Socio-Economic Aspects of PV Roof-Top Installations for Residential Colonies

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Abstract As an alternative source of electric power, roof-top solar photovoltaic (PV) systems stand out above all other options because of their wide distribution and potential to generate electricity at the point of demand, making electric energy a fungible commodity having a high price elasticity of demand. Such installations are particularly closely connected with prospects of improvements in the standard of living of dwellers in colonies. Continuous affordable access to electricity and the Internet helps the population become part of a more global culture. Solar PV has risen as a technology to solve climate change problems by reducing dependency on conventional electricity generation techniques in order to aim at Sustainable Development Goals (SDGs). The objective of this research is to assess the economics of various roof-top solar PV technologies (Renewable Energy Technologies (RETs)) and financial frameworks in the context of a residential society and to find the best working models and practices that can lead to increased efficiency while optimizing cost in the roof-top segment covering various aspects of the entire value chain.

Keywords Rooftop solar PV · Elasticity of demand · Sustainable development · RETs

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1 Introduction

The objective of this study is to realize the PV potentials and provide recommendations to use this potential, while taking into account economical and social constraints, as an aftermath. Technical, economic and social parameters of the PV energy provides potential under the policy of a net-metering law and same kind of conditions can be seen in order to realize under which condition and for what type of consumer it is profitable to adopt PV in the reference of Socio Economic aspects.

The less final energy prices can have a strong impression on the income received by selling energy at differential rates, additionally in the savings due to self-consumption as from installing a certain PV system. For various residential case studies [1], income and savings are recoupled for a system size of 4 kWp (kilowatt peak). For various case studies shown the income produced by selling energy to the grid is five times higher than the savings made due to self-consumption per kWh. This is due to comparatively low demand of the residential case studies and it would be favorable to increase the total income generated by a PV system of a certain system size. Undeliberately, income earned by selling electricity to the grid is higher compared to self-consumption of electricity in spite of the differential tariff described by net-metering law comparable to the feed-in tariff for energy of PV systems [2]. In case of residential, savings on self usage is lower, but earnings on selling electricity are more in most of these cases. Levelised Cost of Electricity (LCOE) and Net Present Value (NPV) could be calculated for economical aspects and following formulas can be implied for this.

For LCOE

$$\text{LCOE} = \frac{\sum_{t=1}^{n} \frac{\text{Expenditures}_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{\text{Electricity generated}_t}{(1+t)^t}} \left(\frac{\text{USD}}{\text{MWh}}\right) \tag{1}$$

For NPV

$$\text{NPV} = \sum_{t=1}^{n} \frac{\text{CF}_t}{(1+i)^t} \,(\text{USD}) \tag{2}$$

where n is the average life, t refers to the year, i is the rate of discount and CF_t is the cash flow for the ongoing year [3].

For a Net Energy Metering (NEM) policy to be achievable and get an investment, price of electricity generated from PV should be lower or comparable to retail electricity cost. NEM schemes may be varied according to how the net energy during a billing period is used to bill the customer. In case this net energy is greater than zero (i.e. the usage is greater than generation) the consumer may be billed only for this value of net energy at the retail electricity price, known as “full netting”.

Presently, Delhi residential consumers pay about Rs. 8.75/kWh, which shows it is the market segment with the highest roof-top potential for solar installations at

1.24 GW. The proposed study can play a crucial role as various public policies are introduced for green and clean environment and social issues to be addressed immediately have been taken into consideration by Ministry of New and Renewable Energy (MNRE), especially planning laws, strategize to implement and promote new projects to inculcate residential solar roof-top segment. It is clear that, in the Indian scenario large amount of funds are released in form of subsidies by Government of India to promote roof-top solar PV in residences and institutions.

In regard to social aspects, a detailed survey has been done with support of DISCOM, Tata Power Delhi Distribution Limited in which feedback from customers, who have withdrawn their solar power plant installation interest, was noted. In the results it was found that different people from almost the same area of Delhi were having different reasons to not install solar power plants on their roof-tops. Some people want to use their roof-tops for other applications, which they realized after showing interest in solar roof-top installation, some were finding the installation with average price INR 50,000/kW [4] to be expensive and are waiting for the prices to decrease by technology development while others are totally not prepared for this type of power production.

