



Trading in Solar Renewable Energy Certificates by the Households: An Underutilized Potential in India

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Abstract:

Renewable energy is a growing market all over the world. Solar RE is the only source of RE that may be generated at micro economic level by the households. Renewable Energy Certificates (RECs) are the market instrument that permits the exchange of power as a commodity between the institutional stakeholders in the energy market. India is blessed with the enormous opportunity to harness the energy of sun for power generation; still its power market is inefficient due to many reasons. Households may have the key to remove these inefficiencies by increasing the consumption of solar energy and trading in RECs with excess energy units. Unfortunately, households' role in the energy market is largely ignored in power exchanges where the dealings are restricted only to the institutional players. This paper explores the possible savings by including households in solar RE generation, and suggests theoretical frameworks, infrastructures, and market for optimum functioning of the solar RE market.

Keywords: Solar Energy, Renewable Energy Certificates, Households, Power Exchanges

1. Introduction

A promising alternative energy source to non-renewable energy sources for decades, the solar energy is the radiant light and heat from the sun harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, solar thermal energy, solar architecture, and artificial photosynthesis, all harnessing the power of sunlight to create electricity, and by far is most the cleanest sources of energy available on this planet. The traditionally used non-renewable resources of energy take centuries, even millions of years to form naturally, are finite and cease to exist in foreseeable future. Pollution, depletion of natural resources and ecological imbalances are the primary reasons calling for use of renewable energy. Reports have shown that pollution is a major environmental issue in India (Irfan, 2017). Millions of people in India are breathing the air that is many more times over the safe limit given by the WHO resulting in the maximum premature deaths in the country (The Lancet, 2017) with 6 out of 10 most polluted cities in the world are from India (Whiting, 2014). A major cause for this is thermal power plants, most of them inefficient and highly polluting, for production of electricity. Sixty percent of India's electricity generation is still through burning coal, others being Diesel, Gas, Hydro, Nuclear, and Renewables.

Though the efforts are there to expand the solar and other renewable energy sources, the renewables don't hold much share in the overall energy production. There is huge potential in this sector to not only bring the clean air, reducing the emissions of greenhouse gases, reducing the burden of health cost, reducing ecological imbalances, triggering sustainable development, but also to reduce the dependency on the fast-depleting non-renewable sources of energy. This is the main driving force behind all green energy technology, as nations attempt to meet climate change obligations in curbing emissions. Solar energy doesn't rely on constantly extracting, refining, and transporting of expensive raw materials, thus saves a whole lot of additional costs of procuring, transportation, pollution and wear

and tear of infrastructure. Besides, among all other renewable sources of energy, solar energy is the only one, which individual households can generate and contribute for a greener environment. India being a sunny country has a geographical advantage to opt for solar energy. However, the scope of this source of energy at micro level is still not fully utilized. Keeping in mind the need, benefits, and potential of solar energy, particularly from the individual households' point of view, this study investigates the present market for Solar Renewable Energy Certificates (REC), and the scope for its expansion.

2. Current scenario in India for solar energy market

The National Action Plan on Climate Change (NAPCC) in combination with the policies framed under the Electricity Act, 2003 provides a roadmap for increasing the proportion of the renewable energy in total energy generation. Renewable Purchase Obligations (RPO) are the amount of renewable energy purchase specified by the Central or State Electricity Regulatory Commission (CERC/SERC) for the Distribution Licensees (power distribution companies or DISCOMs), Open Access Consumer procuring power from power exchanges (IEX/PXIL), traders or bilateral agreements, and Captive consumers generating and consuming power from captive coal/natural gas power plants (primarily industrial users in cement, steel, chemical sectors). The Regulatory Commission in each state mandates a certain percentage of electricity to be generated from the renewable sources but due to the high cost and uneven spread of potential of different states in RE generation discourage the local distribution companies (Discoms) to purchase renewable energy beyond the mandated amount.

