SMALL AND MEDIUM ENTERPRISES: ENERGY EFFICIENCY KNOWLEDGE SHARING

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SAMEEEKSHA NEWSLETTER

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Promoting Energy Efficiency in SMEs

SAMEEEKSHA

VISION

SAMEEEKSHA envisages a robust and competitive SME sector built on strong foundations of knowledge and capabilities in the development, application, and promotion of energy-efficient and environment-friendly technologies.

Bureau of Energy Efficiency

SHAKTI SUSTAINABLE ENERGY FOUNDATION

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Creating Innovative Solutions for a Sustainable Future

MSME
MICRO, SMALL & MEDIUM ENTERPRISES

A PLATFORM FOR PROMOTING ENERGY EFFICIENCY IN SMEs

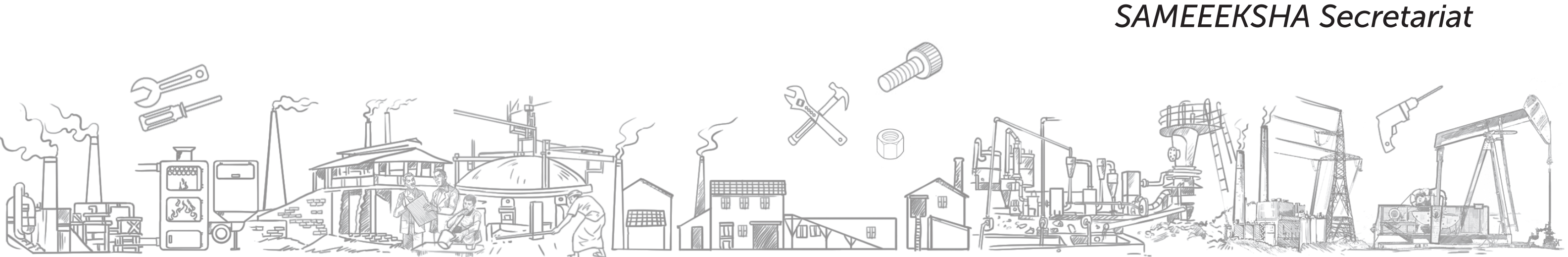
IN THIS ISSUE…

The theme of this issue is solar thermal technology, which in essence enables the conversion of sunlight to heat energy that can then be used for a range of applications including industrial process heat.

The theme article presents a simple overview of solar thermal technology and its importance and relevance for decarbonization of India's industrial sector. It carries a brief account of two significant projects being undertaken to promote solar thermal technology for industrial heat in India, with focus on the MSME sector: (1) the project titled 'Promoting business models for increasing penetration and scaling up of solar energy' being implemented by the United Nations Industrial Development Organization (UNIDO) and the Government of India with funding support from the Global Environment Facility (GEF); and (2) the study project being conducted by TERI with support from Shakti Sustainable Energy Foundation (SSEF) to explore the potential for introducing solar thermal technology in energy-intensive MSME sub-sectors. The article includes a few examples of techno-economic studies conducted in different industrial units for the implementation of solar thermal systems, as well as snapshots of two implementations. The article also summarizes a few key insights from these projects, and the strategies and initiatives that could help scale up the adoption of solar thermal systems among industries across the country.

The issue also carries a summary of an international webinar held on 20th November 2024 to explore opportunities and take forward initiatives to accelerate on-ground deployment of solar thermal projects for industrial and other heat applications. The event was organized jointly by the Solar Energy Society of India (SESI), International Solar Energy Society (ISES), SSEF, and TERI.

SAMEEEKSHA Secretariat



SOLAR THERMAL TECHNOLOGY FOR INDUSTRIAL HEAT: OPPORTUNITIES, CHALLENGES AND SOLUTIONS

Backdrop

Industries use huge amounts of energy, most of it in the form of heat: the International Energy Agency (IEA) has estimated that the heat energy needs of industry make up as much as two-thirds of overall industrial energy demand.[1] As industrial heat is mainly obtained from fossil fuel combustion, the challenge is to replace the existing fossil fuel-based heating technologies with low or zero emission technologies. Addressing this challenge is of critical importance to India as it strives to achieve its target of becoming a net zero economy by 2070 even while its industrial sector expands in tandem with the nation's growing economy.[2]

Electrification of fossil fuel-based technologies can be explored as a 'clean' option for certain industrial heating processes because electricity sourced from non-fossil sources has zero emissions at the user's end. India is making significant progress in 'greening' grid electricity by increasing the proportion of renewable energy (RE) in the overall grid electricity 'mix'.[3] However, as explained in earlier issues of this newsletter,[4] there are numerous and significant technological, financial, infrastructural and capacity barriers that prevent or discourage industries— MSME manufacturing units in particular—from adopting electricity-based solutions in place of their existing fossil fuel-based technologies, even in cases where such electrical options are readily available. Also, industries in energy intensive sub-sectors such as aluminium, cement, chemicals, and iron & steel require high-temperature heat for extended periods of time in certain processes; and as yet there are no proven, affordable and easily accessible electrical technologies for such long-duration, high-temperature heating processes.

