Will Net Metering Model for Residential Rooftop Solar PV Projects Work in Delhi? A Financial Analysis

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Abstract- In order to promote decentralised solar energy generation in Delhi, Delhi Electricity Regulatory Commission (DERC) has implemented a scheme for 'net metering' based Solar Photo Voltaic (SPV) rooftop projects. The paper aims to examine the financial viability of the notified scheme for residential consumers based on the current costs and applicable electricity tariff in Delhi, India. The self-owned and the third party owned models are evaluated for different SPV system sizes which are suitable for installation on residential rooftop spaces. The paper compares the Internal Rate of Return (IRR) based on cash flows for different cases using a deterministic financial model. Results indicate that with the current costs, smaller systems (2.5 and 5 kWp) are suitable for self ownership, but require the existing 30% subsidy in order to be financially viable. However, the return on larger self-owned systems (10 kWp and above) is sufficiently high and does not warrant the subsidy. On the other hand, third party ownership model is financially not feasible for smaller systems, but returns on larger systems (10 kWp and above) are sufficiently high. The paper while analyzing the IRR for various cases concludes that there are certain drawbacks in the scheme as it does not allow optimal utilization of rooftops for generation of electricity. These limitations if relaxed, can improve the financial viability of the scheme for both self owned and third party owned models and can encourage decentralized generation of electricity in Delhi.

Keywords- Solar Photo Voltaic (SPV) systems; net metering; Internal Rate of Return (IRR).

1. Introduction

Solar energy is one of the cleanest and fastest growing sectors in the renewable energy segment. The Jawahar Lal Nehru National Solar Mission (JNNSM), which is a part of the National Action Plan on Climate Change (NAPCC) for India, was officially launched in November, 2009. The plan lays out a roadmap to commission 20 GW of grid connected and 2 GW of off-grid solar power by 2022 [1]. The program is divided into three phases: 2010–2013; 2013–2017 and 2017–2022 and the respective targets are: 200 MW, 1000 MW and 2000 MW (for off-grid) and 1000-2000 MW, 4000-10,000 MW and 20,000 MW (grid power including roof top). Although the JNNSM has been hailed as an unparalleled success, its success has been challenged on the grounds of delayed project commissioning and failure to deploy solar thermal systems [2].

In order to provide a boost to the program, the Ministry of New and Renewable Sources of Energy (MNRE), India has launched a pilot scheme in 2013 for grid connected rooftop PV power projects which is being implemented by Solar Energy Corporation of India (SECI). The scheme allows installation of grid-connected systems without battery backup (varying from 100 to 500 kWp[1]) and provides 30% of the cost

[1] kWp stands for kilowatt peak and specifies the power output achieved by a solar module under standard test conditions. The actual power output is approximately 15-20% lower than the peak power due to non standard test conditions in the field.

of the system as subsidy [3]. Although aggregation of capacity from smaller roofs is allowed, the scheme is meant for captive generation for large scale projects (intended to replace diesel-based generation for industrial and commercial users). Three phases of the scheme has been launched in 2013 in various cities of India, with a total target of approximately 30 MW and project developers have been selected through a competitive bidding process.

In India, electricity tariffs vary significantly for various classes of consumers, across states. The four main categories of consumers are commercial, industrial, residential and agricultural. While commercial and industrial consumers are generally charged rates which are higher than the average cost of production and distribution, residential and agricultural consumers often get subsidised electricity. It has been shown that grid parity has already been achieved for commercial consumers in Maharashtra, Andhra Pradesh, Kerala, Karnataka and Delhi [4]. On the other hand, in the case of industrial consumers, the levelised cost of energy (LCOE)[2] for solar power (installed system capacity of 100 kWp and above), is approaching grid parity (when subsidy and accelerated depreciation is included). However, achieving grid parity for residential consumers will still take a couple of years. This is because the tariff for commercial[3] and industrial consumers[4] in Delhi is substantially higher, than that for residential consumers [5]. The rooftop SPV potential for residential consumers in Delhi is estimated to be about 1.24 GW, which is the highest amongst the three categories of consumers in a city [4]. It is therefore important that this category of users is targeted for installation of rooftop SPV systems.

This paper aims to analyse the financial viability of the scheme for residential consumers based on the current costs and applicable electricity tariff in Delhi. The next section presents the current status of rooftop SPV programs in India and section 3 discusses the salient features of the net metering scheme for Delhi. The methodology section presents the financial model and justifies the assumptions which are used for calcultions in the model. The cash flows for different SPV system sizes and business models are calculated in Section 5. The results are presented in the form of Internal Rate of Return and payback period and are then discussed iwhere certain drawbacks in the scheme are highlighted before concluding the paper.