Renewable Energy Certificates (Solar RECs) are the market-based instruments that certifies the bearer owns one megawatt-hour (MWh) of electricity generated from a renewable energy source. The REC received can then be sold on the open market as an energy commodity once the power provider has fed the energy into the grid. Also known as green energy certificates or tradable energy certificates, these certificates are the proof that energy has been generated from renewable sources (Kelly, 2015). Solar RECs help to promote renewable energy, facilitate compliance of Renewable Purchase Obligations (RPO) by balancing the mismatch between the available RE sources and required RPOs, encourage RE capacity building by creating a national market for such RECs, and recovering cost of RE generators. Generating companies engaged in generation of electricity from renewable energy sources are eligible for participation under REC scheme subject to fulfillment of specified conditions. The Central Agency usually issues the Renewable Energy Certificates to the Eligible Entity within 30 days from the date of receipt of application form along with complete information necessary for processing of application for issuance of RECs.

Seemingly effective, certain inefficiencies in energy market diminish the impact of the policy on RE. The rationale behind electricity generation through renewable sources is to promote the usage of green energy and substitute non-renewable energy with green energy. It covers entities (distribution companies and generating companies) which generate electricity or distribute electricity but does not consider the scope of the individual households who also reserve the capacity to generate green energy but don't have sufficient knowledge and are not motivated enough to shift their consumption pattern. As a result, the market created for trading Solar RECs only covers the institutional entities with the responsibility and liability to generate green energy through renewable sources falling back on these entities. The procedure to issue Solar RECs is also complicated, and time and money consuming, further demotivating the participants to procure these certificates. This further pushes these corporates to find loopholes in the policy of RPO and avoid the obligation. Though the number Solar RECs generated is high, the dealing in Solar RECs market is restricted due to the small number of participants. The market also is inefficient. Any market is said to be efficient when the instrument traded is easily bought or sold but under the current system of regulations, the Solar RECs are not freely traded. The certificates are not instantly bought and sold. The prices determination of such securities is also complicated. The procedure has made the market dormant and not an option for an

organization to invest into voluntarily. The players involved are again large institutions at center and state levels. Have there been more participants and efficiencies in the market for RECs, the RE participation in overall energy generation would have been increased.

The technical complexities and restrictions listed above of the solar energy market restrict a very important component of the market, i.e., the households from entering and participating in the market. In face of the global climate changes, the need is to involve all the components of the global economy - independent households, power generating companies, distribution companies, organizations, societies and cooperatives, governments - to contribute to a sustainable environment by employing solar technology. No economy can halt its economic development in today's competitive business environment, but it can work towards creating an environment where damage is minimized. In addition, households or groups of households resist to change their electricity consumption trend due to lack of knowledge with respect to initiatives launched by the government which forces them to believe that alternative sources of energy are non-affordable. As the basic unit of any economy and nation, if the individuals' participation is encouraged and ensured, it can change the whole dynamics of tackling the power crisis and global efforts on climate changes. As soon as households get involved, government will also get higher savings by removing subsidies on electricity generated by conventional sources and making households self-reliant in generating electricity. Also, schemes of government to electrify rural households can be sustained in the long run by installing solar panels especially in the remote regions. The benefit of renewable energy seeps down to the environment where less pollution is caused, and lesser carbon is emitted. This reduces the pressure on non-renewable sources of energy, improves health of people, and helps in restoring the ecological balance. At the manufacturing level, the savings and profits of manufacturing sector will rise with increase in the demand for solar energy, leading to higher national income, which in turn will catalyze the economic growth and accelerate the development through a greener means.

As there is no participation from households in RECs market, there is a gap in the existing energy structure, which this research intends to fill via a conceptual framework for Household Participation in RECs Market and Green Power Exchange.

3. Research objectives

This research aims to present (1) a conceptual model of comparative costs and savings to an average household by installing a solar panel for its energy needs. (2) It also aims to briefly investigate the problems faced by the solar panel manufacturers. (3) It proposes a framework for increased participation of the individual households for the solar energy market in India via RECs, (4) to suggest a framework for Green Power Exchange to facilitate trading in RECs by households, (5) lastly, it aims to suggest some practical solutions to promote RE market in India.