On the other hand, there are numerous industrial processes and applications that require heat at low to medium temperatures (50–400°C) and that account for a substantial portion of total energy consumption even in the energy intensive sub-sectors. Hence, there is a clear case for exploring technological options based on RE—in particular, on solar energy—for meeting such low and medium temperature industrial heat requirements.[5] This is particularly when India is richly endowed with solar energy potential, with around 250–300 days a year of clear sunny weather and annual solar radiation ranging between 1600–2200 kWh/m^2.

The next section presents a simple overview of solar thermal technology. It is followed by a brief account of two significant projects being undertaken to promote solar thermal technology for industrial heat on a large scale, including a few examples of techno-economic studies conducted in different industrial units for the implementation of solar thermal systems, as well as snapshots of two implementations. The article also summarizes a few key insights from these projects, and the strategies and initiatives that could help scale up the adoption of solar thermal systems among industries across the country.

Solar thermal technology

Solar thermal technology converts sunlight to useful heat. It is thus distinguished from solar photovoltaic (SPV) technology, which converts sunlight directly into electricity. In essence, solar thermal technology gathers sunlight by means of a solar collector and uses it to heat up a 'heat transfer fluid' (e.g., water, certain solvents and oils, molten salt) that is circulated through a receiver. The heat energy in the fluid can be utilized immediately for various applications like industrial process heat, space heating. etc. The hot fluid can also be stored in insulated tanks for later use—for instance, after sunset or in cloudy conditions—thus ensuring that the heat energy is available without break 24/7.

Flat plate collector

1 See https://www.iea.org/commentaries/clean-and-efficient-heat-for-industry

2 In India, the industrial sector accounts for almost 57% of the total final energy consumption. [Source: 'India's CST sector – Vision 2022': Report prepared under MNRE-GEF-UNIDO project titled 'Promoting business models for increasing penetration and scaling up of solar energy'.]

3 TERI estimates that by 2030, the share of zero-carbon sources of electricity generation in the grid electricity can be between 42-47%.

4 For example, see SAMEEEKSHA issues 10(3), September 2019; 11(3), September 2020.

5 According to the MNRE-GEF-UNIDO study titled 'India's CST Sector – Vision 2022', the very conservative industrial market potential for concentrated solar thermal (CST) technologies in India is estimated at 6.45 GWth, but only 1% of this potential has been realized. See https://downloads.unido.org/ot/12/71/12714793/India%20CST%20Roadmap%202022Prot.pdf

Scheffler dish

Solar thermal systems are categorized based on the two broad types of solar collectors they use (table 1):

- **Non-concentrating solar collectors** absorb sunlight over their entire surfaces, and the fluid in the receiver gets heated to relatively lower temperatures. Non-concentrating solar systems are comparatively simple in design with lower costs; they are typically used for applications that require low temperature heating.
- **Concentrating solar collectors** have mirrors and/or lenses that gather sunlight across a large area (100 m^2 or more) and focus the light (i.e., concentrate it) on to a small area on the receiver, thereby greatly increasing the intensity of the solar radiation and achieving higher fluid temperatures. Concentrating solar systems are more efficient than non-concentrating systems; but they are also more complex in design with higher costs. These systems are typically used for medium to higher-temperature applications (up to 400°C) like industrial process heating or power generation.

