Solar Rooftop PV in India

Need to prioritize in-situ generation for self consumption with a net-metering approach

Prayas Policy Discussion Paper, November 2012

Prayas Energy Group

Solar Rooftop PV in India

Need to prioritize in-situ generation for self consumption with a net-metering approach

November 2012

Policy Discussion Paper

Authors

Ashwin Gambhir
Shantanu Dixit
Vishal Toro
Vijaypal Singh

प्रयास
Prayas Energy Group

About Prayas

Prayas (Initiatives in Health, Energy, Learning and Parenthood) is a non governmental, non-profit organization based in Pune, India. Members of Prayas are professionals working to protect and promote the public interest in general, and interests of the disadvantaged sections of the society, in particular. The Prayas Energy Group works on theoretical, conceptual regulatory and policy issues in the energy and electricity sectors. Our activities cover research and intervention in policy and regulatory areas, as well as training, awareness, and support to civil society groups. Prayas Energy Group has contributed in the energy sector policy development as part of several official committees constituted by Ministries and Planning Commission. Prayas is registered as SIRO (Scientific and Industrial Research Organization) with Department of Scientific and Industrial Research, Ministry of Science and Technology, Government of India.

Prayas (Energy Group)
Athawale Corner,
Karve Road, Deccan Gymkhana,
Pune 411 004
Phone: 020 - 6520 5726; Fax : 020 - 2542 0337
E-mail: energy@prayaspune.org;
Website: http://www.prayaspune.org/peg

The authors would like to thank Dr S P Gon Chaudhari, Hemant Lamba, Ajit Pandit, Ranjit Deshmukh and Akhilesh Magal for giving valuable comments and suggestions on the first draft of this paper. We also thank our colleagues at Prayas Energy Group for their support at all stages.

For Private Circulation
November 2012

Printed by:
Shailesh Art Print, 136, Narayan Peth, Sitaphalbagh Colony,
Pune – 411 030 Tel: 020-24481052

Abstract

While the Jawaharlal Nehru National Solar Mission (JNNSM) opened up the solar electricity sector in India, the focus has primarily been on large-scale grid-connected power plants. With the drastic fall in prices of solar photovoltaic (PV) modules and balance of systems (BOS) on the one hand, and the high and rising tariffs of certain consumer categories in India on the other, grid-connected solar Rooftop PV (RTPV) systems are becoming increasingly viable economically. RTPV systems can offer substantial benefits in terms of providing peaking supply of power, reducing T&D losses, improving tail end voltages, and creating local jobs. Considering the existing governance and M&V structures in India, this paper argues that a balanced approach for all stakeholders for promoting RTPV would be to adopt a national policy of 'net-metering' to encourage in-situ generation primarily for self consumption, coupled with the provisions of grid inter-connection and energy banking facilities from the local utility. RTPV systems should not be subsidised through capital subsidies which would add to the budgetary deficit and limit their adoption. They should also not be allowed to qualify for the Renewable Energy Certificate (REC) mechanism, which would result in windfall profits and go against the spirit of the REC mechanism, thus defeating the core purpose of facilitating RTPV. Instead, we propose that tariffs of commercial and high-end residential consumers should be aligned with those of RTPV costs, thereby incentivising them to shift to solar or pay the full marginal cost of supply. On the one hand, policy should focus on the removal of procedural hurdles, permitting, and other barriers in order to facilitate the quick adoption and deployment of RTPV systems. On the other hand, policy should be pro-active towards creating avenues for low-cost financing, and allowing innovative models of third-party ownership and leasing, aggregators, etc. to expedite cost reduction. To operationalise net-metering for RTPV, the Ministry of New and Renewable Energy (MNRE) should bring a national policy on net-metering, while the Central Electricity Authority (CEA) should specify metering arrangements specifically for RTPV and their finalised grid interconnection standards for distributed generation sources should be notified by Ministry of Power (MoP). Similarly, the Forum of Regulators (FOR) should recommend standard guidelines including model regulations and agreements, and specify a very clear and simple institutional structure (a simplified version of the REC accreditation process) with details of energy accounting, billing, M&V, and mechanisms for inter-connection and dispute redressal. Finally, we believe that such a net-metering approach to RTPV promotion is ideally suited for India, since it is socially equitable (high energy using consumers pay for solar thus preventing the incremental costs of solar electricity generation from being passed on to everyone), economically viable (avoided consumer tariffs are at par with solar PV), and environmentally sustainable (through the use of solar PV, a renewable resource in the grid-connected mode, thus avoiding the use of batteries).

Contents

Figures

Tables

Box

Rooftop PV Systems

Introduction

There is an increasing focus on the development of solar energy in India for a variety of reasons, including our limited conventional energy reserves, their local environmental and social impacts, energy security, climate change and energy access. The Jawaharlal Nehru National Solar Mission (JNNSM) was envisaged as one of the eight missions under the National Action Plan for Climate Change (NAPCC). The first phase of the mission will come to a close by March 2013. A total of 1300 MW (1100 MW grid-connected and 200 MW off-grid) capacity is targeted for the phase I of the solar mission. Large MW scale grid-connected projects were selected on the basis of competitive bidding with the Central Electricity Regulatory Commission (CERC) determined feed-in-tariff (FiT) acting as a ceiling rate. In the last few years, MW scale grid-connected PV electricity tariffs have reduced dramatically from Rs. 17.91/kWh to as low as Rs. 7.49/kWh, which was the lowest winning bid in batch 2 of the phase I bidding for PV under the JNNSM. India presently has an installed capacity of 1030 MW of PV [1], mostly in the form of large grid-connected PV plants. In recent years, there has been a dramatic price drop in solar PV systems worldwide, with over a 50% drop in only the last two-three years.[2] This in turn has allowed for a high deployment of PV systems worldwide, resulting in a cumulative PV capacity of 69 GW by the end of 2011, and averaging an annual growth rate of 44.5% over the last 10 years.[3] The total new investment in solar power was to the tune of $147 billion in 2011 alone, an increase of over 50% compared to 2010 levels.[4] According to most predictions, cost reductions in PV will continue further, although not at such a rapid rate. Such price reductions coupled with the ever increasing price of conventional fossil fuels, appear to bring the holy grail of PV, grid-parity, closer to reality much faster than one could have predicted. These developments have led to an increasing interest in RTPV systems as a self consumption source of power in India.

Rooftop PV (RTPV) systems are PV systems installed on rooftops of residential, commercial or industrial premises. The electricity generated from such systems could either be entirely fed into the grid at regulated feed-in-tariffs, or used for self consumption with the net-metering approach. A net-metering mechanism allows for a two-way flow of electricity wherein the consumer is billed only for the ‘net’ electricity (total consumption – own PV production) supplied by the DISCOM. Such RTPV systems could be installed with or without battery storage, and with one integrated net meter or two separate meters, one for export to grid and one for consumption. Irrespective of the commercial arrangement, RTPV systems offer several advantages. These include,

- Savings in transmission and distribution (T&D) losses
- Low gestation time
- No requirement of additional land
- Improvement of the tail-end grid voltages, and reduction in system congestion with higher self consumption of solar electricity
- Local employment generation

In this brief policy discussion note, we discuss the need for and advantages of emphasising rooftop PV with net-metering as a self consumption power source in India, especially in large cities. We begin with a short overview of the global and Indian rooftop PV scene, and then discuss the challenges of the feed-in-tariff approach to rooftop PV.

Overview of the global and Indian experience

The international experience

Japan, USA and Germany were the early leaders in adopting RTPV systems, while Italy, Australia[5] and China have seen strong growth in recent times. The European Photovoltaic Industry Association (EPIA) estimates that 40% of the EU's total electricity demand by 2020 could technically be met by RTPV (1500 GWp producing ~ 1400 TWh).[6] Similarly, a 2008 study from the National Renewable Energy Laboratory (NREL), USA estimated that RTPV could technically generate 819 TWh/yr (through 661 GW), which would roughly be 22% of the total demand for electricity in the USA in 2006.[7] While the FiT route is the norm in Europe, the net-metering arrangement is more popular in the USA.

Germany [8] and Italy have the highest cumulative installed PV capacity with 24.6 GW and 12.7 GW respectively as of 2011. Over 60% of the capacities in both countries are in the form of RTPV systems, both in the residential and commercial segments. In Europe, of a total of 50.6 GW PV capacity, over 50% (26 GW) is in the rooftop segment.