The social aspects of solar roof-top on which further work can be done are:

1.1 Job Creation

While solar roof-top installations may create jobs, there is high need of skilled local labor to install solar plant at roof-top. If local residents are unqualified for the jobs, outside labor will be brought in. Since residential solar plant installation creates relatively few jobs, and the bulk of these jobs are temporary, solar energy development has little effect on population growth.

1.2 Fiscal Impacts

It is difficult to generalize the fiscal impacts of extractive facilities because taxation systems vary by State. An influx of new workers will create a demand for more stores and restaurants, which will in turn hire workers who will spend their incomes locally.

1.3 Quality of Life

The sentiments of the people who have installed, or are going to install solar PV roof-top system, gets disturbed as some people consider solar roof-top system a burden on them and have a negative impression of solar roof-top installation;

further studies can be done on these people as to how they ponder upon the installation of solar roof-top. The impact on the quality of life of different class of the population i.e. poor class, middle class and rich class after going for solar roof-top can thus be studied in detail.

1.4 Social Cohesion

Tensions may arise in the minds of people if the profits are not shared equally or if the solar electricity producer does not get adequate returns after installation of plant [5]. For e.g. in a NEM system, if the government utility stops buying electricity from the solar producer or buys at a very cheap price, then problems may arise in a way that residential owners will not opt for large capacity solar power plants, as they will not be paid for producing surplus energy through a solar power plant.

1.5 Utility in Loss

Solar photovoltaic installations are been negotiated globally at a fast pace in upcoming years due to overage tariff affecting size of future residential PV investments. These tariffs credit electric energy generated by the solar system, but not consumed by the household and thus transferred back to the utility, at a rate below the going retail electricity rate. This results into net metering policy forces the utility to buy surplus electricity at the going retail rate for electricity, though it could procure the same power at the lower wholesale rate. Thus making them run into losses [6].

2 Load Assessment of Delhi

Figure 1 shows the load assessment of Delhi for a period of 3 days i.e. from 30th January to 1st February 2018. The electricity consumption for State of Delhi is characterized by high time homogeneity, having high loads at morning and evening rush hours.

Other than this, there are disruptive impacts of solar roof-top installations. By installing solar panels, a consumer pays the utility less and, for the first time, becomes an energy producer rather than a consumer only. Net metering rules—which allow homeowners to sell surplus electricity from their solar panels back to the grid—are being challenged as well. Utilities are seeking additional restrictions on net metering or to reduce the price they pay homeowners for this surplus power. Also, no body knows what to do with PV modules after a lifespan of 25–30 years. Can there be a way to utilize used panels in a profitable way?

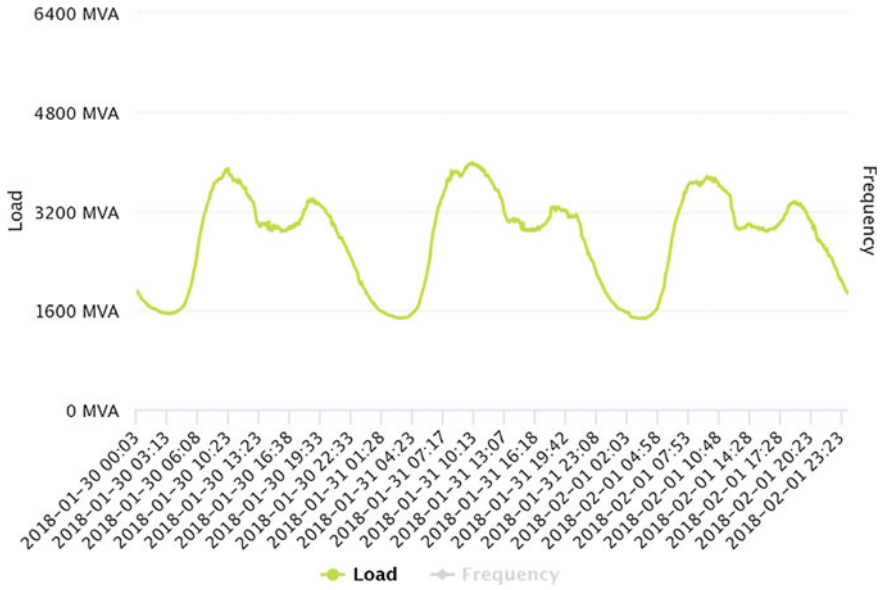

Fig. 1 Delhi electrical load assessment [7]

3 Model Formulation Framework

Technological capabilities for development of new PV installations at the places of the studies can be found out. A top-bottom approach can be used for optimizing the technical PV potential [8]. Firstly, the net solar radiation in an hourly time-step format for a year for the locations defined in the case studies are found (the theoretically calculated PV capability). Secondly, the solar radiation as well as temperature data are inducted to a PV model to calculate hourly energy output for every location (technical potential) accepting as true, the installation capacity of one kWp.