Parabolic dish

Parabolic trough

Table 1. Some common solar thermal systems

Technology	Indicative temperature Range (°C)[a,b]	Thermal Efficiency	Cost (Rs./sq. m of collector area)[a]
Non-concentrating collectors			
Flat plate collector	30–80°C	40–60%	6000–8000
Evacuated tube collector	50–150°C	45–60%	7000–10000
Concentrating collectors			
Compound parabolic collector	~150°C	60–65%	12000–16000
Parabolic trough	~ 400°C	70–75% [c]	18000–24000
Scheffler dish	~ 250°C	50–55%	15000–20000
Parabolic dish	>250°C	75–80%	20000–26000

a. *India's CST Sector- Vision 2022, MNRE-GEF-UNIDO*
b. *Solar Heat For Industry India, Solar Payback, 2020*
c. *Generation of a Parabolic Trough Collector Efficiency Curve from Separate Measurements of Outdoor Optical Efficiency and Indoor Receiver Heat Loss, NREL*
d. *https://www.jocet.org/vol4/304-R0014.pdf*

Note: Temperatures and efficiencies vary depending on the size of the mirror field, tracking, collector area, and direct normal irradiance (DNI).

Projects to promote solar thermal technology

GEF–UNIDO project

The United Nations Industrial Development Organization (UNIDO) and the Government of India are implementing a project titled 'Promoting business models for increasing penetration and scaling up of solar energy' with funding support from the Global Environment Facility (GEF). The project aims at promoting, demonstrating and scaling up the application of concentrating solar thermal (CST) technologies for process heating and cooling in the manufacturing sector in India. The project activities aim at overcoming the barriers to solar thermal technology in the domains of policy, technology, awareness & skills, market, and finance. The key thrust areas include:

- Strengthening the policy and institutional framework for solar thermal technology

- Facilitating technology investments and implementations through technical and financial viability assessments of projects; preparation of detailed project reports (DPRs); strengthening the local manufacturing capabilities for solar energy systems along with quality assurance and certification framework; and supporting CST demonstration projects.
- Designing business models to help scale up the implementation of CST projects.

UNIDO had partnered with Indian Renewable Energy Development Agency (IREDA) to develop and implement an innovative finance/loan scheme[6] to encourage the adoption of CST projects. The project has also developed an information package which includes technical details of different solar collector technologies, operation and maintenance (O&M) guidelines, and other sector-specific information such as information about stakeholders and successful case studies.

During its initial phase from 2015–21, the project was executed through Ministry of New and Renewable Energy (MNRE). From 2022 onwards, the project is being executed through the Ministry of Micro, Small and Medium Enterprises (MoMSME) to focus specifically on solar thermal technology applications in five MSME manufacturing clusters, namely: Ankleshwar chemical cluster (Gujarat); Jorhat tea cluster (Assam); Medak pharmaceutical cluster (Telangana); Surat textile cluster (Gujarat); and Vellore rice milling cluster (Tamil Nadu). The MSMEs in these clusters require low to medium temperature heat, which can potentially be met by implementing CST technologies.

SSEF–TERI project

In synergy with the GEF–UNIDO project and to build on its experiences and lessons, TERI is conducting a study (launched in early 2025) to explore the potential for solar thermal technology in the MSME sector and identify CST options, as part of an initiative titled 'Industrial heat use and carbon emission reduction: an exploratory study' supported by Shakti Sustainable Energy Foundation (SSEF).

In its initial phase, the study identified energy intensive industrial sub- sectors in which there is significant potential for adopting solar thermal technology, and then pruned down the list of such sub-sectors by applying a set of criteria that assessed, stage by stage, the practicability of implementing solar thermal solutions. For instance, industries such as steel, aluminium and ceramics were dropped from further study, not only because many of their processes require high-temperature heating (typically above 800°C), but because the heat required for low-temperature processes in these industries is often generated by waste heat recovery (WHR) from their high-temperature processes at low or no extra cost. Likewise, industries such as sugar mills and pulp & paper mills were dropped because they generate by-products (e.g., bagasse, black liquor) which are, or can be, effectively repurposed as biofuels.

Based on this rigorous short-listing process, the study has identified five energy-intensive MSME sub-sectors that commonly use fossil-fuel based boilers to provide hot water and/or steam for various processes and offer significant potential for introducing CST systems on a large scale. The sub-sectors are: (1) dairy; (2) food processing; (3) pharmaceuticals; and (4) textiles.

The study focuses on integration of CST systems into the existing systems that meet the demands for hot water and/or steam. Detailed unit-level techno-economic studies are currently being conducted in these sub-sectors to identify suitable CST options.

Case studies

Techno-economic studies

A few examples are presented below, of the techno-economic studies that have been conducted for specific industrial units for implementing CST systems under the above two projects.

Pharmaceutical unit

Process heat requirements

- Hot water at 95°C for process heat applications.

Summary

The hot water requirements were being met by a coal-based boiler of capacity 16 tonnes per hour (tph). The study recommended the adoption of an extended compound parabolic non-tracking type CST system of capacity 2249330 kcal/day that can provide pre-heated feed water for the boiler and thereby meet the process heat needs of the unit at much lower cost.