Until 2010, Germany was the lead global market for solar PV, mainly due to the high FiTs in place. However, due to over-heating of the German PV market, higher cuts in the FiTs were being discussed to limit the growth of PV to sustainable levels. As per the latest revision to solar FiTs in Germany, tariffs will be revised on a monthly basis, and range between 12.71-18.36 eurocents/kWh (depending on the size of the system) for systems installed in October 2012. Earlier, there were two types of RTPV FiTs (depending on whether the electricity was sold to the public grid or consumed locally). Italy too has a policy of FiTs guaranteed for 20 years. From June 2011, tariffs began to be revised on a monthly basis. Italy also allows for a 30% premium for rooftop systems if installed in conjunction with energy efficiency measures.[9] For details on the tariff structure, please see the PV Status Report, 2011.[9]

Net-metering laws which enable and incentivise self consumption now exist in at least 14 countries, with Spain and Brazil adopting this approach most recently.[10,11] Net-metering is popular in the USA[12] (43 states have it in place, but specific rules vary from state to state), and the Energy Policy Act of 2005 further mandates all public electricity utilities to make net-metering option available to all their customers. As of 2010, the USA had about 1.5 lakh net-metering consumers. California has been by far the leading solar rooftop market in the USA, and by the end of 2011, had more than 1000 MW of installed on-site customer generated solar capacity from 115,000 sites. These are primarily net-metering consumers (101,284 consumers with 991 MW).[13]

The Indian experience

Though the solar rooftop segment in India is relatively nascent, it is developing fast, and has a strong growth potential. While it is difficult to accurately estimate the potential for RTPV in India, recent estimates indicate a potential in the range of 20 GW to 100 GW.[14,15] The JNNSM mission document refers to both forms of commercial arrangements for rooftop PV, namely net-metering and sale to utility through preferential FiT. Under the mission strategy, section D on R&D discusses demonstration plants, namely 'Grid-connected rooftop PV systems on selected government buildings and installations, with net-metering'. It also seeks to encourage rooftop PV (connected to the LT/11kV grid) procurement by utilities allowed for Renewable Purchase Obligation (RPO) fulfillment at the State Electricity Regulatory Commission (SERC) determined FiT for the entire metered generation, whether for self consumption by the owner or for feeding into the grid. To operationalise the FiT procurement model, official guidelines for rooftop PV and the Small Solar Power Generation Programme (RPSSGP) were issued on 16th June, 2010. According to the latest available information, projects with a capacity of 98 MW have signed PPAs, and those with a capacity of 82.55 MW have already been commissioned. However, nearly all of these projects have come up as ground-mounted small solar power generators and not as rooftop projects.[16]

Reports indicate that the Ministry of New and Renewable Energy (MNRE) is in the process of formulating a new rooftop policy based on net-metering, including consideration of a capital subsidy.[17] It might begin with facilitating the setting of upto 10 MW of rooftop PV which would be based on the concept of 'rent-a-roof', that is, the owner may rent the roof to the project developer, who in turn would sell the electricity to the utility.[18]

Initiatives in Indian states and cities

West Bengal: The state has initiated a net-metering solar rooftop model promoting self consumption. Under the WBERC Regulations[19], grid-integrated rooftop PV is allowed only for institutional consumers like government departments, academic institutions, etc., with the system size limited to 2-100 kW. Connectivity is allowed at Low Voltage or Medium Voltage, or 6 KV or 11 KV, of the distribution system of the licensee. Solar injection is permitted only upto 90% of the annual electricity consumption, and the net energy supplied by the utility would be billed as per existing slab tariffs, i.e. solar generation would first offset consumption in the highest tariff slab and then the lower slab. Additionally, under the recently passed West Bengal Renewable Energy Policy, buildings with a certain minimum load will have to meet some electricity needs through RTPV.[20] The policy targets 16 MW of rooftop and small PV installations by 2017.

Gujarat: The city of Gandhinagar has initiated a 5 MW rooftop PV programme based on a FiT / sale to utility model.[21] Under this programme, 4 MWs would come up on government buildings, while 1 MW would be installed on private homes. Two project developers for 2.5 MW capacity each have been selected through the process of reverse competitive bidding (in which a bidder offering the highest discount from a ceiling tariff is selected), with the GERC rooftop tariff of Rs. 12.44/kWh acting as a ceiling. The local utility, Torrent Power, will purchase the entire solar power at the discovered price. ‘Torrent Power, a private utility, will buy power from Azure at 11.21 rupees per kilowatt-hour for 25 years. Azure, in turn, will pass on 3 rupees per kilowatt-hour to rooftop owners'.[22] Thus, the effective price of solar without the rooftop rent is only Rs. 8.21/kWh. Given the success of the Gandhinagar programme, 5 more cities in Gujarat will also be following the rooftop model, namely Bhavnagar, Mehsana, Rajkot, Surat and Vadodara.[23] Ahmedabad has started installing pilot rooftop projects most recently.[24] For more details on this programme, please see[21]

Karnataka: Under the new Karnataka Renewable Energy Policy 2009-14, the state seeks to promote rooftop PV with net-metering. Section 10(v) notes the allowable system size range to be 5-100 kWp, and interconnection at 415 V, 3 phase or 11 kV. Maximum energy injection is allowed only upto 70% of the customer’s energy usage from the DISCOM. Further, according to the policy, ‘any injection in a billing period exceeding 70% of the consumption will be treated as inadvertent and will not be considered for commercial purpose; neither the deficit is carried forward to next billing period. Such injection will be settled on Net Basis with the consumption of the said consumer from the distribution licensee’s source in each billing period.’ Section 13(vi) also encourages rooftop PV with a net-metering facility to feed surplus power to the grid. According to the policy, the Solar Karnataka Programme is targeted for 25000 Solar Roof Tops of 5 to 10 kWp with Net-Metering, which will be taken up with a 250 MW potential during the next 5 years with a generation potential of 350 MU.[25] Under the new Green Energy Fund, rooftop grid-connected solar projects will be encouraged, and the first pilots may come up in the cities of Mysore and Hubli-Dharwad.[26]

Tamil Nadu: Under the recently released state solar policy-2012, a target of 350 MWs of RTPV to be installed in three years from 2013-15 has been approved. 50 MW of RTPV would be supported through a generation based incentive (GBI) of Rs. 2/kWh for the first two years, Re. 1/kWh for the next two and Rs. 0.5/kWh for the subsequent two years will be provided for all

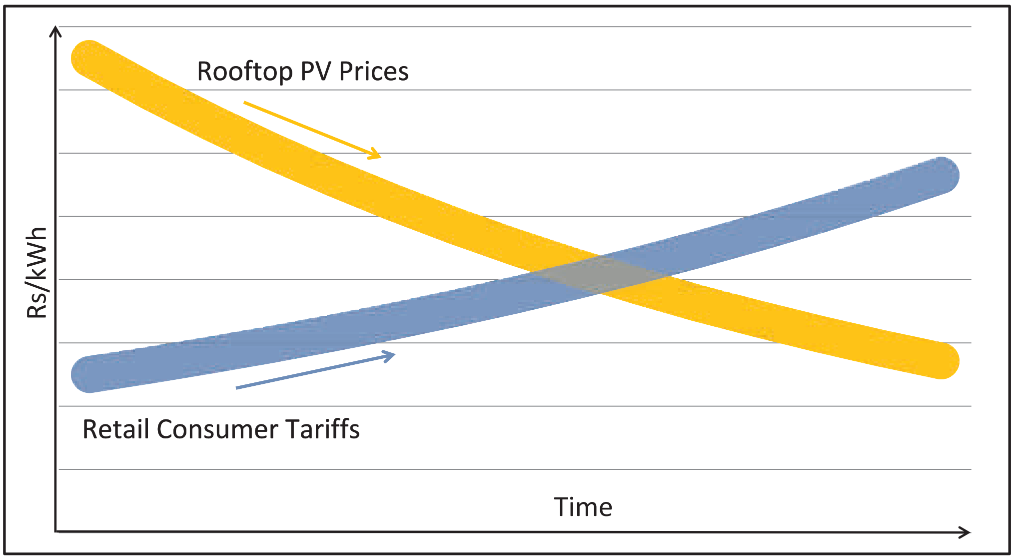


Figure 1: Likely evolution of Rooftop PV prices and consumer tariffs with time

solar installations completed before 31st March 2014.[27] For more information on RTPV in Tamil Nadu please see .[28,29]

Other states like Rajasthan under its solar policy 2011[30], Andhra Pradesh, Chattisgarh and Odisha are also considering rooftop PV policies or programmes.[16] Similarly, some cities are also going forward with pilot projects.[31]

The need for a dynamic policy approach

The PV sector is in a very dynamic phase of its evolution, considering the rapid changes in prices and technology development. The policy approach for such a sector needs to be equally dynamic and evolving. For example, the public policy approach for solar PV before and after it achieves grid parity will have to be different.

Considering the falling prices of PV, the expectation of a further significant reduction in the years to come[32] on the one hand, and the rising consumer tariffs on account of higher prices of fossil fuels on the other, makes for very interesting policy analysis. The expected trends for rooftop PV prices and retail consumer tariffs are depicted in the schematic Figure 1. We have the downward sloping band representing rooftop prices varying (within the band at a particular time) according to location (insolation), size and profitability expectations. Also, we have the upward sloping band representing consumer tariffs varying according to the type of consumer (residential, commercial, industrial) and the quantity of energy consumed. Hence there is not one unique point of grid parity but a space wherein a certain category of consumers at specific locations will achieve parity over time. At present in 2012, considering the existing consumer tariffs and current solar costs, we are bordering on entering this parity space. Policy needs to achieve a fine balance between promoting RTPV for its societal and systemic benefits, while at the same time limiting incremental societal costs and avoiding windfall gains to developers or particular consumers. In this dynamic environment, policy formulation needs to be nimble and flexible to allow for quick corrections, since the interests and motivations of various stakeholders in the time prior to the parity space and after will be significantly different. Policy formulation needs to take these critical considerations into account.

