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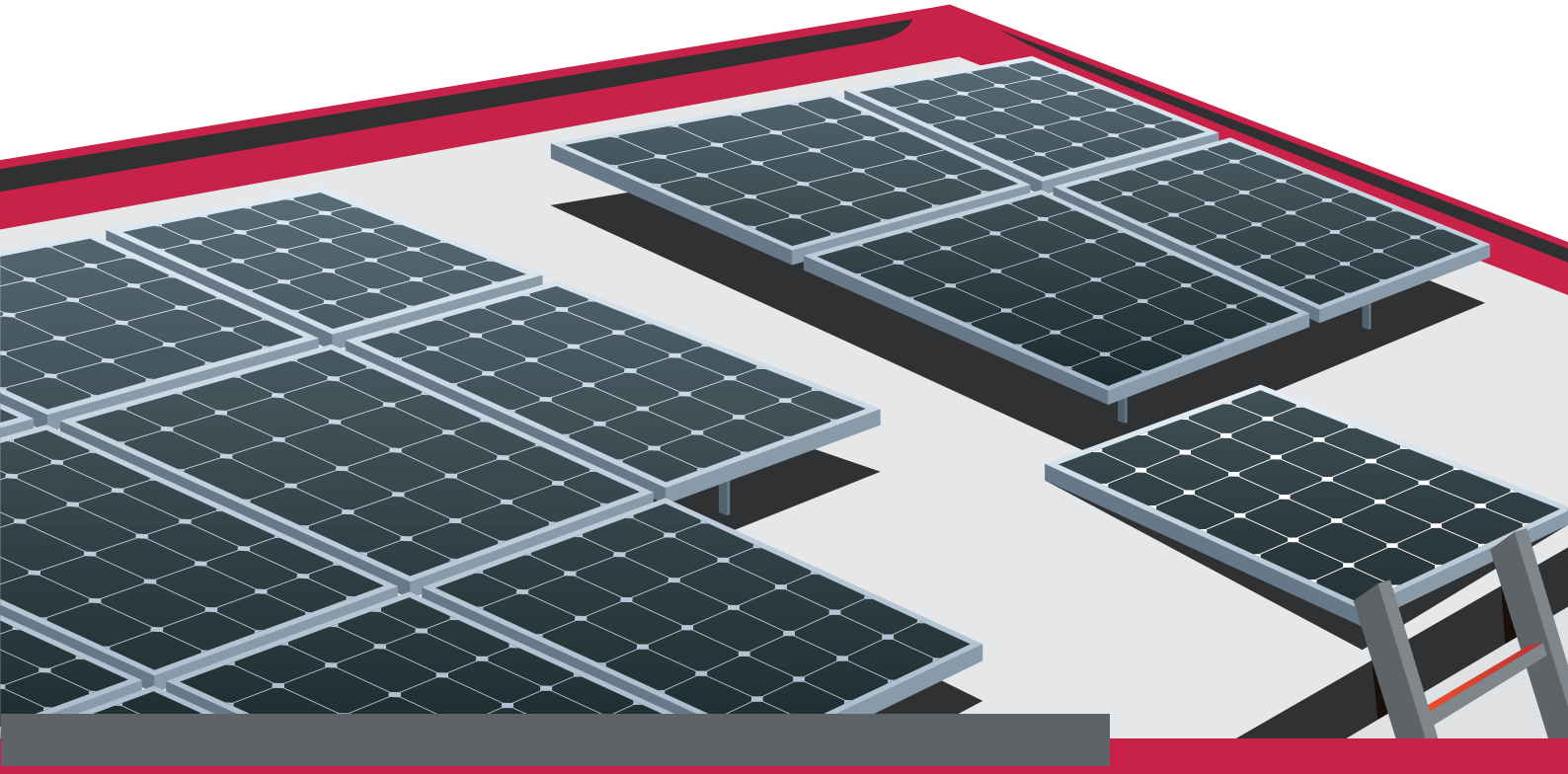

Mass-scale Rooftop Solar PV Program: Centralised

Procurement and De-centralised Deployment

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Introduction

India is the third largest consumer of electricity in the world. It is also one of the fastest developing markets for renewable energy. At the start of this year, India ranked fifth globally in terms of solar energy installed capacity. Its closest rival Germany has an installed solar capacity of about 60 GW, while India has installed 63.3 GW capacity by December 2022.

