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Role of Co-operatives in Promoting Solar Power Projects in India

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Solar energy is the genesis for all forms of energy in the world. It is the only perennial source in India, as the country is located in the tropical zone of the earth. This study proposes to assess the commercial viability and the carbon abatement of a solar power project so as to ensure energy sustainability. It is confined to the solar photovoltaic (PV) project as the generated power can be converted into monetary values. The commercial viability has been measured using the benchmark rate of Ministry of New and Renewable Energy, Tamil Nadu Electricity Regulatory Commission and Tamil Nadu Generation and Distribution Corporation. It is witnessed from this study that solar power is highly viable for both domestic and non-domestic promoters. The outcome reveals that the 1 MW solar PV project for Tamil Nadu is highly viable for industrial and commercial promoters owing to drop in initial investment and increase in power generation. Moreover, solar would be a great mitigating factor for carbon footprints. For instance, the 1 MW project is expected to abate an average of 1,283 and 32,087 tonnes of CO_2 annually and its lifetime respectively. Therefore, the contribution of co-operatives is immense in advocating this perpetual source of energy to curb carbon emissions. Consequently, energy co-operatives should be promoted in India as in other industrialised countries.

Introduction

India is the third largest electricity producer in the world, yet power shortages remain a key impediment owing to continuous surges in population and industries. There are 237 million people without access to electricity, of which the rural population accounts for 221 million (International Energy Agency, 2015). The total deployed power capacity in India is 2,84,303 megawatt (MW), of which thermal contributes nearly 70 per cent (Tamilnadu Energy Development Agency, 2012). The major sources of fuel for thermal are coal, gas and oil. Moreover, the country relies on coal (53%) for its power generation and it is anticipated that the coal deposits will not last beyond 2040-2050. In order to ensure inclusive energy, various alternative energy sources need to be endorsed; however the available energies are either seasonal or place-bound. Solar is the only perennial energy source in India, as it is located in the tropical zone of the earth and receives 4-7 kilowatt hour (kWh) of solar radiation per sq.m per day (Sasikumar & Jayasubramaniam, 2013).

The Solar Photovoltaic (PV) system may either be on-grid or off-grid. On-grid projects are directly connected to the grid and function without batteries, thus they cannot function during power outages. However, it is best suited for massive power generation. Off-grid projects function with battery backup, thus offering power during power blackouts. The preferred capacity of Solar Power Project (SPP) varies according to the power requirement of the users. Generally, a 1 kilowatt (KW) project generates one unit of electricity per hour. Likewise, a 1 MW project is able to generate 1,000 units of electricity per hour.

Solar is a panacea to mitigate carbon emission. The reduction in carbon emissions depends on how much conventional heat or power is displaced, that is the substitution of carbon rich fuels by renewables such as solar, and the carbon intensity of the fuel displaced. In addition, the amount and type of energy that is used in manufacturing, installing and functioning of a solar energy system needs to be considered (Nelson et al., 2014). Based on the composite electricity factor of the International Energy Agency (IEA), it is apparent that there could be massive carbon abatement from solar, for instance, a 1 KW project reduces over 1 tonnes of Carbon Dioxide (CO_2) emission per year (Brander et al., 2011).

The carbon emission of emerging countries has surpassed industrialised countries and keeps rising alarmingly. The total carbon emission in India from fuel combustion was 1,868.6

million tonnes in 2013, of which electricity and heat generation accounted for over half of the emission (944.6 million tonnes). And the per capita CO_2 emission in India was 1.49 tonnes (IEA, 2015), it is imperative to reduce CO_2 emissions in the country by the way of energy substitution, enhanced use of clean energy, and improving the thermal efficiency of power generation (Central Electricity Authority, 2014). The emission mitigation policies must focus on the electricity and transport sector to curtail a sizeable portion of the nation's greenhouse gas emissions (Arif, 2013). Co-operatives, with 1 billion members across the globe, can spearhead communitities to curb carbon emissions (Sustainability Solution Group, 2014). This would best serve the electricity needs of local consumers since it is decentralised and community-led, which can also extend the national grid at a faster rate than utilities (Yadoo & Cruickshank, 2010).

