

# Going Solar- Conducive Shift to Domestic Solar Electric System



Amit Kumar, GunjanAnand, Ajeet Kumar Sahoo

**Abstract:** Growing needs and heavy consumption of non-renewable energy sources led to the growth of the solar power system across the world. But, this mechanism couldn't be absorbed by struggling economies as it was expected. Despite the regular and sustainable supply of electricity people across the developing countries were found reluctant to adopt solar technology to meet their daily energy requirements. This paper would explore the 'emergence & trends of domestic solar power generation system, challenges for RTS technology across Indian Households, discussion on sustainability & reliability of solar power system in developing countries, review consumers' behavior towards use of solar power system and Identify the Incentives and Subsidies attached with domestic RTS in developing countries'. The study observed a positive perception of people towards domestic RTS and willing to adopt it if potential limitations would be removed. Negative behavior is derived from technical as well as economic limitations of this technology. The overall growth is quite impressive and shows a bright and progressive future ahead.

**Keywords:** Solar Energy, Solar Power, Domestic Solar Electricity System, Energy Requirement, Developing Countries, Renewable Energy Sources

## Abbreviations:

RTS : Rooftop Solar Power System  
DTE : Down-to-Earth  
GW : Giga Watt  
MW : Mega Watt  
MNRE : Ministry of New and Renewable Energy

## I. INTRODUCTION

Solar power creation is a well marketed and communicated phenomenon across the developing world as there is a limited and non-renewable energy sources are being exploited for energy requirements. The power sector across all developing economies is running short of technical infrastructure and limited sources of production (Muneer&Munawwar, 2005). There is a huge gap between demand and supply of electricity in struggling economies.

Hence, countries are tend to shift over renewable &lasting source of energy resources such as 'solar energy' (Dutt, 2004).

Countries are thoroughly working upon an effective policy mechanism which can promote green energy production with affordable cost so as to meet citizens' daily energy requirement for their livelihood (Chandrasekaran, 2016). Solar power is the fastest growing industry across the world especially in developing countries as industrialized economies have already been shifted over it long back (US-India Energy Partnership Summit, 2010).Filling the gap of demand and supply of electricity countries like India which is in acute scarcity is shifting for domestic power generation through use solar technology. The strategic shift would offer multiple benefits to the country in the form of- individual micro investments into domestic solar power generation for personal use, mitigating climate change, minimizing carbon footprint, green production, easy reach which not only affecting people's livelihood but also significantly affecting industrial development of the country (Shrivastava&Shrivastava,2013).Technological advancement among countries has also risen the need of electricity, thus, government now promoting solar power system for domestic use. Solar power system as a clean and renewable source of energy has come up as the best solution for endless energy requirements. This is not only good for household energy need but also meeting industrial energy requirements across the world. Countries like India has already launched policy named 'National Solar Mission' in 2010 in order to transform country's socio-economic development (Chatterjee, 2010).Taking India as study area the current research endeavor to explore India's stand for adopting solar power generation system to meet energy requirement for citizen. It would also evaluate the current trend of solar adoption along with people's understanding of this technology. The research will produce a complete scenario of solar electric system of the country and how it is being growing gradually.

## II. RESEARCH GAP & OBJECTIVES

**GAP:**Literature evidences shows extensive researches have been conducted on 'Roof Top Solar Power System' in India which includes both domestic as well as commercial purpose. Majority of studies centered over commercial RTS and only few studies were taken over domestic RTS. This has given a chance to conduct a thorough investigation on solar power generation system in India for domestic purpose. Also there is little evidences of trend of RTS among domestic users, people's approach towards RTS, fruitfulness of RTS from domestic consumers' point of view etc.**OBJECTIVES:** Based on the gap found in previous studies,

Manuscript published on November 30, 2019.

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the current research is being conducted with following objectives:

1. Analyzing the emergence of solar power generation system for domestic use of households in India.
2. Challenges for RTS technology across Indian Households.
3. Analyze the 'sustainability and reliability' of solar power generation system in India.
4. Understand consumers' behavior towards RTS in India.
5. Identify the Incentives and Subsidies attached with domestic RTS.