4. Research methodology

The study has been planned as a mixed method theoretical research. The primary data for analysis of the problems in the target market was collected through an interview-based survey of 50 households in Delhi (for understanding the households' perspective in general and gauge the consumption requirements of an average 2 BHK household) and an interview of a solar panel manufacturer (to understand the working of the solar panels, the manufacturer's perspective, and the current situation persisting in the solar energy market). The primary data collected has been utilized to analyze the comparative cost of consuming energy from non-renewable sources and energy generated through solar panels, and also to gauge the problems encountered by manufacturers of solar panels. The secondary data sources have been studied to draw statistics on the solar RECs from different online portals. Conclusions are drawn from the analysis of the data and information to suggest the required frameworks.

5. Analysis and Results

On the basis of the interviews from the household and manufacturer and a review of online cost structures for solar panel installation, a comparative cost sheet is prepared to check the amount of savings to a household keeping a steady consumption of 6 kw per month if they opt for solar panel installation. Table 1 presents the comparative costs and savings to a household by opting for solar energy instead of electricity distributed through electricity companies.

Table 1: Comparative cost sheet for household

PARTICULARS	TIME	PVF @ 10%	NORMAL CONSUMPTION OF ELECTRICITY (Rs.)	SOLAR ENERGY CONSUMPTION (Rs.)
CASH OUTFLOWS:				
INITIAL COST	0	1	12000 = (12,000)	250,000 X 1 = (2,50,000)
ELECTRICITY BILL	1- 20 YEARS	8.51	120000 * 8.514 = (10,21,680)	
DEPRECIATION	1- 20 YEARS	8.51		12,500 * 8.514 = (1,06,425)
REPAIRS AND MAINTENANCE	5	0.621		80,000 * 0.621 = (49,680)
	10	0.386		80,000 * 0.386 = (30,880)
	15	0.239		80,000 * 0.239 = (19,120)
TOTAL OUTFLOWS			(10,33,680)	(4,56,105)
TOTAL SAVINGS			5,77,575	

*Compiled by author

Basic Assumptions of the calculations:

- For a building with 2BHK Apartments, middle income category
- Electricity required: 6kW
- Initial establishment cost: Rs.12,000
- Electricity bill /year: Rs.1,20,000 (Rs. 10,000 p.m. * 12 m)
- Solar Panel Initial Establishment Cost: Rs. 2,50,000
- Life: 20 years\ Depreciation – Rs. 250,000/20 = Rs. 12,500 cost every year
- Depreciation based on straight-line method.
- Battery replaced after every 5 years.
- Repair and Maintenance after every 5 years: Rs. 80,000
- The rate of return or marginal rate at 10% for the purpose of calculation

Table 1 shows that a household can generate an approximate saving of Rs. 5,77,575 assuming the above framework of suppositions. The savings can increase if any excess power generation is exchanged by the household with the grid companies. The calculations are tentative but the objective here is not to produce exact amount of savings but to justify the monetary economies of solar RE. Table 2 presents the estimates of the monetary savings if only 10% of the households used the energy generated through the solar panels.

Tables 2: Approximate Savings by % installation of Solar panel by households in select states

States	Number of household Units (2011) *	Savings by Solar Panel Installation by 10% households (Rs.)
Rajasthan	12,711,406	7,341,790,320,450
Tamilnadu	18,493,003	10,681,096,207,725
Gujrat	12,248,482	7,074,416,991,150
Punjab	1,812,188	1,046,674,484,100
Madhya Pradesh	15,095,256	8,718,642,484,200
India	246,740,228,000	142,510,987,187,100,000

*Compiled by author.....