This paper consists of five sections; section two overviews the various initiatives of solar power policies of Central and State governments. Section three portrays the methods, which includes a literature review and empirical evidence. The results and discussions and, conclusion and practical implications are elaborated in sections four and five respectively.

Indian Solar Power Policy Initiatives

The National Action Plan on Climate Change (NAPCC) outlined eight missions to address issues related to climate change in 2008. The National Solar Mission (NSM) is one among the eight initiatives, which aims to make solar power competitive with fossil fuel-based power (Pandve, 2009). Thus, the central and state governments came up with their own solar power policies, namely Jawaharlal Nehru National Solar Mission (JNNSM) and Tamil Nadu Solar Energy Policy respectively. The JNNSM has set an ambitious target of deploying 100 gigawatt (GW) by 2022 (Solar Energy Corporation of India Ltd., n.d.). The total investment for setting up of 100 GW will be around Rs. 6,000 billion. And this would abate over 170 million tonnes of CO_2 during its life cycle (Press Information Bureau, 2015). Furthermore, the Tamil Nadu Solar Energy Policy intended to achieve 3 GW of solar power by 2015 (TEDA, 2012).

The solar power promoters are the ones who deploy SPP at their premises, which include domestic, institutional, industrial and commercial promoters. The central as well as the state governments offer various perks to promote the deployment of solar power in the country and the state respectively. The central government offers 30 per cent of capital as Central Financial Assistance (CFA) to household and institutional promoters who belong to ordinary category states and union territories. However, the promoters from special category states are entitled to 70 per cent of capital as CFA. Moreover, CFA is applicable to projects up to a maximum capacity of 500 KW (Ministry of New and Renewable Energy, 2015). The central government grants both direct and indirect tax benefits to solar power projects. In case of direct tax benefit, the project developers are entitled to 10 years of tax holiday for the proceeds of selling the generated solar power. Indirect tax benefit consists of tax exemption from excise duty, custom duty and central sales tax. It also offers an accelerated depreciation benefit to the industrial and commercial promoters to write off 80 per cent of the project cost in the first year itself and the remaining in the subsequent year, as there is no subsidy benefit to them. The domestic promoters who borrow money for the deployment of SPP are eligible to claim such amount as part of a home loan or home improvement loan. Therefore, they are entitled to add up that amount while claiming interest and principal deduction of housing loan subjected to a maximum of Rs. 2 lakhs and Rs. 1.5 lakhs respectively. The Feed in Tariff (FiT) is a standard rate fixed by the Central Electricity Regulatory Commission (CERC) for encouraging the developers to take part in the deployment of clean energy projects. It facilitates the developers to obtain a reasonable return for their investments by entering into a long term Power Purchase Agreement (PPA) with the power Distribution Companies (Discoms). A reverse bidding process had been adopted in the phase I of JNNSM, which ensures lowest FiT for the chosen projects (Rohankar et al., 2016).

The Tamil Nadu government offers a flat subsidy of Rs. 20,000 to grid-tied domestic projects, which are selected under Chief Ministers's Solar Rooftop Capital Incentive Scheme. Net meter is a bi-directional meter, which takes into account both power imported from the grid and exported to the grid. The unconsumed solar power can be banked with the state utility using net-metering. The banked solar power must be consumed within 12 months. Thus, the promoter has to pay only for the net energy imported from the grid. The developers who have signed the PPA with the state utility can offer the generated solar power at a preferential tariff fixed by Tamil Nadu Electricity Regulatory Commission (TNERC). The latest rate for the projects commissioned after 1 April 2016 is Rs. 5.10 per unit (PV Magazine, 2016). In addition, the solar power generators do not want to pay wheeling and transmission charges for selling power within Tamil Nadu. It is apparent that both Central and State governments offer various eye-catching perks to endorse the deployment of solar power projects. However, there are no exclusive perks for co-operatives to initiate SPP deployment.