Challenges and limitations of the Feed in Tariff (sale to utility) approach

Some states have recently introduced FiTs specifically for RTPV. For example, the Maharashtra Electricity Regulatory Commission (MERC) has fixed a price of Rs. 11.66/kWh[33] for projects not availing accelerated depreciation, while the Gujarat Electricity Regulatory Commission (GERC) has fixed it at Rs. 12.44/kWh.[34] The Central Electricity Regulatory Commission (CERC) too has introduced draft guidelines on setting tariffs for rooftop PV. [35]

There are several concerns with the FiT approach to RTPV, some of which are listed below:

Higher Monitoring, Verification (M&V) and governance challenges:

One of the key concerns about the FiT approach to RTPV is about the DISCOM's ability to monitor and verify the process adequately. Weak metering at the consumer end has been a perennial challenge for several Indian utilities. The table below shows the metering status in Pune urban circles, where losses are relatively low (Aggregate Technical and Commercial Efficiency (ATCE) between 81.76-85.96% for April -May 2012). Close to 11% of meters in the residential, commercial and industrial consumers status are faulty, show a zero reading, or average billing. Such data does not inspire much confidence in the ability of the utilities to undertake adequate metering and monitoring of RTPV systems. This is especially critical, since in the case of RTPV, the FiT utility will have to pay such consumers at very attractive rates (over Rs. 10 / unit). In fact, such concerns have led to the Delhi RTPV policy being shelved. According to a recent article, "Delhi, which had proposed a rooftop programme with feed-in tariffs as incentives, recently said it had given it up, because of the question 'what if somebody produces electricity using a diesel genset and claims higher feed-in tariff meant for solar-generated power?' ".[36] The FiT could be misused in other ways too, such as feeding back utility supply, generation from subsidised fuels, etc. However, reducing solar prices and increasing diesel prices may make such a situation very improbable.

Table 1: Metering status for urban Pune consumers in March 2012

Consumer Category	Zero Reading	%	Average Reading	%	Faulty Reading	%	Total Zero+ Average+ Faulty	%	Total Consumers
RESIDENTIAL	69,549	5.4%	38,245	3.0%	25,744	2.0%	133,538	10.4%	1287461
COMMERCIAL	14,833	8.1%	7,921	4.3%	4,342	2.4%	27,096	14.8%	182471
INDUSTRIAL	2,741	10.2%	0	0.0%	12	0.0%	2,753	10.3%	26791
TOTAL :	87,123	5.8%	46,166	3.1%	30,098	2.0%	163,387	10.9%	1496723

Source: MSEDCL, data for Pune urban circles (Ganeshkhind and RastaPeth)

Higher burden on the utility:

RTPV systems are generally small in size and therefore their cost of electricity per kWh tends to be slightly higher than large grid-connected MW scale solar projects. Hence, it makes more sense for utilities looking to fulfill their RPO mandate to procure power from large PV projects with lower tariffs. The higher RTPV tariffs translate to higher burden on the utilities, whose financial health is already precarious.

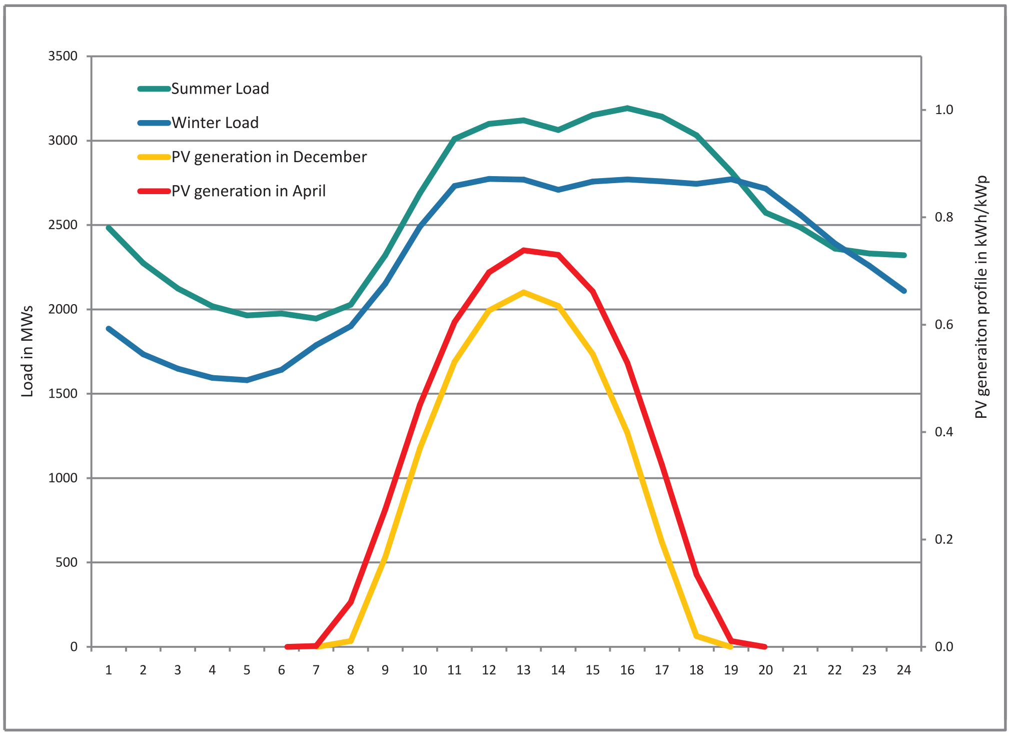
Difficulty in estimating appropriate Feed in Tariffs:

Estimating appropriate FiTs for RTPV is inherently quite difficult given the paucity of publicly available information, rapid technological development, the dynamic market conditions and the information asymmetry. GERC declared an FiT of Rs 12.44/kWh assuming a total cost of a rooftop PV system including installation at Rs 120/W (50% - PV panels & 20% - inverters[37]). To compare with Germany (where prices have reduced by 65% over the last 6 years), the 2012 second quarter prices of systems less than 100 kW were roughly 1.776 Euro/W[38] (i.e. Rs. 124.3/W at an exchange rate of Rs. 70/Euro). While FiTs are based on estimates of capital costs and other parameters, the recent selection of two companies under the competitive reverse bidding route in the Gandhinagar rooftop programme revealed much lesser prices in comparison to FiTs. Azure Power is developing 2.5 MW rooftop projects at their winning bid of Rs. 11.21/kWh, from which Rs. 3/kWh would be passed on to the rooftop owner, resulting in a net solar price of Rs. 8.21/kWh.[39] Bidding for a 100 kW rooftop system at the Raipur airport, on 9th April 2012, discovered a price of Rs.8.87/kWh (levelised with a discount rate of 10.62%).[40] Anecdotal evidence suggests that RTPV costs have gone down further and are presently estimated to be about Rs. 85-90/W. This underscores why the FiT route is not appropriate for RTPV.

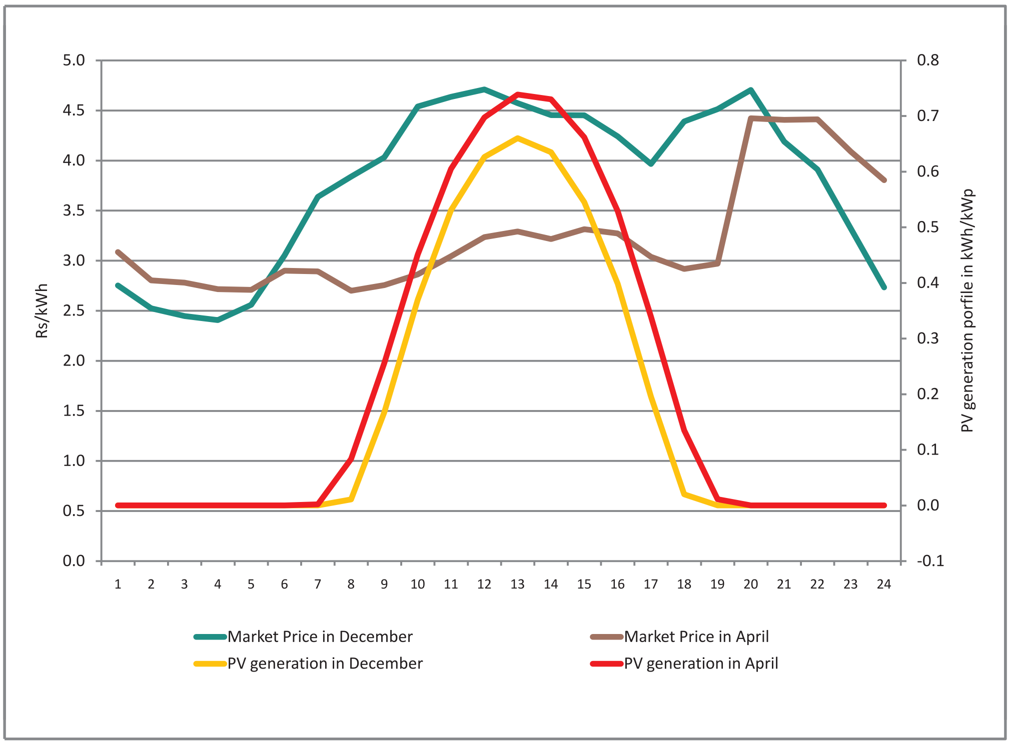
Rooftop PV approach based on prioritising self consumption with net-metering

Due to the challenges and limitations mentioned above, it is desirable to move away from the FiT route for RTPV, and prioritise the self consumption of RTPV with net-metering, as has been the approach in West Bengal. According to this approach, utilities should allow grid connection and provide banking facility for RTPV systems (as is provided for wind power in certain states), rather than providing any financial support or FiT. With net-metering, consumers would install RTPV and first use the solar generation for their own consumption, and feed in only excess RTPV generation into the utility grid. They will continue to draw their power requirement from the grid as and when needed. At the end of the billing period, excess RTPV power fed into the grid will be deducted from the power supplied by the DISCOM during the billing period, and the remaining ‘net’ consumption will be charged at normal tariff slabs. Thus, RTPV power will be used to offset consumption from the marginal tariff slab for the consumer. In case the RTPV generation is more than the total consumption of the consumer during the billing period, the difference could be carried forward to the next period within a certain limit. In this approach, there is no actual financial transfer from the utility to the consumer, who is benefitted through an offset of marginal consumption. Also, normal consumption of the consumer as well as RTPV generation would be monitored through separate meters or special net-meters. Such measures would reduce the M&V and governance problems in the case of the self consumption route for RTPV through net-metering.