2. Current status of rooftop SPV programs

Traditionally, solar generation has always been supported by various governments with capital subsidies, Feed In Tariffs (FIT), Generation Based Incentives (GBI), Accelerated Depreciation (AD), tax credits and other fiscal benefits. SPV rooftop program has been successfully deployed in Japan, Germany, US, Australia and other countries [6]. Such programs are based on gross metering as well as net metering arrangements and are supported by tax credit rebates (California), Renewable Purchase Obligations (RPO) (Japan) and FIT (Germany). Germany which has a 33% share in the world’s installed SPV capacity has 71% of its capacity on rooftops, 28% are ground mounted while less than 1% is Building Integrated PV (BIPV). Out of the 71% of the rooftop installation, 10% are small systems (1–10 kWp) which are fitted on houses or private buildings, 38% (10–100 kWp) are fitted on commercial, social and agricultural buildings and 23% (larger than 100 kWp) are fitted on large commercial buildings.[7]

Successful gross/net metering models have been implemented in various states in India over the past couple of years. Rooftop Public Private Partnership (PPP) models which are based on gross metering are currently running in Gandhinagar, Gujarat where Azure Sun Energy and Sun Edison, (both are independent power producers) have deployed 2.5 MW of rooftop solar plants and have entered into a long term Power Purchase Agreement (PPA) with the

[2] LCOE is defined as the constant price per unit of energy that causes the investment to just break even over the lifetime of the project. Its calculation includes all costs over the lifetime of the project, including initial investment, operations and maintenance, fuel, cost of borrowing capital etc.

[3] The electricity tariff for commercial consumers is INR 8.5/kVAh (14.2 cents/kVAh) for a connected load of upto 100 kW.

[4] The electricity tariff for industrial consumers is INR 8.8/kWh (14.6 cents/kWh) for a connected load of upto 10kW and INR 7.9/kVAh (13.2 cents/kVAh) for a connected load of upto 100 kW [5].

utility, Torrent Power. INR 11.21 (18.68 cents)[5] will be paid for 25 years to the power producers per kWh of electricity, as tariff for surplus energy, out of which INR 3.0 (0.05 cents) is passed on to rooftop owners [8]. In Tamil Nadu, the state government offers an additional subsidy of INR 20,000 (333.34 $) apart from providing a GBI of INR 2.0/kWp (0.03 cents/kWp) for first two years followed by INR 1/kWp (0.017 cents/kWp) for the next two years which further reduces to INR 0.5/kWp (0.008 cents/kWp) for the following two years and is suspended thereafter. Kerala offers an additional capital subsidy of INR 39,000 (650 $) for each system (capacity 1 kWp and above). In Uttarakhand, the Uttarakhand Power Corporation Limited pays INR 9.20/kWh (0.0153 cents/kWh) to rooftop owners generating excess solar power based on net metering.

Ministry of New and Renewable Energy (MNRE), Government of India (GoI) gives a 30% capital subsidy as Central Financial Assistance (CFA) for installation of SPV systems. This subsidy was initially intended for large off grid power plants but was later extended to smaller plants as well. This subsidy can be availed through the MNRE approved channel partners anywhere in India. However, much of the subsidy for the year FY 2013-2014 has not been disbursed as the original budgetary allocation of INR 15.2 billion (253.34 million $) was slashed to INR 4.4 billion (73.34 million $) to curtail the growing Current Account Deficit (CAD) of the GoI. The subsidy disbursements for rooftop solar was therefore suspended, which resulted in many Engineering Procurement Construction (EPC) companies, shelving their planned projects. Although the scheme was not suspended, a large amount of money is still due to the MNRE-esta blished channel partners. Hence, no new projects are being sanctioned under the rooftop subsidy scheme, which has more or less been taken over by the Solar Energy Corporation of India (SECI) bidding based rooftop allocations [9]. However, MNRE has recently[6] revived the 30 % CFA[7] [10] and state nodal agencies can now independently approve and implement projects up to 50 kWp. Notwithstanding the above, solar rooftop is gradually becoming an attractive proposition as the cost of PV modules has fallen sharply from 1.8 $/W in 2010 to 60–80 cents/W in 2013 and is expected to come down further in the next few years. This has lead to a situation where India can now experiment with a model that may not have any upfront capital subsidy. In such a situation, the role of the government is limited to policy making and implementation, while leaving the rest to the spirit of entrepreneurship.

3. Net metering based model for Delhi

There are four advantages of rooftop generation. The first is to bridge the peak power deficit and the energy deficit, which has stubbornly plagued the Indian power sector despite massive capacity additions over the years. The second advantage is that such a system provides power to the household in case of grid failures (in sunny hours of the day) which are quite frequent in northern India. Thirdly, there are no Transmission & Distribution (T&D) losses in such a system which can result in approximately 20-30% of energy savings. Lastly, the utility also benefits by purchasing power at rates which are much lower than power purchased from the short-term electricity market and via the Unscheduled Interchange (UI) mechanism. The net metering scheme which is designed to promote self-generation of electricity should therefore be seen as a solution to Indian power woes.

