a quarterly magazine on **concentrated solar heat**

SUN FOCUS

Issue 3 | January–March 2014

INDIA'S QUEST FOR SOLAR STEAM AND PROCESS HEAT

SPECIAL ISSUE

CSTs for Industrial Application

gef
MNRE
UNDP
Empowered lives. Resilient nations.

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

Financial Support Available for CST Based Systems

MNRE

- 30% of system cost as capital subsidy in general category states. Higher subsidy (60% of cost) in special category states, including hilly states, islands, and union territories, except to commercial establishments.

UNDP-GEF Project

- 15% of system cost to a maximum of Rs 30 lakhs for demonstration projects of 250 sq. m and above for performance monitoring, O&M expenses, feasibility report/DPR
- Rs 4 lakhs for replication projects of 250 sq. m and above for providing performance/fuel saving data, O&M expenses, etc.
- Rs 2 lakhs for projects below 250 sq. m but not less than 90 sq. m mainly for partly meeting O&M expenses
- Additional 10% of cost to a maximum of Rs 15 lakhs for projects done in ESCo mode
- Up to Rs 15 lakhs for 5-year-old systems for repair and renovation, subject to the condition that an equal amount is spent by the beneficiary

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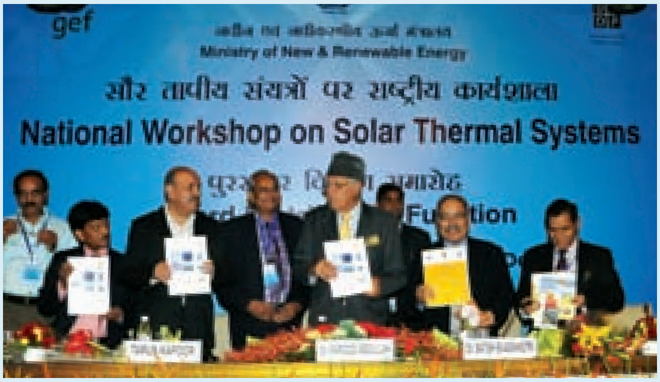
INside...

Policy 04

Feature 06



National Workshop on Solar Thermal Systems

A National Workshop on Solar Thermal Systems cum Award Distribution Function was organized by the Ministry of New and Renewable Energy (MNRE) under the aegis of the UNDP-GEF project on Concentrated Solar Heat on 17 December 2013 at Hotel Ashok, New Delhi. Around 250 stakeholders from various parts of the country participated in the Workshop, which included of cials from State and Central government departments, State Nodal Agencies, manufacturers and bene ciaries, technical experts, and consulting organizations. The workshop included a technical session conducted under the chairmanship of the Secretary, MNRE, along with an award distribution function. The awards for the year 2012 13 were presented to various stakeholders working in the   elds of solar water heating and concentrated solar thermal systems by Dr Farooq Abdullah, Hon ble Minister for New and Renewable Energy. A total of 28 awards were presented, which included awards to State Nodal Agencies, bene ciaries, and Channel Partners of the Ministry.

A few knowledge documents developed under the project were also released by the Hon ble Minister on this occasion, including success stories and video   lms on installations,   iers on concentrating solar technologies (CSTs), and a compendium of such existing technologies. Besides this, a video   lm on the use of CSTs in industries for process heat and cooling applications was also played during the workshop, which was appreciated by all the participants.

Readers' Responses

I am in receipt of the inaugural issue of SUN FOCUS and congratulate you. I appreciate the contents therein and would motivate the industries to consider use of concentrated solar systems in a positive manner.

Jaideep N Malaviya, Editor
www.insolthermtimes.in

The entire issue content giving the focus on Scheffler dish is very useful and has given the insight into the technology. Thanks for the awareness and way of sharing. Wish the SUN FOCUS long knowledge sharing and spread into people.

G Balaji, CSP Initiatives – Solar Water & Renewable Energy IC, Larsen & Toubro Limited

From the editor's desk...

Dear Readers,

Let me begin by wishing you all a very happy and prosperous new year! In this new year, I am happy to share the third issue of SUN FOCUS with you all.

The first two issues of SUN FOCUS have been much appreciated and I thank you all for your letters of encouragement and support. They help reassure us that we are heading in the right direction.

In this issue, we have focused on industrial applications of CSTs, one of the key focus areas of the UNDP-GEF Project on Concentrated Solar Heat. This issue brings you articles to guide you on how to optimize CST choice for maximizing fossil fuel displacement in industrial process heating, global technological advancements that have taken place in this arena, as well as the status of international policies and programmes supporting CST for industrial heating applications. Our endeavour is to make readers aware of the enormous opportunities provided by CSTs and to bring in an understanding of the international policies and regulatory initiatives in the area.

We also present to you success stories of CST application in the Indian dairy industry, with case studies of the Mahanand and Chitale dairies in Maharashtra that are reaping the benefits of early CST installation.

I hope this issue throws light on this aspect of CST application and that you find it as useful as the previous issues. As always, we await your comments and suggestions to help us improve the quality of the magazine further, and hope that you contribute to future issues with enthusiasm. Once again, I wish you a bright and sunny year ahead!

Sd/-

Tarun Kapoor

Joint Secretary, Ministry of New and Renewable Energy

INTERNATIONAL STATUS ON POLICIES AND PROGRAMMES SUPPORTING CST FOR INDUSTRIAL PROCESS HEATING

Siddha Mahajan

The world's energy demand continues to increase, with consequential rise in consumption of fossil fuels. The energy intensive industrial sector, which continues to draw power at an escalating rate, can contribute to a rapid scaling-up of solar applications to meet its processing energy requirements in a cost effective manner. This is particularly significant in case of the medium (from 100 °C up to 150 °C) and medium to high temperature (150 °C up to 300 °C) ranges which consume a substantial share of the total energy used.

Studies conducted under the International Energy Agency's Solar Heating and Cooling (IEA SHC) Programme suggest that the most significant areas for use of solar thermal plants for process heating include foods and beverages, chemical industries, and textile industries, all of which demand a temperature of more than 100 °C for several activities during their processes. Till date, parabolic trough collectors are the most mature concentrating solar technology (CST) to generate heat at temperatures up to 450 °C for process heat applications.

