Rooftop Solar PV Experience in India

The National Action Plan for Climate Change (NAPCC) released in June 2008 outlines a national strategy that aims to enable the country to adapt to climate change and enhance the ecological sustainability of India's development path. As a part of NAPCC, the Government of India launched the Jawaharlal Nehru National Solar Mission ("JNNSM" or, "National Solar Mission") which inter alia targets 20 GW of grid connected solar capacity by year 2022. The JNNSM Phase I (2010-13) implementation has witnessed appreciable scaling up of solar capacities in India in a short time span of three years. In addition, several state governments have declared their own state level solar policies to promote solar generation. As a result, the installed capacity of solar energy has increased from mere 2 MW in 2008-09 to more than 1,686 MW by 31 March 2013. The aggressive participation from the private sector in the grid-connected segment under Phase I of JNNSM has already resulted in lowering of solar tariffs for both the solar thermal and solar PV projects.

Apart from promoting the ground mounted solar PV projects, the JNNSM also has a mandate to encourage the rooftop solar segment. Under Phase I of JNNSM, a separate scheme called 'Rooftop PV and Small Scale Solar Generation Program (RPSSGP)' was implemented for developing solar PV projects with maximum capacity of 2 MW as rooftop or, small scale ground mounted solar projects. A total of 100 MW capacities of projects under this program were to be installed and connected at a level below 33 KV and same GBI linked tariff was provided for both the categories of project. While more than 90 MW of projects have been installed under this scheme, it is observed that this scheme garnered enthusiastic responses primarily in the ground-mounted segment, while it received almost negligible responses in the rooftop segment. Similarly, the focus under most state solar policies, programs has been on the ground mounted grid-connected solar PV projects.

Several cities and towns in the country are experiencing a substantial growth in their peak electricity demand. Municipal Corporations and the electricity utilities are finding it difficult to cope with this rapid rise in demand and as a result most of the cities and towns are facing severe electricity shortages. Various industries and commercial establishments e.g., Malls, Hotels, Hospitals, Nursing homes etc housing complexes developed by the builders and developers in cities and towns use diesel generators for back-up power even during the day time. These generators capacities vary from a few kilowatts to a couple of MWs. Generally, in a single establishment more than one generator are installed; one to cater the minimum load required for lighting and computer or, other emergency operations during load shedding and the others for running ACs and other operations such as lifts and other power applications. With an objective to reduce dependency on diesel gensets, a scheme to replace them with solar PV is being proposed. Further, in order to utilize the existing roof space of buildings, the scheme proposes to promote rooftop solar PV systems on buildings to replace DG gensets installed for minimum load requirement for operation during load shedding. These loads are generally varying between 25 kW to 100 kW or, so.

Thus a rooftop solar PV system could be with or, without having grid interaction. In grid-interactive system, the DC power generated from solar PV panels is converted to AC power using power conditioning unit and is fed to the grid either of 11 KV three-phase line or, of 220V single-phase line

depending on the system installed at institution, commercial establishment or, residential complex. It used to generate power during the daytime which is utilized fully by powering the captive loads and feeding excess power to the grid as long as grid is available. In cases, where solar power is not sufficient due to cloud cover etc. the captive loads are served by drawing power from the grid. The grid-interactive rooftop solar PV systems thus work on 'net-metering' basis wherein the beneficiary pays to the utility on net meter reading basis only. Ideally, grid interactive systems do not require battery back up as the grid acts as the back-up for feeding excess solar power and vice-versa. However, to enhance the performance reliability of the overall systems, a minimum battery-back of one hour of load capacity is strongly recommended. In grid-interactive systems, it has, however to be ensured that in case the grid fails, the solar power has to be fully utilized or, islanded immediately feeding to the grid (if any in excess) so as to safe-guard any grid person/technician from getting shock (electrocuted) while working on the grid for maintenance etc. This feature is termed as 'Anti-Islanding Protection'.