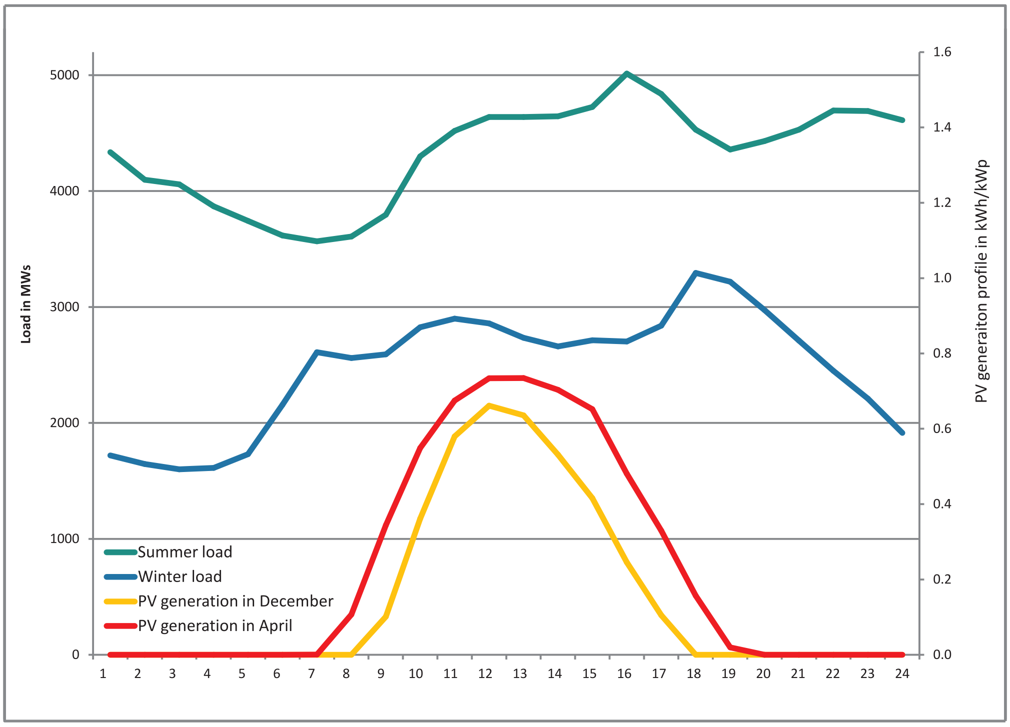
The viability of this approach would primarily depend on the underlying rate structures (tariffs and energy charges) and the amount of electricity use.[41] As Table 2 below shows, the RTPV generation cost is already competitive with consumer tariffs (only considering energy charges) in several Indian cities, even without factoring in the tariff increases in the future. Similarly, this approach would be more viable if certain new taxes like the service tax on electricity are taken into consideration.[42]



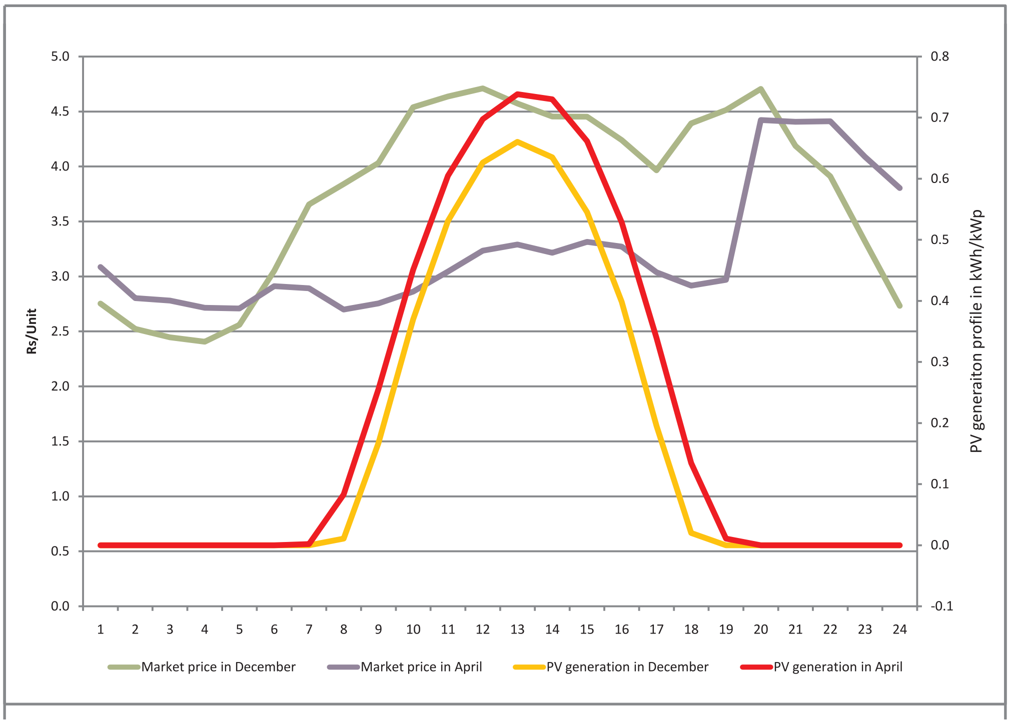
Figures 2 : Mumbai Summer and winter load curves and corresponding PV generation profiles



Figures 3 : Mumbai PV generation profiles and corresponding market rates



Figures 4 : Delhi Summer and winter load curves and corresponding PV generation profiles



Figures 5 : Delhi PV generation profiles and corresponding market rates

Source for figures 2-5:Solar generation profiles for Delhi and Mumbai has been simulated assuming a fixed c-Si system using NREL's Solar Advisor Model. Load curve data is from respective State Load Dispatch Centres (SLDCs), and market price data is from India Energy Exchange (IEX).

Table 2: Existing energy charges for residential and commercial consumers in various Indian cities

Consumer category	Energy charges (Rs./kWh) in major cities					
	Bengaluru	Hyderabad	Kolkata	Mumbai	New Delhi	Pune
Domestic (High end consumption)	5.60 (> 200 kWh)	6.75 (301-500 kWh); 7.25 (>500 kWh)	7.75 (> 300 kWh)	4.40 (Tatapower); 5.30 (BEST); 9.16 (Rinfra) (all > 300 kWh) 5.30 (Tatapower); 6.80 (BEST); 10.61 (Rinfra) (all > 500 kWh)	4.80 (0- 400 kWh); 6.40 (> 400 kWh)	7.92 (300-500 kWh); 8.78 (500-1000 kWh); 9.50 (> 1000 kWh)
Commercial	7.20 (> 50 kWh)	7.00 (> 100 kWh)	7.80 (> 300 kWh)	5.05 (Tata power); 9.80 (BEST); 10.91 (Rinfra) (all >50 kW)	7.25 – 8.50 (subject to load demand)	8.38 (0-20 kW; >200 kWh); 8.44 (20-50 kW); 10.91 (>50 kW)

Source : Compiled from various SERC tariff orders[44]

Consumers with high tariffs and high energy use would benefit most from installing RTPV. Bill savings from such avoided costs would determine the viability of rooftop PV with net-metering. Looking ahead, two reports have predicted a rooftop market of 2.3 GW by 2016, and between 4-5 GW in 2016-17. [43]

Penetration of air conditioners has increased in several Indian cities. As a result, load during the day is increasing (shifting of peak to daytime) in urban India, and is comparable to evening peak hours. Also, the summer load is much higher than monsoon or winter loads. In such a situation, RTPV is highly suitable to offset peak load at the consumer end, as the RTPV generation profile closely matches peak load times [Figures 2&4] and compares favourably with times in which average monthly market exchange prices are high [Figures 3&5]. Also, PV generation in the summer is 25% higher than that in the winter, and 50% higher than that in the monsoon for cities like Pune, which is in line with seasonal changes in demand in urban areas.

In order to facilitate RTPV systems for self consumption based on net-metering, the policies and regulations must co-evolve and provide an appropriate enabling framework for RTPV deployment. MNRE should bring out with a National Net-Metering Policy for Rooftop PV, with the primary objective of promoting self consumption as a priority, and allowing for feed-in of excess generation. Some important policy-regulatory considerations for such a net-metering approach are discussed below.