Fig. 1 shows two different models which have been proposed by Delhi Electricity Regulatory Commission (DERC) in respect of operation of rooftop SPV projects in Delhi [11][8]. The self- owned

[5] 1 USD = INR 60, is considered as the average exchange conversion rate

[6] MNRE order No. 30/11/2012-13/NSM dated 26 June 2014.

[7] Up to 10% of the financial assistance can be provided at the time of approval followed by the balance subsidy at a later date.

[8] Guidelines under DERC Regulations for net metering for renewable energy, 2014 have been issued on 02 Sep 2014 after discussions on the proposal in a public forum. These regulations have been therafter notified in the gazette and have been implemented.

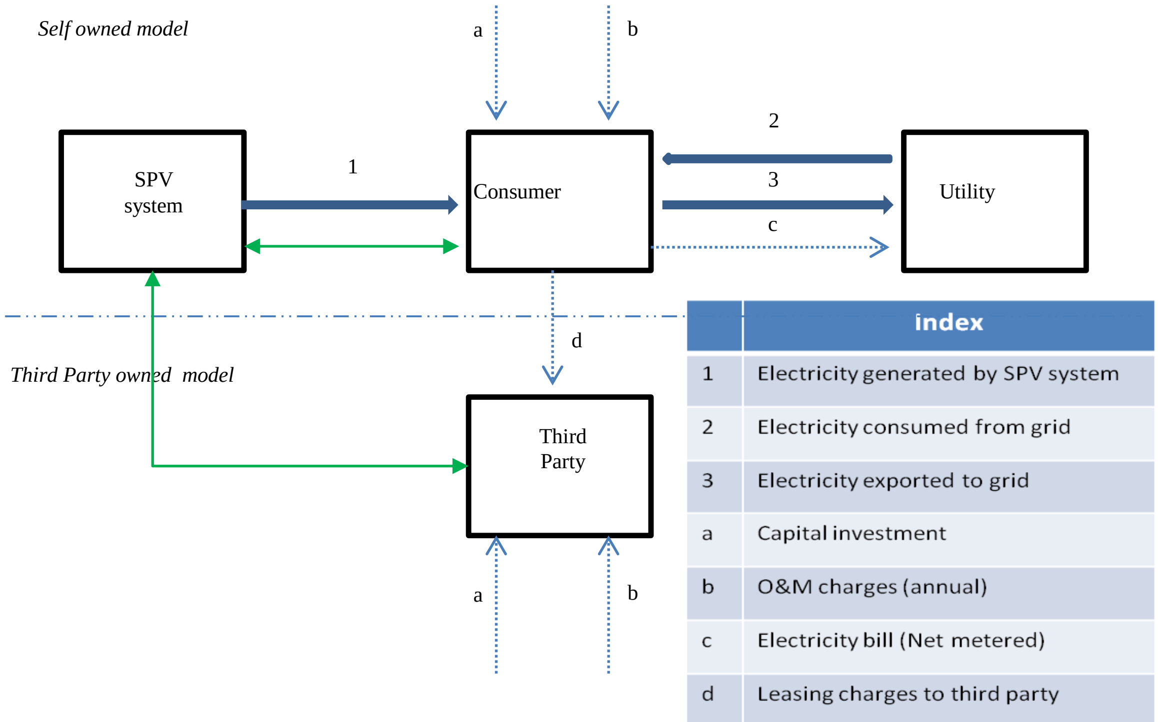

Figure 1. Rooftop SPV projects—self-owned and third party models

model and the third party owned model both operate on the net metering principle. The actual energy flows are shown in bold lines and are identified as (1–3), while cash flows are shown in dotted lines and are identified as (a – d). In the self owned model, there are two entities, the consumer and the utility. The consumer installs the SPV system on his rooftop for personal consumption. Surplus electricity which is generated by the SPV system during day time can be exported to the grid. The consumer also draws electricity from the grid during the night time. The physical flow of electricity is therefore bi-directional and electricity can be exported/ imported from the grid. The net import/export is metered via a bi-directional meter which measures the net flow of electricity at the connection from the distribution utility to the consumer. A second meter called the 'solar meter' is installed at output of the SPV system which measures the gross electricity generated by the SPV system [12].

The upper part of Fig. 1 shows the self-owned model where the onetime capital investment and the annual Operation & Maintenance (O&M) charges for running the SPV system are paid by the owner who is also the consumer. He also pays a monthly electricity bill to the utility, based on net consumption (export-import) of electricity. Therefore he benefits by reducing the electricity drawn from the utility and is also partly isolated from the increase in cost of electricity over the years.