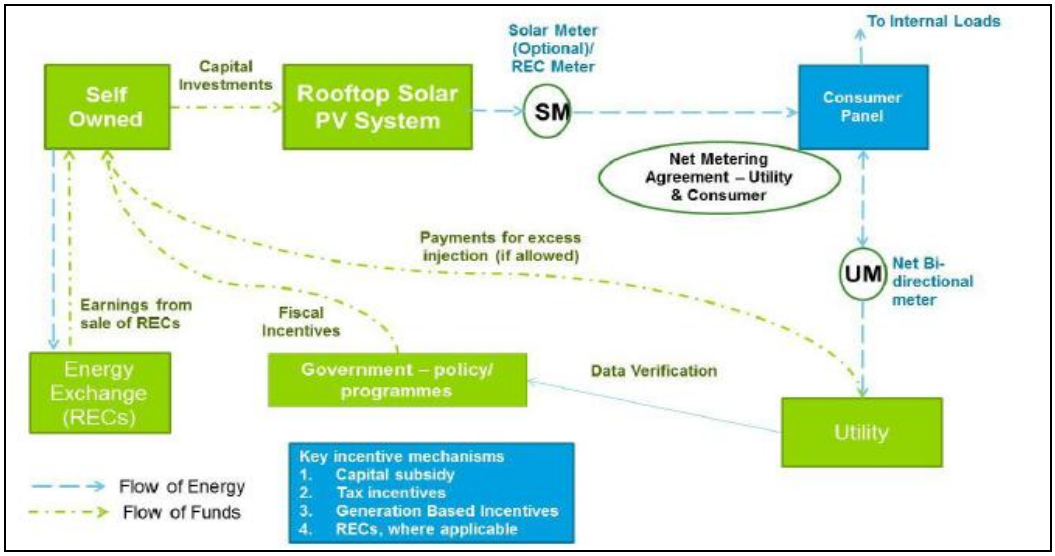
Non-grid interactive systems ideally require a full load capacity battery power back-up system. However, with the introduction of advanced load management and power conditioning systems, and safety mechanisms, it is possible to segregate the day-time loads to be served directly by solar power without necessarily going through the battery back-up. As in the previous case of grid-interactive systems, minimum one hour of battery back-up is, however, strongly recommended for these systems also to enhance the performance reliability of the systems. The non-grid interactive system with minimum battery back-up is viable only at places where normal power is not available during daytime. In case the SPV power is to be used after sunshine hours, it would require full load capacity battery back-up which will increase the cost of system which may not be economically viable even with support from Government.

Although the JNNSM and state solar policies have been successful in kick-starting the development of utility scale solar power projects in India, the small scale rooftop solar segment remains in a nascent stage of development in India. The inherent benefits of the rooftop solar projects have been well recognized by the policy makers and the initial push for the development of these projects has started in India. The rooftop based solar projects installations have several advantages over the ground mounted projects from the following perspectives. Rooftop solar PV is connected to the distribution system and ingestion of power is into a load centre thereby avoiding transmission and distribution (T&D) losses incurred in the case of centralized, larger plants. This is a strong rationale for rooftop solar projects in India, where the national average of T&D losses hover at close to 30%. The ease of connectivity with the consumer premises, particularly in net-metered arrangement, also provides an opportunity for utilizing the rooftop solar for captive consumption even when the grid is not available. This is thus relevant in abating the consumption of diesel or, liquid fossil fuel, which dominates as the choice for back-up power across most parts of India. Rooftop solar projects also have the potential to create economic value for unutilized rooftops and are not faced with the issues of land availability, applicable for ground-mounted projects. The self-replication potential is thus very high for rooftop projects.