Solar energy growth has been very rapid since the inception of National Solar Mission (NSM) in January 2010. Per the original action plan, the objective was to achieve 20 GW of grid-connected solar power project capacity by FY22. In 2015, this target was revised to 100 GW, of which 40 GW was to be achieved through grid-connected rooftop solar PV (RTPV) and the balance 60 GW from utility-scale projects.

In reality, only around 8.1 GW capacity of RTPV has been achieved as of December 22. The shortfall in target versus achievement is particularly stark when compared to the growth in utility-scale solar industry.

Further, of this 7.6 GW only about 15% of installations are made by the residential consumers (with industrial consumers accounting for roughly 50%, commercial consumers 20% and the balance 15% by public sector including government schools, hospitals and municipal buildings etc.).

Globally RTPV has also been recognized as a tool for alleviating poverty, especially in rural areas. In China for instance, photovoltaics deployment is counted in the identified ten initiatives for targeted poverty alleviation.

In this White Paper, we analyze the reasons for stymied growth of the RTPV sector and present a centralized approach for achieving desired

[2] Top countries ahead of India, by capacity installation of solar energy include: China, United States, Japan and Germany. Source IRENA Country Rankings https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Country-Rankings

[3] Some studies suggest that the actual capacity is ~ 10.22 GW. Bridge to India, India Solar Rooftop Map, June 2022 https://bridgetoindia.com/report/india-solar-rooftop-map-june-2022/

[4] Zhang, H., et al. Solar photovoltaic interventions have reduced rural poverty in China. Nature Communications 11, 1969 (Apr 2020) https://www.nature.com/articles/s41467-020-15826-4

[5] Rodriguez, L., et al. Mitigating energy poverty: Potential contributions of combining PV and building thermal mass storage in low-income households. Energy Conversion and Management. Volume 173, October 2018. https://doi.org/10.1016/j.enconman.2018.07.058

[6] The other nine interventions include vocational education and training, providing microcredit, relocation of rural villagers, e-commerce, tourism, planting paper mulberry and entrepreneurial training.

capacity installations with an aim to tackle the twin issues of poverty alleviation and domestic clean energy transition.

We aim to start conversations for a wider discussion on the suggested approach and tweak the program contours accordingly. We believe that after the success of programs initiated in the last few years targeting village electrification, water, rural roads, cooking gas and such, poverty alleviation via rooftop solar could be the next big opportunity for uplifting local economy and jobs growth.

This White Paper is structured as follows. Chapter 1 provides a synopsis of the historical trends of rooftop solar industry in India. It also details out why RTPV should be promoted given the country's ever-growing energy demands and the solar industry's promise to achieve multiple goals including energy security at affordable price along with as a means for poverty alleviation especially for rural India.

Chapter 2 looks at the reasons for slow uptake of investments in rooftop solar. In addition, central and state government sponsored programs and policies which have shaped the industry till date have been covered in this chapter. Basis these, a laundry list of basic building-blocks for a successful RTPV program is discussed in Chapter 3.

We then detail out a government sponsored program titled **RACE – Rooftop solar Adoption for Consumer Empowerment** – that aims to achieve the desired growth. The idea is to present a market size estimation, along with government sponsorship required and a balance of risks and rewards for all stakeholders. While in Chapter 4 an overall discussion of regulatory and policy levers required to make the suggested program a success, are discussed.

Chapter 1: Is there a problem of plenty?

Summer 2022 brought back the harsh reality of power outages. Even though India was declared a power surplus nation , the system demand outstripped supply and consumers were left 'powerless'!

There has been enough discussion of what caused the recent power demand-supply mismatch. Experts have reasoned from high prices of imported coal and natural gas as a result of the Russia-Ukraine war, to limitations in transportation of domestic coal from mines to power plants, to unfortunate timing of planned/unplanned maintenance shutdowns of power stations and to an increase in demand due to an early and harsh summer.

Data of power plant utilization suggests that the current challenge is of commodity (lack of fuel and transportation bottleneck) rather than capacity (lack of installed power plants). The all-India average plant load factor (PLF), a factor representing utilization or actual operations of a power plant) has progressively reduced since 2010 and is currently below 60%.

Availability of coal and its timely transportation is not a new problem for India. Stress on increasing domestic coal production, thereby reducing dependance on import of costlier coal and natural gas, has been a policy directive for long. On the other hand, as a result of steep investments in generation during the 12th plan period and afterwards, current installed capacity is close to 400 GW (~204 GW of coal-based capacity). Thus, capacity is not a limiting condition, at least in the short to medium-term. However, fuel constraints put limits on energy generation potential.