Efforts towards promoting CSTs have been made across the world in different capacities, technologies, and applications to promote solar harnessing for meeting industrial demands. Several country level initiatives have been taken (see Table 1) to assess the scope of CSTs, and to prepare mid-term and long-term roadmaps/targets for their adoption. Other than these, several international level multi-year and multi-task projects have also been conducted with and without government aid to assess and explore the possible interventions and suitable technologies. Some of these programmes have been listed in Table 2. Further, R&D is being conducted across the world with demonstration and pilot projects in public private partnership mode to develop an understanding of on-ground application and performances.

Solar thermal technologies contribute significantly to hot water production in many countries and increasingly to space heating and cooling as well as industrial processes. According to the REN 21 Report, by the end of 2010, about 200 process heat systems were operating worldwide, totalling about 42 MWth. India was in the lead (with 10%), followed by Brazil (7%) and Israel (6%). Currently, process heat accounts for less than 1% in total solar thermal utilization across the globe. Within this percentage, the largest share of large-scale solar thermal capacity is utilized in Austria and for most of Thailand's commercial solar heat subsidies. Most of the solar heat demand is being met through

Table 1: RE targets of various countries with CST for process heat as a component

Country	Purpose	Share*
Belgium	Heating and cooling	11.9% share of renewables in gross final consumption in heating and cooling by 2020
China	Solar thermal	280 GWth (400 million sq. m) by 2015
Denmark	Heating and cooling	39.8% by 2020
France	Heating and cooling	33% by 2020
Germany	Heating	14% renewables in total heat supply by 2020
Greece	Heating and cooling	20% renewables by 2020
Italy	Heating and cooling	17.15% by 2020
Luxembourg	Heating and cooling	8.5% renewables in gross final consumption in heating and cooling in 2020
Romania	Heating and cooling	22% by 2020
South Korea	Solar thermal	1.882 million TOE by 2030
Thailand	Heating by solar	100 kTOE by 2022

Source: REN 21 GSR 2013 Report

***These targets are set for solar thermal applications in general, of which concentrating solar thermal power in industrial process heating is a part.**

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Table 2: Some programmes/policies on CST for industrial process heat

Programmes/ Policies/Other Initiatives	Year	Countries	Implementing organization	Description**
IEA Solar Heating and Cooling Programme	2008	Australia, Italy, Germany, Austria, Spain, Mexico, Portugal	International Energy Agency (IEA)	• Collaborative projects of SHC programme, IEA and SolarPACES • Aim was development of STP for industrial process heat
Solar Heat for Industrial Processes	N/A	Morocco, Tunisia, Egypt, Jordan, Turkey	The Observatoire M diterran en de l Energie (OME), supported by UNDP and UNEP	• To provide overview of Solar Heat for Industrial Processes (SHIP) application in the Mediterranean • To learn from best practices
Renewable Energy Law	2012	China	Government of the People s Republic of China	• Intensi ed efforts towards medium and high temperature industrial applications of solar energy along with other solar thermal technologies
Jawaharlal Nehru National Solar Mission	2009	India	Government of India	• To achieve 15 million sq. m solar thermal collector area by 2017 and 20 million sq. m by 2022
High Temperature Solar Thermal Technology Roadmap	2008	Australia	New South Wales and Victorian Government	• To aid development of suitable policy regime for deployment of high temperature solar thermal technology in Australia for domestic, residential, and industrial purposes
Market Development and Promotion of Solar Concentrator Based Process Heat Applications in India (2012 2017)	2011	India	Ministry of New and Renewable Energy, Government of India and UNDP	• Study was conducted to develop understanding of installed systems and their functionality for up-scaling
Solar Heating and Cooling for a Sustainable Energy Future in Europe	N/A	Europe	ESTTP Secretariat jointly run by European Solar Thermal Industry Federation (ESTIF), European Renewable Energy Centres Agency (EUREC Agency) and PSE	• Vision document for 2030 to assist in de ning strategic research agenda for heating and cooling in Europe and worldwide

***The descriptions are part of larger multi-year projects, of which concentrating solar thermal power in industrial process heating is a part.*

NEP Solar Collector Field on Sun in Newcastle, Australia

non-imaging solar collectors for low temperature processes. REN 21 also reports that automation of manufacturing processes increased in 2012, with innovation spanning from adhesives to materials and beyond.

The major drawback that this industry suffers is because of lack of awareness as well as the persisting high cost of the system. Further, the no interest no know-how no market problem means there is a great lack of information across the value chain. These problems need to be addressed quickly to increase the share of CSTs for producing industrial process heat. ■

GLOBAL TECHNOLOGICAL ADVANCEMENTS IN CST FOR INDUSTRIAL PROCESS HEAT

Chinmay Kinjavdekar

SMirro's solar steam for textile industry at Germany, 2010

There is a pressing need to accelerate the development and deployment of advanced clean energy technologies in order to address the global challenges of energy security, climate change, and sustainable development. Concentrating solar thermal (CST) systems for industrial process heat (IPH) can have an important role to play in realizing targets in energy security and economic development and in mitigating climate change. Today, concentrating solar heating technology development is mainly focusing research and development (R&D) resources on goals related to power production, for example, realizing higher temperatures. But the thermal energy produced by concentrating solar technology can also be used for heat applications, such as for low, medium, or high temperature industrial processes in areas with good levels of direct normal irradiance (DNI). Although this application has till now received far less attention, it has huge potential in both developed and developing countries.

As per the Technology Roadmap: Solar Heating and Cooling report published by the International Energy Agency, solar heat has a very signi cant role in industrial applications. The report estimates that by 2050, the potential of solar heat in industrial applications will be around 3,200 GWth for only low temperature applications (up to 120 C). The Scenario also estimates more than 1,000 GWth capacity for solar cooling systems by 2050.

CST systems for IPH have speci c bene ts. They are compatible with nearly all sources of back-up heat and almost universally applicable due to their ability to deliver heat in the form of low or high pressure steam, pressurized hot water, and thermic oil heating.

Research, Development, and Demonstration

CST systems for IPH are still at an early stage of development. At present, only around 200 operating solar thermal systems for process heat are estimated worldwide, with a total capacity of about 42 MWth (60,000 sq. m), or only 0.03% of the total solar thermal capacity installed. Most of these systems are of small scale experimental or demonstrational nature.