Literature Review

Solar energy is the genesis for all forms of energy in the earth. The energy received from the sun is a thousand fold superior than the present consumption rate of all commercial energy sources (Nayak, 2012). The key factors which trigger customers to opt for solar energy are dearth and high cost of electricity (Chinnammai, 2013). Solar power structures are easily accessible for manufacturing and household applications with an added advantage of less maintenance. Government tax incentives and rebates are essential to guarantee the financial viability of solar power. An economical cost base will be at the core of flourishing solar ventures in India (Srivastava & Srivastava, 2013).

The Photovoltaic (PV) Levelised Cost of Electricity (LCOE) continues to decrease, grid electricity prices go on to soar, and manufacturing experience progresses, thus PV can gradually turn into an economically precious source of power (Yaqub et al., 2012). However, there is a lack of awareness of the present cost of solar power among many commentators, policy makers, energy users and even utilities due to drastic fall in module price, the prevalence of outdated information, and ambiguity surrounding many of the metrics and concepts (Bazilian et al., 2013). Finally, it is projected that solar power prices could be up to 10 per cent lower than coal power prices by 2020. Moreover, solar has already achieved grid parity with imported coal; however, it is expected to achieve grid parity with domestic coal by 2020 (Klynveld Peat Marwick Goerdeler, 2015).

Energy co-operatives are contributing to the accomplishment of sustainable energy. They play an imperative role in the energy shift of Germany, for example where energy co-operatives can be differentiated based on their primary activities such as production, distribution, trading and other co-operatives that do not fit into the three main categories (Yildiz et al., 2015). In USA, the customer-owned utilities procure electricity on a wholesale basis and deliver it directly to the consumer, which account for 12 per cent of the electricity consumers (Wanyama, 2014, p. 10).

India has also witnessed the significant role of co-operatives in the accomplishment of energy sustainability. The Solar Pump Irrigators' Cooperative Enterprise (SPICE) was established in 2016 at Dhundi, a village in the Anand district of Gujarat, where there is no access to the agricultural grid. Thus, the farmers were using expensive and eco-destructive diesel pumps to irrigate their crops. The six vegetable farmers of this co-operative decided to switch over to solar water pumps for irrigation. They installed an SPP with an aggregate capacity of 56.4 KW in their fields with the help of the International Water Management Institute (IWMI) by contributing a partial amount. This project can generate almost 85,000 units of electricity per year. The farmers have signed a 25-year PPA with Madhya Gujarat Vij Company Limited (MGVCL) to sell the surplus power at Rs. 4.63 per kWh. In order to irrigate their total seven acres of land, the farmers would use 40,000 units of power and infuse the remaining 45,000 units into the grid, thus they could earn over Rs. 2 lakhs revenue per year from the distribution company. Consequently, sunshine returns a money yielding crop to the farmers (Shah et al., 2016). Solar power for them comes much cheaper than diesel as almost 3,600 litres are essential to generate 40,000 units and solar is also more reliable than subsidised grid power. If we solarise India's 20 million grid-connected electric pumps that farmers currently use to pump groundwater, it would save around Rs. 60,000 — Rs. 70,000 crores (600-700 billion) of farm power subsidy (The Indian Express, 2016). This would help the government to eliminate farm power subsidies painlessly and can also be the answer for groundwater over exploitation.