### III LITERATURE REVIEW

Stoltzfus (2018) opined that solar power system has immense significance for the developing world to ensure easy and cost effective energy supply for households. It has also a great means for eradicating poverty through sustainable energy supply to industries as well as households. India in its continues effort increasing production capacity of solar power generation and recorded significant growth from 2650 MW in 2014 to 20 GW in 2018 (Business Today, 2018). Whereas, the installed capacity has reached to 31.101 GW during 2019 (Ministry of New and Renewable Energy, 2019). India's investment into solar power system has reached over \$ bn 300 during the year 2014 and Modi's government has set the target of 100 GW electricity production through solar energy by 2022 (Dawn, et al., 2016). India rank in top ten position across the world in electricity generation with installed capacity of 243 GW and in case of solar electricity generation its rank is 5<sup>th</sup> around the world (MNRE, 2018). The contribution of rooftop solar power generation to the nation is around 2.1 GW wherein major portion belongs to industry or for commercial use (DTE Article, 2019). The challenge is to increase domestic use of rooftop solar power system. Government has ambitious plans for promoting rooftop power generation technology among domestic users to facilitate required amount of electricity to the people. In this way, government has announced subsidies to the households on installation of rooftop solar power system and extended loan facilities for easy payment (Shahsavari&Akbari, 2018). One of the significant reasons of adopting RTS is the cost per unit, it is even less than Rs. 2.40 per unit. But countries like India wherein per capita income of households is very less they couldn't afford the cost of RTS installation (Greenpeace, 2013). Despite of government concession by the way of subsidies and tax credits households still reluctant to adopt this mechanism. This is one of the prominent reasons why domestic adoption of RTS is low than industrial adoption in India (Goel, 2016).

### IV. METHOD

The study is more of 'descriptive' nature thus it provides comprehensive picture of rooftop domestic solar electric power generation system of India. It describes the scenario of RTS with future scope of the technology. As the study is descriptive hence, it present its findings by answering of what, when, how and where the phenomenon works.

Thorough investigation of literatures on RTS technology and referring official websites of the government the study has gathered data on the concept draw its conclusion. The methodology is completely built in accordance to the research objectives thus can fill the gap observed in previous researches.

### V ANALYSIS

**Objective 1:** Analyzing the emergence of solar power generation system for domestic use of households in India.

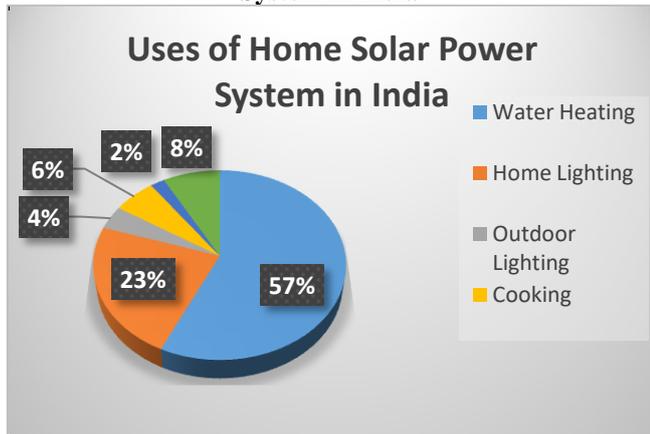
Solar thermal and photovoltaic has a very bright future and scope in India and its potential can be seen in power generation capacity which is about five thousand trillion KWh/year (MNRE Report, 2018). Solar power is a great source of renewable energy and can provide huge scalable production. But, despite a smart source of heating, cooling and power households are not much willing for adopting this technology. The portion of domestic RTS is still very negligible and needs to be grown. RTS system is most likely being adopted for water heating only and still struggling to occupy a place of a reliable source of electricity for home purposes. Hence, the country has a total installed capacity of less than 25 GW which is much lesser than other developed countries (MNRE Review, 2018). The below table 5.1 represents the potential of states (in terms of installed capacity) for solar power generation:

**Table 5.1- Statistics of Solar Power Generation Capacity (Region Wise)**

Capacity in Mega Watt					
Region	2015	2016	2017	2018	2019
Northern Region	1226.4	1898.21	3318.18	4297.97	6102.05
	-	54.78% Increase	74.80% Increase	29.53 % Increase	41.98% Increase
Western Region	1926.98	2378.88	2701.78	3511.40	6169.03
	-	23.47% Increase	13.57% Increase	29.97% Increase	75.68% Increase
Southern Region	54.97	95.98	237.35	284.25	648.09
	-	74.60% Increase	147.29% Increase	19.76% Increase	128% Increase
Eastern Region	5.03	5.27	17.78	18.26	37.94
	-	4.77% Increase	237.38% Increase	2.70% Increase	107.78% Increase

