Solar Heat Project on May 8, 2014 at Goa International Centre, ICG, Dona Paula. Dr Tarun Kapoor, Joint Secretary MNRE inaugurated the meet. Dr A K Singhal, National Project Manager, UNDP–GEF Concentrated Solar Heat Project, MNRE, Dr R P Goswami, Director MNRE, and Dr Pramod V Pathak, Member Secretary GEDA were also present for the same. The meet mainly focussed on raising awareness about solar concentrated power systems and their utilization. There were presentations on Scheffler Technologies by Unisun, Bangalore, Arun Technology by Clique development, Mumbai, and on Parabolic Trough Concentrators by Thermax, Pune. Around 52 delegates including local media and press participated in the programme.

BUSINESS MEET AT AGRA ON JUNE 3, 2014

A half-day workshop was jointly organized by the National Chamber of Industries and Commerce, Agra, Uttar Pradesh and the Ministry of New and Renewable Energy (MNRE), Government of India, on the "Use of Concentrated Technologies in Food Processing and Other Industries" on June 3, 2014 at Hotel Samover, Agra, Uttar Pradesh, under UNDP–GEF Concentrated Solar Heat Project. The workshop was attended by Mr Atul Kumar Gupta, President, NCIC; Mr Abhishek Agrawal, Chairman, Non-conventional Energy Cell, NCIC; Mr Krishna Goyal and Mr Anoop Goyal, Vice-President, NCIC; and Mr Girish Chand Goyal, Treasurer, NCIC. Dr R P Goswami, Director, MNRE, and Dr A K Singhal, National Project Manager, UNDP–GEF Concentrated Solar Heat Project, MNRE, also attended the workshop. Around 50 representatives of food processing industries, other industries, and technology providers participated in the workshop. Representatives from various technology providers were also participants in the workshop.

BUSINESS MEET AT JAIPUR ON JULY 31, 2014

A half day workshop on "Concentrating Solar Thermal Technologies for Industrial and Commercial Applications" was organized by Rajasthan Renewable Energy Corporation Limited (RRECL) at Jaipur on July 31, 2014. The workshop was sponsored by UNDP–GEF Project on Concentrated Solar Heat. The objective of the workshop was to promote awareness to accelerate the growth of concentrating solar technologies for community cooking and process heat application in the potential area in the state. Presentations were given by senior officials and experts from the institution/SNA and manufacturers. Representatives from various industries and institutions, technology providers, and user agencies participated in this workshop. Over 50 participants attended the workshop.

TRAINING-CUM-AWARENESS PROGRAMME ON "ONLINE PERFORMANCE MONITORING OF CST BASED INSTALLATIONS" ON JULY 11, 2014 AT NISE

A "Training-cum-Awareness Programme on online performance monitoring of CST based installations at NISE", under UNDP–GEF CSH Project, was conducted on July 11, 2014 at National Institute of Solar Energy (NISE), Gurgaon. The Programme was attended by representatives of 11 (out of 15) CST based installation sites in different parts of the country. Mr S K Singh, Director, NISE welcomed the guests and presented a glimpse of the available facilities, technologies developed, and future plan of the Project. He also explained about the various types of solar concentrator technologies and their applications. Dr A K Singhal, NPM-CSP, MNRE, Dr R P Goswami, Director, MNRE, and Dr P Saxena, DG, NISE, were also present in the Programme. The Programme was also attended by beneficiaries.

FORTHCOMING EVENTS

RENEWABLE ENERGY INDIA EXPO
September 3–5, 2014
Greater Noida, India
Tel. 022 61311452
E-mails: zahid.shaikh@ubm.com / ashwini.chaudhary@ubm.com

DESERT SOLAR SAUDI ARABIA CONFERENCE AND EXHIBITION
September 17–18, 2014
Riyad, Saudi Arabia
Tel. + 971 50 2450388 (UAE)
E-mail: info@solargcc.com

INTER SOLAR SUMMIT INDIA 2014
September 22, 2014
Bangalore, India
Tel. +49 228 9714345

29TH EUROPEAN PV SOLAR ENERGY CONFERENCE AND EXHIBITION
September 22–26, 2014
Amsterdam, The Netherlands
Tel. +49 89 720 12 723
E-mail: pv.manuscripts@wip-munich.de

SWIC: SOLAR AND WIND INTERNATIONAL CONFERENCE
October 2–3, 2014
Bucharest, Romania
Tel. (+40 249) 413 830

SOLAR POWER INTERNATIONAL
October 20–23, 2014
Las Vegas Convention Center
Las Vegas, Nevada
E-mail: info@solarpowerinternational.com

INTERSOLAR INDIA 2014
November 18–20, 2014
Mumbai, India
Tel. +49 7231 58598-211
Fax +49 7231 58598-28

gef

सत्यमेव जयते

UNDP
Empowered lives.
Resilient nations.

Concentrating
Solar Thermal Systems

A technology to save precious fuel oil & other fossil fuels in industries, institutions & commercial establishments for process heat, community cooking & space cooling applications using solar energy

Steam Cooking System at Brahma Kumaris Ashram, Mount Abu

Laundry application at Gajraj Dry Cleaners, Ahmednagar

Milk pasteurization at Chittlay Dairy, Maharashtra

Space Cooling System at Honeywell Technologies, Hyderabad

Salient Features

- Can provide steam/hot oil/ pressurized water at 90-350° C
- A smallest system of 100 sq. m. requiring double the land space can save 5,000 to 10,000 liters of fuel oil per year depending on technology used & available Solar radiation
- Is integrated with conventional boiler to have trouble free operations during non-sunshine hours
- A number of technologies suitable for various applications are available
- Pays back the cost in 3-5 years depending on sunshine, application & fuel being used
- Over 150 systems of various capacities working in country

Financial Support

- 30% government subsidy to all category of beneficiaries with additional benefit of 80% accelerated depreciation to profit making bodies.
- Higher subsidy for special category states.
- In addition, up to 15% support available from UNDP-GEF project for systems sizing 150-250 sq. m. & above for specific activities.

Interested beneficiaries may contact our Channel Partners at **Pune: Thermax** 020-67308885 / 8889; **Forbes Solar** 020-39851236; **Leverage Net Solutions** 020-30560130; **Mumbai: Clique** 022-28609011; **Ultra Conserve** 022-25145602; **Bangalore: Airier Natura** 080-23417353 / 7753 / 0784; **Unisun** 080-25505015 / 65307555 / 65732555; **Dhule: Essential Equipments** 02562-239330; **Ahmedabad: Taylormade** 079-40035875; **Noida: Megawatt Solutions** 09654451401; or write to us at following address indicating the heat requirement, fuel being used, space availability etc:

National Project Manager
UNDP-GEF CSH Project, Ministry of New & Renewable Energy
Block 3, CGO Complex, Lodi Road, New Delhi-110003 | Telefax: 011- 24363638 | E-mail: singhalak@nic.in

SHARAD

Toll Free Helpline No. 1800 2 33 44 77 could also be accessed during Monday to Friday between 9.30 am to 6.30 pm & on Saturday: 9.30 am to 1.30 pm