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Use Solar Heat for Prosperity, Healthy and Pollution Free Life

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Abstract- Solar heat is utilized in residential sector for heating water for bathing, cleaning and washing throughout the world. Its utilization is very much less is in commercial, industrial and agricultural sectors. Solar heat is also utilized for cooking food but limited. Solar thermal applications are economical and efficient for our daily life. India has a high solar resource; therefore, need to develop solar thermal applications in residential, commercial, industrial and agricultural sectors. Cooking food by solar cooker is clean and free from smoke, thus it can provide quality way of life to the millions of people using chulhas and kerosene for cooking. Need innovation, technological development, implementation, awareness and encouragement to increase use of solar heat in all walks of life, under the guidelines Jawaharlal Nehru National Solar Mission.

Index Terms- Aware, Cook stove, Encourage, Innovation, Solar resource

Abbreviations- CSPC - Concentrated Paraboloid Solar Cooking, GWth - Gigawatt Thermal, ETC- Evacuated Tube Collector, FED – Full Energy Delivery, FPC – Flat Plate Collector, JNNSM – Jawaharlal Nehru National Solar Mission, MNRE – Ministry of New and Renewable Energy, PED- Partial Energy Delivery, R&D – Research and Development, SWHS-Solar Water Heating System.

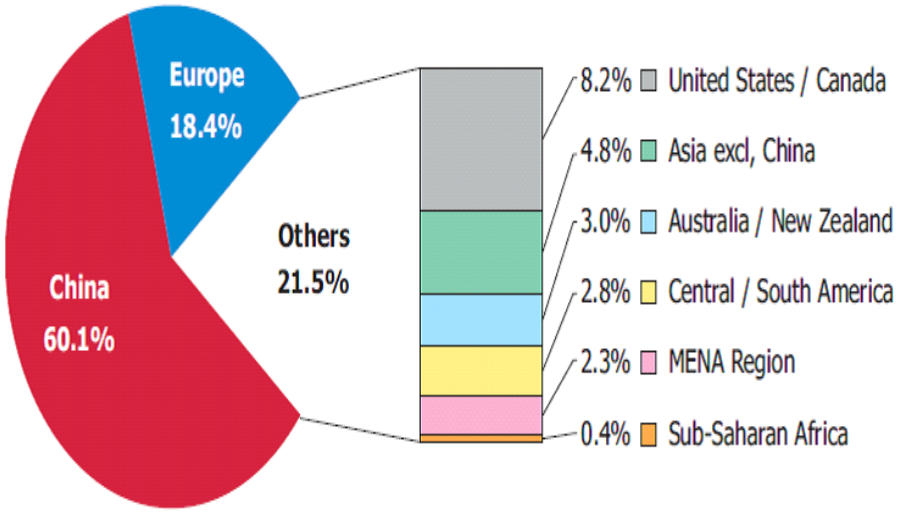
I. Introduction

Solar thermal applications are the efficient means for utilizing solar energy. Sun rays are directly converted into heat; no mechanical or electrical conversion is required. Solar hot water collectors are used by more than 200 million households (over half of them in China), as well as in schools, hospital, hotels and government and commercial buildings, and there is growing trend to use solar resources to generate process heat for industry (1). India is a tropical country, where sunshine is available for longer hours per day and in great intensity. Solar thermal applications are economically viable and can be used for water heating, drying and cooking. Solar thermal applications have a wide range of temperature, below 100^0C and above 400^0C (2). Solar water heating is well established, matured technology; its applications are used in many sectors; residential, hotels, hospitals, industry and other (railway, defence, hostel, religious places). Flat Plate Collectors (FPC) and Evacuated Plate Collectors (EPC), non concentrating solar collectors, are used up to 100^0C for solar water heating and solar drying and industrial heat processing. Concentrated solar technologies (Parabolic Trough) are used for temperature above 100^0 C for cooking and industrial process heat. Solar dryer utilizes FPC based solar air heating system to absorb solar energy. Solar thermal dryer are suitable for drying agricultural produce (cereals and pulses), food processing industry (tomatoes, bananas, mango, peaches, pulp). Solar dryer is also suitable for fish drying, tea, leather, tanneries, spice drying and drying of the painting in paint workshop (automobiles, motor cycle and bicycles). Solar cookers are the best for clean and hygienic cooking of food. Use of solar resource is very much less in India as compared to available solar resource. Special attention is required for development of R&D to meet the requirement of various sectors. MNRE should develop pilot projects in all the sectors and exhibit for technology development and encourage for adoption. State governments have a vital role for development of solar heat applications in all the sectors, protecting loss of agricultural produce, saving of electricity, gas and oil. Presently, India's substantial and sustained economical growth, coupled with rapid industrialization and population growth is placing immense pressure on the country's non renewable natural resources (fossil fuels and nuclear fuels) and increasing India's dependence on imported fuels (3). There is need to curb this increasing import for increasing our competitiveness in international market and raising living standard of peoples. Increased adoption of solar thermal applications would not only reduce import, but emissions also.