Source: Compiled from wiki database, [https://en.wikipedia.org/wiki/Solar\\_power\\_in\\_India](https://en.wikipedia.org/wiki/Solar_power_in_India) If we look into the home use of solar power system in India it is restricted to few purposes viz. water heating, recharging home appliances etc. But, for commercial purposes solar power system has come up as a very useful source of renewable energy which is being used for industrial heating, ventilation, boiling, warming room temperature etc. The below pie chart 5.2 shows the domestic use of solar power system by Indian households:

**Pie Chart 5.2- Domestic Use of Home Solar Power System in India**



The data reveals that Indian households doesn't make strategic use of solar power system as the majority of them use it only for 'water heating (57%)' purpose, but, it is much more than that. Solar water heater becomes a commonplace among Indian households and has replaced electric/gas geyser that's all what RTS could be done for Indian households. Home lightening (23%) is the second-highest purpose for which RTS is being installed. Growing rates of state electricity and large consumption have led high-income families to shift over RTS technology whereas middle and low-income groups still couldn't be shifted over it. Other uses of RTS contributes a very little to the use of solar electric power system which includes 'outdoor lighting (4%)' which is popular only among high income group families, 'solar cooking (6%)' very common and popular among families who can devote ample time for cooking, 'house heating (2%)' very common to high-income families living in North-East area and 'others (8%)' includes various purposes which doesn't fall in any of the discussed categories like- battery charging, water pumping, steamer etc.

**Objective 2: Challenges for RTS technology across Indian Households.**

Rooftop solar electric systems for domestic use always be debatable and questionable before Indian households. Limitations associated with RTS technology and socio-economic factors never let this technology be so adaptable and freely accessible. It is being harder and harder for a household or a layman to easily adapt and maintain this system at their home. On the other hand, a major part of the country where financially sound families live who can afford RTS installation cost has hardly experienced a shortage of electricity coming from the state electricity board. The left out places including villages, hills and faraway places families cannot afford its cost. Therefore, it becomes a challenge for the government and despite the government's subsidies on domestic RTS installation, households are reluctant for it. Some of the prominent challenges in the form of limitations of RTS to Indian households are encountered as below:

**Table 5.3- Challenges**

Challenges for Domestic RTS Technology in India	Authored
High installation cost	Patrick Howden (2019)
Required Large Area for Installation to Meet Minimum Domestic Requirement Which usually not available with Indian households	Amit Anand (2016)
Regular maintenance	The Hans India (2017)
Lack of consumer awareness	EAI Report
Energy reliability issue	Milton Kazmeyer (2018)
Slow production rate	Shahsavari&Akbari (2018)

Source: Author Preparation

Due to above discussed challenges Indian solar energy program or mission couldn't achieve its goals during previous years. Institutional irregularities and weak demographics have never supported the country's move towards solar dependency and made it harder for future moves. Quoting the example of Uttar Pradesh, Madhya Pradesh and Chhattisgarh problem of irregular supplies of electricity couldn't be solved and weak demographic profile of the families never support solar technology. With the help of government census data on capacity of solar energy production the study needs to remark that how much Indian states are behind from developed nation –

**Table 5.4- Data Showing Poor Production Capacity of States due to Challenges Ahead**

Region	Solar Energy Production Capacity till 31 March' 2019	Challenges
<b>Northern Region</b>		
Delhi	126.89 MW	• Lack of rooftop space availability with households
Chandigarh	34.71 MW	• High pollution causing low heat

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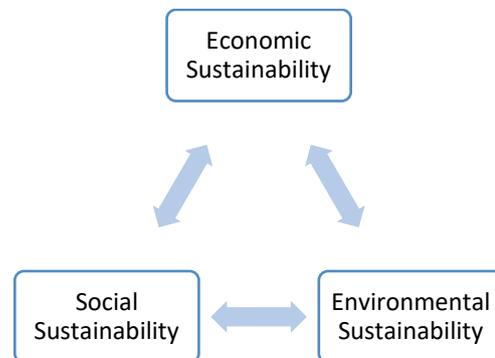
Himachal Pradesh	22.68 MW	<p>Intensity</p> <ul style="list-style-type: none"> <li>• Uneven sun intensity at various locations</li> <li>• Adequate supply of state electricity thus people are not in need of alternative source</li> <li>• Sun rays stay for very short time and that to with very low intensity</li> <li>• Topography is a biggest challenge</li> <li>• Low income of families</li> </ul>
<b>Southern Region</b>		
Kerala	138.59 MW	<ul style="list-style-type: none"> <li>• Environmental problem (windy, rainy, storm etc.)</li> <li>• Families are economically backward</li> <li>• Lack government focus</li> <li>• Lack of infrastructure</li> <li>• Poor economic condition</li> <li>• Not a government's priority</li> </ul>
Puducherry	3.14 MW	
<b>Western Region</b>		
Daman and Diu	14.47 MW	<ul style="list-style-type: none"> <li>• Low population density</li> </ul>
Dadra and Nagar Haveli	5.46 MW	<ul style="list-style-type: none"> <li>• Low per capita family income</li> <li>• Lack of government interest</li> </ul>
Goa	3.92 MW	<ul style="list-style-type: none"> <li>• Financial problems</li> </ul>

