INDIA'S QUEST FOR GLOBAL SOLAR THERMAL INDUSTRIAL PROCESS LEADER

- Jaideep N. Malaviya (Secretary General), Solar Thermal Federation of India
info@stfi.org.in, *Phone: +91-9890033399*

INTRODUCTION

Fifty-seven per cent (nearly 240 Metric tons of oil equivalent) of the final energy consumption in India is used for thermal applications. Industrial process heat, residential cooking, and water heating are the main thermal applications accounting for more than 90% of the thermal energy requirement. Presently India's thermal energy demand is primarily being met through coal, biomass, and petroleum fuels. Several areas in India receive good DNI and solar thermal energy has potential to convert this radiant energy to meet the heating needs up to 250 ^{O}C. 15 million tonnes of fuel oil in industries requiring heat up to 250 ^{O}C & 5,000 trillion kWh of electricity (excluding LPG consumption) in various sectors for heating water & air being consumed annually. Even if 1% of this energy requirement is met using concentrated solar thermal (CST) systems the potential estimated is over 2.5 million m^2. However, to achieve these targets there need to be market drivers and one of them suggested is to obligate solar thermal heating in high energy consuming industries and encourage Energy Service Companies (ESCo's).

INDIA'S ACHIEVEMENT IN CST SYSTEMS

More than 200 steam generating systems have been installed so far in the country with a cumulative figure of little over 75,000 m2 of dish area equivalent to about 50 MW. These are largely due to subsidy programmes of Ministry of New and Renewable Energy (MNRE), government of India and programmes under GEF-UNDP and GEF-UNIDO. Most of these have been installed mainly at places where steam generated through conventional boilers for process heating and community based steam cooking besides few demonstration projects for cooling. During the period April 2012 to March 2017 the country witnessed net installation of 44,949 m2 of dish area under the GEF-UNDP Concentrated Solar Thermal Heating programme. Solar Heat for Industrial Process had the lion's share of almost 70%. Table 1 below gives the break-up wise of installation occurred under this programme besides projects supported for revamping.

Sl.	**Application**	**Area (m2)**
1	Process Heating	28,188
2	Steam Cooking	9,208
3	Space Cooling	3,826
4	Repair and Maintenance	3,727
	TOTAL	44,949

Table 1: Application wise installations under GEF-UNDP programme

The true market potential of CST technologies in the industrial sectors has been assessed as 6.4 GW in India in a study recently commissioned by UNIDO. Fourteen industry sectors have been identified (Table 2) by UNIDO where CST technologies make economic and technical sense in terms of ready acceptability for their deployment for a variety of process heat applications in the temperature range up to 350°C.

Sl.	**Sectors**
1	Textiles (Weaving, Finishing)
2	Pharmaceuticals
3	Automobiles
4	Breweries
5	Pulp & paper

doi:10.18086/swc.2017.26.07 Available at http://proceedings.ises.org

6	Electroplating
7	Food processing (including Dairy & Sugar)
8	Rubber
9	Chemical & Fertiliser
10	Petroleum Refineries
11	Desalination
12	Ceramic tile & pottery
13	Plaster of Paris, Steel rerolling, Cement, Mining
14	Tobacco

Table 2: Highest potential sectors for solar thermal process heating

In India mainly 3 types of concentrating solar technologies are presently in promotion:

i) Manually tracked dish solar cookers to cook food for 10-40 people,

ii) Fixed focus E-W automatically tracked elliptical dishes (Scheffler) for direct indoor cooking for about 50-100 people & for steam generation for community cooking, laundry, space cooling etc. of any capacity and

iii) Dual axis fully tracked Fresnel dishes (Arun) for all such applications.

The CST systems can be broadly classified as below

- ★ Fixed Focus Elliptical Solar Dish (Scheffler)
- ★ Fresnel Reflector Based Dish
- ★ Linear Fresnel Reflector Concentrator
- ★ Compound Parabolic Collector
- ★ Parabolic Trough Concentrator
- ★ Paraboloid Dish

There are 22 Manufacturers offering 6 types of CSTs in promotion with varying designs & sizes. Figure 1 gives the technology-wise CST systems. There are couple of solar grade cut mirror glass manufacturers offering international standards quality developed technologies for edge sealing & back coating and state of the art parabolic trough mirrors.