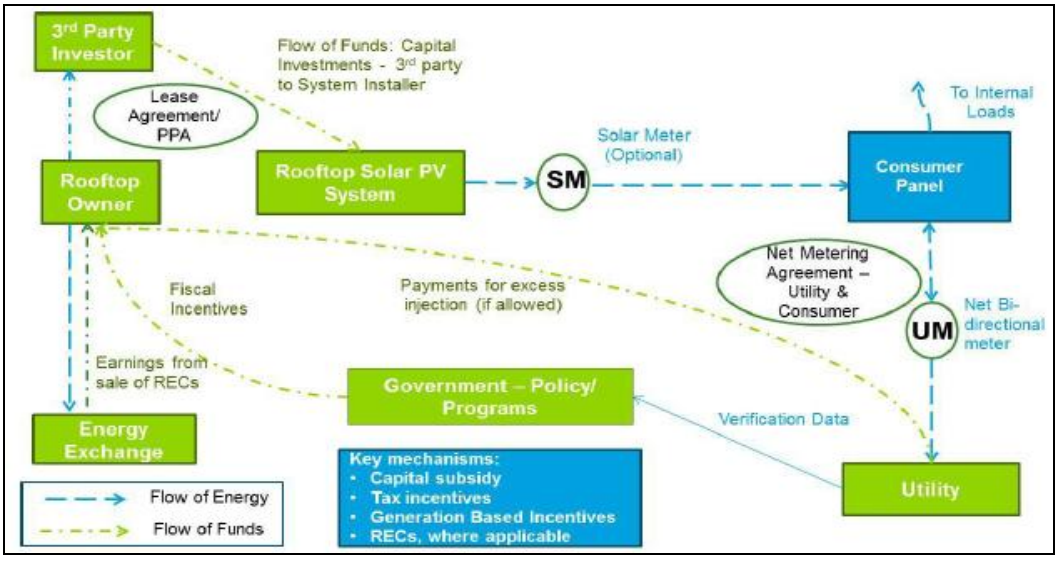
Net-Metering Business Models:

The net metering based rooftop solar projects facilitates the self-consumption of electricity generated by the rooftop project and allows for feeding the surplus into the network of the distribution licensee. The type of ownership structure for installation of such net metering based rooftop solar systems becomes an important parameter for defining the different rooftop solar models. In the international context, the rooftop solar projects have two distinct ownership arrangements:

- Self-owned arrangement wherein rooftop owner also owns the PV system (refer below mentioned figure):



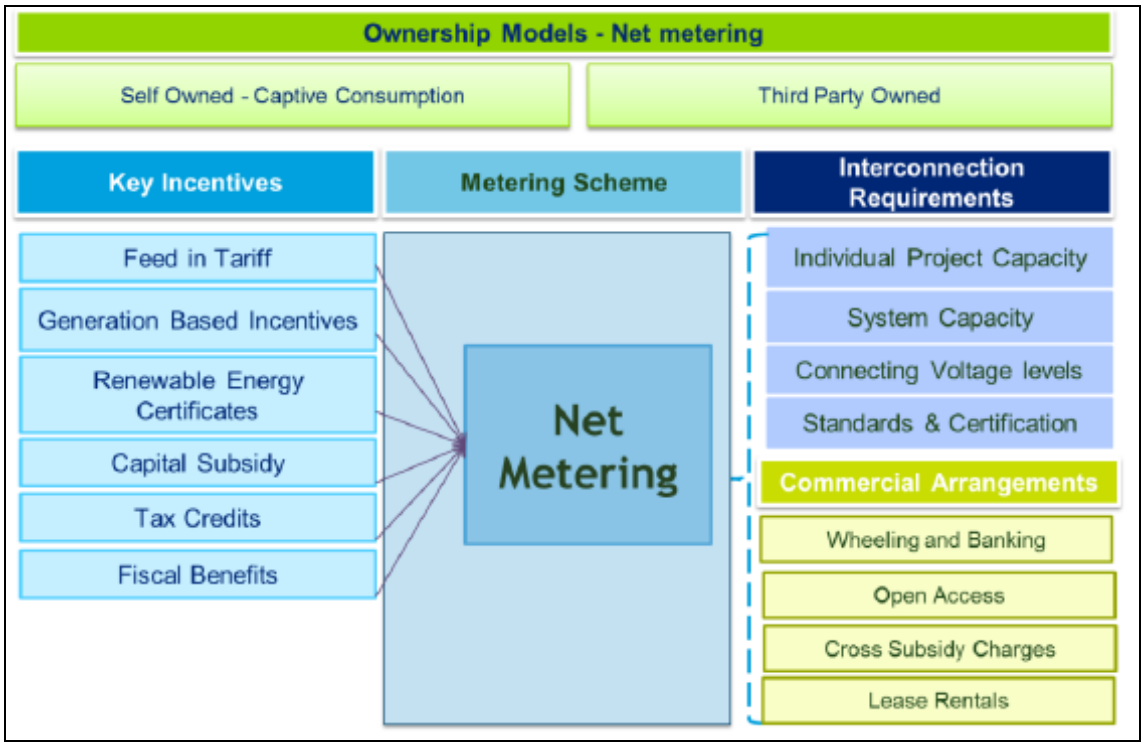
- Third party ownership in which a developer owns the PV system and also enters into a lease/commercial arrangement with the rooftop owner (refer below mentioned figure):