The residents of Grace Co-operative Housing Society, with the long term objective of saving future generations from the adverse consequences of climatic changes, have installed 29.4 KW solar project on the terraces of the buildings in Mulund, that caters electricity needs of 160 apartments. The project costs around Rs. 14 lakh (1.4 million) after a 30 per cent subsidy received from the Ministry of New and Renewable Energy (MNRE). This project is expected to produce 45,000 units of power every year with an expected life span of 25 years. Now the society's sprawling campus, lobbies and parking area will be lit by the solar energy generated during the day. The net-metering system allows surplus power generated by the project to be automatically transferred to the state grid and any shortage is imported from the grid. The Society will be charged by the power supplier only for the net usage at the end of the financial year. This would save Rs. 5 lakh per annum in electricity bills, which means a monthly saving of Rs. 41,000. They have also estimated that this project would reduce almost 30 tonnes of CO_2 emissions in a year, which is equal to planting 1,250 trees. This project will not only benefit the residents of the society, but also the nearby areas of the city where there is a reduced electricity supply (Hindustan Times, 2017).

A village co-operative society in Sriganganagar district of Rajasthan has set up a 20 KW on-grid rooftop solar project in 2,000 square feet area at the co-operative society's office in Bandha Colony village to meet their own energy needs and supply the surplus electricity to the power grid. The members of the society decided to install the plant in view of heavy electricity bills paid for operating the facilities created for the villagers. These facilities include a supermarket, gymnasium, Reverse Osmosis (RO) based water purifier plant and a training centre for women. An expenditure of ₹12.65 lakh was incurred on the solar power project, while the co-operative society received 30 per cent subsidy from the MNRE. This plant is likely to produce 33,000 units of electricity annually, of which 23,000 units will be utilised for the co-operative society's own needs. The surplus 10,000 units will be supplied to the power grid to bring additional revenue to the co-operative society (The Hindu, 2017).

In general, the efforts taken by the Indian co-operative organisations to promote SPP are negligible owing to lack of awareness on the viability of SPP. The solar PV system is a conducive way of supplying economical power to the outskirt residents of India (Hiremath et al., 2009). It is obvious from the literature that there is no comprehensive study to unveil the commercial viability and carbon abatement of SPP for diverse promoters. Consequently, this paper intends to explore the commercial viability and carbon abatement of SPP.

Empirical Evidence

This study assesses the commercial viability and the carbon abatement of SPP so as to ensure energy sustainability. Moreover, it is confined to the solar PV project as the generated power can be converted into monetary values. The commercial viability has been assessed using the benchmark rate published by MNRE, TNERC and Tamil Nadu Generation and Distribution Corporation (TANGEDCO) in 2015. The investment cost has been calculated using the MNRE benchmark rate of Rs. 80/ watt for up to 500 KW of grid-connected project. As the MNRE has made public the benchmark rate up to 500 KW only, the TNERC mentioned cost has been taken for the 1 MW project. The CFA offered by the MNRE to the domestic and institutional promoters has been taken into account to calculate the initial investment. The operating and maintenance cost would be 1.4 per cent of the project cost in the first year and it has been elevated to 5.72 per cent every year, as decided by TNERC. The annual power generation is computed using the widely acknowledged assumption of 4 units of power generation per day (up to10 KW) for 330 days. Thereafter, it has been escalated to 4.5 units until 100 KW and 4.52 units thenceforth, as it is concurrent with the output of the real projects. In order to consider the degradation of panels, reduction in power generation of 1 per cent year-on-year basis is considered. Moreover, the commercial viability analysis focuses diverse capacities with different states of affairs such as on-grid and off-grid. The commercial viability is assessed in terms of expediency of a SPP for domestic and non-domestic consumption. The carbon abatement of a SPP has been computed using the composite electricity factor of IEA.

Results and Discussion

This section confers the commercial viability and carbon abatement of solar power projects for domestic and non-domestic promoters. Domestic promoter means the household who deploys SPP. Non-domestic promoters include institutions, industries and commercial establishments.

Expediency of SPP for domestic consumption

The expediency of an SPP for domestic consumption has been assessed by comparing the solar on-grid and off-grid LCOE with the electricity tariff charged by TANGEDCO. See Table 1.