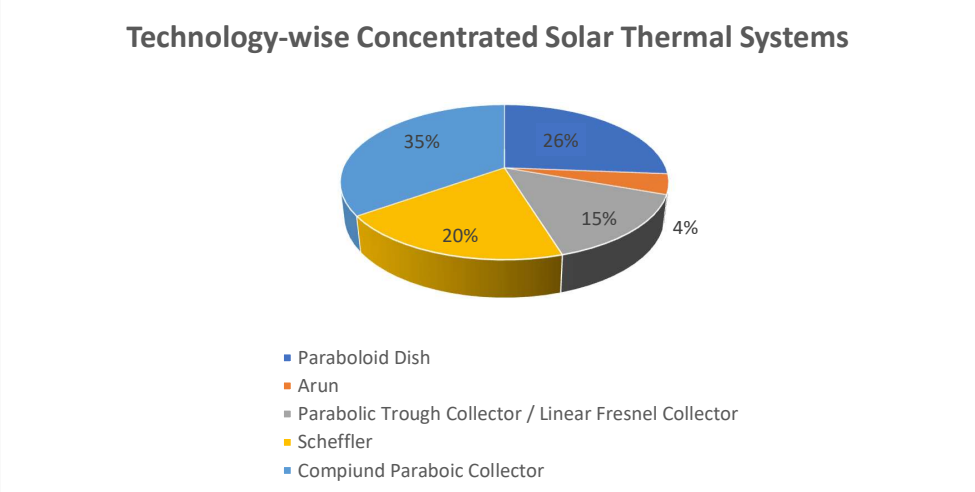

Figure 1: Technology-wise CST systems

DNI MAP OF INDIA

The Direct Normal Irradiation (DNI) in India varies from 4.0 to 6.0 kWh/m²/day as shown in the Figure 2 and is an indicator of the potential regions that can use solar thermal.

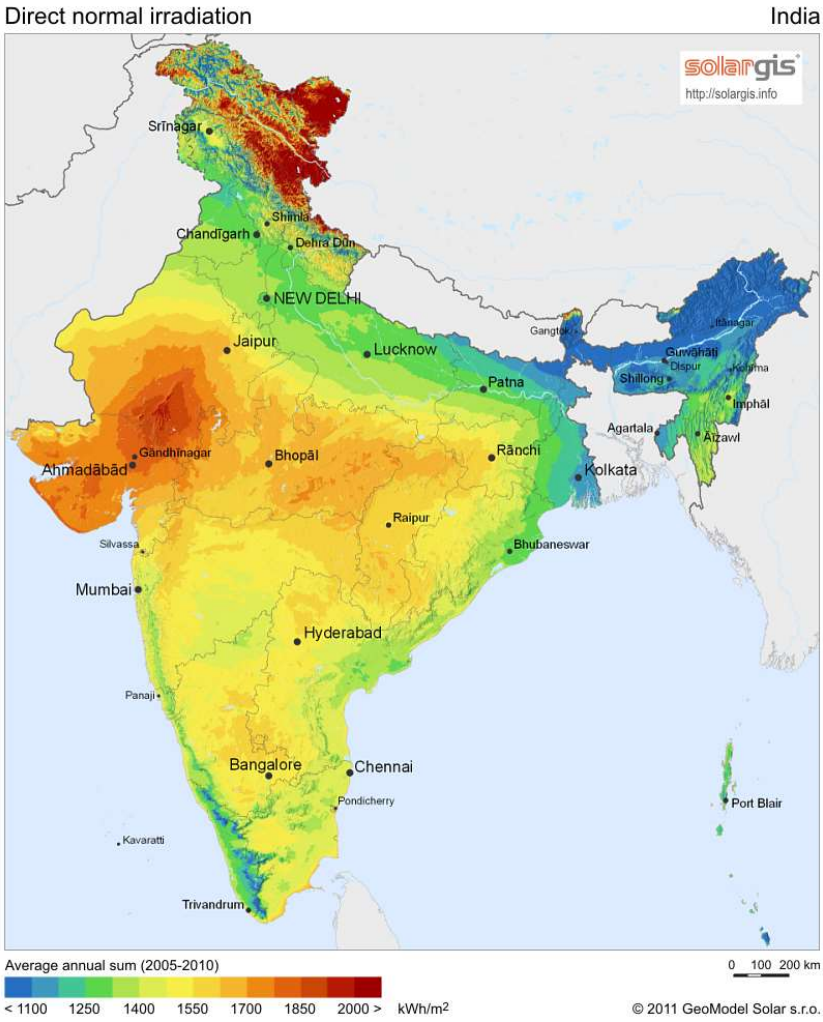

Figure 2: DNI Map of India (Geo Model Solargis, EU)

Based on the DNI the potential states with medium to high DNI that facilitate implementation of CST projects are listed in Table 3.