II. Status of the World by End of 2010

Total installed capacity in the world by end of 2010 was 195.8GWth, a total of 279.7 million square meters of collector area. China has been leader with the installation capacity of 117.6 GWth and followed by Europe - Albania, EU 27, Macedonia, Norway, Switzerland, Turkey 36.0 GWth, United States and Canada 16.0 GWth, Asia excluding China -India, Japan, Korea South, Taiwan, Thailand 9.4 GWth, Australia and New Zealand 6.0 GWth, Central and South America -Barbados, Brazil, Chile, Mexico, Uruguay 5.5 GWth, the MENA countries- Israel, Jordan, Lebanon, Morocco, Tunisia 4.4 GWth and Sub - Saharan African countries - Namibia, South Africa and Zimbabwe 0.8 GWth (4).

Figure1, Share of Total Installed Capacity in Operation by Economic Regions at the end of 2010.



Source: Solar Heat Worldwide, Market and Contribution to Energy Supply 2010

China has been a leader with an installed capacity 117.6 GWth and majority of solar water heaters are installed in urban residential sectors (both multi-storey as well as independent houses). 10% households are using solar water heaters and have a target of 30% by 2020. In Europe, 90% capacity is in residential sector, predominantly in individual houses.

III. Solar Water Heaters

Status of Solar Water Heater in India

Solar water heater is used in households, hotels, and guest houses, hospitals, for bathing, washing, cleaning and cooking. In industries, solar water heaters are required for process and steam generation. Solar water heaters installed in India by 2009, residential 80%, hotels 6%, hospital 3%, industry 6% and others (railway, defence, hostel, religious places) 5% (5). Karnataka and Maharashtra are leading states in utilizing solar water heater, more than 65% installed capacity of India and total installed capacity in India was 3.5 million m^2 till 2009(6).

Table 1, Estimated Breakup: Functional SWH Installation till 31 December, 2009 -3.1 million m^2, assumes functional are 85% of the installed SWH.

Sector	Million m^2
Residential (80%)	2,108
Hotels (6%)	0.158
Hospital (3%)	0.079
Industry (6%)	0.158
Other (Railway, Defence, Hostel, Religious places, other) (5%)	0.132
Total	2.635

Source: Greentech knowledge Solutions.

IV. Solar Water Heaters Technology for Residential, Hotels, Hostels and Hospitals Sectors

A solar water heater consists of collector to collect solar energy, insulated storage tank and pipelines. The solar energy incident on absorber panel coated with selected coating transfer the heat to riser pipes underneath the absorber panel. The water passing through the risers get heated and delivered to storage tank. The re- circulation of same water through absorber panel in the collector raises the temperature up to 80^0 C. There are two types of water heater, flat plate collectors and evacuated tube collectors. The solar radiation is absorbed in Flat Plate Collectors (FPC). FPC is consisting of an insulated outer metallic box covered on the top with glass sheet. Inside there are blackened metallic absorber (selectively coated) sheets with built in channels or riser tubes to carry out water. The absorber absorbs solar radiation and transfer heat to flowing water. Evacuated tube collector is made of double layer borosilicate glass tubes evacuated for providing insulation. The outer wall of inner tube is coated with selective absorbing material. This helps absorption of solar radiation and transfer heat to the water which flow in inner tube.

Flat Plate collectors are more efficient than ETC during sunshine conditions. The energy output of Flat Plate Collectors is reduced in comparison to ETC in cloudy and extremely cold conditions. Solar Water Heaters for domestic purpose are generally available between 100 to 300 litres. For hotels, hostels and hospitals large size of water heaters are available.