The lower part of Fig. 1 shows the third party owned model where the onetime capital investment and the annual O&M charges are paid by the 'third party'. The consumer pays the electricity bill to the utility based on net consumption (export-import) of electricity, as in the self-owned model. The third party has the option of selling the electricity to the consumer at a price which is lower than what the utility charges the consumer. The rooftop owner may also opt to pay monthly rental charges to the third party for leasing the solar PV system, based on a predetermined agreement. According to this arrangement, the consumer benefits by saving on the electricity bill, avoids large upfront capital investment and is free from maintaining the system. He is also partially insulated from escalation of the cost of electricity tariffs in future. On the other hand, the third party receives a lease rental from the consumer and, as the SPV system is owned by him, he is eligible for claiming depreciation on the capital cost of the system. Hence both models are suitable for application, provided they are financially viable for the stakeholders.

(a) The typical sanctioned domestic load for one household in upper middle class houses in Delhi is in the range of 2–5 kW. The average rooftop area which is suitable for installation of solar panel in such houses is 50–100 sq. m. and hence systems upto 10 kWp can be easily installed in these houses. We consider three system sizes, viz., 2.5, 5.0 and 10.0 kWp for analysis.

(b) Due to ageing of components, a derating of the performance of SPV panels has been considered. For 0-3 years it is assumed to be nil and for 3-25 years it has been assumed to be 0.5% per year [13].

Table 1. Assumptions for rooftop SPV plant

	System size 1	**System size 2**	**System size 3**
System Size (kW_P)	2.5	5.0	10.0
Derating factor	0.5% each year after 3 yrs		
Capital Cost with installation in INR at INR 100/W_P (shown in $//$W_P$)	2,50,000 (4166.67)	5,00,000 (8333.34)	10,00,000 (16666.67)
Capacity Utilization Factor (%)	19		
Annual O&M expenses for first year at INR1. 23 million/MW (shown in $/MW)	3,075 (51.25)	6,150 (102.5)	12,300 (205)
Applicable Grid Tariff (based on consumed units) **(INR/kWh)** (shown in cents/kWh)	5.95 (10)	7.3 (12.16)	8.1 (13.5)
Escalation in tariff	5% annually		
Plant Life (years)	25		
Third Party ownership			
Debt: Equity ratio	70:30		
Loan Duration (years)	12		
Cost of debt (%)	13.0		
Corporate tax rate (%)	34.0		
Accelerated Depreciation (%)	90% of the asset value over the lifetime of the project with 80% accelerated depreciation applicable in the first year.		

(c) The present benchmark price (approved by MNRE) for photovoltaic systems without battery backup for grant of subsidy is considered as INR100/Wp (1.67 $/Wp) for systems upto 100 kWp and INR 90/kWp (1.5 $/Wp) for systems in the range of 100–500 kWp. This benchmark cost includes hardware costs including PV modules, inverters, minimum storage battery, cost of meters, local connectivity, civil works, foundations, installation, comprehensive maintenance for a period of five years and warranty for the complete system [10]. The price of a SPV module varies as per size and market survey also reveals that a 2 kWp panel costs Rs 1,80,000 [14], a 2.5 kWp system costs Rs 2,25,000 [14] and a 5 kWp panel costs Rs 5,50,000 [4].

(d) The capacity utilization factor (c.u.f) is a function of solar radiation, measured in kWh/sq.m/day and number of clear sunny days. The daily average global radiation incident over India is in the range of 4.3–5.8 kWh/sq.m/day [15]. For the specific case of New Delhi, the mean monthly global solar radiant exposure (kWh/sq.m/day) for specific months from January to December are as follows: 3.70; 4.56; 5.73; 6.69; 6.79; 6.26; 5.30; 4.94; 5.25; 4.67; 3.93; 3.3. This averages to 5.07 kWh/sq.m/day over the year. Further, most parts of India have 290–320 clear sunny days in a year. Based on an average of 300 sunny days and daily average global solar radiation around 5.8 kWh/sq m/day, various project developers around India have estimated the c.u.f for SPV (thin film or crystalline) based power project at 15–25%. However, the CERC has estimated the c.u.f for crystalline and amorphous silicon modules as 18.4 and 19.5 % respectively and has approved the normative c.u.f of 19% for grid-connected SPV-based projects. While theoretical estimates are valid, some attention also needs to be paid to plants which are actually in operation. A case study of an installed PV plant at the German House, New Delhi reveals that the c.u.f varies from 10.5 % in the month of Aug to 21 % in the month of March [4] and the average c.u.f over the year was 16%.

(e) CERC has approved [13] a normative O&M expense of INR 1. 23 million/MW ($20,500/MW) during the first year of operation which will be escalated at a rate of 5.72% per annum over the tariff period.