Tariff trajectory for high-end consumption in residential and commercial sectors:

At current levels, RTPV generation cost is likely to be in the range of Rs. 9-11/kWh depending on the location. Thus, at the consumer end, the utility supply tariff (energy charges) above this range would make it profitable for the consumer to shift to RTPV. The consumption of a typical Indian household which does not own an air-conditioner is unlikely to exceed 300 kWh/month.[45] As shown in Table 2, the energy charges (excluding monthly/fixed charges) for such high-end consumers (whose monthly consumption exceeds 300 kWh/month) are already in the range of Rs. 7-10/kWh for many cities. For such consumers, offsetting marginal consumption through RTPV is already profitable. To facilitate large-scale adoption of

RTPV for self consumption by high-end consumers, SERC's should set the tariff trajectory for residential and commercial consumers above 300 kWh/month consumption level so as to make the marginal tariff higher than the RTPV generation cost, say in a couple of years to avoid a tariff shock. On the one hand, this will give clear price signals to consumers, thus facilitating the deployment of RTPV. On the other hand, if consumers do not install RTPV, the high tariffs will support utility finances.

Interconnection and banking facility with grid: Since RTPV generation is dependent on solar insolation, it will not always match load, and some kind of storage would be required to use RTPV power when needed by consumers. Such storage, typically in the form of a battery (which has to be replaced every few years), will add to the cost of RTPV generation, and will also increase environmental impacts due to battery usage. To overcome this, it would be essential to connect RTPV systems to the grid. Interconnection with the distribution grid, even at low voltages, will allow RTPV generation to be fed into the grid during the high insolation period, and consumers can draw same amount of electricity when needed from the grid. Thus, the grid will act as a battery for RTPV consumers. This would not adversely affect the utility, at least until RTPV penetration becomes very significant, since RTPV generation typically has a high peak coincidence (see figures 2-5), would feed in during peak time (i.e. during the high power purchase rate period), and will draw power from the grid during peak and off-peak hours. This will also flatten the utility load curve.

Apart from these two important aspects, we now discuss other policy design considerations that need to be streamlined:

Billing cycle, roll-over, minimum size and electricity credit: It would be prudent to continue with the existing monthly billing cycle to avoid confusion. Hence, the consumer would be billed as per the existing tariff slab on his net consumption if PV generation is less than that withdrawn from the DISCOM. However, if PV generation is higher than overall withdrawal from the utility (which is probable in summer months), a roll-over of such monthly credit should be allowed upto one year. This is essential to balance out higher generation in the summer, and to allow system sizing to meet annual energy needs rather than the peak demand. Further, if at the end of one year, PV generation is still more than withdrawal from the grid, a maximum of say 10% of annual consumption may be allowed to be carried forward to the next year. This would take care of yearly variation in insolation and demand. Any excess electricity fed into the grid may not be carried forward, and thereby lapse without any compensation. Minimum system size could initially be set at 1-2 kW, and should be decided on technical considerations from the grid perspective and associated transaction costs.

Other Incentives: As we have seen from Table 2, consumer energy charges are already very close to RTPV prices. With solar PV prices expected to drop further, RTPV is expected to achieve grid parity in the near future. Hence, instead of further subsidising the system cost through capital subsidies and adding to the budgetary demand, policy should focus on removal of procedural hurdles, permitting, and other barriers, in order to facilitate the quick adoption and deployment of RTPV systems. According to Drury, E. et al., "Recent studies have found that residential customers weigh several factors in addition to system prices or revenues when considering a potential investment in PV or energy efficiency products. Social marketing studies have found that energy-related decisions are typically less about motivating customers than helping customers overcome barriers to taking actions that are consistent with their motivations".[46] Comprehensive stakeholder consultation would expedite the understanding of potential barriers and roadblocks. One important barrier to overcome could be in the case of common ownership of a building roof. In such a situation, virtual net-metering[47] as has been tried in California could be thought of.[48] Another enabling provision could be that of aggregate metering.[49] A pro-active approach towards creating avenues for low-cost financing and allowing innovative models of third party ownership, leasing, renewable energy service companies (RESCOs), aggregators, etc. can expedite cost reduction. Policy and regulation should aid in the development of the RTPV ecosystem, thereby accelerating the deployment of RTPV in consumer categories where parity already exists or will come about very shortly.

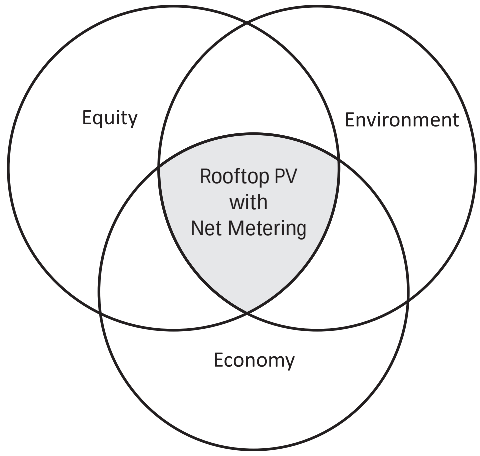
Renewable Purchase Obligation (RPO) and Renewable Energy Certificate (REC) : Utilities should not be allowed to claim RPO benefit for rooftop PV because investments are not done by the utility, but by individual consumers, and the utility is not purchasing the electricity. Similarly, the central objective of promoting RTPV based on net-metering is to incentivise and facilitate self generation and consumption, thereby avoiding T&D losses and providing distributed local peak supply. Similarly, RTPV (for self consumption) should not qualify for REC. The REC mechanism was instituted mainly for large grid-connected RE projects to overcome the geographical resource variation in states, and is not meant to be an added incentive as is made out at times. The solar resource for PV is abundantly available throughout the country, and hence allowing RECs for RTPV based on net-metering goes against the spirit of the REC mechanism. Additionally, wind fall gains are inevitable if the REC mechanism is allowed for rooftop PV with net-metering, as the consumer would offset energy charges at ~ Rs.8-9/kWh, gain a minimum REC benefit at Rs.9.3/kWh (floor price until 2016-17), even though the RTPV price would be ~ Rs. 8-10/kWh.[50] In general, as a principle, no additional benefits should be allowed for any RE generator (for self consumption) whose cost of generation is lower than the shadow consumer tariff.[51] Hence, REC should not be allowed for RTPV systems.

Going forward, given the rising costs of conventional power and the anticipated further decreases in costs of solar, there is a possibility of large-scale deployment of solar RTPV in the future. Hence, each utility should carry out detailed planning studies for both technical (to decide on how much RTPV can come up in each area) and financial reasons (for possible loss of high paying consumers who might opt for RTPV[52], and the resulting tariff implications for other consumers). The last issue needs to be studied comprehensively, since there is the added pressure on utilities from consumers opting for open access.

Rooftop PV for self consumption with net-metering: Aligning Equity, economic and environmental concerns

The Indian power sector is facing multiple crises, ranging from financial viability of distribution utilities to the challenges in ensuring electricity for all while trying to reduce adverse local socio-environmental impacts. Such a scenario requires innovative policies which can help address more than one crisis. Promoting RTPV for self consumption is one such policy approach.

Figure 6: Rooftop PV policy, a case for sustainable development



Equity: The suggested tariff approach would only require commercial outfits and households with high energy consumption owing to AC usage (consuming > 300 kWh/month) to either adopt RTPV or pay much higher tariff. This in turn would free up electricity generated from precious natural resources (i.e. coal-based thermal power) for the benefit of the needier populace, and thereby reduce shortages/load shedding. If consumers do not shift to RTPV, it could raise financial resources for utilities, thus enabling them to absorb the higher cost of fossil-fuel based generation for consumers with lower tariffs. The higher incremental cost of RTPV electricity would not be passed on to all consumers, which will make the approach more equitable.

Economy: Net-metering is economically viable for consumers with high levels of energy usage and high avoided tariffs, and further provides cost certainty over the lifetime of the project. Additionally, it is well accepted that current fossil fuel based power is unsustainable, and in the long term, a shift to renewable sources is inevitable. Hence, the suggested approach essentially implies that high-end domestic and commercial consumers would have to pay a long-term marginal price for electricity. Such an approach based on a long-term marginal price is economically efficient as it forces consumers to pay the real cost of electricity, and would require consumers to use electricity more judiciously. Also, since the investment decisions will be made by the consumers, this will help avoid many 'governance' and 'agency' problems of the utility deciding on behalf of consumers. The net-metering approach will also be economically efficient as it would not involve any subsidy from tax payers or rate payers.

Environment : Since RTPV is a renewable source of energy, does not require dedicated land, and saves on precious water use, it is an environmentally benign option. Further, with grid interconnection and banking facility, the use of batteries, which have significant environmental implications, is also avoided.

Box 1: Indicative potential and incremental cost for rooftop PV in Pune

In the last 5 years, (2007-08 to 2011-12), 27,479,718 m2 of floor space (commercial and residential) construction took place in Pune. Assuming an average of 8 floors per building, Pune has added new terrace area of 3,434,965 m2. Further, assuming that 20% of terrace area could be used for RTPV, and an area requirement of 10m2/kW, RTPV potential in Pune would be 70 MWs from the construction only in the last 5 years. This is roughly 6-7% of peak load in Pune (~1100 MW).