Despite the limited penetration of solar technologies in the industrial sector, its potential is quite large. Indeed, in 2007 the industrial sector represented 28 per cent of the nal energy consumption in the EU 27, with a large part of the heat required being below 250 C. Tapping into this potential would provide a signi cant solar contribution to industrial energy systems. Many reputed organizations such as Fraunhofer, DLR (Germany),

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NREL (USA), etc., are active in R&D in this eld. Their efforts can be mainly classi ed as:

- **Solar Collector Development:** The current solar collector technologies, such as parabolic trough collectors, parabolic dishes, and linear concentrating Fresnel collectors, can be adapted to serve medium and high temperature process heat applications. So the focus is on development of modular and low cost design and ef ciency improvements in order to cater to high temperature applications. Extensive work is also being done on stationary concentrators, such as CPC or evacuated tube collectors, having high ef ciency in the low temperature region (up to 120 C). These types of concentrators cost comparatively less and are exible in installation. Additionally, their ability to supply heat in the form of low pressure steam and pressurized water increase their potential applications tremendously.

- **Integration Systems:** A lot of work is going into optimization and cost reduction of the integration systems, such as direct steam generation in collectors which eliminates the requirement of a heat exchanger and enables an easy control strategy. Work is also being done on the possible use of new thermal storage technologies which will enable CST systems to deliver heat as per the requirement of the load pro les.

- **New Applications:** There is a lot of work going on to identify new applications in the medium and high temperature ranges that will be suitable for CST systems. Applications such as high pressure direct steam generation, desalination, co-generation, tri-generation, and high temperature thermo-chemical processes are being studied extensively. Fraunhofer ISE has worked thoroughly on the combined generation of heat, electricity, and cooling in the Medifers project, and has concluded that decentralized combined heat, cooling, and power can be an interesting future option, but further demonstration projects are required. Work is also being carried out for hybrid applications such as solar heating systems with biomass boilers, PV-T systems, and solar assisted heat pumps.

Some examples of recently installed CST systems are:

Brick Drying at Laterizzi Gambettola, Italy

A solar eld of total 2,640 sq. m of LFR technology has been installed by Soltigua. 1,584 sq. m re ector area is used for direct steam generation, and the rest of the re ector area is used for indirect steam generation via thermic oil heating. The total peak thermal capacity of the solar eld is about 1.2 MWth. The solar eld generates steam at 12 bar, 180 C which is used in the steam red radiant heat exchangers (brick dryers). The steam is also used for air pre-heating. The system was commissioned in 2012.

Solar Based Thermic Oil Heating for Milk Powder Production at Lácteas Cobreros (LACO) Castrogonzalo-Zamora, Spain

Parabolic trough collectors of 2,040 sq.m aperture area have been installed by SMirro. The solar eld is used for thermic oil heating at 200 C. Steam is generated using a heat exchanger at ~ 185 C. The capacity of the solar eld is 1 MWth. The system was commissioned in 2012.

Solar Process Steam Plant at BEVER, Engadin, Switzerland

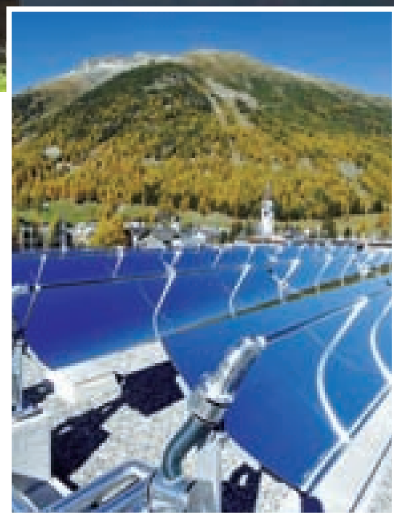
NEP Solar has installed 116 sq. m of parabolic trough collectors for thermic oil heating at 200 C. The saturated steam is generated at 4 6 bar using shell and tube heat exchanger. The nominal capacity of the plant is 70 kWth. The system was commissioned in November 2011, and has been fully operational since then.

Solar Process Steam for Textile Industry at Germany

SMirro Gmbh has installed parabolic trough collectors with nominal capacity of 50 kWth at textile industry Carl Meiser Gmbh. The plant generates pressurized steam at 4 bar, 140 C which is fed directly to the main boiler header. The installation was commissioned in 2012.

Solar process steam for brick drying at Italy installed by Soltigua, 2012

NEP Solar system for milk powder production LACO, Spain, 2012



NEP Solar steam installation for dairy processes at Bever, Switzerland, 2011

Solar Steam Generation Plant at Saignelégier, Switzerland

NEP Solar has installed 627 sq. m of parabolic trough collectors at T• te de Moines Cheese Factory for pressurized hot water generation at 130 C. The nominal capacity of the plant is 400 kWth. The system was commissioned in November 2011, And it has been fully operational since then.

Solar Based Thermic Oil Heating System, California, USA

Abengoa has installed 5,068 sq. m of parabolic trough collectors for thermic oil heating at ~ 300 C for indirect steam generation at 41 bar, 250 C for Frito Lay. The oil is used for cooking corn and potato chips. The solar system has a back-up of natural gas red steam generators. The system is operational since 2008.

International Collaboration

International collaboration will ensure that important issues are addressed by making full use of areas of national expertise and taking advantage of existing R&D activities and infrastructure. One example of collaboration in the eld of solar heating and cooling is the IEA Solar Heating and Cooling Implementing Agreement which includes technology experts from 20 countries and the European Union. Other examples of collaboration are the International Solar Energy Society (ISES), the International Association of Plumbing and Mechanical Of cials (IAPMO), ISO TC 180, the European Solar Thermal Industry Federation (ESTIF), and the European Technology Platform on Renewable Heating and Cooling. The IEA Solar Heating and Cooling programme has launched a four year research project (IEA SHC Task 49/ IV: Solar process heat for production and advanced applications) aimed at growing market for solar heat in industrial processes. Researchers at IEA SHC (DLR, Fraunhofer, SPF, AEE INTEC, etc.) and SolarPACES will work together for this project.

Addressing the Barriers

Deployment of concentrating solar technology in industry needs adapted industrial system designs and optimization of industrial processes to increase the potential integration of CST systems. Integration system standardization and solar collector performance characterization is needed to encourage use of CST systems. From the perspective of the demand side, barriers hindering the uptake of CST for IPH systems include a general lack of information about the technology and its potential. Some countries have chosen to carry out awareness raising campaigns, thus building up understanding and con dence in the technology. Important stakeholders can also be addressed with speci c actions, such as tackling the high priority given to low capital cost energy systems in various industries. Increasing transparency on energy costs including external factors that are not included in the market price for energy such as the costs of natural resource depletion, health impacts from pollution, and climate change should also help. It should be emphasized that overall the bene ts of CST systems for IPH are substantial and sound, from both the nancial and the sustainability points of view. ■

PARABOLOID DISH TECHNOLOGY FOR INDUSTRIAL PROCESS HEAT

Siddharth Malik

Indian manufacturing industries are today facing a dire situation with their cost of production rising disproportionately over the last few years due to rise in raw materials and energy costs. While demand is in uenced by macro-economic factors, Indian industries, especially the energy-intensive ones which utilize diesel, furnace oil, electricity, coal, etc., need to look towards addressing this critical input energy, and its costs.