(f) Grid tariff for domestic consumer in Delhi was revised on July 17, 2014 (For details refer to Table 1 placed at Appendix). The blue line in Fig. 2 shows the electricity tariff in Rs/kWh for different consumption slabs for 2014–15. The average tariff (shown in green bar) increases as the monthly electricity consumption (shown in red bar) increases.

(g) The average electricity tariff has risen by 27%, 37% and 33% for domestic, industrial and non-domestic categories over the past five years [4,16]. Although price was not revised between 2004–2005 and 2010–2011, the CAGR since 2010–2011 to 2013–2014 was 5%. Based on the past trends, the applicable tariff has been assumed to rise at 5% annually.

(h) Other charges are also applicable on the electricity bill for the domestic consumer (For details refer to Table 2 placed at Appendix). It can be seen that the total bill is a function of demand charges and energy charge and can be written as 1.084A + 1.197B. Hence a lower monthly consumption of electricity will lower the overall electricity bill by a factor[9] of 1.197.

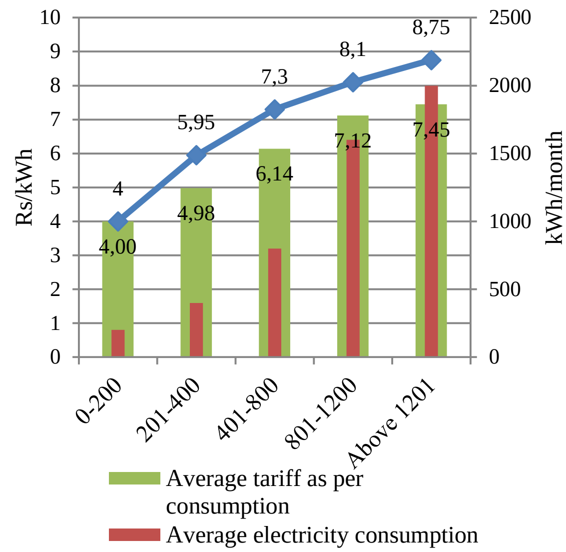

Figure 2. Average per unit cost for different levels of consumption

5. Calculation of cash flows

The amount of electricity which is generated over the year is given by Eq. (2).

$$\textit{Electricity generated (kWh) = installed cap. } (kW_P) \textit{ x cap. utilization factor (\%) x 8760 (h)} \quad (2)$$

where, installed capacity is the peak installed capacity,and 8760 is the number of hours in a year.

There are both positive and negative cash flows. Negative cash flows are upfront capital costs, and thereafter as O&M costs throughout the lifetime of the plant. Positive cash flows on the other hand are given by Eq. (3).

Annual Revenue (Rs) = Electricity generated in a year (kWh) x applicable electricity tariff (Rs/kWh) (3)

The operational annual cash flow (CF_1, CF_2 ,… CF_n) is given by Eq. (4).

[9] However, for the ease of calculations we neglect this factor.

Operational annual cash flow = Annual revenue – Annual expenses due to O&M.. (4)

For a company engaged as a third party, the Earnings Before Interest, Depreciation, Tax And Amortization (EBIDTA) equals the operational cash flow and can be calculated from Eq. (4). In the third party model, there are two components: equity and debt. The annual amortization for servicing the debt will then be given by Eq. (5)

$$A = P\left[\frac{\{r(1+r)^n\}}{\{(1+r)^n-1\}}\right] \quad .. (5)$$

Where, P is the amount of loan; r is the rate of interest (annual); and n is the number of instalments.

Although the debt may have to be serviced monthly or quarterly, we assume annual repayment in order to keep the calculations simple. Eq. (6–8) are used to calculate the free cash flows.

EBIT = EBIDTA –Depreciation .. (6)

Tax = Corporate Tax at 34% on (EBIT – Interest) (7)

Free cash flows = EBIDTA – Interest–Tax Amortization .. (8)

A total of 90% of the cost of machinery is allowed as depreciation out of which 80% can be claimed in the first year itself. AD is attractive for integrated Indian companies [17] as significant profits from other business ventures can be offset against the depreciation value and tax can be saved. As 80% of AD is allowed in the first year, the tax benefits due to AD are added to the free cash flows to calculate the total earnings of the company in Eq. (9).

Total Earning = Free cash flows + tax benefits due to AD .. (9)

The IRR is then calculated[10] on the annual total earnings using the financial model shown in Eq. (1) which can be modified as Eq. (10).

$$\text{Investment} = \mathrm{CF1}/(1+IRR)^1 + \mathrm{CF2}/(1+IRR)^2 + \sum \mathrm{CFi}/(1+IRR)^i \; .... \quad (10)$$

where Investment, is the initial capital investment;
CF1,2..i,..,N are the total earning (cash flows) for the year 1, 2..i..,N and
N, is the life of the system in years,
IRR is the discount rate (in%)

5.1. Business models

Three different system sizes with an installed capacity of 2.5, 5.0 and 10.0 kW_P are discussed and the IRR is calculated for different cases.