Solar Water Heaters for Residential Sector

Hot water is required in households for bathing, cleaning and washing. In urban households water is heated on LPG stove, electric geyser, and electric immersion rod and LPG/PNG geysers, where as in villages wood and biomass or agricultural waste is utilized for heating of water. Now a day, rates of electricity have been regularly increasing, Government of India has limited the LPG gas cylinders, consequently, heating water

by electric immersion rod, electric geyser and LPG/PNG would be costly. Potential of Solar water heater depends upon three factors, availability of solar resource, period of utilization of hot water and purchasing power of peoples. Throughout India a good solar resource is available. The period of utilization of water is 4to 5 months in north India and 8 to 12 months in south India. Therefore, payback period is less in south India in comparison to north India. North Indian has to pay more for same quantity of water and identical size of solar water heater. Urban population has very much higher purchasing power in comparison to rural population. Considering all above factors, urban areas of five states Karnataka, Maharashtra, Tamil Nadu, Andhra Pradesh and Gujarat and National Capital Regions have the highest potential for solar water heating system. 100 litres SWH at residence can save 1500 units of electricity annually, 1000 SWH of 100 litre capacity saves 1MW peak load (7). Ambitious target of JNNSM for installation of solar collectors is 20 million sq. metres by 2022. Residential sector has a share of 80% of total solar collector area - 16 million sq. meters. 100 litre of solar water heater requires 2 m^2 of solar collector area. 8 million solar water heaters of capacity 100 litre could be installed –saving of 8 GW peak load.

Solar water heaters for Hotels, Hostel and Hospitals

Hot water is required in Hotel, hostel and hospitals for bathing, cleaning and washing. In Hotels, hostel and hospitals gas stove, Electric geysers, immersion rods and LPG geysers are used. Two factors affects for potential of solar water heater, availability of solar resource, period of utilization of hot water. The period of utilization of water is 4to 5 months in north India and 8 to 12 months in south India. Therefore use of solar water heater is economical in south India. Huge requirement of water in early morning before sun shines and limited area / roof available for installation in hotel, hostels and hospital are great barriers in adoption of solar water heaters.

Solar Water Heaters for Industrial Sector

Solar water heaters for industrial use can be classified on the basis of temperature used for the process, Low Temperature - below 100^0C, Medium Temperature - below 400^0C and High Temperature- above 400^0 C. 30% of total industrial heat demand is required at the temperature below 100^0C and 57% below 400^0C (2). Solar heat can be utilized in the sectors like food (including wine and brewages), textile, transport equipment, metal and plastic treatment, and chemical. The application depends of upon temperature level required for the process in industry. Use of solar water heater, vary country by country, firstly - solar resource in the country, secondly- level of temperature required for process for the industry in that country.

Solar Water Heating Technology for Industrial Use

In India, solar water heating technology developed for industrial purpose (Arun 160) is under pilot scale demonstration. It is a Fresnel paraboloid concentrator mounted on flat dish with down ward facing cavity receiver at its focus designed to absorb concentrated solar energy and to transfer it for useful application. The concentrator track the sun on two axes, continuously facing it to capture maximum amount of solar radiation over a day. The dish concentrator along with the receiver is mounted on specially designed tower. Number of concentrators can be installed according to requirement of steam /water. Example of pilot scale demonstration solar water heaters are in operation in industrial sector in India, Mahanand Dairy at Latur - Pressurized hot water for milk pasteurization with storage, Chitale Dairy at Sangli - Steam generation for milk Pasteurization, Mahindra & Mahindra at Pune - Pressurized hot water for degreasing process, Heavy Water Board, Kota - Steam for effluent evaporation.

Applications of Solar Water Heater in Industry

Solar water heating can be utilized in many industries such pulp and paper, textile, dairy, leather, food processing, electroplating, fertilizer, drug and pharmaceuticals. There is high potential of solar water heating in Pulp and paper, dairy and textile in India.

Pulp and Paper

High quantity of hot water and steam is required in pulp and paper for preparation of pulp, cooking, drying and bleaching. Presently, Heavy furnace oil and coal is utilized for generation of steam. Million ton of coal and furnace oil can be saved by use of solar thermal application.