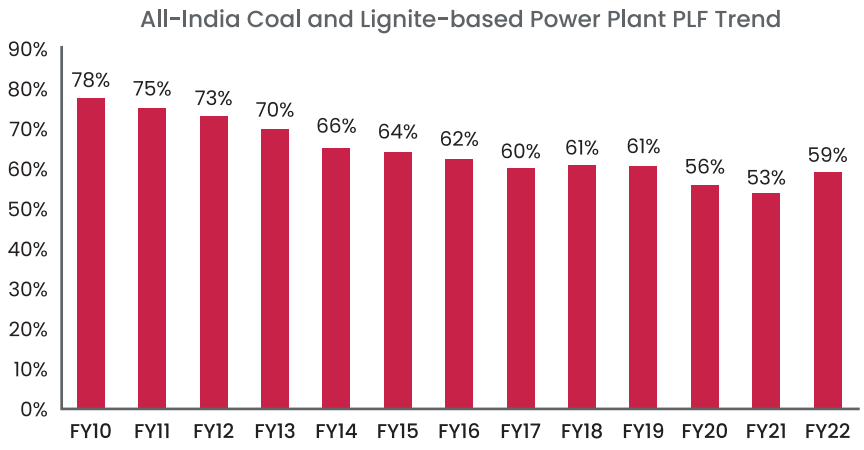


Figure 1: PLF trend (Source: Author's analysis based on data from Ministry of Power)

[7] "... the country as a whole is likely to have an overall peak surplus of 8.2% and energy surplus of 6.4% with the generation programme finalized for the year 2021-22. Energy surplus is anticipated of the order of 24.0%, 7.9%, 7.6% and 7.5% in the North-Eastern, Western, Southern and Northern Regions respectively." Central Electricity Authority, Load Generation Balance Report 2021-22 https://cea.nic.in/wp-content/uploads/l_g_b_r_reports/2020/LGBR_2021_22.pdf

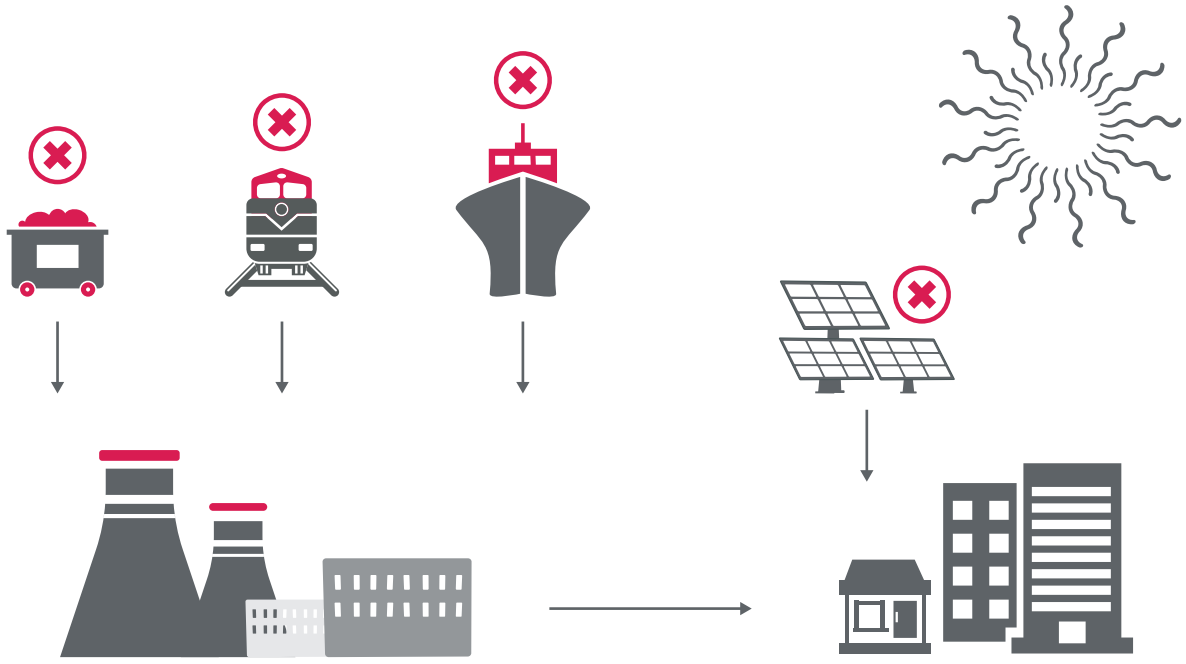
On the renewable energy side, even though India has abundant insolation and is considered as the most cost-effective country globally for rooftop solar PV, the actual investments are way behind economic and technical potential. As per a recent study, India has an RTPV potential of 1.7 petawatt-hour per year whereas its electricity demand is 1.3 petawatt-hour per year.