Both these models are relevant in the Indian context and have been discussed in the section below.

Supporting Framework:

The implementation of net-metering based rooftop solar system needs to address critical factors relating to nature of incentives being made available to the net metered schemes, metering arrangements to be finalized, interconnection requirements for net metered projects and the commercial framework. Figure mentioned below summarizes the various factors which a model regulation will need to consider and address.



Example of Smart Grid-Connected Rooftop Solar PV System:

Smart Grid-connected solar PV system ensures with its modular design that system operators can individually determine to what extend they want to carry out energy management. This kind of solution applies to existing and new systems, for a wide range of power classes and to individual storage solutions. Smart Grid-connected solar PV system is primarily based on its essential functions as “intelligence”, automatic load control, temporary PV electricity storage and thermal use of solar power. Thus, everyone can take part in the energy transition.

There are several global inverter manufactures such as, SMA Solar Technology AG, Delta Energy Systems, Kaco Systems etc. whereas, some of the Indian manufacturers namely, Optimal Power Solutions Pty Ltd, Su-Kam Power Systems Limited, Luminous Power Technologies (P) Limited are also providing solutions for both type of rooftop solar PV systems i.e., grid-connected, and battery back-up systems.

Rooftop Solar PV System Cost and Area Requirement:

The average potential roof-space requirement for a typical 1 KWp solar PV power plant will be 80 sq-ft. (approx) shade-free area and similarly proportionately higher area for higher capacity system (refer to below mentioned table). The tentative cost of grid-interactive 1 KWp rooftop solar PV plant will be Rs. 1.1 to Rs 1.3 lacs (approx). Similarly, 1 KWp off-grid system with minimum battery back-up shall require Rs. 1.5 lacs to 1.7 Lacs (approx). In addition, all such systems, 30% subsidy shall be availed from Ministry of New and Renewable Energy (MNRE), Government of India, through state nodal agencies.

Roof Area Needed in Square Feet (shown in **Bold Type**)							
PV Module Efficiency (%)	PV Capacity Rating (Watts)						
	100	250	500	1,000	2,000	4,000	10,000
4	**30**	**75**	**150**	**300**	**600**	**1,200**	**3,000**
8	**15**	**38**	**75**	**150**	**300**	**600**	**1,500**
12	**10**	**25**	**50**	**100**	**200**	**400**	**1,000**
16	**8**	**20**	**40**	**80**	**160**	**320**	**800**
For example, to generate 2,000 watts from a 12%-efficient system, you need 200 square feet of roof area.							

References:

- Online documents from Ministry of New and Renewable Energy (MNRE)
- Deloitte Research Reports;
- Power Finance Corporation Report on “Performance of State Power Utilities for the Years 2007-08 to 1009-10”;
- Online documents from SMA Solar Technology AG.