Dairy

India is the largest producer of milk in the world. Milk production in the country was estimated around 94.5 million MT in 2005 (5), the milk production was expected to grow to 120 million MT by 2012.In dairy large quantity of hot water is required for multiple purposes, utensil cleaning, pasteurization process (60 - 85^0C), sterilization process (130-150^0C) . In milk dairies the furnace oil is used as a fuel. Million litres of furnace oil can be saved by solar thermal applications.

Textile

Textile industry is the largest industry in India. The industry is growing 5% annually. In textile industry, major part of steam is required for chemical processing, such as scouring, bleaching, dyeing, mercerizing, printing, curing etc. The steam requirement is 20 Kg/ Kg of cloth. Textile industry utilizes coal and biomass for steam generation. Presently, coal and biomass are cheaper; therefore, adoption of solar water heater would be at slow rate.

Solar Water Heaters for Cooking

Steam is generated by Concentrated Paraboloid Solar Cooking (CSPC), which is utilized for cooking. Cooked food by steam is clean, healthy and hygienic. Solar water heating cooking plants can provide thousand meals per day, and can be installed in hotels, hospitals, schools and religious places. Especially, solar water heater is most suitable for cooking mid day meals in schools. Million tons of gas, oil and coal can be saved.

Solar Water Heating Technology for Cooking

Steam is generated by Concentrated Paraboloid Solar Cooking (CSPC), which is utilized for cooking. CSPC system consist of pairs of sleeping dish and standing dish in parallel, aligned in east -west direction. Receiver is placed at the focus point of each pair of dish, water flows through the receivers and converts into the steam which is utilized for cooking. A number

of parabolic solar concentrators are employed to heat the water and form steam, which can be effectively used for large - scale cooking in community cooking. CSPC system is provided with diesel/ LPG back up to enable to cook in cloudy days, night hours, monsoon periods, and no separate system is required. A pilot scale demonstration solar water heating cooking plant is installed at Bramhakumaris Ashram at Mount Abu, can provide 600 meals in a day i.e. 300 meals twice a day (requires 300 Kg of steam per day). It saves 9,600 litre diesel and 25,728 Kg CO_2 emission per annum (8).

Solar Drying

Drying process is carried out in agricultural, food processing industry and other industries. Main function of drying is to remove the moisture from the substance for preserving for a longer period. In India, agricultural produce are produced in bulk quantities in seasons, it becomes difficult to utilize them, and wasted due non- availably of preservation. By use of solar drying techniques vegetables, fruits and cereals wastage can be minimized and consumption of coal and firewood can be substantially reduced.

Solar Drying Technology

For agricultural products average temperature required for drying ranges between 50^0C to 80^0C. For drying, most commonly used dryers are FPC -based solar air heating system to absorb solar energy. There are two systems, Full Energy Delivery (FED) and Partial Energy Delivery (PED). Full Energy Delivery (FED) system is used when the temperature requirement are lower. Partial energy delivery system are associated with back up and can be used when temperature requirement are higher. Generally higher temperature 140^0C to 220^0C are required in Industries and provided with back of fossil fuels or biomass.

Solar Drying of Fruits, Vegetables and Cereals

35% of agricultural produce roughly amounting to Rs. 500,000 million goes to waste annually after harvesting (9). 10% of cereals and pulses, 40% of fruits and vegetables are wasted annually (10). Farmers sell their produce at a cheaper rate in the top season and do not get full value of their produce. Fruits and vegetables are very cheap in the season and very costly in off-season, therefore, there is wide gap between seasonal rates and off-seasonal rates. Farmers are not getting full amount of their produce and purchaser paying more due to wastage. By using proper solar drying techniques wastage can be minimized. Farmers dry grains in open air by direct sun rays for preserving. This method has several disadvantages such as uncontrolled and slow rate of operation, dependent on environment and weather conditions, contamination, dusting, fermentation, attacks by birds and insects and other unfavourable conditions. Waste of agricultural produce and other produce can be eliminated by using proper solar drying applications. Solar drying applications are economical, energy saving and environment friendly. Solar drying can effectively used in food processing industries, for meeting the demand of solar dried tomatoes, bananas, peaches and mango pulp in international market.