Case 1: Self-owned system with upfront investment and no subsidy

In the first case we examine a self owned system with no subsidy. Hence the entire capital has to be paid upfront by the rooftop owner. Using Eq. (2), Eq.(3) and assumptions in Table 1, the annual revenue for various years is calculated. The operational cash flow for the rooftop owner is calculated using Eq. (2) – Eq. (9).

Case 2: Self-owned system with GoI subsidy

In this case we have assumed that the upfront subsidy at 30% of the initial cost of the project is available to the customer. All other parameter remains the same as for Case 1.

Case3: Third party-owned system—Base Case

This case examines the third party owned system and it is assumed that 30% subsidy is provided by the GoI. The base case initially considers the IRR for the third party assuming that he supplies electricity at the same rate as the utility. Therefore in the base case there is no benefit/return for the customer who is also the rooftop owner. The base case is considered in order to examine if the IRR is sufficiently high for different system sizes.

Case 3(a): Generation based model

[10] The IRR is quite difficult to calculate without the use of a financial calculator. Otherwise trial and error must be used.

This case considers that a 10 kW_p system is installed and we assume that the rooftop owner gets a discount of 10% (on the applicable grid tariff) for purchase of electricity generated from the SPV system. This discount rate can be increased or decreased according to the expected rate of return and needs to be fixed mutually between the third party and the consumer prior to operationaisation of the contract in the generation based model.

Case3 (b): Fixed lease rental model

This case also considers the 10 kW_p system, and it is assumed that the third party charges a fixed amount to the rooftop owner for lease of the SPV system, based on the capacity of the installed plant (per kW_p). This case assumes a stepped cost structure with a lease amount of INR 12,000 per kW_p ($200) for the first five years, followed by INR 15,000 ($250); 19,000 ($317); 23,000 ($383) and 27,000 ($450) for the subsequent blocks of five years respectively. Such a graded structure ensures that the rooftop owner always has cost savings and the third party also gets adequate return on his investment.

6. **Results and Discussions**

The IRR and payback period for case 1 and 2 are shown in Table 2a &2b, and for case 3 in Table 3.

Table 2a. IRR and payback period for case 1

	Case 1 (w/o Subsidy)		
System Size (kWp)	**2.5**	**5.0**	**10.0**
IRR (%)	9.08	11.76	14.5
Payback period (yrs.)	11-12	9-10	8-9

Table 2b. IRR and payback period for case 2

	Case 2 (With Subsidy)		
System Size (kWp)	**2.5**	**5.0**	**10.0**
IRR (%)	13.10	16.43	19.94
Payback period (yrs.)	8-9	6-7	5-6

Results for Case 1 shows that the IRR for 2.5, 5 and 10 kWp systems are 9%, 11.76% and 14.5%, respectively. As evident, the IRR increases with increase in system size. This is due to the increase in average electricity tariff rate, as the electricity consumption rises. While an 11-12 year payback period with an IRR of 9.08% (for a 2.5 kWp system) may not be attractive (as a consumer can get equivalent returns from investment in bank fixed deposits), the financially viability for larger self-owned systems increases with their size. Results for Case 2 show that a 2.5 kWp system has an IRR of 13.1% which increases to approximately 20% for a 10kWp system, which is highly attractive. We can therefore conclude that while subsidy for smaller systems (below 5 kWp) is desirable so as to make the proposal attractive for self ownership of systems, there are sufficiently high returns to households which set up large systems. Hence subsidies for self-ownership of large systems (10 kWp and above) directly benefit rich households and should be avoided.

Table 3. IRR for case 3

	kWp	**IRR (%)**
Case 3	**2.5**	7.01
(Base Case)	**5.0**	12.1
	10.0	18.35
Case 3 (a)	**10.0**	14.72
Case 3 (b)	**10.0**	14.29

In the base case for third party owned systems, (when electricity is provided to the consumer at the same rate as the utility), the IRR for a 2.5, 5 and 10 kWp system is 7, 12 and 18.35% respectively. While 7% and 12% returns are too low to encourage investment by the third party, an IRR of 18.35% would be attractive for the third party. Results of case 3(a) show that in the case of a 10 kWp system, when a discount of 10% is given to the rooftop owner for purchase of electricity generated from the rooftop SPV, the IRR is 14.72% while for the fixed lease rental model it is 14.29%. As the expected rate of return for undertaking a project by a third party is assumed to be approximately 15%, a discount higher than 10% to the consumer, will lower the IRR for the third party and hence it may not be financially attractive for him to adopt the model.