Benefits of CST system

- Saves 300 tonnes of coal each year, equivalent to cost saving of about Rs 28.5 lakhs.
- Avoids 546 tonnes of CO_2 emissions annually.
- Estimated capital cost of the CST system: Rs 266 lakhs.
- Discounted payback period on investment: about 4.23 years with accelerated depreciation and 30% capital subsidy provided by UNIDO.

6 Details on the IREDA loan scheme for CST can be found at https://www.ireda.in/doc/financing-norms/approved-unido-loan-scheme.pdf

Dairy plant

Process heat requirements

- Hot water at 70–95°C for pasteurization and cleaning
- Steam at 110–150°C for sterilization, evaporation of milk

Installed boilers in dairy plant

Summary

The hot water and steam requirements are normally met by a natural gas (NG)-based boiler of capacity 8 tph. The study recommended the adoption of an extended compound parabolic concentrating solar system of capacity 3084665 kcal/day that can provide pre-heated feed water for the boiler and thus meet the regular hot water and steam needs of the plant at much lower cost.

Benefits of CST system

- Saves 123 tonnes of NG annually, equivalent to cost saving of about Rs 64 lakhs.
- Avoids 330 tonnes of CO_2 emissions annually.
- Estimated capital cost of the CST system: Rs 364 lakhs.
- Discounted payback period: 2.48 years with accelerated depreciation and 30% capital subsidy provided by UNIDO.

Textile processing unit

Process heat requirements

- Hot water at 60–90°C for dyeing and other applications.

Summary

The hot water requirements were being met by a coal-fired boiler of capacity 4.5 tph. The study recommended the adoption of an extended compound parabolic CST system of capacity 1735124 kcal/day to provide pre-heated feed water for the boiler and meet the hot water needs of the unit at much lower cost.

Benefits of the CST system

- Saves 260 tonnes of coal each year, equivalent to a cost saving of about Rs 13 lakhs.
- Avoids 474 tonnes of CO_2 emissions annually.
- Estimated capital cost of the CST system: Rs 205 lakhs.
- Discounted payback period on investment: about 8.10 years with the 30% capital subsidy provided by UNIDO

Implementations

Presented below are snapshots of two implementations of CST systems by MSMEs, with summaries of the benefits that the CST systems are bringing in terms of savings in fossil fuel consumption and energy costs. In both cases the MSME unit obtained financial support under the GEF–UNIDO project.

1. Pharmaceutical industry

Natural Capsules Ltd is a public limited company with a modern, well-equipped plant in Puducherry manufacturing a range of capsule shells such as hard gelatin capsule shells and hard cellulose capsule shells for pharmaceutical dosages. The plant requires hot water at a steady temperature of 61°C for process heating and for washing. The plant had been meeting its entire needs for hot water using a diesel-fired boiler.

In March 2021, the unit installed a paraboloid dish-based CST system that supplies pre-heated feed water to the boiler, and thereby reduces its diesel consumption as well as energy bill.

CST system at Natural Capsules plant

Key features of CST system

- Comprises an array of 64 highly efficient paraboloid dishes with total collector area of 281.6 m^2, equipped with a dual-axis tracking mechanism.
- Generates heat of 110–120°C in the receiver at 1.5 bar pressure. The system is designed to supply an average of 800,000 kcal/day for pre-heating boiler feed water.
- Operates 8–9 hours daily under direct sunshine. Can provide 12–14 hours of pressurized hot water.
- The system is also provided with a solar PV-based heat pump for backup.

Benefits of the CST system

- Saves 150–200 litres diesel daily, representing an annual cost saving of about Rs 42 lakhs.
- Cost of CST system was Rs 138 lakhs, for which the unit obtained a bridge loan of Rs 16.8 lakhs against MNRE subsidy. The simple payback period for the CST system works out to 2.9 years.

2. Silk reeling industry

Uttarakhand Cooperative Resham Federation (UCRF) is an umbrella federation of entities engaged in silk reeling and silk fabric manufacturing activities in Uttarakhand. UCRF works under the aegis of the state's Department of Sericulture, and includes cooperative societies engaged in silkworm rearing and silk reeling; self-help groups (SHGs); and NGOs. The silk reeling units use hot water at 90°C and above for processing the cocoons into silk. The hot water is supplied by means of a wood-fired boiler in the UCRF campus.