Solar Drying in Industries

Utilization of solar drying is limited in industries. Very few installations of solar drying applications are available in India. Solar drying applications can be utilized for drying spice, leather, fish, tanneries, food pulp, painting (all type of automobiles including motor cycles and bicycles). Presently, solar drying systems are installed at Sakthi Masala, Erode and leather dryer with hot air ducts at M.A. Khizar Hussain & Sons, Chennai. In India, the high potential is expected in fish and tea industry. India has large coastline and island water ways which contributes million tons of fish and millions of peoples are involved in fish industry. Fish spoils quickly, it cannot sustain for long period without freezing or drying. Fishing is carried out almost in the year except one or two months. Ample Solar resource is available in coastal areas. Million tons of firewood can be saved by adoption of solar drying techniques. India is among the largest tea producing country of the world. Several million tons of coal is used for drying of tea. By adoption of solar drying techniques million tons of coal can be saved.

Solar Cooking

2.7 billion Peoples relied on traditional use of biomass for cooking, around 40% of global population, out of which 836 millions in India (around 72% share of population of India) (11). Chulha (cook stove) is used for cooking, traditional fuels are burnt in chulha, emits hazardous smoke. Chulha emits smoke in open atmosphere; pollutants are 5 to 15 times higher than industrial combustion of coal. Use of culha deteriorates air quality, create chronic health problems, and damage to forest, eco system and global climate. World health organization claimed approximately 1.5 million people per annum in the world die of indoor pollution and carbon monoxide poisoning every year because of burning of biomass in chulha, out which 300,000 to 500,000 die in India. These chulhas are required to be replaced by solar cookers. Generally, three types of solar cookers are available in the market - box cooker, dish cooker, community solar cooker.

Box Cooker

Solar box cookers are useful for small family consist of three to four members in the family. The moderate and high temperatures can be obtained with box cookers. Cost of box type solar cooker is less, but could not replace chulha due lack of important features such as boiling of water, roasting of chapatti, frying/ tadka/ vagar. It cannot replace chulha due lack of facilities required in Indian foods.

Dish Cookers

It is concentrating type parabolic dish solar cooker. Temperature can be achieved 350 to 400^0C; therefore, can be used for boiling, roasting and frying. It can be used in households in rural and urban areas, dhabas, tea shops, etc.

Community Solar Cookers

Food can be cooked in kitchen by community solar cookers. It consist of large reflector, which reflects the light in kitchen through in its north wall while a secondary reflector further concentrate rays at the bottom of the pot/ fry pan painted with black. High temperatures are achieved in order of 400^0C, therefore, enables to cook food in shorter period. It acts like gas,

electric or fire wood system. 7 sq. meter sized reflector solar cooker can cook the food of 50 people; bigger size reflector can be used for more than 50 people but limited 100 peoples. Traditional food cooking is possible - making chapatis, purees, dosa etc. including vaghar/tadka in dal and vegetable

Jawaharlal Nehru National Solar Mission

Jawaharlal Nehru National Solar mission emphasized the need to encourage solar heating system below 80^0C - solar collectors, which are already using proven technology and are commercially viable. Mission has set the ambitious target for temperature below 80^0C for domestic and industrial applications. The mission targets are 7 million sq meters -phase 1 (2010-13), 15 million sq meters - phase2 (2013-17), 20 million sq meters-phase 3 (2017-22)

Role of Government

Using of solar heat is at infancy stage in India. Technology is to be developed in Industrial and agricultural sectors. There is need to develop pilot demonstration projects in India in industrial and agricultural sectors for technological development and awareness. Initial cost of solar equipment are very higher, needs Government support. Solar thermal applications vary region to region and, therefore, state government can effectively encourage for adoption.

MNRE

MNRE is working for development of R&D, setting up pilot demonstration projects, providing subsidies. Under the guidelines of MNRE Fresnel paraboloid reflecting concentrator (named Arun 160) was developed by M/s Clique Development Pvt. Ltd., Mumbai. Arun-160 has been installed as pilot demonstration projects at milk dairies and hotels. There is need to develop pilot demonstration projects in other industries also.

State Governments

Solar thermal applications differ from state to state. State governments form the policy and regulation according to their requirement. State Governments can provide additional subsidy or incentive in addition to the MNRE for progress of solar thermal applications. State Governments may issue mandatory regulations for incorporating solar water heating system in new or renovated buildings with financial incentives such as discount on monthly electricity bills. State governments need to take step to reduce wastage of fruits, vegetables, fish and cereals in their state by development of solar drying centres in the state. Similar steps are required by the state governments in industries and commercial sectors.