The study will lead to promotion of Renewable Energy with an already identified scope i.e. the presence of a provincial planning and specific laws, the presence of technologies and renewable resources and also the potential for interaction between multiple factors already inculcated [9]. Also, the limiting problems i.e. lack of knowledge and diffusion, less profitability, stoppages on the concerned sectors, less confidence in government policies and also lack of local generation potential can be dealed with.

For solar to be acceptable to residential consumers, a payback period of 5–7 years is preferred. A seven-year payback for 5 kW PV system corresponds to equity internal rate of return (**IRR**) of 15%, which would make returns from solar significantly higher than alternate, low-risk investments. Under these conditions, residential solar will reach parity [10].

4 Support to People

Supporting the wide spread network of Renewable Energy Technologies means supporting people, not technologies. This support is extended on the basis of motivation, financial possibilities, energy needs and risk averse. A survey was conducted approaching potential investors and knowing their possible motives for investing into PV metering (Table 1) [2].

According to this, Households and Industrialists are into distributive RETs, whilst Unknown Investing people and Big Utilities move towards centralized arrangements. Municipalities and Energy Producers may use the two systems. Moreover not all investors are applying heat and electricity producing systems to the same levels. Preferring some investor types over others means inculcating specific RET, which are-various stages of RET market introduction. The more the potential investor gets economically motivated, the more relevantly RET has to be spread over the market. Hence the pioneer investors, which are mainly non-commercially motivated, contribute the introduction of RET to the market. Its capability also vary from one country to other. Certainly House Owners and Industry can do much more higher in the long run compared to Energy Communities or Anonymous Investors and will become more and more important in the future [11]. Depending on the stage of market introduction, different investor types should be approached.

4.1 Anonymous Investors

Anonymous Investors contribute seeing ideal structure influencing them to pick up a high pay and spare to return on speculations. High devaluation stipends are appealing for Anonymous Investors with high wage. No potential client ought to be rejected from the help. Co-agents, utilities and outside financial specialists ought to have the capacity to apply for this help [4]. Remote financial specialists increase exceptional significance as it is imperative to guide cash-flow to the destinations with good normal conditions. At the present Anonymous Investors want to put resources into power creating RET. They are of developing significance for the prominence of expansive RET.

Table 1 Investors and their motives for profit

Investor type	Large motive	Energy community
Motivation of investors	Economical, strategic	Ecological, political
Importance	Medium	High
Operator	Self	Self
Purchaser of produced energy	Own grid	Grid, third parties
Readiness for financial risks	Low	High

4.2 Industry

State-possessed temporary workers like Energy Agencies go for broke beginning from long pay-back circumstances with modern interests in RET. Beyond any doubt reserves is another approach to decrease the individual dangers because of probability about future vitality buy [12]. Additionally changes in the administrative and lawful structure could upgrade crafted by temporary workers. Reasonable conditions for the entrance to the power lattice cultivate power creating RET. In spite of different conceivable modern uses of RET, actuating the mechanical RET potential will remain an intense errand.

4.3 Large Utilities

Huge Utilities, for example, wind ranches or half breed sunlight based warm power plants, are imperative for huge scale RET. Since their hierarchical structure is pointed on extensive unified power plants and vitality circulation. Upgrades in the administrative casing fill in and additionally access to people in general endowment spending plans persuade them to put resources into RET. In any case, this must be considered, that Large Utilities acquire cash because of the present status of the vitality framework. As profit for ventures picked up by ordinary vitality sources will be higher than return on placing cash in RET, Large Utilities will just put ineffectively in RETs [3].