Sl.	Region	Indicative average DNI/ m² / day* (In kWh)	Sunshine days	Fixed focus elliptical dish^ / Non-evacuated heat receiver PTC		Evacuated heat receiver PTC/ LFTR		Fresnel reflector/ Paraboloid based dish	
				Efficiency at 150C**	Heat delivery** */ m²/ year (in million kcal)	Efficiency at 150C**	Heat delivery** */ m²/ year (in million kcal)	Efficiency at 150C**	Heat delivery** */ m²/ year (in million kcal)
1.	Leh Ladakh	6.5	320	35%	0.626	40%	0.715	60%	1.073

2.	Gujarat Rajasthan & western M.P.	6.0	300	40%	0.620	45%	0.697	65%	1.010
3.	Southern & Central	5.0	280	40%	0.482	45%	0.542	65%	0.783
4.	North, West & Himalayas	4.5	250	35%	0.339	40%	0.387	60%	0.581
6.	North – east & Eastern part of Orissa & A. P.	4.0	250	40%	0.344	45%	0.387	65%	0.559

Table 3: Potential states with medium to high DNI

^ Average effective aperture area of 16 m^2 fixed focus elliptical dish for receiving normal radiation during whole year is to be taken as 11 m^2. The heat delivery from a 16 m2 elliptical dish in a year in different regions will, therefore, be 11 multiplied by figures given in above table.
Also, dual axis automatic tracked elliptical dishes may have higher heat delivery by say 5% in comparison to single axis tracked dishes due to avoided errors in manual N-S adjustments.

* Can vary by +/- 10% at a location in the region

** Its average annualized efficiency and is linked with ambient temperature and wind conditions of particular region. It reduces in the regions having lower ambient temperature and high wind velocity. It also reduces marginally for CSTs working at higher temperatures due to higher heat losses, thereby reducing the heat delivery. Temperature range which can be achieved by various CSTs, their salient features, installed cost & payback period are given below.

*** Heat delivery will:

i) increase if the fluid temperature goes down due to less heat losses. Likewise, it will also decrease if working temperature is raised high say up to 350 ^{O}C or so especially in case of Fresnel reflector /Paraboloid dishes which are designed for such temperatures.

ii) decrease by 10% or more if the mirrors are not of solar grade quality.

INTRODUCING SOLAR THERMAL CERTIFICATE SCHEME

Perform Achieve and Trade (PAT) scheme of Bureau of Energy Efficiency, designed to accelerate energy savings in energy intensive and large industries by incentivizing energy savings. The identified industries classified as Designated Consumers (DC's) are aluminum, cement, chlor-alkali, fertilizers, iron and steel pulp and paper, railways, textiles, petroleum processing and refining, sugar, chemicals, commercial buildings and electricity distribution companies. The PAT – Part 1 scheme that ended in March 2015 achieved 8.67 million tonnes of oil equivalent (MTOE) and abated 31 million tons of CO_2. The PAT Part 2 scheme notified on 31st March 2016 has a target reduction of 8.869 MTOE assigned to 621 DC's.

These DC's who achieve reductions in their targets receive ESCerts (energy saving certificates) which can be traded with facilities that are having trouble meeting their targets, or banked for future use.

One tonne of oil equivalent (TOE) is One ESCert is issued.

1 TOE = 1 ESCert = INR 10,968

Each TOE at 890 kgs/m3 density is equivalent to 1,125 litres of fuel oil.

Concentrated Solar Thermal (CST) Technologies can provide a good alternative to reduce their specific energy consumption as shown in Table 4 below:

	Solar PV	Unit	Solar Concentrator (PTC/Dish) >120^{O}C	Solar CPC (NIC) 80-90^{O}C	Unit
Energy (TOE/Year)	1		1	1	
Equivalent Energy	**11,630**	**kWh**	10,000,000	10,000,000	kcal
Capacity	8	kWe	5	5	kWth
Area Required	84	m^2	14	11	m^2
Cost (INR**)**	6,00,000	INR	283,173	163,929	INR

Table 4: Cost Comparison of energy generation using solar PV, CPC and Parabolic/Dish

Hence for the same amount of TOE, CST technologies offer a viable alternative and hence including it in the reporting structure of PAT will ensure that designated consumers (DCs) will invest in CST technologies.