Table 2 shows that state-wise if only 10 percent of the households are installing solar panels at their roof tops for their energy needs, it yields to crores of monetary savings in energy consumption only. Only those states are selected for calculation, which have the geographical advantage for solar energy generation, i.e. the western region. However, depending on the potential for solar RE generation, more cities or states can reap these savings. Last segment of the table shows the calculations for the country and one can see the voluminous monetary savings. Moreover, these are only monetary savings; the economic, social, environmental, and ecological benefits make it far more advantageous proposition. In the next step, the responses of the households and manufacturer are analyzed, producing the following points of observations:

- Households are aware about the solar energy panels as an alternative to their energy supplies through cables
- Households are not fully aware about the potential of the solar energy in monetary, economic, environmental and ecological savings
- Households are deterred by the high installation cost in adaptation to solar RE.
- Manufacturers are optimistic about the expansion of the Solar RE market
- Manufacturers import solar cells from China, Taiwan and Korea due to the cost savings but will prefer country made cells if available at reasonable cost
- Manufacturers will appreciate if government take promotional steps to increase the awareness about and use of the solar RE in people to increase the demand for solar panels

The study of the current solar market through secondary sources of data and the study of perceptions of households with respect to solar energy and the current status of manufacturers of solar panels reciprocates inefficiency and lack of participation in solar RE market. It also highlights the huge potential of the households as a stakeholder in the solar RECs market. At present, there are two power exchanges in India offering trading in Renewable Energy Certificates: Indian Energy Exchange (IEX) and Power Exchange of India Ltd (PXIL) since 2008, both functioning for institutional stakeholders, including state-owned private utilities, generating companies and consultants with no provisions for individual households as a party, leaving their potential totally unutilized.

6. Discussion

It became apparent from the secondary data analysis that there is a gap in the RECs actual requirements and generation. Renewable energy sources are not evenly spread across different parts of the country. There are western belt states like Rajasthan and Gujarat having huge potential for RE sources and states

like Delhi in which the potential is not that great. Due to huge costs of generators, the institutional players are skeptical and do not go beyond the mandated Renewable Purchase Obligations, even if the potential is higher. The RECs can solve the issue but at present the market is not participated by the households who can be the great players in installing the efficiency in the market in addition to saving their money on energy consumption.

Thus, as an alternative solution this study suggests that the smaller participants such as households, who are the end consumers and key demand generators of electricity, should be involved in RE and RECs market. Applying it will require a four stage strategy: (1) promoting the solar energy usage by individual households, (2) establishing infrastructure for sale of electricity by households, (3) creation of a flexible market for solar RECs where households can trade, and (4) creating awareness.

6.1 Promoting the solar energy usage by individual households

The households will accommodate a change in their consumption trend only when it accrues a greater benefit to them. Not only that this will create the savings for them, it will also tap the under-explored potential of this segment as a game changer and an important stakeholder. As soon as households install solar panels to generate electricity, the monetary savings will start accruing to them in three forms:

- 1.Savings from Electricity Bill: The households will no longer procure electricity and instead produce the electricity themselves through solar panels. Thus, the money which was paid earlier as electricity bill will accumulate as savings.
- 2.Savings generated through sale of excess electricity: The households can choose to install a solar panel that generates electricity in excess of their respective requirement which can be sold to the grid.
- 3.Savings from exchange of Solar RECs: Households will be awarded Solar RECs which can be traded in the market on the basis of generation of electricity through solar panels.

6.2 Establishing infrastructure

The infrastructure required for the suggested solution might function in the following three phases:

6.2.1 Phase I: Installation of Solar Panel and Determination of Electricity Requirement

At this stage, households will install solar panels in accordance with their requirements. Households can choose to install solar panels individually or in groups depending on the geographical conditions. In case a household has a separate rooftop and can finance itself, it can choose to install it independently and if the building constitutes multiple apartments, the owners can choose to put up a panel with greater capacity to accommodate needs of all and finance it collectively. Here, it is crucial for households to understand their individual needs and install a solar panel of the required capacity. Households can also choose to install a solar panel of additional/excess capacity to produce electricity which can further be sold.