Research and Development

Solar thermal applications in commercial, industrial and agricultural sectors are limited worldwide. Solar resource countries have an opportunity for development of solar thermal applications. Our country has high solar resource; therefore, solar thermal applications can be implemented in domestic, commercial, industrial and agricultural sectors. Solar water heater, for the domestic purposes have matured technology. Solar water heaters for industrial purpose are to be developed according to the requirement of industry (temperature and pressure of water and steam is different for different industries). Similarly, solar drying system is to be developed for agricultural and industries as per requirement of temperature and ways of drying (drying temperature and drying ways are different for different articles). India is losing Rs. 500,000 million per annum on account wastage of cereals, fruits and vegetables due to lack of drying and preservation. Solar drying techniques are required to be developed to avoid huge loss to the country every year. Million ton of fish is wasted every year; this wastage is to be reduced. Solar cookers available in market for domestic purposes do not fulfil the requirement of cooking of Indian traditional food. There is need to develop solar cookers according to the requirement of cooking Indian traditional food at reasonable and affordable cost.

Impact of Import

Presently, India is importing coal, gas, oil and uranium to meet the energy needs. Energy needs would further increase with population, economic and industrial growth of country. Thus the import of coal, gas, oil and uranium would substantially increase. The import of such things is very much costlier in comparison to our own resources. More import means, the cost of energy produced would be high, our product and services would become costly, our competitiveness would be reduced in the international market. Costly product and services would make our life costlier and lower standard of living. It has become imperative to use solar resource in our day to day life for leading economical and pollution free life.

V. Discussions and Conclusions

Use of solar heat is increasing worldwide, since economical and energy efficient. Our country has been importing coal, natural gas, oil and uranium for requirement of energy needs. Solar heat, which is abundantly available, can be used in residential, commercial and industrial and agricultural sectors. Utilization of solar heat can substantially reduce the import of coal, gas, oil and uranium.

Presently, gas geysers/ electric geyser, gas stoves and kerosene are utilized at residence in urban areas for requirement of hot water in our country. At this stage, we need to follow China, 10% households use solar water heaters and targeting for 30% by 2020. Solar water heating is a matured technology. Increase in installation of solar water heaters would save peak load in Gigawatts and million ton of gas and huge quantity of kerosene. Need to aware and encourage for fast growth of adoption of solar water heater at households.

Presently, solar water heaters are used at Mahanand Dairy at Latur and Chitale Dairy at Sangli, need to encourage in other milk dairies to adopt solar water heating system. Detailed study may be conducted for developing and implementing for solar heating system in industries like food (including wine and brewages), textile, transport equipment, pulp & paper metal and plastic treatment, and chemical.

Solar water heaters for cooking food are installed at Brahmakumaries Ashram at Mount Abu, there is need to design and develop water heater on similar pattern for cooking food in hotels, hostels, hospitals, mid day meals in schools and big mess. Millions of gas cylinders and furnace oil can be saved.

40% of fruits and vegetables are going waste every year due to lack of preservation. Farmers are not getting full cost of their produce, they sale their produce in cheaper rates in seasons. Fruit and vegetables become very costly except top season period. Purchaser pay high cost if purchases in off season. In similar way grains are also going waste due lack of preservation. Solar drying technique may be developed for preservation of fruits vegetables and grains. Solar drying has not been put in use in industrial sectors except one or two industry. Solar drying applications, needs to be encouraged for fish drying, tea drying, drying of spices, leather, foods pulp and painting.

In India, 836 million people are without access to clean cooking facilities, use traditional fuels - fire wood, agricultural waste and biomass cakes. Solar cooker manufactured do not meet the requirement of Indian cooking. Another drawback of solar cooker, the food cannot be cooked in kitchen; one has to remain in the scorching heat of sun. Solar cookers need to be redesign as per requirement of Indian cooking to enable to adopt solar cookers.

Use solar heat, save coal, oil, gas, electricity to make country competitive and prosperous. There is need to aware about the impact of using solar heat to the masses and involve them for adoption. Government of India and State Government need to work together for development of solar thermal application in residential, commercial, industrial and agricultural sectors. NGO should come forward for increasing adoption of solar thermal applications.

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