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Indian Pulp and Paper Technical Association

Using Concentrating Solar Thermal Technology to integrate with Industrial process to reduce the dependence of fossil fuels


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1.0 Introduction

India is endowed with a vast solar energy potential. About 5,000 trillion kWh per year of solar energy is incident over India's land area, with nearly all of India receiving an average sunshine hour of 5-7 kWh/m2/day. The abundant solar radiation, clean character of solar energy, high cost of fossil fuels and negative emission consequences, along with large requirements for process heat below 250°C are the key drivers of the strong focus on the development of solar thermal applications in India.

UNIDO has identified a total market potential of 12.5 GW for industrial applications, including low temperature applications, in India during preparation of CST Roadmap 2020 (Source:https://mnre.gov.in/sites/default/files/India.pdf). The Concentrating Solar Thermal (CST) technologies, due to efforts of the indigenous technology providers, are making technical and economic sense today in many applications such as steam cooking, laundry services, dairy thermal applications and the automotive sector.

The heat requirement is met by burning conventional fuels such as coal, furnace oil, natural gas and electricity.Use of solar concentrator technology integrated with system process heat demand can help replace/ reduce conventional fuels which in turn will help reduce GHG emissions.

Solar Thermal Technology

CSTs are very well suited for industrial process heat applications in the medium or medium-high temperature ranges. They can be used effectively to supply energy in the form of heat, and therefore huge potential exists for the use of concentrated solar energy in the industrial sectors.

Industrial heat is characterized by a wide diversity with respect to temperature levels, pressures and production processes to meet the many different industrial process demands. CST technologies track the sun's incoming radiation with mirror fields, which concentrate the energy towards absorbers, which then transfer it thermally to the working medium. The heated fluid or steam may reach high temperatures and may be used for various processes requiring heat.

CST technologies can produce a range of temperatures, between 60°C and up to over 350°C, which can be used in a variety of industrial and commercial heat applications. The industries showing good potential for implementation of solar concentrators are food processing, dairy, paper and pulp, chemicals, textiles, fertilizer, breweries, electroplating, pharmaceutical, rubber, desalination and tobacco sectors. Any other industrial/ commercial establishments currently using steam/hot water for process applications can also employ CST with a minimum tinkering to the existing setup. For industrial processes where lower temperature range less than 120°C is required, technologies such as the Scheffler dish and Compound Parabolic Concentrator or Non-- imaging Concentrators are common and for higher temperature range applications, technologies such as Parabolic Trough, Linear Fresnel and Paraboloid dish with tracking are preferred.

CST technologies like Scheffler dish, Linear Fresnel and Parabolic trough can generate 0.35 kWh//m2 of solar concentrators area on a clear sunny day (in a region with good solar irradiation like Gujarat, Rajasthan, Tamil Nadu etc.). Technologies like Paraboloid dish may have higher heat delivery by approximately 0.45 kWh/m2 i.e. 20-25% higher in comparison to the single axis technologies due to avoided errors in manual North-South adjustments.

(Source:https://mnre.gov.in/file-manager/UserFiles/Anticipated-Heat-Delivery-from-CSTs-in-different regions.pdf)

Calculation of heat output per MW of CST Project

The following table and graph indicate that the cost and size of project is based on the available DNI of 5.0 kWh/m2/day in India.

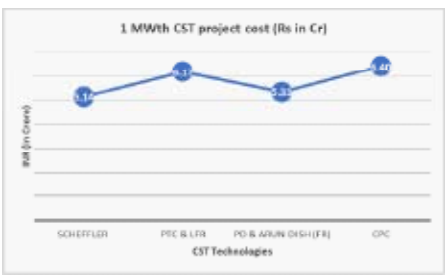

Fig 1: *Technology wise project cost*

Table 1: Design of project cost and land requirement for installation of CST system

Capacity	Tracking	Types of CST Technologies	Instantaneous power output per unit area at an average DNI of 5 kWh/m^2/day		Heat delivery per m^2 per year (Range)	System cost per m^2	Collector area	Land area	Project cost
			kWh per m^2	kW per m^2 per day	In Lakhs of kCal	Rs	m^2	m^2	Rs in Cr
1MW (or 1000 KW)	Single	Scheffler	0.35	2.80	4 to 7	18,000	2,857	6,400	5.14
		PTC & LFR				21,600	2,857	11,686	6.17
	Double	PD & Arun dish (FR)	0.45	3.60	6 to 11	24,000	2,222	4,578	5.33
	Non-tracking	CPC	0.225	1.80	3 to 5	14,400	4,444	5,778	6.44

Industrial Applications

The different types of concentrating solar thermal technologies have been developed or are currently under development for various commercial and industrial applications.

For industrial processes where temperatures above 80°C are required, concentrating solar collectors such as parabolic trough, paraboloid dish, non-imaging concentrators, a Linear Fresnel based system are required to be used.

Fig 2: *Types of CST technologies*

Overview of CST Technology application in paper industry

The exhibit below illustrates an overview of the concentrated solar heating technology in Pulp and Paper industry.

The table below illustrated the heating and cooling requirement in the Pulp and paper sector2.