6.2.2 Phase II: Grid Connection

In order to sell any excess electricity generated from solar panels, the entire solar power system has to be connected to a grid. An electrical grid is an interconnected network for delivering electricity from suppliers to consumers. It consists of generating stations that produce electrical power, high-voltage transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers. With a grid-connected system, when a renewable energy system generates more electricity than required, the electricity goes onto the electric grid for your utility to use elsewhere. The metering arrangements are:

- a.Net purchase and sale: Two unidirectional meters are installed as part of this configuration; one tracks electricity drawn from the grid and the other tracks electricity generated in excess and fed back into the grid. The entity pays retail rates for the electricity consumed, and the utility company buys the

surplus production at its avoided cost (wholesale rate). However, the retail rate paid and the avoided cost of the electricity provider may vary significantly.

- b. Net metering: Net metering provides the greatest benefit to a consumer. The electricity an entity uses from the grid and the extra electricity its system feeds back into the grid are both tracked by a single, bi-directional meter in this setup. As the entity uses the electricity, the meter rotates forward; as the extra is fed into the grid, it spins backward. The entity must pay retail pricing for any excess electricity if, at the end of the month, it used more electricity than its system generated. The power company often reimburses for any excess electricity produced beyond what is consumed at the avoided cost. The real benefit of net metering is that the power provider essentially pays you retail price for the electricity you feed back into the grid.

6.2.3 Phase III: Register with the Renewable Energy Certificate Registry of India

In this phase, the households will be required to get their systems attested and registered with Renewable Energy Certificate Registry of India following their procedures and fulfilling the requirements. This will enable these units to operate in power exchanges.

6.3 Creating a flexible market for solar RECs through Green Power Exchange

The present system does not allow individuals to trade freely in the power market or the present power exchanges. The study proposed to create a Green Power Exchange where individual household can trade their RECs using market mechanism. Ministry of New and Renewable Energy (MNRE) can choose to establish and maintain a green exchange where Solar RECs can be freely traded between suppliers of Solar RECs or generators of green energy (solar energy) and industries which have to comply with the restrictions on the amount of non-renewable electricity consumption or restrictions on carbon emissions.

The green power exchange may work on the same dimensions as that of a regular stock exchange. The peculiar fact about this market is that the consumers will generate the Solar RECs based on the generation of electricity by solar panels unlike the stock market where consumers pay to receive stocks in Initial Public Offerings. Here consumers will not purchase and sell Solar RECs to fund the capital needs of a corporate but instead to fulfill the mandatory compliances regulated by the government. The money in this case earned by the first offering of a Solar REC will rest with the owner of that REC. The green power exchange will have different participants such as households, institutional investors, companies, Discoms, cooperatives etc., who want to deal in Solar RECs. The green power exchange will function online. All dealings and settlements may take place online. Solar RECs will serve as a substitute to other securities such as shares, bonds, fixed deposits etc. Green Power Exchange will save time and money of the participants by creating hassle free processes which can be accessed online from anywhere in the world.

The prices of Solar RECs will be fixed by the forces of demand and supply of such certificates. The demand will be influenced by companies which have to comply with the state's regulations with respect to energy consumption and carbon emissions. The Central Government or State Government can fix an upper limit of emissions that can be generated by industries and any excess shall lead to heavy penalties. Similarly, government can fix the percentage of electricity consumption which has to be necessarily met from renewable energy sources. In such cases, Solar RECs can help such companies to decrease their burden and comply with the regulations. On the other hand, supply will be controlled by generating, companies, distribution companies and households which generate electricity through solar panels and accordingly earn Solar RECs.

The green power exchange will function just like a stock exchange in terms of process of trading but the procedure will entail certain specific regulations and restrictions. Accreditation and registration with the concerned authority: A person who wants to trade on the green power exchange will be required to

get accredited and registered with the Renewable Energy Certificate Registry of India. This process is important to ensure that the Solar REC is credited to a certified person who is dealing in the exchange. It is somewhat similar to the clause of the stock market where companies have to get listed on a particular stock exchange to enable trading of their securities. The process of filling application will be present online. The details with respect to size of the solar plant, the type of solar plant, the energy requirement of household and capacity of the plant to generate electricity will be included there. Post filling of an online application, the MNRE will send an investigation team to check the systems thus installed at the place in question. Here, MNRE can set up a committee/department to look after certification of solar power plants which are capable of generating Solar RECs which can be traded. The process currently installed requires a issuance process which is lengthy and cumbersome. To reduce such complexities, MNRE can choose to certify systems instead of going through the entire procedure every time to issue Solar RECs. Here, the important component of certification will be the meter which will measure the amount of electricity generated by the solar power system. There can be a regular inspection authorized by MNRE to ensure that the concerned person does not alter the system to measure more units than required or any such action which leads to incorrect readings on the meter.