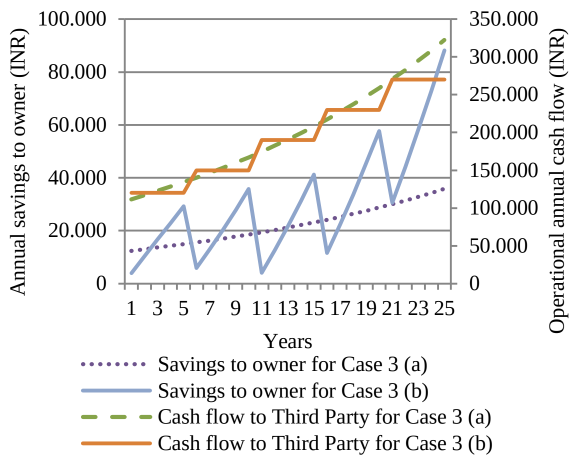

Figure 3. Benefits to third party and rooftop owners for different business models

Fig. 3 compares the savings to owners and operational cash flows for third party for cases 3(a) (shown in dotted lines) and 3(b). While the cumulative annual savings for rooftop owners and the operational annual cash flows for the third party are gradually rising in case 3(a), the technical and performance risks are borne mainly by the third party. Such an arrangement leads to variable cash flows for the third party as it is based on actual generation of electricity and its tariff (which is assumed to increase at 5% every year). This variable cash flow may not be an attractive business option for an entity that has to repay fixed debt costs. On the other hand, in case 3 (b), although the cumulative operational cash flow to the third party is lower, it is assured of fixed cash flows, which rise in steps, thereby lowering the risk on returns. However this mechanism would result in shifting of technical and performance risks from the third party to the rooftop owner. This may not be acceptable to the rooftop owner who has to pay a pre-decided fixed amount as lease rental (irrespective of the prevailing cost of utility-supplied electricity). Hence there is a trade-off between risk and returns for both parties and a clearly drafted legal agreement which agrees on the mechanism and amount of payment is essential before undertaking such a project.

While the financial assessment has been undertaken using the promulagated salient features of the scheme, there are certain drawbacks in the scheme which have emerged from the above analysis and are highlighted below.

(a) The size of the solar panel has been limited to the connected load. For example, a household having 5 kW_P of sanctioned load can only install an SPV system of 5kW_P. Further, the maximum energy which a consumer can export to the grid is limited to 90% of the electricity which he consumes. As an example, if the customer draws 1000 units of electricity from the grid, then he can export upto a maximum of 900 units only to the grid. Any electricity generated above this quantity (at the end of the settlement period) will not be carried forward to the next financial year and would be considered as free energy which is injected into the grid. This cap is presumably introduced primarily due to three reasons:

(i) To encourage the utility to absorb the generated power without excessively losing out on its fixed revenue stream.
(ii) To avoid overflowing of energy accounting issues to the next financial year.
(iii) To limit the flow of electricity to available capacity of the service line so as to avoid overloading at any time.

This limitation has certain important implications which are discussed here.

The paper assumes that upper middle class houses have 1000-2000 sq. ft of rooftop space per house and have an average monthly consumption of 400-600 units of electricity. A 2.5 kW_P system will therefore occupy only 375 sq ft of space (150 sq. ft per kWp). This will have a maximum output of (2.5 kWp x 24 h x c.u.f x 30 = 288 to 342 kWh of electricity generated per month (first number corresponds to a c.u.f of 16% while the second number corresponds to a c.u.f of 19 %). However, due to the 90% cap on electricity export, the owner is entitled to claim only 180 to 270 units of electricity which results in an unpaid amount for 108 to 72 units. It can be argued that a smaller sized system should be used, but even a 2.5 kWp system uses only 25% of the available rooftop space and hence there is suboptimal utilization of rooftop space. In case the residential plot has four floors with independent houses, a larger system can be installed on the rooftop. The case of a 2.5, 5 and 10 kWp system is shown in Table 4.

Table 4. Suboptimal utilization of area and unpaid units for different system sizes

Installed capacity (kW_P)	No. of floors	Required area (sq. ft)	Monthly output from SPV (kWh)	Total monthly electricity	Electricity eligible for export (kWh)	Unpaid Units (kWh)
2.5	1	375	288-342	400-600	180-270	108-72
5.0	4	750	576-684	1600-2400	720-1080	NIL
10.0	4	1500	1152-1368	1600-2400	720-1080	448-288

Table 4 show that while a 5 kWp system fully utilizes the generated electricity, it leads to suboptimal utilization of rooftop space. If the system size is increased to 10 kWp, the rooftop space is fully utilized but excess electricity is generated and therefore 288 to 448 units of electricity would be unpaid. This discussion shows that while sizing of a system is extremely important, the cap on 90%, for export of electricity, discourages optimum utilization of roof space and lowers the rate of return from the rooftop SPV plant. In effect, the above regulation only encourages self-consumption and does not promote electricity generation for import to the grid.