Indian industries consumed about 138 MTOE of energy in 2011 12, including about 28.80 MTOE of petroleum products and 87.43 MTOE of coal and lignite, which are mostly used for process heating applications. Concentrated Solar Thermal (CST) power is a solution which can meet the quality of energy demand required in industries and emerge as a viable long-term alternative. There is a tremendous potential for retro tting, augmenting, or replacing fossil fuel-based heating systems in industries using CST systems which operate on the simple principle of shifting the majority of industrial heat loads onto CST technology during sunshine hours. Like most other renewable energy systems, CST systems are a one-time capital investment with a 20 30-year equipment lifetime. It then becomes critical to ensure maximum energy yield throughout the lifetime of the CST system to make it a commercially viable option.

This article summarizes the key criteria for selecting a CST system since the commercial viability of a CST system hinges on the ability to maximize solar energy contribution and fossil fuel savings. One particular CST technology the dual axis tracking paraboloid dish CST technology meets the above requirements.

How it Works

Almost all CST systems utilize the re ection or refraction principle to concentrate incoming solar radiation to achieve high ef ciencies and deliver energy to the subsequent working uid. Utilizing a basic set of fundamental physical principles, various technology con gurations have emerged. Unlike PV, since the concentration necessarily requires direct normal irradiance (DNI), it necessitates the tracking of the concentrator to follow the sun. The solar energy thus captured and converted into thermal energy of the working uid is then routed to the end application using instrumentation and piping networks.

Based on combinations of the above elements, various technology con gurations are largely classi ed either as line concentrators or point concentrators. Both these are well known and understood in the global industry. One particular CST option is the Dual Axis Tracking Paraboloid Dish which has the highest thermal ef ciency, and therefore high operating temperatures. While applying CST systems to industrial process heat (IPH) applications, operational and practical constraints become critical for the economic viability of the application.

Dual Axis Tracking Paraboloid Dish

Key Questions when Choosing a CST System for IPH

Typically, certain key metrics may be utilized to evaluate overall feasibility of

Table 1: Common elements of all CST technologies

SNo.	Element	Alternatives
1.	Re ectors	Glass based, Metal based, Curved, Flat, etc.
2.	Tracking	Single axis, Dual axis, Ez/AL, Polar/Declination, etc.
3.	Thermal receiver	Cavity receiver, Evacuated tube, Selective coated materials, etc.
4.	Heat transfer uid	Water, Steam, Organic uids, Air, etc.
5.	Thermal piping	Suitable to heat transfer uid temperature, pressure, and mass ow rate
6.	Structure and foundation	Central, Nodal, Truss, Torque tube, etc.

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adopting a particular CST technology (see Table 2).

Fuel from the Sky: Direct Normal Irradiance (DNI)

The nature, quality, and availability of input DNI to a CST plant differs signi cantly from those of conventional heating plants. A clear understanding of the impacts of DNI on CST plants is required to understand how various technology con gurations respond to a wide range of incoming DNI. The usable instantaneous value of this parameter ranges anywhere from 100 W/m^2 to 1,000 W/m^2. When integrated over an entire day, it is expressed in kWh/m^2/day. While a long-term data set is required to accurately predict the performance of a given CST system, there are certain larger trends on treatment of DNI by each CST technology-type which is a strong indication of how well the particular CST technology is suited for an industrial application.

A striking feature of CST systems is that for a given technology, the annual energy yield for two different locations on earth for the same value of cumulative annual DNI is drastically different, i.e., a DNI of 2,000 kWh/m^2/year at two different locations will result in drastically different outputs for a given amount of area. This is due to two factors:

- Histogram distribution of a given cumulative value of DNI: A function of frequency distribution of DNI values
- Non-linear response of CST technology to DNI value: A function of geometrical con guration and thermal response

Figure 1 shows the frequency distribution of DNI at two locations: in India and in Spain. It can be seen that while the cumulative value for both locations might be similar, their distribution of high and low DNI values is different.

Hence, it is evident that a CST technology in India which has good response across the entire wide DNI range, including lower DNI values, will outperform an alternate CST system that is designed and engineered to harness high instantaneous DNI values for a location such as Spain. Among all CST con gurations, only Paraboloid Dishes have high concentration ratio (CR) to provide maximum energy response even at small values of DNI since their loss characteristics are almost at compared to Parabolic Troughs, as is shown in Figure 2.

To summarize, paraboloid dishes ensure maximum fuel savings and emerge as the ideal choice for heating in industrial applications.

Table 2: Key metrics for choosing an optimum CST system

Criteria	Requirement for IPH	Advantage of Paraboloid Dish
Modularity	System needs to be designed and engineered suitable to industrial scale applications	Being a modular technology, it can be deployed at all scales. Therefore, optimal system design is possible for all applications and scales.
Installation space	Smaller installation footprint is desirable	The dish is mounted on a single column so installation footprint area is very small.
Dependence on electricity grid	Needs to be low so that stand-alone operation is possible	Very low auxiliary power consumption makes the technology suitable for stand-alone operation.
Optics and concentration ratio (CR)	Perfect optical pro le and high concentration ratio is desirable for higher energy output per unit area and higher operating temperatures	The concentrator is a perfect paraboloid and has high concentration ratio which ensures high thermal performance and high temperatures.
Availability: System and component	Indigenously developed technology desirable to ensure technology support	The dish is indigenously developed and designed, and a majority of the components are available off-the-shelf.
Annual energy yield	Highest energy yield per unit cost is desirable	The dish has high thermal performance which ensures high energy per unit cost.