In May 2017, UCRF installed a compound parabolic CST system for supplying pre-heated feed water to the boiler, thus helping reduce wood consumption, energy costs and CO_2 emissions.

Key features of CST system

- Comprises an array of 90 parabolic reflectors with total collector area of 295.5 m^2.
- Operates for an average of 7–8 hours daily, and supplies feed water at 90°C to the boiler where the water is further heated to about 120°C for supplying to the silk reeling units.

Benefits

- Saves about 415 kg of wood per day, equivalent to a reduction of over 50% in wood consumption.
- Annual emissions reduced by 186.75 tCO_2 eq.
- Cost of CST project was Rs 62.3 lakhs, for which UCRF obtained financial assistance totalling about Rs 28.3 lakhs.
- The payback period is 4.5 years.

CST system at UCRF

Looking ahead

The project experiences demonstrate the significant benefits that industries can obtain by adopting solar thermal systems to meet their process heat needs, in terms of savings in energy bills along with reduced levels of fossil fuel consumption and carbon emissions. The potential to benefit from implementing solar thermal solutions is particularly high in the MSME sector, because over 80% of the process heat in MSMEs is currently derived from fossil fuels such as coal & furnace oil; biomass and in certain energy intensive sectors such as textile dyeing, dairy, and food processing, the thermal energy share of total operating cost is reported to be as high as 25–40%.

Indeed, there are barriers to be overcome in introducing solar thermal technology—as is the case with all new/innovative technologies that are introduced in the MSME sector—but the project experiences have shown that these barriers can be overcome through a package of measures comprising awareness creation, unit-level assessment studies, careful technology selection and adaptation, capacity building, and financial support mechanisms.

The success of this approach is illustrated by the growing number of industries and other end-users that are adopting solar thermal systems in India. During the current phase of the GEF–UNIDO–MoMSME project on CST technology, around 11 CST demonstration plants have been successfully implemented, covering over 9975 m^2 of collector area. Besides, expressions of interest in solar thermal systems have been received from 55 MSME units in eight MSME clusters, and feasibility studies have been completed and DPRs prepared for 35 MSME units, with one unit in Surat having already initiated procurement. Also, a dedicated pool of 30 solar thermal experts has been developed through a 'Training of Trainers' program.

The material and data for this article have been sourced primarily from the various documents associated with the GEF–UNIDO project and the SSEF–TERI project on CST.

WEBINAR ON SOLAR THERMAL TECHNOLOGIES FOR INDUSTRIAL APPLICATION

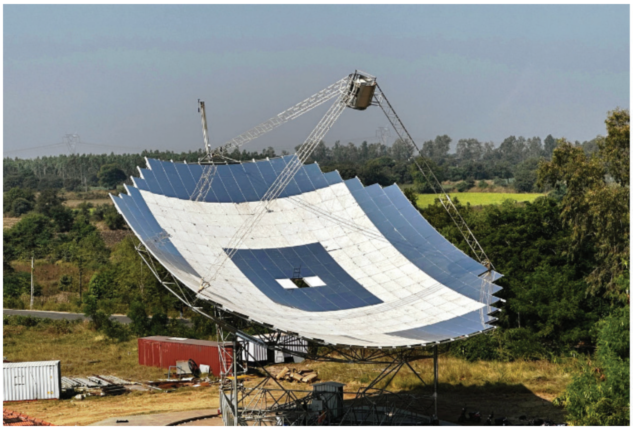
An international webinar was held on 20th November 2024 to explore opportunities and take forward initiatives to accelerate on-ground deployment of solar thermal projects for industrial and other heat applications. The event was organized jointly by the Solar Energy Society of India (SESI), International Solar Energy Society (ISES), Shakti Sustainable Energy Foundation (SSEF), and TERI, and saw attendance by over 60 participants from various countries.

Welcoming the participants, Mr Prafulla Pathak, President, SESI, underlined that solar thermal technology is of as much interest and relevance for India as solar PV, and efforts must be sustained to promote solar thermal applications in the country as a key decarbonization strategy. Setting the agenda for the meeting, Dr Ashvini Kumar, Advisor, SSEF and Board Member, ISES, requested the participants to focus on issues that hinder the deployment of solar thermal systems, and to identify bottlenecks related to technology and financial viability; as the idea behind the webinar was to receive feedback for the purpose of proposing policy and regulatory measures that could accelerate the deployment of solar thermal systems in India and in other nations.