Air conditioner usage requires roughly 1000 kWh/yr/AC. Given that solar energy generation from an RTPV system in Pune is estimated at 1530 kWh/kWp/yr, each AC would need a 0.65 kW RTPV system to offset this energy consumption. Hence, if a house with 1000 sqft area goes for a 0.65 kW RTPV system, it would incur an additional cost of Rs. 0.55 lakhs (@ Rs 0.85 lakhs/kW), which translates to an additional Rs. 55/sq ft. Considering a base rate of Rs. 5000/sqft,, this is a 1.1% increase. Thus this quick calculation shows that cities like Pune which are undergoing large construction have significant potential for RTPV installations.

The way forward

As Box 1 explains, RTPV has significant potential to contribute to meeting peak load from urban areas. To realise this potential, several government and regulatory agencies will have to work in coordination. This section discusses measures which should be undertaken by different agencies.

Forum of Regulators and State Electricity Regulatory Commissions (SERCs): A set of standard rules and regulations (as far as possible) across the country would greatly reduce the soft transaction costs associated with RTPV permitting, and reduce the gestation time considerably. Additionally, grid-connected RTPV systems with net-metering for self consumption require interconnection and banking facility from utilities, and its approval by state regulatory commissions. Hence, FoR can recommend standard guidelines (model regulations, agreements, etc.) for the adoption of RTPV with net-metering. FoR may also recommend an appropriate tariff trajectory for commercial and high end residential consumers to be adopted by SERCs. Similarly, a very clear and simple institutional structure (simplified version of the REC accreditation process) with details of energy accounting, billing, M&V, inter-connection, dispute redressal mechanism, etc. should be specified. The roles and responsibilities of each stakeholder must be defined along with appropriate timelines. For all areas opting for RTPV, detailed 11 kV load data should be made available in the public domain. Such an approach would help to bring about greater transparency and accountability in the programme.

Ministry of New and Renewable Energy (MNRE): The Ministry should come out with a National Net-Metering Policy for Rooftop PV with the primary objective of promoting self consumption as a priority, and allowing for feed-in of excess generation. The MNRE's role will be critical in promoting RTPV with net-metering for self consumption, and hence should play a pro-active facilitative role in the removal of non-tariff barriers. This can include, through MNRE's state nodal agencies, building a supporting ecosystem of technicians, system integrators, O&M agencies, awareness and training programmes, and an engagement with FoR, SERCs and city municipalities. The MNRE should further commission studies to assess the solar rooftop potential in India. There are various methods for assessing rooftop potential, specifically based on census data, floor space construction data, etc. However the study should be based on high resolution GIS data in combination with solar radiation data to allow any potential consumer to estimate solar generation on any roof in India.[53] Such solar rooftop maps are already available for some cities in the west, notably the New York solar map.[54]

Central Electricity Authority (CEA): On the technical front, the reliable integration of rooftop PV in the distribution grid is a critical issue, especially in India, given its weak grid and frequent brownouts and blackouts due to persistent shortages. While CEA has finalised their draft[55] grid-interconnection standards for distributed generators, they still have to be approved and notified by the MoP. Ground experience with early pilot RTPV systems suggest that CEA should bring in further clarity on the definition of the interconnection point[56], and should appropriately change their existing metering regulations to account for rooftop connections at the distribution grid. An earlier CEA report details the various types of configurations and metering arrangements possible for rooftop PV.[57] While RTPV (distributed generation) is known to improve the reliability of the distribution grid [58], very high and quick deployment rates could result in some problems with the grid.[59] All such issues should be studied by CEA/utilities in the Indian context prior to large-scale deployment.[60]

Conclusions

Considering the increasing viability and multiple benefits of RTPV, this paper argues that a balanced approach for promoting RTPV would be to adopt a national policy of 'net-metering' to encourage in-situ generation primarily for self consumption. Instead of further subsidising RTPV, we propose that tariffs of commercial and high-end residential consumers should be aligned with those of RTPV costs, thereby incentivising them to shift to solar or pay higher tariff. Policy should help create an enabling eco-system for RTPV and focus on the removal of procedural hurdles and other barriers in order to facilitate the quick adoption and deployment of RTPV systems. Finally, we believe that such a net-metering approach to RTPV promotion is ideally suited for India, since it is socially equitable, economically viable, and environmentally sustainable. We hope this discussion paper would facilitate thorough debate and appropriate policy actions for promotion of RTPV.

References

1 Ministry of New and Renewable Energy (MNRE), http://www.mnre.gov.in/, Accessed on 16th August 2012.

2 Morgan B. et al., 2012, Re-considering the Economics of Photovoltaic Power, http://bnef.com/PressReleases/view/216.

International Renewable Energy Agency, 2012, Renewable Energy technologies: Cost Analysis Series, Volume 1, Power Sector, Issue 4/5, SolarPhotovoltaics, http://www.irena.org/DocumentDownloads/Publications/RE_Technologies_Cost_Analysis-SOLAR_PV.pdf.

3 European Photovoltaic Industry Association (EPIA), 2012, Global Market Outlook for Photovoltaics Until 2016, http://www.epia.org/publications/epiapublications.html.

4 United Nations Environment Programme - Bloomberg New Energy Finance, 2012, Global Trends in Renewable Energy Investment 2012, http://fs-unep-centre.org/publications/global-trends-renewable-energy-investment-2012.

5 "The National Electricity Market in Australia has experienced a rapid uptake of rooftop PV over the last four years, with total estimated installed capacity rising from 23 MW in 2008 to an estimated 1,450 MW by the end of February 2012."

Australian Energy Market Operator (AEMO), 2012. Rooftop PV Information Paper, pp.2 http://www.aemo.com.au/Electricity/~/media/Files/Other/forecasting/Rooftop_PV_Information_Paper.ashx

6 Stuart B., Rooftop PV and BIPV could generate 40 percent of EU's electricity demand, PV Magazine, 24th June 2010, http://www.pv-magazine.com/news/details/beitrag/rooftop-pv-and-bipv-could-generate-40-percent-of-eus-electricity-demand_100000269/#ixzz1z07B8fDO

7 Denholm P. et al., 2008, Supply Curves for Rooftop Solar PV-Generated Electricity for the United States Supply Curves for Rooftop Solar PV-Generated Electricity for the United States, http://www.nrel.gov/docs/fy09osti/44073.pdf.

8 Germany met nearly 50 percent of the nation's midday electricity needs for a few hours on a Saturday in May 2012. Kirschbaum E., Germany sets new solar power record, institute says, Reuters, 26th May 2012, http://www.reuters.com/article/2012/05/26/us-climate-germany-solar-idUSBRE84P0FI20120526.

9 PV Status Report, 2011, p. 45, http://re.jrc.ec.europa.eu/refsys/pdf/PV%20reports/PV%20Status%20Report%202011.pdf.

10 Ahmed, S. et al., 2012, Renewables 2012 Global Status REPORT 2012, http://www.ren21.net/default.aspx?tabid=5434 and Sun and Wind Energy Magazine, The new Net Metering system in Spain will open new business opportunities, 24th May 2012, http://www.sunwindenergy.com/news/new-net-metering-system-spain-will-open-new-business-opportunities.

11 Nielsen S., Brazil promoting rooftop solar with new policies, Bloomberg, 19th April 2012, http://www.bloomberg.com/news/2012-04-18/brazil-rules-let-consumers-trade-renewable-power-to-utilities.html.

12 For more information on net-metering in the USA, please see the DSIRE solar policy guide, http://www.dsireusa.org/solar/solarpolicyguide/?id=17, Chapman, S., Varnado, L. and Sweetman, K., 2011, Freeing the Grid, www.newenergychoices.org/uploads/FreeingTheGrid2011.pdf (specially pp. 12-22).

13 Loewen, J. et al., 2012, California Solar Initiative Annual Program Assessment, http://www.cpuc.ca.gov/PUC/energy/Solar/2012CASolarLegReport.htm.

Additionally, "In May 2012, the CPUC adopted a decision which established a methodology for calculating the cap on participation in the Net Energy Metering (NEM) program. Per statute, the NEM cap is defined as five percent of the utility's aggregate customer peak demand. The decision clarifies that aggregate customer peak demand should be interpreted as the aggregation, or sum, of individual customers' peak demands, i.e., their non-coincident peak demands. This new interpretation of aggregate customer peak demand increases the number of MW that may be installed under the NEM cap."

14 Gupta, J. P., 2011, The Untapped Gigantic Potential of Solar Rooftop Projects in India, Inter PV, http://www.interpv.net/market/market_view.asp?idx=633&part_code=04.

15 Ramesh M., Govt rejects industry plea for import duty on solar modules, The Hindu Business Line, Chennai, 20th December 2011, http://www.thehindubusinessline.com/companies/article2732376.ece.

16 Commissioning Status of Solar PV Projects under Batch – I, Phase – I of JNNSM, http://mnre.gov.in/file-manager/UserFiles/commissioning_status_spv_batch1_phase1.pdf, Accessed on 16th August 2012.

17 Ministry of New and Renewable Energy (MNRE) write up on Rooftop Solar PV systems, http://mnre.gov.in/file-manager/UserFiles/rtspv_wrtieup.pdf.