Paraboloid Dish Technology Developed by Megawatt Solutions

Megawatt Solutions has developed a paraboloid dish which has a completely paraboloid optical pro le. The dish has a highly ef cient cavity receiver which is suitable for both thermic oil heating and direct steam generation. The dish also has a completely automated two-axis tracking system with very high accuracy (~ 0.1). It is mounted on a

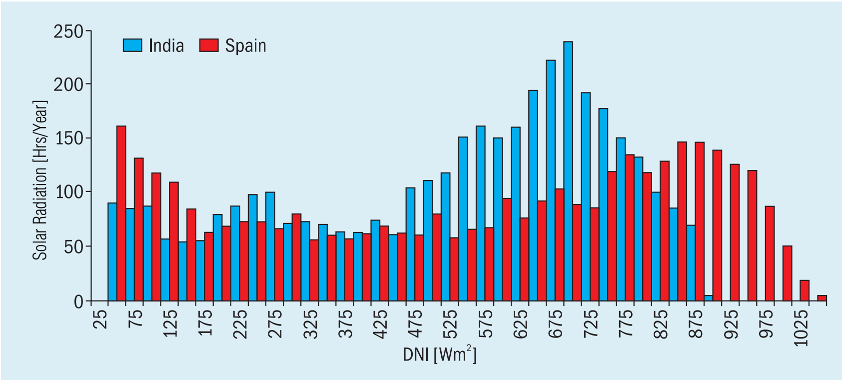

Figure 1: Frequency distribution of DNI in India and in Spain

Image courtesy: Suntrace

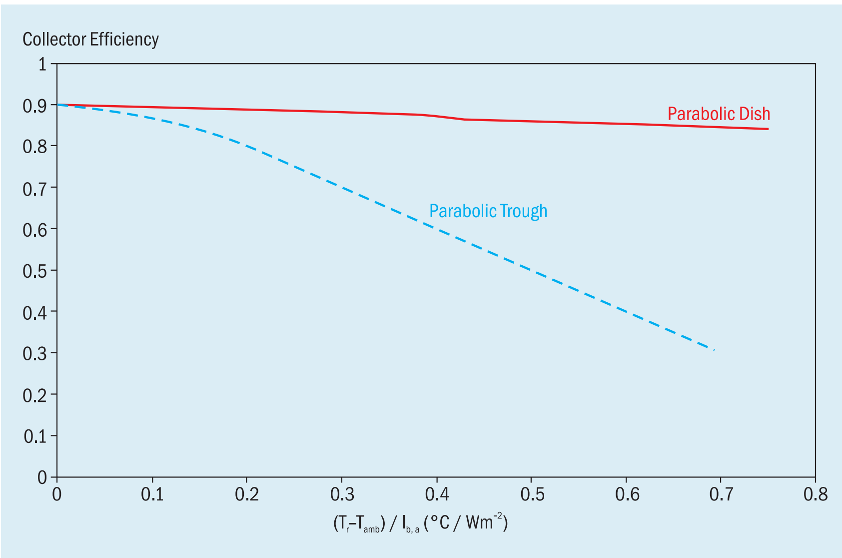

Figure 2: Comparison of Parabolic Dish and Parabolic Trough performance

Image courtesy: William B. Stine's Power from the Sun

single column which requires very little installation area. The technology has been developed with the support of the Ministry of New and Renewable Energy, Government of India. The thermal performance of the dish has been extensively tested in the eld. The dish has high thermal ef ciency (peak ef ciency = 70% at 300 C) due to high concentration ratio (more than 700) and dual axis tracking. The dish is currently available in two sizes: 90 m² and 55 m². The performance details of these two models are mentioned in Table 3.

Table 3: Performance details of paraboloid dishes developed by Megawatt Solutions

Model Name	Aper-ture Area (m²)	Thermal Output at DNI = 750 kW/m²	Total Weight (Tonnes)
M90	90	40,000 kcal/hr	4
M55	55	20,000 kcal/hr	1.5

Summary

Amongst all the available CST technology options, the paraboloid dishes developed by Megawatt Solutions have the following advantages:

- Manufactured with commercial off-the-shelf components
- State-of-the-art technology: automated dual axis tracking, highly ef cient receiver, and high concentration ratio
- Requires minimal land for installation

The paraboloid dish technology developed by Megawatt Solutions (M90 and M55 dishes) is thus offering a commercially viable alternative to diesel and furnace oil-based heating systems. Its highly ef cient state-of-the-art indigenously developed technology and high performance per cost ratio have put the technology on the cusp of successful commercialization, making it the most well-suited for industrial applications. ■

Table 4: Thermic fluid based systems of MWS under execution/ in pipeline

Project Size	Application	Location
1440 m²	Industrial process heat	Gujarat
275 m²	-do-	Haryana
90 m²	-do-	Haryana
2250 m²	-do-	Andhra Pradesh
450 m²	-do-	Andhra Pradesh
55 m²	Cooking	Nepal
55 m²	Cooking	Andhra Pradesh
55 m²	Cooking	Gujarat
540m2	Thermic Oil Heating	Andhra Pradesh

ARUN DISHES INSTALLED AT MAHANAND AND CHITALE DAIRIES FOR MILK PASTEURIZATION

Abhishek Bhatewara

ARUN dish installed at Mahanand Dairy

India is the largest milk producing country in the world, with the present level of annual milk production estimated at 100 million tonnes. The dairy industry utilizes a large amount of energy for milk processing, pasteurization, sterilization, cleaning-in-place (CIP), etc., which is in the form of medium temperature thermal energy, and can be provided through the use of solar concentrators. The automatic dual axis tracking ARUN solar concentrator system has been successfully deployed for over 7 years at Mahanand Dairy and for 4 years at Chitale Dairy. This article covers details of these two installations.

ARUN Dish Installation at Mahanand Dairy

Mahanand Dairy, although a comparatively small dairy pasteurizing around 30,000 litres per day, has been a pioneer in the adoption of new technologies. When the then Chairman of Mahanand Dairy chanced upon the pilot 10 sq. m ARUN installation in Pune way back in 2004, use of solar concentrators to deliver thermal energy at high temperatures for process heat applications had never even been attempted. With his vision, nancial support from MNRE, and the technical capabilities of Clique Solar, India s rst solar concentrator for commercial use in industry was installed in 2006 at Mahanand Dairy in Latur, Maharashtra. It has been running successfully ever since. At Mahanand Dairy, milk pasteurization takes place over just 3 4 hours. Since solar energy is available for over 8 hours in Latur, a thermal storage system had to be designed so that no energy is wasted. A brief explanation of the operations with the integration schematic is explained as follows:

- In the morning, the circulating pump extracts water from the storage tank and circulates it through the receiver coil.
- The water is then heated and sent back to the storage tank. The water is stored at 18 bar, 180 C.
- The hot water then ows through the heat exchanger to transfer the heat to milk for pasteurization.

This system continues to save about 100 to 115 litres of furnace oil on a clear sunny day. On these days, 100% of the thermal energy requirement is met by the ARUN dish installation.