<b>Eastern Region</b>		
West Bengal	75.95 MW	<ul style="list-style-type: none"> <li>• Small houses having inadequate roof space</li> </ul>
Jharkhand	34.95 MW	
Sikkim	0.01 MW	<ul style="list-style-type: none"> <li>• State's topography is not supportive</li> <li>• Low government interest</li> <li>• Poor income</li> </ul>

Source: Author Preparation Using Census Data from enwikipedia

**Objective 3:** Analyze the 'sustainability and reliability' of solar power generation system in India.

**Issue of Sustainability:** Solar energy is a sustainable source by one way but converting it into electricity is not sustainable. Neither of constant supply nor manufacturing of instruments which convert solar heat into electricity. Here sustainability doesn't mean consistent supply only but also meet social as well as environmental sustainability. Helder (2015) cited three important aspects of 'renewable energy sustainability' in the figure 5.5-



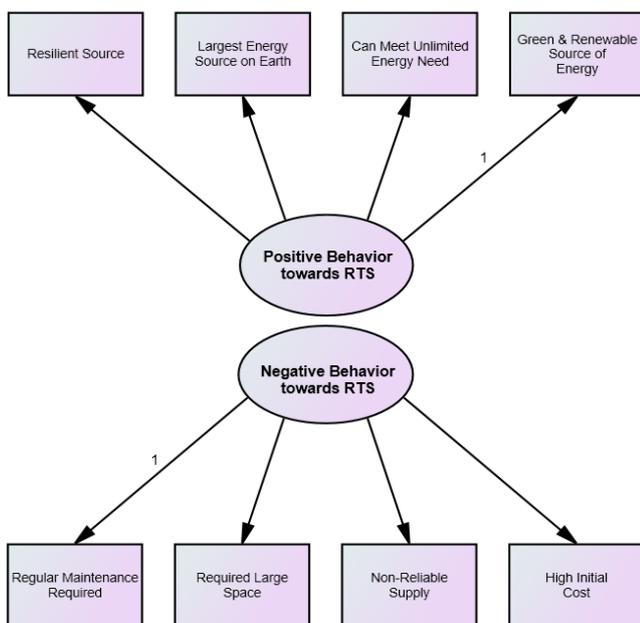
**Fig 5.5 Measures of Solar Energy Sustainability**

Economic sustainability of renewable energy sources is a debatable topic across the world as non-renewable energy sources are highly subsidies. Likewise India too gives heavy subsidy on coal and other fossil fuels in that way, initial cost of RTS seems to be high and lose its attractiveness. On the other hand, regular maintenance and replacing cost of equipment over a period of time raise questions on its economic sustainability. From all angles, domestic RTS for power generation in India is not so cost effective despite government concession or subsidy (Helder (2015), Abbasi (2010). Energy sustainability at social front has other area of concern wherein social cost is to be compared with energy generation cost. This is very diverse and complex equation, researchers believed that, manufacturing of RTS tools and equipment gives long lasting adverse social effect than its services in the form of energy.

It is not so much value given to the society and sustainability, thus solar energy production is questionable among developing countries (Helder (2015), Abbasi (2011). Environmental sustainability deals with environmental effect of energy production technique. Energy production from fossil fuels never have environmental sustainability as it damage environment badly. In case of renewable energy, manufacturing of devices or equipment must not consume energy greater than it would generate in its lifetime. On the other hand, it must not emit pollution or degrade the ecosystem (Helder (2015), Asumadu (2016d). *Issue of Reliability*: Envisaging uninterrupted and consistent supply of electricity from RTS is still a question across Indian households which hinder its growth across domestic consumer market. The energy production level depends upon ideal situation wherein full electrons in the form of semiconductors are charged to generate desired electric charge (Burt, 2015). And such situation varies place to place which affect adversely the energy production from RTS technique. As a result, every state or city has different ability to produce energy. Thus, RTS is not fully considered as a reliable source of energy across the nation.