(b) The limitation of injection of power to 15% of the capacity of the utility transformer (though subject to revision at a later date) is indicative of protecting the interest of utilities which may lose out on revenues from sale of electricity. It is evident that there are no technical restrictions as the approved limit is 30% for Tamil Nadu and 50% in the case of Andhra Pradesh and Kerala [18].

(c) As the RPO mechanism has not been enforced strictly, there is no incentive for the utility to encourage solar rooftop generation by customers and absorb the excess power generated from SPV system. However, if the RPO mechanism is enforced strictly, the electricity purchased by utilities will qualify as deemed RPOs to meet their solar RPOs. This will be the cheapest way for a utility to fulfil its RPO obligation.

(d) Bankability of domestic solar rooftop projects is relatively low as the small size of the systems makes this an unprofitable sector for the banks. Further, the poor financial health of the distribution companies (DISCOMs) also weighs negatively on the mind of the financers. Hence, while funding is limited for startup solar companies, favours are shown for large vertically integrated companies, which have other assets as collateral. In such a scenario, governments and the financing intermediaries such as Indian Renewable Energy Development Agency (IREDA) can play the role of an enabler by providing loans at lower interest rates.

7. Conclusion

Rooftop SPV program has a great potential to ease the energy deficit in India. Technical feasibility of the net metering model has already been proved in various states in India as well as in other countries. Analysis of IRR for self owned systems indicate that with the current costs, smaller systems (2.5 and 5 kWp) are suitable only for self ownership, but require 30% subsidy in order to be financially viable. However, the return on larger (10 kWp and above) self-owned systems is sufficiently high and therefore do not warrant the government provided subsidy. On the other hand, third party ownership not feasible for smaller systems, even with 30% upfront subsidy. However, returns on larger (10 kWp and above) systems are sufficiently high to attract third party ownership. Analyses of different business models for third party ownership reveal that there are inherent uncertainties in the assumption of parameters (such as annual escalation in the price of electricity) and hence both, the rooftop owner and the third party would favour a model which gives them a fixed, albeit lower, returns. In the face of moderate returns, this uncertainty acts as a hurdle for widespread deployment of rooftop SPV. Various caps on export of generated electricity in the grid discourage the optimum utilization of roof space and limit the potential for surplus generation of power. We can therefore conclude that while various business models are financially feasible, the net metering model for rooftop SPV projects may be more successful, provided these limitations are relaxed and the applicable regulations for residential spaces in Delhi are modified suitably.

List of abbreviations

AD:	Accelerated Depreciation
BIPV:	Building Integrated PV
c.u.f:	Capacity Utilization Factor
CAD:	Current Account Deficit
CFA:	Central Financial Assistance
DISCOM:	Distribution Company
DERC:	Delhi Electricity Regulatory Commission
EBIDTA:	Earnings Before Interest, Depreciation, Tax And Amortization
EPC:	Engineering Procurement Construction
FIT:	Feed In Tariffs
FY:	Financial Year
GBI:	Generation Based Incentives
GoI:	Government of India
IREDA:	Indian Renewable Energy Development Agency
IRR:	Internal Rate of Return
JNNSM:	Jawahar Lal Nehru National Solar Mission
LCOE:	Levelised Cost Of Energy
MNRE:	Ministry of New and Renewable Sources of Energy
NAPCC:	National Action Plan on Climate Change
NPV:	Net Present Value
O&M:	Operation & Maintenance
PPA:	Power Purchase Agreement
PPP:	Public Private Partnership
REC:	Renewable Energy Certificate
RPO:	Renewable Purchase Obligation
SECI:	Solar Energy Corporation of India
SPV:	Solar Photo Voltaic
T&D:	Transmission & Distribution
ToD:	Time of Day
UI:	Unscheduled Interchange
W:	Watt

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Appendix

Table 1. Electricity tariff slabs for FY 2013-2014 and FY 2014-2015 applicable for Delhi [19]

FY 2013-2014		**FY 2014-2015**	
Units consumed	**Rs/kWh**	**Units consumed**	**Rs/kWh**
0-200	3.9	0-200	4.00
201-400	5.8	201-400	5.95
401-800	6.8	401-800	7.3
Above 801 units	7.0	801-1200 units	8.1
		Above 1201 units	8.75

Table 2. Components of electricity bill approved by DERC for FY 2013-2014 [19]

Name	**Nature of charge**	**Type**	**Charges**
A	Demand charge	Upto 2 KW Fixed for 2-5 KW Above 5 KW	Rs 40/month Rs 100/ month Rs 25/KW/month
B	Energy Charge	Based on units consumed	Slab wise
C	*Power* Purchase Cost Adjustment Charges (PPAC**)**	-do-	6% of B
D	Surcharge	-do-	8% of (A+B)
E	Electricity Tax	-do-	5% of (B+C+D)