ARUN Solar Boiler at Chitale Dairy

Chitale Dairy is one of the most respected and largest private dairies in Maharashtra. It is well known for its state-of-the-art process plant and attractive pricing due to its superb cost control.

ARUN dish installed at Chitale Dairy

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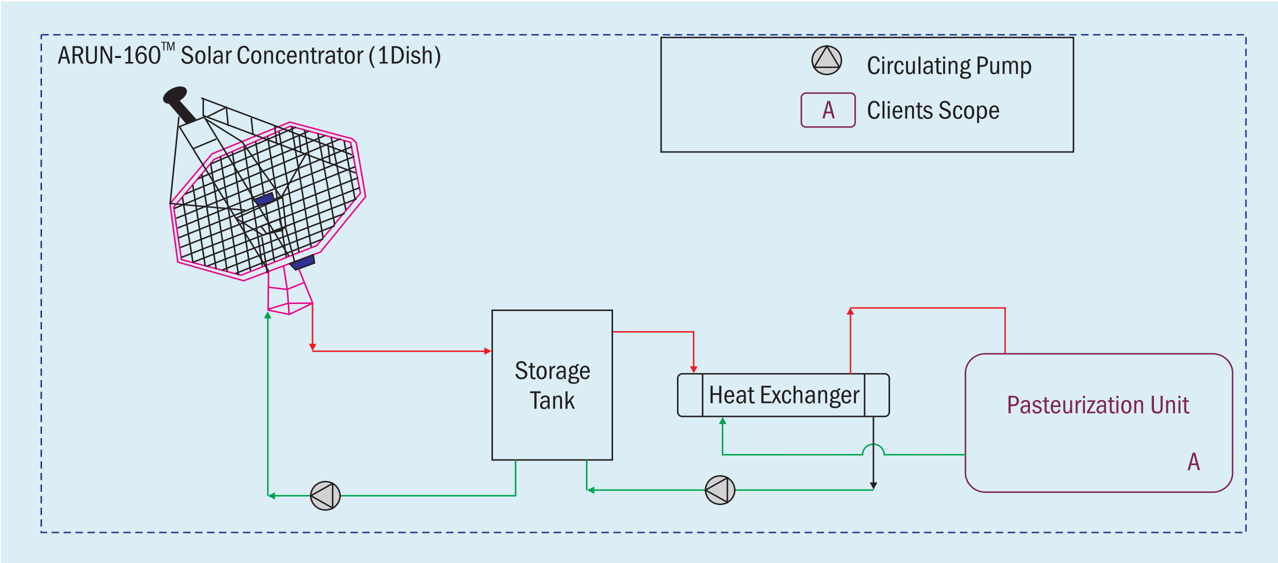


Figure 1: Schematic of ARUN solar concentrator integration with pasteurization unit at Mahanand Dairy

The dairy s visionary leadership identi ed very early that furnace oil cost would increase sharply with time. They began their search for a back-up in 2007 08. Initially, they explored the use of biomass. However, due to issues with future availability, quality, transportation, and storage, Chitale Dairy decided to explore the solar options. After evaluating various technologies, Chitale Dairy opted for the ARUN technology due to the following factors:

- It could deliver 5 6 bar steam: the pressure rating of the existing system
- The robustness of the technology: it has to last for 25 years
- The footprint area required was very small: less than 10 sq. m per dish
- Clique Solar s experience with integrating ARUN with the dairy process

Operation Philosophy

The operation philosophy of this scheme is explained here. The basic aim of the control system in this scheme is to deliver steam to the existing boiler header.

The ARUN dish automatically tracks the sun from morning to evening. The solar radiation falling on the reflecting collector surface is concentrated at a single point at which the receiver is placed. The receiver coil at the focus of the dish transfers the heat of the sun to the heat transfer medium (water). The steam generation system consists of the ARUN 160 dish system, pumps, valves, etc. Once the system starts generating steam, the pressure in the line starts increasing. Once this pressure matches the pressure in the existing boiler header, a valve will open and steam will be delivered to the common header. This process will continue whenever sunlight is available. When sunlight is not available, the conventional heating system will turn on. This switchover between the solar and existing conventional system is automatic.

Economics

A typical financial feasibility model for a single ARUN160 solar boiler installation is presented above.

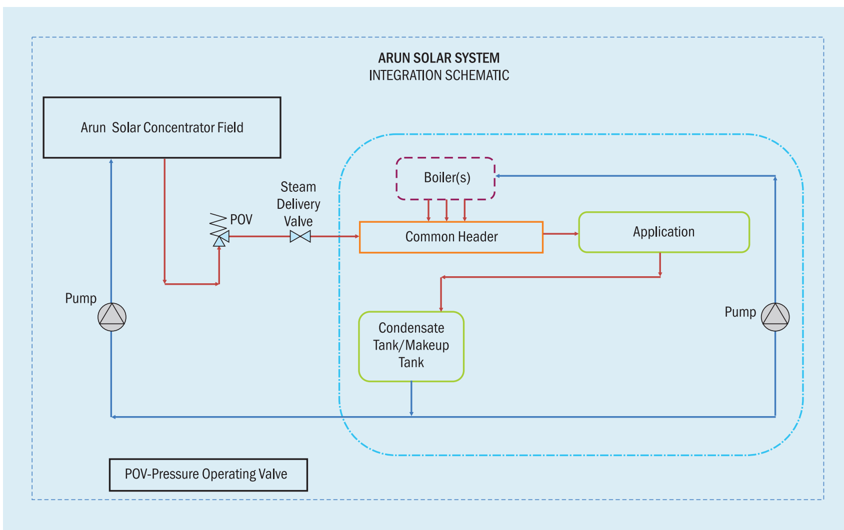


Figure 2: Schematic of ARUN solar concentrator integration with operations at Chitale Dairy

Table 1: Typical financial feasibility model for single ARUN160 solar boiler installation

Item	Cost (in lakhs)	Comments
ARUN160 Dish Supply	33.80	Selling Price for ARUN160
Dish Erection and Commissioning	2.00	
ARUN160 Price	35.80	
Add: Balance of Plant	4.00	Includes piping, control panel, etc.
Add: Civil Foundation	3.50	For mounting of dish
Add: Transport	2.00	From workshop to site
Total Project Cost	45.30	
Less: Subsidy*	-10.14	Fixed MNRE subsidy on ARUN160
Less: Tax Bene t due to AD**	-9.56	
Net Project Cost to User	25.60	[A]

Annual Savings		Comments
Furnace Oil (in litres)	17,000	Using 1 ARUN160
Rate per Litre of FO (in Rs/litre)	48	
Total Fuel Savings (in Rs)	816,000	[B]
Simple Payback Period = [A]/[B]		**3.14 years**

MNRE provides a capital subsidy of Rs 6,000 per sq. m of aperture area for dual axis automatically tracked system (ARUN160 has an aperture area of 169 sq. m).