The Renewable Energy Certificate Registry of India will issue a Solar REC based on the readings of the meter. The Renewable Energy Certificate Registry of India will set a standard for issuance of one Solar REC. Currently one Solar Rec is equivalent to 1 MWh (one megawatt hour = 1000 Kilowatt hour). The meter will be connected to the account of the person dealing on the green power exchange. As soon as this standard is met, one Solar REC will be automatically credited to the balance of Solar RECs of such holder. This will reduce transaction cost and will ensure smooth and efficient functioning of the market. However, one more point has to be taken care of. The Solar REC will be issued to the person who generates electricity through solar panels and not the one which further uses or distributes this electricity. This means that when a household generates electricity for consumption as well as selling purposes, the Solar RECs will be credited to the account of such household and not the account of the distribution company which purchases electricity from such household.

Each participant on the green power exchange will be required to maintain an online account with the green power exchange which will facilitate trading. The account will feature the current prices of Solar RECs being traded on the exchange, the amount of Solar RECs standing to the credit of the person in question and the option to place a bid for purchase or sale of Solar REC. The prices of Solar RECs will be determined by the market forces of demand and supply. The participants will trade the requisite number of Solar RECs based on the current price prevailing in the market and the bid placed by them the participant will also register the bank account from where the payment made for purchase will be deducted and payment received for sale will be added. The settlement of Solar RECs between two parties will take place only when it has been verified that the person selling such Solar RECs has sufficient balance of certificates and the person purchasing such RECs has sufficient balance of money in the bank account to make payment.

6.4 Creating Awareness

The Indian citizens do not participate in the solar energy market due to lack of awareness with respect to use and benefits of solar panels. The Indian education system imparts knowledge about renewable sources of energy but fails to address the problem of bringing such technologies to use. The information with respect to the functioning of the solar energy market should be included in textbooks at the secondary schooling level. Apart from that, marketing campaigns endorsed by eminent personalities can help popularize the scheme. Similarly, solar energy market has to be marketed. The government provides many incentives and tax exemptions in the non-conventional energy sector but because households and small business units are not aware of these schemes, most of the households do not employ solar energy. Promoting different funding options for solar panel installation such as loan or lease and tax/subsidy incentives on these options may also increase the participation. Intensive

advertising and education campaigns can help increase awareness. New helplines can be commenced to address queries of people and help avoid any primary misconceptions with respect to solar energy generation. More rebates and incentives may be offered on financing of solar panel installations. Keeping in view the significance of RE sector, various incentive schemes have been facilitated by both Central and State Governments under wind energy, solar energy and other renewable energy projects. Creating more awareness about these schemes may unlock this hidden potential.

7. Conclusion

Renewal energy sector is one of the fastest growing sectors in India. There are huge savings in consuming energy generated through solar panels in comparison to the electricity generated through coal or natural gas. The households need greater awareness of modes of generating such savings through employment of solar energy and a market which can help them equate Solar RECs with other securities such as shares, fixed deposits, bonds etc. Government has taken various initiatives and awarded various exemptions in order to promote energy consumption through solar mode, but the implementation and penetration of such policies has been problematic due to non-participation of households. This research paper suggests a four-stage strategy to fully utilize the potential of the under-recognized segment, i.e. the households. The suggestions include promoting the solar energy usage by individual households, establishing infrastructure for sale of electricity by households, creation of a flexible market for solar RECs where households can trade, and creating more awareness about solar RE. The study discusses and suggests in detail the frameworks, infrastructures, and markets to tap the Indian households as an important stakeholder and participant in renewable energy sector and RECs with the hope that this may serve as a sustainable strategy for sustainable development in future.

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