Table 1: Expediency of SPP for Domestic Consumption

Electricity Consumption bi-monthly (in units)	Solar Power Capacity	TANGEDCO (Rate Per Unit)	Solar Power		Rate differential (Savings in %)		Preference	
			On-grid (LCOE)	Off-grid (LCOE)	On-grid	Off-grid	On-grid	Off-grid
Up to 100	1 KW	Rs. 3	Rs. 2.1	Rs. 5	30	-	SOP	EBP
101-200	1 KW	Rs. 3.25	Rs. 2.1	Rs. 5	35	-	SOP	EBP
201-500	1 KW	Rs. 4.6	Rs. 2.1	Rs. 5	54	-	SOP	EBP
	2 KW		Rs. 2.7	Rs. 4.9	41	-	SOP	EBP
Above 500	2 KW	Rs. 6.6	Rs. 2.7	Rs. 4.9	59	26	SOP	SOP
	5 KW		Rs. 3	Rs. 4	55	39	SOP	SOP

SOP = Solar Power and EBP = Electricity Board Power

In case of the on-grid solar power project, the solar LCOE is less than that of TANGEDCO tariff, whereas in off-grid, the solar LCOE is nearer to the bi-monthly consumption of 500 units as the TANGEDCO tariff is less. Thus, on-grid solar is desirable regardless of the power consumption of the domestic promoter. Furthermore, it saves 30-55 per cent of TANGEDCO tariff according to the deployed capacity. However, off-grid does not suit if the power consumption is less than 500 units bi-monthly.

Expediency of SPP for non-domestic consumption

The expediency of an SPP for non-domestic promoter has also been computed by comparing the solar LCOE with the TANGEDCO tariff. See Table 2.

Table 2: Expediency of SPP for Non-domestic Consumption

Solar Power Capacity	Institution		Industry		Commercial		Rate differential (Savings in %)			Preference		
	TANGEDCO (Rate per unit)	Solar (LCOE)	TANGEDCO (Rate per unit)	Solar (LCOE)	TANGEDCO (Rate per unit)	Solar (LCOE)	INS	IND	COM	INS	IND	COM
10 KW		Rs. 3		-		-	53	-	-			
100 KW	Rs. 6.35	Rs. 2.9	Rs. 6.35	Rs. 4.2	Rs. 8	Rs. 4.2	54	34	48	SOP	SOP	SOP
500 KW		Rs. 2.9		Rs. 4.2		Rs. 4.2	54	34	48			
1 MW		-		Rs. 3.7		Rs. 3.7	-	42	54			

The TANGEDCO tariff for industries and institutions is Rs. 6.35 irrespective of the unit of electricity consumption. However, commercial establishments pay higher charges of Rs. 8 per unit. It is noticeable from the Table that solar power is highly suitable for all the promoters as it saves 53-54, 34-42 and 48-54 per cent of the electricity cost of institutions, industries and commercial establishments respectively. Therefore, the solar power best suited for non-domestic promoters as their TANGEDCO tariff is higher than that of domestic promoters.

Comparison of solar with diesel generator for non-domestic promoter

The non-domestic promoters consider the diesel generator as an alternative to utility grid power. However, the generation cost of diesel generator is far higher compared to solar. Thus, the solar LCOE is compared with the rate per unit of diesel generator so as to exhibit the rate of savings. See Table 3.

Table 3: Comparison of Solar with Diesel Generator for Non-domestic Promoter

Solar Power Capacity	Institution		Industry		Commercial		Rate differential (Savings in %)			Preference		
	DGet (Rate per unit)	Solar (LCOE)	DGet (Rate per unit)	Solar (LCOE)	DGet (Rate per unit)	Solar (LCOE)	INS	IND	COM	INS	IND	COM
10 KW	Rs. 15	Rs. 3	Rs. 15	-	Rs. 15	-	80	-	-	SOP	SOP	SOP
100 KW		Rs. 2.9		Rs. 4.2		Rs. 4.2	81	72	72			
500 KW		Rs. 2.9		Rs. 4.2		Rs. 4.2	81	72	72			
1 MW		-		Rs. 3.7		Rs. 3.7	-	75	75			

As per the MNRE, the per unit cost of diesel power generation is Rs.15 as about 3 units of power can be generated from 1 litre of diesel. It is clear from the table that solar power is highly suitable for the users of diesel generator as it saves 80-81 and 72-75 per cent of electricity cost for institutions, and industries as well as commercial establishments respectively. Therefore, solar power best suits for non-domestic promoters who are using diesel generators.