*****According to Income Tax rules, any investment in solar equipment will be eligible to avail 80% accelerated depreciation (AD) on the investment, i.e., 80% of the capital value of the equipment can be expensed in the first year itself. This helps in reducing the taxable income, thus reducing the tax payment.***

(The simple payback period calculation does not include any escalation in fuel prices or the economic benefit after the payback period up to the 25 years+ life of the product. It also does not include any maintenance expenses incurred during the life of the system.)

Concluding Remarks

The Mahanand and Chitale Dairies have set an example by pioneering the successful use of solar technology for satisfying their thermal energy needs for various applications such as pasteurization, can washing, crate washing, and CIP. Not only have the systems been operating successfully, but the economics of the investment also makes a strong case for all industries in general, and dairies in particular, to install such CST systems. ■

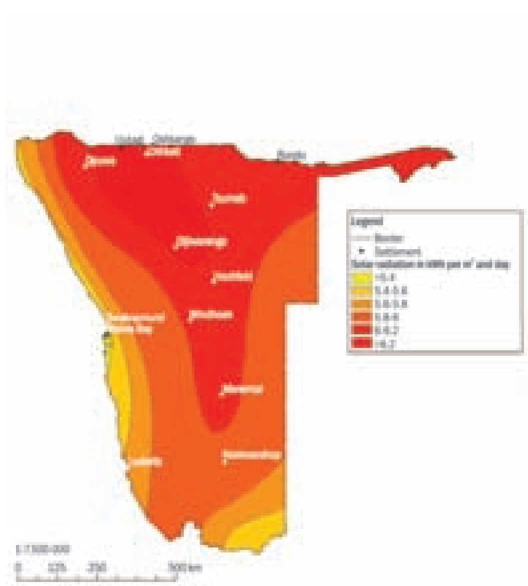
SOLAR CONCENTRATOR PROJECTS IN UNDP-GEF PORTFOLIO

Butchaiah Gadde, Chitra Narayanswamy, and S N Srinivas

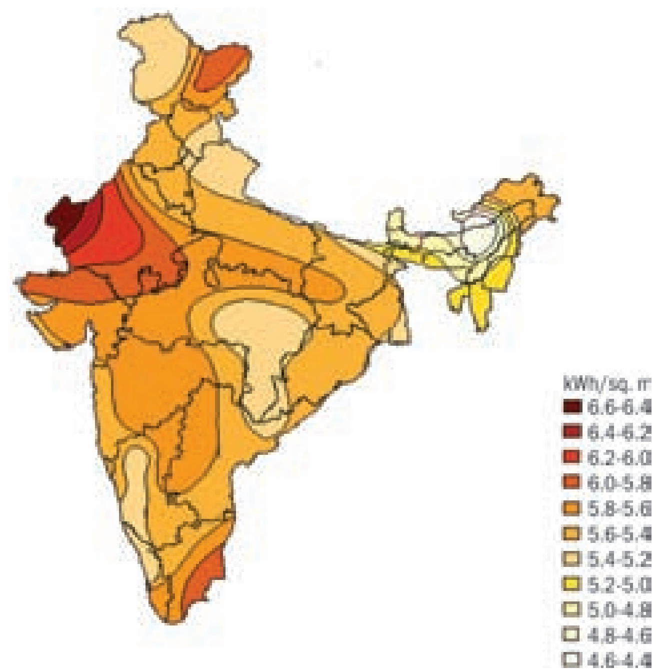
Two concentrated solar projects are being implemented in the UNDP-GEF portfolio, one in Namibia and the other in India. Both countries have a high potential for capturing solar energy. Both countries have around 3,000 sunshine hours per year with 6 kWh per sq. m per day insolation. Annual solar insolation is about 2,200 kWh per sq. m.

The concentrated solar power (CSP) project in Namibia is a technology transfer project that applies concentrated solar technologies for power applications. The electricity generated from the pilot projects will be supplied to the national electricity grid. As part of technology transfer, it aims to establish partnership agreements between concentrated solar power technology suppliers from abroad and Namibian stakeholders in the private sector, government, and academia. It also aims to develop a market policy framework for CSP technology development and to increase CSP investments in the country. The rst pilot project of a 50 MW CSP plant is supported with loans from local banks for its construction. Thus, project interventions are expected to overcome the barriers related to technology, policy, and nance. In contrast, the concentrated solar technology (CST) for process heat applications project in India builds on the experiences of solar water heater development in the country and contributes to the target of the Jawaharlal Nehru National Solar Mission (JNNSM). While concentrated solar heat (CSH) application has been successfully demonstrated for institutional cooking in the past, this CSH project is aiming to expand its scope to other applications such as dairy and food processing, metal treatment, and space cooling.

System integration of CSP for process heat applications is complex due to the intermittent nature of solar energy as process heat demands constant thermal energy. Therefore, solutions need to be tailored in combination



Average values for solar radiation in Namibia



Average solar radiation in kWh/m² in India

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Table 1: International experience base of CSH applications

End Use	Sector	Location
Cooling	Hospital	Ipswich, Australia; Thane, Maharashtra; Harnosand, Sweden; Morocco
	Industry	Gurgaon, India; Chennai, India; Bergamo, Italy; Long Island, USA; Germany
	Stadium	Doha, Qatar
	Hotel	Dalaman, Turkey; Jordan
	Shopping mall	Newcastle, Australia
	Supermarket	Antalya, Turkey
	Of ce building	Abu Dhabi (Masdar), UAE; Abu Dhabi, UAE; Rosenfeld, Germany
	University/Technology institute	Seville, Spain; Newcastle, Australia; Gebze, Turkey
Food production	Winery	Grombalia, Tunisia
Steam cooking	Institutions: hostels, religious institutions, hotels, etc.	More than 50 installations in India
Baking of bread	Bakery	India; Burkina Faso; Argentinian Altiplano, Argentina
Hot water/steam generation	Dairy (pasteurization)	Latur and Sangli, India; Marrakech, Morocco
	Auto industry (7-tank process)	Chakan, India
	Ball bearing factory	Ankara, Turkey
	Metal factory	Germany
	Piano factory	Long Island, USA
	Beverage factory	Fritolay, Turkey
	Laundry	India; Dalaman, Turkey
Evaporation	Nuclear facility	Kota, India

with the existing or backup heating systems. The UNDP-GEF CSH project aims to simplify this through establishing standard technology application packages, and is currently assessing the performance of existing CSH systems in the country. There are 14 existing CSH technology suppliers in India and the project is trying to add 12 more suppliers to meet the increasing demand for CSP for process heat applications. The CSH project targets a cumulative installed CST area of 60,000 sq. m by the end of the project in July 2016.