To encourage these DC to go for CST a scheme of s**olar thermal certificate (STCert)** to be launched by Bureau of Energy Efficiency (BEE). A defined target to be given to potential DC's to generate STCert. The minimum project size to qualify for STCert to be 250m^2 for single axis and 150m^2 for double axis. If the scheme is successful and finds more buyers of STCert, the incentive can be reduced gradually with time. Non-DC's can also apply for STCert and should be an entity consuming at least 5,000 litres/ year of fuel oil annually. Those DC's not able to meet their STCert can buy these STCert from non-DC's.

BARRIERS IN CST'S GROWTH

Major barriers listed in large-scale promotion of CSTs at the start of project were as follows:

- Lack of awareness about the technologies & their benefits.
- Information on successful projects not accessible to public.
- Lack of confidence on technologies. Lacking in trained manpower of technicians.
- No test standards & test set ups for measuring performance exists
- Space constraints for installations to beneficiaries
- Non-availability of solar grade mirrors in required sizes at reasonable prices.
- Non-availability of soft loans to beneficiaries & ESCOs
- Low returns on investments as compared to solar flat plate collectors. Requires higher support, especially for space cooling & standalone systems
- Very few manufacturers. Not much competition.
- Difficulties for cost control measures.

While most of the barriers have been addressed in the last five years however the demand creation has not occurred to a level of commercialisation.

PROJECT SOLAR PAYBACK

The Solar Thermal Federation of India (STFI) and the Indo-German Chamber of Commerce (IGCC) have teamed up for the international 'Solar Payback' project, which aims to increase the use of solar thermal energy in industrial processes. Supported by the German Federal Environment Ministry funded by the International Climate Initiative, the three-year project will be implemented in India, South Africa, Mexico and Brazil. It is coordinated by the German Solar Association BSW-Solar and eleven partner organisations: three German companies, plus each target country's national solar industry association and German Chamber of Commerce. The use of solar heat for cleaning, steam

production, bath heating and surface treatment in manufacturing is still a niche market in India and around the world

The initial study has so far focused on an in-depth analysis of market barriers and drivers by drafting a solar process heat roadmap and making policy recommendations. In addition, it intends to strengthen the industry by offering training for planners and raise awareness by organising an industry conference. The project partners will use a wide range of activities and communication tools to get in touch with the relevant stakeholders in politics, business and financing. Key activity targets include:

- Drafting a National Solar Process Heat Roadmap
- Developing a financing/business tool for planners and investors to offer preliminary analyses of solar process heat plants
- Developing policy recommendations for uptake of solar process heat at national level
- Organising train-the-trainer workshops on planning / designing solar process heat systems
- Implementing an online matchmaking network for investors and technology providers
- Organising a local industry / stakeholder conference

Conclusions:

Looking at the huge heating demand and reducing dependence on imports of fuel oil India has the quest to quest for becoming global leader for deploying solar thermal industrial process heat and meeting the identified target of 6.4 GW. The areas that need to be addressed can be summarised as below:

- MNRE to create demand worth INR 100,000 m^2 in 3 years in food processing industries, automobile and defence etc.
- MNRE to invite manufacturers to develop products and infrastructure to bring down the costs through R&D and have budget for
- Make the available DNI data of various locations to public at no cost.
- Introduce performance based incentive equivalent of MWth or MTOE avoided.
- Output be close to the manufacturer's claim & co-relate to the DNI of that area. Any reduction be suitably penalised. A Renewable Heat Incentive (RHI) policy need to be framed.
- Provide concessional loan to manufacturing industries to scale up operations and business.
- Perform Achieve Trade (PAT) operated by BEE must have a special mention about solar thermal heating in their curriculum.
- Large scale capacity building workshops for skilled personnel for better upkeep and maintenance
- Encourage ESCo model as it ensures proper operation of the installations and can give is the recovery. Easy funding be made available for ESCo projects.

REFERENCES:

Solar Thermal Federationof India (http://www.stfi.org.in)
Ministry of New and Renewable Energy, government of India (http://www.mnre.gov.in)
GEF-UNDP Concentrating Solar Thermal Programme (www.cshindia.in)

- X – X – X -