Sushma U. N., Govt plans to roll out 3,000-MW solar power projects, Bangalore, 13th June 2011, *http://www.thehindubusinessline.com/industry-and-economy/article3522476.ece.*

18 *Ramesh M., Three cities show interest in rooftop solar, Chennai, 22nd February 2012,* *http://www.thehindubusinessline.com/companies/article2920510.ece.*

Ramesh M., Ministry to come up with policy for rooftop solar plants, Bangalore, 3rd September 2012, *http://www.thehindubusinessline.com/industry-and-economy/article3854579.ece?homepage=true&ref=wl_home.*

Athrady A., Set up rooftop solar panels and get paid, New Delhi, 14th October 2012,

http://www.deccanherald.com/content/285442/set-up-rooftop-solar-panels.html

19 *West Bengal Electricity Regulatory Commission (WBERC), 2010, West Bengal Electricity Regulatory Commission (Cogeneration and Generation of Electricity from Renewable Sources of Energy) Regulations, 2010,http://www.wberc.org/wberc/regulation/under_2003_Act/index.htm.*

20 *West Bengal Policy on Co-generation and Generation of Electricity from Renewable Sources of Energy, 2012, "Building codes shall be framed under which it would be mandatory for the buildings of business and commercial entities, schools and colleges, hospitals, large housing societies and Government establishments to install rooftop PV devices." As per clause 7.17, "It shall be mandatory for all the public buildings to have solar devices to meet electricity requirements and other applications. All existing and upcoming commercial and business establishments having more than 1.5 MW of contract demand will be required to install solar rooftop systems to meet at least 2% of their total electrical load. Further, all the existing and upcoming schools and colleges, hospitals, large housing societies and Government establishments having a total contract demand of more than 500 KW will be required to install solar rooftop systems to meet at least 1.5% of their total electrical load." Industrial infrastructure would also be mandated to use rooftop PV to meet some part of their load.*

21 *Gandhinagar Solar Rooftop Programme website, http://rooftopsolargujarat.com/gpcl_rsg/index.html.*

22 *Wang U., Azure Power's rise in the Indian solar world, 8th May 2012, http://gigaom.com/cleantech/azure-powers-rise-in-the-indian-solar-world/.*

Pandit V., Azure Power to set up rooftop solar power project in Gujarat, The Hindu Business Line, 21st April 2012, *http://www.thehindubusinessline.com/industry-and-economy/article3339460.ece?ref=wl_opinion.*

23 *IFC Concludes First Rooftop Solar Project, to Replicate Five More in India, New Delhi, 30th April 2012,* *http://www.ifc.org/IFCExt/Pressroom/IFCPressRoom.nsf/0/7FB3E4453509ECC7852579F0005AAFBA.*

24 *Ahmedabad Municipal Corporation to use rooftop solar power, The Times of India, 2nd July 2012,* *http://articles.timesofindia.indiatimes.com/2012-07-02/ahmedabad/32508164_1_solar-power-solar-systems-power-unit.*

25 *Karnataka Renewable Energy Development Limited (KREDL), Karnataka Renewable Energy Policy 2009-14,* *http://kredl.kar.nic.in/Index.asp.*

26 *Anon, Karnataka sets solar target at 200 MW, DNA, Bangalore, 4th September 2012,* *http://www.dnaindia.com/bangalore/report_karnataka-sets-solar-energy-target-at-200mw_1736447.*

27 *Tamil Nadu Solar Energy Policy -2012, http://www.teda.in/pdf/tamilnadu_solar_energy_policy_2012.pdf*

28 *State will promote rooftop solar power plants, says Minister, The Hindu, 14th January 2011,* *http://www.thehindu.com/news/states/tamil-nadu/article1093106.ece.*

According to P.W.C. Davidar, Principal Secretary, IT and Energy Department, "The State is formulating a public policy for promoting rooftop solar power plants. The policy will be submitted to the Tamil Nadu Energy Regulatory Commission for approval."

29 *M. Ramesh, TN starts implementing solar home lighting programme, The Hindu Business Line, Chennai, 31st August 2011,* *http://www.thehindubusinessline.com/news/states/article3844082.ece.*

30 *Rajasthan Solar Energy Policy 2011 http://re.indiaenvironmentportal.org.in/files/rajasthan%20Solar%20Policy2011.pdf.*

31 *"Jaipur, Mysore and Thane have come forward to do pilot projects for grid-connected rooftop solar, Mr Tarun Kapur, Joint Secretary, Ministry of New and Renewable Energy, told Business Line. "Talks are on with one or two more (cities)," Mr Kapur said. [excerpt from 18]*

32 *According to a recent report, industrialisation can still yield significant future cost reductions for solar PV. Specifically, with regard to a commercial-scale rooftop (c-Si multi-crystalline solar PV system), it notes that a further 58% cost reduction from 2011-2020 is possible. Aansen K. et al., 2012, Solar Power: Darkest before dawn, Available at: http://www.mckinsey.com.*

33 *Maharashtra Electricity Regulatory Commission, 2012, Determination of Generic Renewable Energy Tariff, Order for FY*

2012-13 (Case 10 of 2012), p. 59, http://www.mercindia.org.in/pdf/Order%2058%2042/MERC_RE%20Tariff%20Order%20(SuoMotu)_for%20FY2012-13_Case%20No.%2010%20of%202012.pdf.

34 *Gujarat Electricity Regulatory Commission (GERC), 2012, Determination of Tariff for Procurement by the Distribution Licensees and Others from Solar Energy Projects, Order No. 1 of 2012, 27th January 2012 (for the projects commissioned between 29th January 2012 and 31st March 2013), http://www.gercin.org/renewablepdf/Solar%20Tariff%20Order%201%20of%202012.pdf.*

35 *Central Electricity Regulatory Commission (CERC), 2010, Draft Tariff Guidelines for Rooftop PV and other small solar power plants, p. 18, http://www.cercind.gov.in/2010/Whats-New/Draft_Model_Tariff_Guidelines.pdf.*

36 *Lalchandani N., Solar rooftop policy scrapped, The Times of India, 9th February 2012, http://articles.timesofindia.indiatimes.com/2012-02-09/delhi/31041338_1_solar-power-solar-project-solar-mission.*

37 *Gujarat Electricity Regulatory Commission (GERC), 2011, Discussion Paper on Determination of Tariff for Procurement of Power by Distribution Licensees and Others from Solar Energy Projects for the State of Gujarat,http://www.gercin.org/discussionpdf/en_1320228496.pdf.*

38 *http://www.solarwirtschaft.de/fileadmin/media/pdf/bsw_solar_fakten_pv.pdf*

39 *Wang U., Azure Power's rise in the Indian solar world, 8th May 2012,http://gigaom.com/cleantech/azure-powers-rise-in-the-indian-solar-world/.*

"Azure plans to install silicon solar panels on over 60 rooftops – 2MW on government and commercial buildings and 0.5 MW on residential ones – and complete the project by March 2013. Torrent Power, a private utility, will buy power from Azure at 11.21 rupees per kilowatt-hour for 25 years. Azure, in turn, will pass on 3 rupees per kilowatt-hour to rooftop owners, Wadhwa said".

40 *Forum Of Regulators, 2012, Minutes of the Twenty Ninth Meeting of Forum of Regulators, http://www.forumofregulators.gov.in/Meetings.aspx*

See presentation Rooftop Solar PV Power: Connectivity, Metering, Energy Accounting and Tariff Related Issues.

41 *Darghouth, N., Barbose, G. and Wiser, R., 2010, The Impact of Rate Design and Net Metering on the Bill Savings from Distributed PV for Residential Customers in California, http://eetd.lbl.gov/ea/EMS/reports/lbnl-3276e.pdf.*

Darghouth, R., Barbose, G. and Wiser, R., 2011, The impact of rate design and net metering on the bill savings from distributed PV for residential customers in California, Energy Policy, 39, pp. 5243-5253.

42 *Malviya S., Shoppers Stop turns to solar power to avoid service tax on electricity, 14th September 2012, http://articles.economictimes.indiatimes.com/2012-09-14/news/33844109_1_tax-on-commercial-rentals-kumar-rajagopalan-service-tax.*
Also see notification on service tax http://www.servicetax.gov.in/notifications/notfns-2012/st24-2012.htm.

43 *A recent report, 'India Solar Handbook' by Bridge to India, notes that, "Net metering will be a key driving factor of this [Commercial Captive] business model" and predicts a market size of 2.3 GW by 2016. Bridge to India, India Solar Handbook, June 2012, http://bridgetoindia.com/our-reports/the-india-solar-handbook*

Another report from KPMG, 'The Rising Sun-II: Grid Parity gets closer, predicts grid parity at the consumer end for certain consumer categories within the coming years and hence notes that solar rooftop can be a game changer in the coming five years. It predicts a market for RTPV at 4-5 GW by 2016-17. KPMG, The Rising Sun-II: Grid Parity gets closer, September 2012, http://www.kpmg.com/in/en/issuesandinsights/articlespublications/pages/the-rising-sun-grid.aspx

44 *Compiled from various tariff orders, (Delhi - DERC Tariff Order for TPDDL, July 2012, p. 203; Kolkata - WBERC Order for CESC, 2011-12; Hyderabad - APERC Tariff Order, 2012-13, 31st March 2012; Mumbai - MERC Orders for BEST, Rinfra and Tata Power; Bengaluru: KERC in Tariff Order 2012, 30th April 2012 for BESCOM; PUNE- MSEDCL Order, 16th August 2012).*

45 *Prayas own calculations*

46 *Drury, E. et al., 2012, The transformation of southern California's residential photovoltaics market through third-party ownership, Energy Policy, 42, pp. 681-690, http://linkinghub.elsevier.com/retrieve/pii/S0301421511010536.*

47 *"VNM is an electric tariff that allows for the net-metering credits from a single solar generating system to be distributed among multiple electric service accounts." From Wickless Andy, Virtual Net Metering, 24th February 2011, in Renewable Energy World, http://www.renewableenergyworld.com/rea/news/article/2011/02/financial-trends-virtual-net-metering.*

Also see http://www.cpuc.ca.gov/PUC/energy/DistGen/vnm.htm.