The worldwide experience to date in actual working CSH applications is rather limited. A survey conducted under the IEA Task 33 Solar Heat for Industrial Processes in 2007 showed that there were then about 10 CSH installations worldwide (the survey excluded India). As per the information available in December 2010, there are around 70 CSH installations in India (this has increased to more than 140 in 2013) and it is estimated that there are around 100 working CSH installations worldwide. This places India as one of the leading countries in the practical CSH market deployment domain. The current experience in CSH applications is summarized sector-wise in Table 1.

The knowledge generated under both the projects will provide useful inputs to the global effort by networking with institutions such as the International Energy Agency (IEA).

The IEA established the Solar Heating and Cooling Programme (SHC) in 1977 to enhance the use of solar thermal energy and promote its technologies for varied applications in industry and commercial sectors. The multidimensional approach through its 51 projects/tasks (as of date) helps to educate potential users and decision makers, expand and strengthen the solar thermal energy market, and facilitate research and testing of the hardware components. Two specific tasks Task 33 Solar Heat for Industrial Processes (SHIP), and Task 49 Solar Heat Integration in

Industrial Process Heat look into the use of solar thermal power for industrial process heat applications. Task 33, completed in 2007, looked at industrial processes requiring heat up to a temperature of 250 °C, and published useful material including user toolkits to design a solar heating system for industrial processes, potential studies for solar thermal power in select European countries, and different collector technologies. Task 49, through its sub-tasks, is working to support future project stakeholders by providing design guidelines and simplified, fast, and easy to handle calculation tools for solar yields and performance assessment, in addition to comprehensive recommendations for standardized testing procedures. It is also gathering information on current solar thermal plants for industry through online submissions under its SHIP survey (http://task49.iea-shc.org/). ■

FORTHCOMING EVENTS

International Renewable Energy Jobs Conference
Abu Dhabi, UAE
21 January, 2014
The conference will examine how the renewable energy sector has become a significant employer, with the potential for adding millions of jobs worldwide in the coming years. Organized by the International Renewable Energy Agency (IRENA) and taking place alongside the World Future Energy Summit (WFES), the jobs conference is open to experts, practitioners, academics and other stakeholders from the private and the public sector and will provide a platform for experts and policy makers to share knowledge, experiences, and best practices on all aspects of renewable energy job creation.
The conference will provide insights into:

- The latest trends and dynamics in renewable energy job creation
- The potential for job creation along the different segments of the value chain
- The policy environment needed to maximize the potential for jobs
- The education, training, and skills required to accompany the deployment of renewable energy technologies
- The local development benefits linked to renewable energy applications in rural areas, including the empowerment of local communities and women

SMEThermal 2014
Solar Thermal Materials, Equipment and Technology Conference
Berlin, Germany
18 February, 2014
This conference, organized by SolarPraxis, will discuss the future of solar thermal technology. 160 stakeholders from the solar thermal manufacturing business as well as material suppliers, specialists in automation and production technology, and representatives from the banking sector and market consultancies are expected to participate. Hot topics are:

- Smart collector design: new solutions of PVT/hybrid collectors
- Trends in the supply chain: quality and prices of glass
- Process heat collectors: international survey among manufacturers worldwide
- Future design of compact thermal energy storages
- New business models for the solar thermal industry

Solar Energy India 2014
Mahatma Mandir Convention Centre, Gujarat
8–10 April, 2014
Solar Energy India 2014 is the latest in a series of events brought to the international industry by Solar Media Ltd. In 2012, with the institutional support of the Government of Gujarat and the Gujarat Power Corporation Ltd, the Indian Solar Investment and Technology Summit attracted over 750 conference delegates and 1,000 exhibition visitors across the two day event. The event focuses on three core themes investment, technology and manufacturing, and the potential for project deployment in solar energy throughout India.

Concentrating Solar Technologies

Salient features

- A technology to provide steam/hot oil/ pressurized water at 90o -350oC for applications e.g. community cooking, process heat, laundry, air-conditioning etc
- Smallest system of 100 sq. m. reflector area requiring double the land space can save 5000 to 10,000 liters/kg of fuel oil/ LPG per year
- Is integrated with conventional boiler to have trouble free operations during non-sunshine hours
- Number of technologies suitable for various applications are available
- Pays back cost in 3-5 years depending on sunshine, application & fuel being used
- 150 systems of various capacities working in country

Financial Support

- **From Ministry/ GoI**
  - ✓ 30% subsidy to all category of beneficiaries. Higher subsidy in special category states.80% accelerated depreciation to profit making bodies in addition
- **From UNDP-GEF Project**
  - ✓ 15% limited to Rs. 30 lakhs for few demonstration projects with emerging technologies/ newer applications, Rs. 4 lakhs for replication projects sizing 250 sq. m. and above for specific activities
  - ✓ Rs. 2 lakhs for project sizing below 250 sq. m. but not less than 90 sq. m.
  - ✓ In addition to above, 10%to a maximum of Rs. 15 lakhs for projects in ESCO mode
  - ✓ Up to Rs. 15 lakhs for repair and renovation of 5 years old systems subject to the condition that equal amount is spent by the beneficiary
  - ✓ Up to Rs.1 lakh with 25% by beneficiary for of feasibility/ DPR through PMU

Interested beneficiaries may contact our Consultants (Sh. Amit Kumar of PWC for industrial sector : e-mail: amit2.kumar@in.pwc.com, Mob:09899452400; Dr. Sudhir Kumar of WISE for Hospitality and Hospitals sectors: e-mail: drsudhirkumar@wisein.org, Mob: 09665020206 and Dr. Ajay Chandak for Institutional and Religious Sectors: e-mail: renewable.consultant@gmail.com, Mob: 09823033344) or write to us at following address indicating the heat requirement, fuel being used, space availability etc.

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 and on Saturday : 9.30 am to 1.30 pm. Our Channel Partners and Manufacturers of such systems may also be contacted whose lists are available at MNRE website: **www.mnre.gov.in.**

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