The following table illustrates the suitable concentrated solar thermal technology in paper & pulp sector, their indicative temperature, cost of delivery and output.

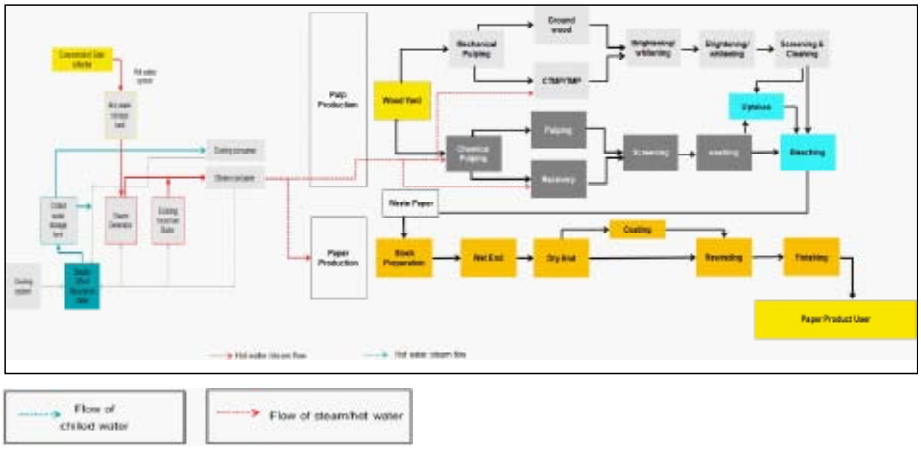

Fig 3: *Process requirement through CST in paper industry*

Table 2: Heating and cooling requirement in pulp and paper industry

Processes		Temperature(°C)
Kraft Pulping (cooking temperature)		170 to 175°C
pulping of rice straw, wheat straw, grasses jute sticks (Cooking temp)		135-140 C.
Refining mechanical pulping CTMP (hard wood - chemical soak)		75-80°C
Refining (thermo-mechanical pulping)	steam	110 to 120°C
	refining	100 to 130°C
Recovery of Black liquor[3]		
Conversion of calcium carbonate to calcium oxide		1000 to 1200°C
Black liquor evaporation[4]		150 to 250°C
Causticizing		100°C

Table 3: CST technologies suitable for paper & pulp industry

Suitable concentrated solar technologies	Indicative temperature of the technology (°C)	Cost of technology (Rs/m^2)	Processes
Linear Fresnel Reflector (LFR)	Up to 250	21600	• Kraft Pulping (cooking temperature) • pulping of rice straw, wheat straw, grasses jute sticks (Cooking temp) • Refining mechanical pulping CTMP (hard wood -chemical soak) • Refining (thermo-mechanical pulping) • Black liquor evaporation • Causticizing
Parabolic Trough Collector (PTC)	Up to 250		
Paraboloid dish	Up to 350	24000	
Fresnel reflector-based dish	Up to 350		

A case study: CST at B.S. Paper Mill, Ludhiana, Punjab

B. S. Paper Mill is situated on Tajpur Road in Ludhiana has used Scheffler based CST system of 160m2collector area to generate pressurized hot water at 98°C, integrated with wood-fired boiler, used in the manufacturing of paper (colored paper, duplicating paper, stamp paper, cover page etc.).

The system was commissioned in 2011 by MNRE approved CST manufacturer and is operation for approximately 8 hrs during sun shine and around 300 days in a year to saving 70 kg/hr of wood (i.e. 183 ton of wood saved per year with saving of 670 tons of CO2 abatement) and with financial support from the Ministry as a Central financial assistance, the IRR comes around 24.18% with payback period 3 years 3 months.

Fig 4: *Scheffler dish installed at roof top in B S Paper mills*

4.0 Status and Installation of CST project in India

The total projects installed with the support from the Ministry are 65461.12m^2 of collector area. Out of these 245 projects, 154 projects with 30010.6m^2 collector area were installed for community cooking, 61 of 23491.12 m^2 for process heat, 13 with 9543.6 m^2 for cooling application and 17 projects of 2415.8m^2 for other applications.

(Source: https://mnre.gov.in/file-manager/UserFiles/staewise_installation_of_CST_based_systems.pdf)

The state-wise installations of CST projects used in different applications are shown in the figures below:

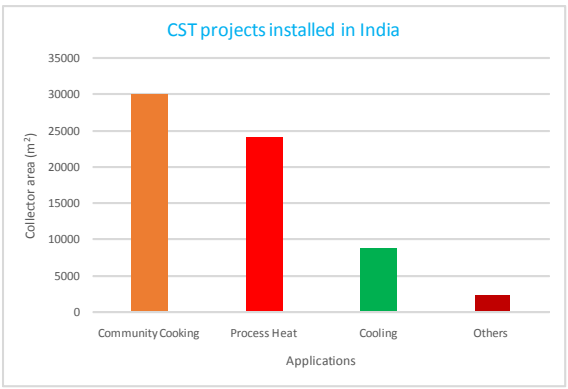

Fig 5: *Application-wise CST system installed in India*

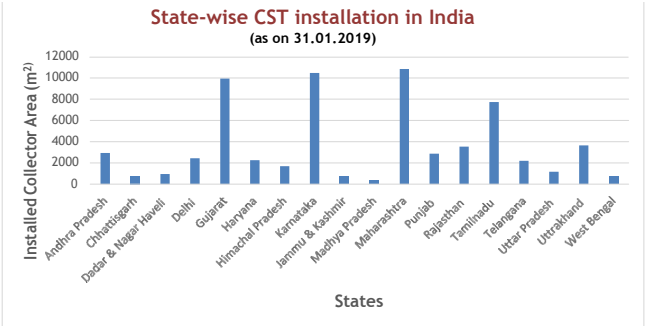

Fig 6: *State-wise installation of CST projects (more than 500m2 project size)*

The project payback usually depends on the cost of the substituted fuel. It ranges from 3–4 years for process heat applications if the substituted fuel is furnace oil, diesel, or PNG. The payback may be slightly longer (5–7 years) to substitute solid fuels such as coal, biomass, and wood. The longer payback period is also seen in cooling applications.

Financial Supports to promote CST

The Ministry of New and Renewable Energy is implementing a programme on concentrated solar thermal aimed at peak shaving, conservation of electricity and fossil fuels and providing a clean, non-polluting solution to meet the process heat requirement in community, commercial and industrial sectors. Various promotional incentives in the form of Central Finance Assistance (CFA) are available for concentrating solar thermal projects under the Jawaharlal Nehru National Solar Mission. This programme is implemented through multiple agencies for scaling up of CST projects. These agencies include SNAs, IREDA, SECI, Channel Partners, and other government agencies like PSUs, Institutions, NHB, NABARD etc. Ministry also has empanelled Channel Partners, Manufacturer/suppliers and Entrepreneurs for CST technology.

(Source: https://mnre.gov.in/file-manager/UserFiles/OM-list_channelpartners_st_cst_jnnsm.pdf)

In addition, the GEF-UNIDO project on "Promoting Business Model for increasing penetration and scaling up of solar energy" was designed to complement Ministry (MNRE) support programme by helping to remove barriers associated with Concentrating Solar Thermal (CST) technologies, its awareness, capacity building, market and financial barriers. The implementing partners of the CST project is Ministry of New and Renewable Energy (MNRE), Indian Renewable Energy Development Agency (IREDA), and National Institute of Solar Energy (NISE).

The project was conceived with an aim to contribute to the GEF Climate Change Strategic Objective namely, promoting investment in Renewable Energy (RE) technologies by transforming the market for solar energy for industrial heat applications in India through investment, market demonstration, development of appropriate financial instruments, development of technical specifications, capacity building and contributions to establish a favorable policy and regulatory environment.

The financial supports for CST project are in the form of Capital subsidy from MNRE and soft loan scheme under MNRE-GEF-UNIDO CST project are given below:

Central Finance Assistance from MNRE

Subsidy rate:

a. @ 20% of the bench mark cost or actual cost whichever is less to all beneficiaries in all states

b. @ 40% of the bench mark cost or actual cost whichever is less to Non-profit making bodies and institutions in special category states, viz., NE states, Sikkim, J&K, Himachal Pradesh, Uttarakhand and islands.

The benchmark cost of the different CST technologies is given in table below:

Table 4: Capital subsidy based on Technologies

Type of Solar Collector	Benchmark Cost of Collector Area (Rs/m^2)
Concentrator with manual tracking (dish solar cookers)	7000
Solar collector systems for direct heating and drying and non- imagine/ Compound Parabolic Concentrators (NIC/CPC)	12000
CSTs with single axis tracking (including Scheffler dish)	15000
CSTs with single axis tracking, solar grade mirror, reflector and evacuated tube collectors	18000
CST based on double axis tracking	20000

Soft Loan Scheme under UNIDO-IREDA supported MNRE project

UNIDO has partnered with IREDA (Indian Renewable Energy Development Agency) to develop and implement an innovative finance/loan scheme to further promote the deployment of CST projects in India for heating and cooling applications in potential industries to reduce energy consumption and Greenhouse Gas (GHG) emissions. The highlights of the currently available financial incentives are as follows.

- The beneficiary's or project developer's contribution would be 25%.
- The financial incentives provided for CST installation include CFA (Central Financial Assistance) from MNRE and accelerated depreciation benefit.
- Additional support is available from UNIDO project in terms of technical feasibility and soft loan from IREDA.
- Bridge loan against subsidy and at normal interest rate would be available.
- Support is available also for improving the manufacturing of CST system/components.

Loan for the CST project would be provided at an interest subvention of 5% from the current rates using funds under the project. Both the loan and MNRE subsidy would be bundled in form a financial package by IREDA. The details of the loan scheme and the application form are available on the MNRE, IREDA & UNIDO websites.

(Source:http://www.ireda.in/writereaddata/Approved%20UNIDo%20Loan%20scheme..pdf)

The project developers and beneficiaries may contact MNRE, UNIDO for further information on the CFA, loan scheme and the technical support available from UNIDO for CST projects for industry process heat applications.