48 *Loewen, J. et al. 2012, California Solar Initiative Annual Program Assessment, http://www.cpuc.ca.gov/PUC/energy/Solar/2012CASolarLegReport.htm.*

49 *'Aggregate metering or group metering allows for aggregation of one consumer's multiple accounts/meters for net-metering across one or different locations'. From Chapman, S., Varnado, L., and Sweetman, K., 2011, Freeing the Grid, http://www.newenergychoices.org/uploads/FreeingTheGrid2011.pdf.*

50 *On top of this, avoided costs (consumer tariffs) would rise and solar costs would further decrease in the future making the way for even higher profits. Hence, rooftop PV should not be allowed to qualify for the REC mechanism. Alternately, the rooftop policy should only allow for projects under 250 kW so as not to automatically qualify for the REC mechanism. In the future, if the minimum size under REC (presently 250 kW) is increased, the rooftop policy can also allow for higher system sizes.*

51 *The present methodology for determining solar REC prices requires finding the minimum viability gap (FiT-APPC) to come to a floor REC price. However in the case of self consumption, APPC should be substituted by consumer tariff. In most cases, no additional viability would be required.*

52 *Bhaskar, R., Will solar power pull down overall power tariffs?,20th June 2012, Moneylife, Available at: http://www.moneylife.in.*

"The biggest fear among state officials now is that industrial units will opt to set up rooftop solar power generation capacities and reduce purchases from MSEDCL by at least 20% or Rs. 5,000 crores. By setting up rooftop solar, they could reduce their electricity costs from Rs. 8 (or more) per unit to less than Rs. 7 (because solar power producers also make profits when selling electricity at this price). In fact, power analysts are convinced that what happens in Maharashtra will spur a tariff revision across the country."

53 *Wiginton, L.K., Nguyen, H.T., and Pearce, J.M., 2010. Quantifying rooftop solar photovoltaic potential for regional renewable energy policy, Computers, Environment and Urban Systems, 34(4), pp. 345-357, http://linkinghub.elsevier.com/retrieve/pii/S0198971510000025, Accessed on 19th June 2012.*

54 *http://nycsolarmap.com/*

55 *Central Electricity Authority (CEA), 2012, Technical Standards for Connectivity of the Distributed Generation Resources Regulations, 2012,http://www.cea.nic.in/reports/regulation/distributed_gen.pdf.*

56 *For more on this issue please see the proceedings of the Prayas/IIT-B workshop on grid integration of small scale decentralised renewable projects, specifically presentations 8 and 9, http://www.prayaspune.org/peg/publications/item/170.*

57 *Central Electricity Authority (CEA), 2009, Report of Subgroup-I on Grid Interactive Rooftop Solar PV System - Grid Connected PV Systems, http://www.cea.nic.in/more_upload/report_rooftop.pdf.*

58 *Deodhar, P.S., Why Distributed Solar Power is Crucial, Power Engineering Magazine, 5th April 2012, http://powersectorworld.blogspot.in/2012/04/why-distributed-solar-power-is-crucial.html.*

Deodhar, P.S., Multi-megawatt Size PV Solar Plants are More a Problem than a Solution, 6th July 2011, http://www.renewableenergyworld.com/rea/news/article/2011/07/multi-mw-size-solar-pv-plants-more-problem-than-solution.

"Feeding power at 400V will actually alleviate grid congestion more than monster plants which more often than not, add to the problem of already congested transmission and distribution system. Voltage swings occur due to high impedance of the grid at its fag end caused due to line drops. Feeding solar power locally at 400V will immediately reduce network impedance and deliver stable clean power."

Eichelbrönner, M., Photovoltaic Rooftop Installations –Benefits for the Indian Grid from the Tail End, 9th December 2011, New Delhi, http://www.equadrat-gmbh.eu/media/downloads/PV%20Rooftop%20Installations%20-%20Benefits%20for%20the%20Indian%20Grid.pdf.

59 *Bhatt S. et al., 2012.Micro-solar Photovoltaic Plant, AkshayUrja, August 2012, Volume 6, Issue 1, p. 14*

High and quick deployment of RTPV in Australia may have caused some voltage and phase imbalance problems.

Hepworth, A., Rooftop solar panels overloading electricity grid, 13th October, 2011, http://www.theaustralian.com.au/national-affairs/carbon-tax/rooftop-solar-panels-overloading-electricity-grid/story-fn99tjf2-1226165360822.

Shahnia, F. et al., 2011, Voltage imbalance analysis in residential low voltage distribution networks with rooftop PVs, Electric Power Systems Research, 81(9), pp. 1805-1814, http://linkinghub.elsevier.com/retrieve/pii/S0378779611001040, Accessed on 19th June 2012.

Similarly, the European grid operator (ENTSOE) has also recently noted in a report that the tripping setting for PV plants in *various countries in the EU may not be appropriate, and given the very high deployment of PV in Europe, could pose a problem to the system. ENTSOE, 2012, Assessment of the System Security with Respect to Disconnection Rules of Photovoltaic Panels, https://www.entsoe.eu/news/announcements/newssingleview/article/assessment-report-of-the-system-security-with-respect-to-disconnection-rules-for-photovoltaic panels/?tx_ttnews%5BbackPid%5D=28&cHash=d5b706e76f57154d4d9a49ab21deeaad.*

For information on the German experience with grid integration of RTPV, please see Eichelbrönner, M. and Spitzley, J., German Experience on the Support Mechanism and Technical Aspects of Grid Connectivity of Solar PV Rooftop-Systems, Delhi, 20th March 2012, http://www.solarguidelines.in/fileadmin/user_upload/Presentation_Solar_Guidelines_MNRE_Round_Table_20032012.pdf.

60 *For more on the development of grid codes for PV in Europe, please see Connecting the Sun – Solar photovoltaics on the road to large scale grid integration, European Photovoltaic Industry Association (EPIA), September 2012.*

Further Reading

1. US Department Of Energy (DOE), 2012,Sun Shot Vision Study, February 2012, http://www1.eere.energy.gov/solar/sunshot/vision_study.html.
2. Renewable Electricity Futures Study (Entire Report), National Renewable Energy Laboratory, 2012, Renewable Electricity Futures Study, Hand, M.M., Baldwin, S.,DeMeo, E., Reilly, J.M., Mai, T.,Arent, D.,Porro, G.,Meshek, M.,and Sandor, D. eds., 4 vols., NREL/TP-6A20-52409, Golden, CO: National Renewable Energy Laboratory, http://www.nrel.gov/analysis/re_futures/.
3. Barnes J and Varnado L., 2010, The Intersection of Net Metering & Retail Choice: An Overview of Policy, Practice, and Issues, http://irecusa.org/wp-content/uploads/2010/12/FINAL-Intersection-of-Retail-Choice-and-Net-Metering-Report.docx.pdf.
4. Bony L. et al., Achieving low cost solar PV: Industry workshop recommendations for near-term balance of system cost reductions, September 2010, Rocky Mountain Institute, http://www.rmi.org/Knowledge-Center/Library/2010-19_BalanceOfSystemReport.
5. McHenry, M.P., 2012, Are small-scale grid-connected photovoltaic systems a cost-effective policy for lowering electricity bills and reducing carbon emissions? A technical, economic, and carbon emission analysis, Energy Policy, 45, pp. 64-72, http://linkinghub.elsevier.com/retrieve/pii/S0301421512000626, Accessed on 16th April 2012.
6. Rokach, J.Z. and Introduction, I., 2011, Net Metering Needs a Safety Net, Energy, pp. 106-108.
7. Solar Headway, 2012, Solar Rooftop Systems in India, http://headwaysolar.com/Solar_Rooftop_Project_India_2012.pdf.

While the Jawaharlal Nehru National Solar Mission (JNNSM) opened up the solar electricity sector in India, the focus has primarily been on large-scale grid-connected power plants. With the drastic fall in prices of solar photovoltaic (PV) modules and balance of systems (BOS) on the one hand, and the high and rising tariffs of certain consumer categories in India on the other, grid-connected solar Rooftop PV (RTPV) systems are becoming increasingly viable economically and offer multiple benefits. This paper argues that a balanced approach for promoting RTPV would be to adopt a national policy of 'net-metering' to encourage in-situ generation primarily for self consumption. Further, instead of subsidizing RTPV, we propose that tariffs of commercial and high-end residential consumers should be aligned with those of RTPV costs, thereby incentivising them to shift to solar or pay higher tariff. Policy should help create an enabling eco-system for RTPV and focus on the removal of procedural hurdles and other barriers in order to facilitate the quick adoption and deployment of RTPV systems. Finally, we believe that such a net-metering approach to RTPV promotion is ideally suited for India, since it is socially equitable, economically viable, and environmentally sustainable. We hope this discussion paper would facilitate thorough debate and appropriate policy actions for promotion of RTPV.

प्रयास
Prayas Energy Group