Carbon abatement of SPP

As per the International Energy Agency (IEA), the composite electricity factor for India was 0.9682265 Kg CO_2/kWh in 2011. The decarbonisation using SPP is being computed using the composite electricity factor. See Table 4.

Table 4: Carbon Abatement of SPP

Solar power project capacity	Average annual power generation (in units)	Lifetime power generation (in units)	Average annual carbon abatement (CO_2 in tonnes)	Lifetime carbon abatement (CO_2 in tonnes)
1 KW	1,173	29,328	1.136	28.396
2 KW	2,346	58,655	2.271	56.791
5 KW	6,599	1,64,968	6.389	159.726
10 KW	13,197	3,29,935	12.777	319.452
100 KW	1,32,561	33,14,017	128.349	3,208.719
500 KW	6,62,803	1,65,70,083	641.743	16,043.593
1 MW	13,25,607	3,31,40,166	1,283.488	32,087.187

The carbon abatement of SPP is measured based on the composite electricity factor of the IEA, which indicates that 1 KW project is expected to abate on an average of 1.136 and 28.396 tonnes of CO_2 annually and during its lifetime respectively. Likewise, 1 MW project would abate on an average of 1,283.488 and 32,087.187 tonnes of CO_2 annually and its lifetime respectively.

Conclusion and Practical Implications

It is evidenced from this study that solar power is highly viable for domestic promoters. In addition, it reveals that on-grid reaches grid parity in all cases, whereas off-grid does not. This means that the cost of solar power is relatively comparable to the cost of utility grid power. Moreover, off-grid is best suited when the electricity consumption of the domestic promoter surpasses 500 units bi-monthly. SPP is also comparatively suitable for non-domestic promoters as their electricity tariff is high. The outcome reveals that the 1 MW project is highly viable for industrial and commercial promoters than other capacities owing to drop in initial investment and increase in power generation. Furthermore, solar would be a significant factor in mitigating carbon footprints.

The contribution of co-operatives, therefore, is significant in advocating this perpetual source of energy so as to curb carbon emission. The energy co-operatives should be promoted in India as in other developed countries. In India, solar energy co-operatives must be encouraged to endorse the deployment of SPP as it is proven that solar power is highly viable and the viability would be enhanced in the years to come on account of drop in module cost. Solar energy co-operatives are less likely to face various impediments as the "underlying technology does not rely on socially complex production processes" (Yildiz et al., 2015, p. 66). Co-operatives can thus endorse the deployment of SPP in the following ways:

i. Solar is still beyond the grasp of some deprived communities, as the upfront cost is high. Thus, rural solar energy co-operatives could be the solution for unelectrified villages, wherein the cost of the project can be shared by the inhabitants.

ii. Urban solar energy co-operative can also be a viable investment avenue for urban dwellers as there is no adequate space to deploy SPP. Therefore, urban communities can work together to share rooftop space.

iii. As PV has a proven viability, farmers can initiate their own solar energy co-operatives to ensure uninterrupted power supply by the way of solar water pumps. Therefore, the upfront cost of the project can be shared among the farmers who possess fields in proximity to each other.

iv. Co-operative banks can also lend for SPP as it is proven that the project is highly viable for all kinds of promoters.

v. Public awareness and acceptance is a key element to rapidly increase clean energy deployment in order to counter climate change. Moreover, large scale deployment can only be undertaken with the approval of the public (Edenhofer et al., 2011). Co-operative organisations therefore can spread the awareness about various perks offered by Central and the respective State governments, which would pave the way for ensuring sustainable and inclusive energy in India.

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