4.4 House-Owners

There is a high potential in heat creating RET in private structures. Private House Owners are a key component for popularizing appropriated RET. Coordinate gifts diminish capital needs of the financial specialist and demonstrate to them people in general affirmation. In this manner, open acknowledgment is raised and open mindfulness is picked up. Low loan fee credits replicate the vitality cost structure to which the private vitality consumer is utilized to. Self-fabricated RET are alluring for individuals with low salary [13].

4.5 Municipalities

Municipalities are viewed as the perfect edge for a general advancement of the entire neighborhood vitality framework under practical and social viewpoints. In addition regions can offer help to conquer a wide range of issues. Districts having

introduced RET out in the open structures have a critical multiplicatory part in turning into a core through that RET of different financial specialists are started. Coordinate city RET ventures can be improved by changing the spending control and in addition by presenting Energy Service Companies.

4.6 Energy Communities

There isn't a strict fringe in Anonymous Investor write and Energy Communities, Motivation profiles and degree of profitability prerequisites of financial specialists of the two kinds can be extremely undifferentiated. Energy Communities have not been made in many nations yet, in spite of the fact that the fundamental thought is very like the customary, co-agent and city driven vitality supply framework. As pioneers, Energy Communities exhibit the attainability of RET [13]. They assume a critical part as an opponent for the built up players on the vitality advertise. Neighborhood acknowledgment of RET can be raised. Regardless of whether their immediate effect as far as the quantity of introduced RET may be not high their aberrant effect is important. Therefore Energy Communities ought to have a similar access to all endowment sources as alternate financial specialists [14].

5 Smart City-Ajmer Data Case Study

The details of the various projects implemented and Energy availability and reduction of outages in the city of Ajmer has been studied. Ajmer smart city limited is incorporated under company act 2013 Ajmer has been selected in round 2, after Round 1 and fast track of smart cities project with a total budget of Rs. 1770.5 Crore [6]. According to a study following steps are taken to procure Renewable Energy Technologies over there.

(i) Replacement of conventional street lights with LED bulbs; 31,000 replaced —100% LED coverage by end of July 2016.
(ii) Ajmer Municipal Corporation has installed 30 kW solar PV system at head office to harness solar energy. ADA (84 kW) and AVVNL are also in the process of tapping solar energy.
(iii) All city based substations of AVVNL are on SCADA and currently being controlled from a centralized location.
(iv) Geographic Information System mapping for the electric utility is in progress and to be completed to support Document Management System implementation by 2015.
(v) Transmission and Distribution losses have come down from 20 to 12% during 2014-2016 (Source: Ajmer Vidyut Vitran Nigam Limited).

(vi) The budget allocated (in Crore) for different sectors related to utility company is as follows

- **Energy Security**

  Solar power generation—48.58
  Power distribution strengthening—56.42

- **Green and Blue grid**

  Anasagar promenade—110.69
  Innovative use of public open spaces—35
  Green buildings—16

5.1 How to Achieve Convergence

Solar Roof toping shall seek support from Ministry of New and Renewable Energy to get 30% subsidy. Solar energy generation in the ABD area has been proposed in public buildings and open parks with a total cost of Rs. 48.58 Crores and amount of Rs. 14.57 Crores has been converged though Ministry of New and Renewable Energy subsidy under Solar Policy and the remaining amount of Rs. 34 Crore would be covered under Smart City Mission [15].

5.2 Consumer Details

Total no. of consumers—139,860
Total sanctioned load—388.793 MW
Sanctioned load of net meter—2512.48 kW
On-grid solar photovoltaic installed—2009.984 kW (assuming 80% sanctioned load as solar PV installed)
By smart city policy, 10% of energy should be generated by solar energy i.e. 38.87 MW
Left over capacity for smart city—36.861 MW.

6 Conclusion

As the demand for renewable energy is increasing so are its socio-economic aspects. This paper has dealt with these aspects and how they affect the lives of people and utility. As the units are being fed back to the utility grid there is advantage during peak load hour the energy is stored for the consumption and the units used from grid are reduced during the time photovoltaic energy is being

consumed during peak load hours energy from utility would be available easily for use. Moreover as power is injected to the grid locally, losses due to transmission are being reduced to a greater extent. It is useful where electricity rates are high. For solar photovoltaic module to be successful, least cost of electricity through this method should be less than retail electricity price. Hence here we successfully conclude this paper.

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