Two special lectures were delivered to provide deeper perspectives on solar thermal technology: by (1) Prof. Yogi D. Goswami, Distinguished Professor and Director of the Clean Energy Research Center at the University of South Florida, USA; and (2) Mr Deepak Gadhia, Chairman, Sunrise CSP India Pvt. Ltd.

Prof. Goswami outlined the principle of 'feed-in tariff', which was conceptualized by Dr Herman Scheer as an effective way to encourage RE development, particularly solar power, by providing a guaranteed price for the RE-based electricity generated by homeowners and businesses. He cited the development of CST systems based on supercritical CO_2 cycles (i.e., where CO_2 in supercritical state is used as the heat transfer fluid), with efficiencies likely to be higher than 50%, resulting in smaller turbine sizes and much better economics. The scope for industrial process heat applications could range from 60–70°C to 1000°C.

Mr Gadhia shared his experience of working with CST systems for cooking and food processing applications in India. He described the two kinds of parabolic concentrator systems—one developed by Dr Dieter Seifert and the other by Mr Wolfgang Scheffler— that have transformed the market for CST systems in India, particularly for large-scale/community cooking. Over 60 such CST projects have been installed, including one at Tirupati that cooks 50,000 meals per day. Mr Gadhia also spoke on a CST technology named 'Big Dish' that had been developed by his company Sunrise CSP in Australia, which requires a relatively small collector area of 25 m^2 to generate about 500 kW_{th} (i.e. 0.5 MW_{th}). One such Big Dish system has been installed at the campus of the Muni Seva Ashram (Gujarat) to provide steam for various applications including cooking, laundry and sterilization, as well as electricity for air-conditioning. Currently, trials are on with a 'tri-generation' system that can be used for power generation, heating and cooling. This offers an opportunity to transform an entire village economy by way of meeting diverse energy needs through a single system. Various other applications are possible including cold storage, desalination, industrial heat, etc.



'Big Dish' CST system at Muni Seva Ashram [Source: https://sunrisecsp.com]

A panel discussion followed, during which insights and suggestions were provided by Dr Christoph Brunner, CEO, AEE - Institute for Sustainable Technologies, Austria; Ms Geetanjali Patil Choori, CEO & Co-Founder, Energy Guru; Mr Siddhartha Malik, CEO, Vulcan Green Energy LLC, Muscat, Oman; Mr Prakash Bhalekar, Co-founder and CEO, Quadsun Solar Solutions; and Mr Madhusudan Rao Rapole, Director, Oorja Energy Engineering Services Pvt. Ltd.

The following salient points emerged from the discussions and the Q&A session that followed.

- Unlike solar PV technology, in which the solar panels are more or less similar for all applications, solar thermal systems have to be industry-specific and application-specific.
- According to IEA's Solar Heating and Cooling (SHC) Technology Collaboration Platform, several countries are planning pilot hybrid technology projects that combine solar thermal with other technologies like solar PV, waste heat recovery, heat pumps, geothermal, and storage.
- Among the current business models for promoting solar thermal technology, the signing of heat purchase agreements is growing in popularity.
- While promoting CST technology, the focus should be on large-scale applications as these will attract private investments as well as the technically proficient personnel required for effective and efficient integration of the CST systems with the existing processes.
- Industries can be encouraged to adopt solar thermal options through the setting of benchmark energy consumption goals by BEE. Also, a regulatory framework can be established under which industries have to meet 'renewable heat obligations', similar to the 'renewable purchase obligations' (RPOs) that electricity distribution companies are required to meet.
- A focused push is needed to support R&D related to CST systems design, engineering and hybridization for various applications, along with demonstration and technology validation plants. This will be critical for domestic capacity building.

ABOUT SAMEEEKSHA

SAMEEEKSHA is a collaborative platform aimed at pooling the knowledge and synergizing the efforts of various organizations and institutions—Indian and international, public and private—that are working towards the common goal of facilitating the development of the Small and Medium Enterprise (SME) sector in India, through the promotion and adoption of clean, energy-efficient technologies and practices.

SAMEEEKSHA provides a unique forum where industry may interface with funding agencies, research and development (R&D) institutions, technology development specialists, government bodies, training institutes, and academia to facilitate this process.

For more details, please contact

SAMEEEKSHA Secretariat
Industrial Energy Efficiency Division
TERI, Darbari Seth Block
IHC Complex, Lodhi Road,
New Delhi - 110 003, India
Tel: (+91 11) 2468 2100
Fax: (+91 11) 2468 2144, 2468 2145
Email: sameeeksha@teri.res.in
Website: http://sameeeksha.org