**Objective 4.1.** Understand consumers' behavior towards RTS in India.

People's willingness to adopt and acceptance to use is important for successful execution of any technological discovery. Rooftop solar electric system is very innovative in nature but couldn't attract Indian households much as the cost involved in it made people reluctant to pay for and accept happily (Sommerfeld, Buys & Vine, 2017). Alsabbagh (2019) cited that there is a difference between consumers' behavior and attitude with respect to RTS technology. People have positive attitude towards RTS but it doesn't reflect in their behavior. The below fig 5.6 represents the dual aspect of consumers' behavior for RTS in India-



**Fig 5.6- Positive & Negative Behavior of Consumers' Towards RTS**

Source: Author Preparation

Consumers' behavior formed out of their experiences and conditions prevailing with them, RTS is a good option, educated people understand this concept and praise it too, but, practically it is not viable as they live in metro cities where rooftop space is scattered in small-small portion which cannot meet the desired energy requirements. Urban areas in developing countries are flooded with working people and follows multi apartment system wherein at small piece of land many families live (in flats). This is again not adequate for RTS system, on the other hand, rural or semi urban areas space is available but disposable income is not sufficient, hence, people have positive look for RTS but negative attitude to adopt it. So, in India adoption and diffusion of RTS technology will take time for its full extension.

**Objective 5:** Identify the Incentives and Subsidies attached with domestic RTS.

Domestic rooftop solar power system is a best alternative source of electricity and government is putting lots of efforts for its promotion among Indian households. Despite abundance and great source of renewable & pure energy RTS technology is losing its shine across Indian consumers due to high upfront installation cost. The fact is unavoidable, hence, government found alternative way to minimize its initial cost by the way of providing various types of incentives and subsidies. Consumers who wish to install RTS may avail these incentives and subsidies if they fall into said categories. The most favorable and workable incentives and subsidies are pointing out below in table 5.7-

**Table 5.7- Government Incentives and Subsidies on Home RTS**

Government Incentives and Subsidies for Domestic RTS Installation in India	
1.	Households can avail subsidy of 30% on equipment and installation cost of domestic RTS for home use.
2.	In case wherein consumer want to fix RTS may avail loan up to Rs. 10 lakhs as home loan from any nationalized bank.
3.	Government has put this into priority sector hence consumers would have smooth and fast processing of loan for RTS installation.
4.	As incentives government has announced monetary benefit of Rs. 2 per unit generated from RTS for domestic use.
5.	Consumers who produce excess units can sell them to state electricity Board and earn from it.

Source: Compiled by accessing data from 'www.pmjandhanyojana.co.in'

**VI CONSLUSION**

Shifting over the smart, renewable and green energy sources is a wise decision by human beings to ensure healthy future on earth. Developed economies started shifting on it long back but in developing economies it couldn't prove its feasibility. Taking India as an example, the study found solar power generation technology is quite happily acceptable and working to have full-scale expansion in the near future.



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But, while talking to the domestic use of solar power energy, it is quite questionable due to its technical limitations. Despite huge promotion and attractive schemes for promoting domestic RTS, Indian households couldn't show their willingness. Still, the contribution of domestic solar energy production is negligible in total rooftop solar production in the country. There is an optimistic trend of RTS in developing countries including India, in fact, India ranks third in solar energy production in the world. It seems to be a progressive future of this technology in India as the government has a positive approach and many high targets. Talking on its sustainability and reliability, there are questions, but it is being modernized with collaborative efforts of countries at the global front. Soon, the size of the panel would shrink with increased production capacity from low intensity of sunlight and would meet the entire needs of every household which would increase the level of acceptance of common families in developing economies. Concluding on consumers' behavior front, India has a mixed approach, wherein, financially sound families with adequate rooftop space look at it with positive sense and respond favorably, whereas, for the financially weaker section the behavior is just opposite. The size of the rooftop doesn't fit between demand and supply of energy to meet the daily energy need of the families. Apart from this, the government of India is putting continuous efforts for its promotion and offering various incentives along with a high subsidy on domestic installation.

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