Even as compared to government's own target of 40 GW of RTPV installation by FY22, we have achieved only a quarter of that. Again, this indicates falling short on utilization of available resources – in this case solar irradiation – for lack of investments in creating corresponding project capacity.

Indeed, we seem to be in a problem of plenty. We fall short of utilizing installed thermal plant capacity for lack of fuel and at the same time are unable to utilize the abundant solar energy potential for lack of investments.

Thus, the need of the hour is to exercise all possible levers to exploit the potential of RTPV. It not only improves India's energy security, especially in times of inflationary and geopolitical pressures on import of fuel, but also accelerates our path on climate action commitments.

Last but not least, RTPV offers a source of income to the masses. Especially so to the rural/low-income households, who not only can take control of their own energy needs but can generate electricity as a source of additional income stream by selling the surplus electricity.



FY22
All-India thermal power plant PLF~59%

FY22
RTPVTarget 40.0 GW
Achievement 7.6 GW

[8] Joshi, S., Mittal, S., Holloway, P. et al. High resolution global spatiotemporal assessment of rooftop solar photovoltaics potential for renewable electricity generation. Nature Communications 12, 5738 (Oct 2021) https://www.nature.com/articles/s41467-021-25720-2

Chapter 2: Creating Value, Conflicting Interests

Renewable energy in India has witnessed a stellar growth over the last decade. The installed capacity of renewable energy resources crossed the 100 GW mark in August last year. Prime Minister Modi has announced the target capacity from non-fossil energy resources to expand to 500 GW by 2030. The share of energy generation from renewable sources is growing steadily. In just six year period from FY15 to FY21, the share of RE generation in total electricity supplied has almost doubled, from 5.56% to 10.66%.

Renewables has been a very attractive sector for domestic and international investors. Foreign Direct Investment equity flows in the last decade totaled 8.4 billion USD. Particularly the solar energy sector has gained the attention of policy makers, investors as well as consumers. India has been consistently ranked as the world's most attractive solar market.

The growth of utility-scale solar has been spectacular. The National Solar Mission (NSM) was introduced in January 2010. By Apr 2022, the installed capacity of solar in India has crossed 55 GW.

On the contrary, the growth in rooftop solar PV has not been up to the mark. This is counter intuitive given RTPV is suitable for the Indian climate with its 300 days of sunny days a year, coupled with poor reliability of supply from distribution companies in several parts of the country. More so given the biggest advantage of RTPV is that no additional land cost is incurred, and consumers can make use of their own premises to generate electricity and become prosumers. The installation also offers a source of protection for the roof and requires only minimum maintenance.

Generation from RTPV provides a clean, green alternative to consumers thus giving them

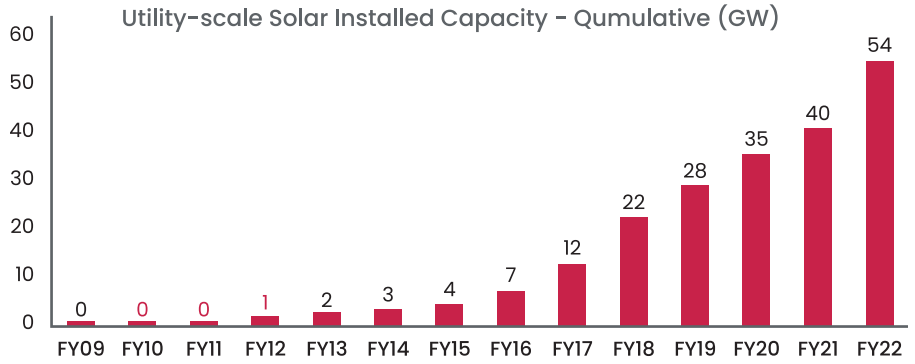


Figure 3: Utility-scale Solar Installations (Source: Author's analysis based on data from Central Electricity Authority)

[9] National Statement by Prime Minister Shri Narendra Modi at COP26 Summit in Glasgow. Press Information Bureau, published Nov 01, 2021 https://pib.gov.in/PressReleasePage.aspx?PRID=1768712

[10] Ernst & Young ranks India as world's most attractive solar market. PV Magazine, published May 21, 2021 https://www.pv-magazine.com/2021/05/21/ernst-young-ranks-india-as-worlds-most-attractive-solar-market/

an option to reduce their carbon footprint. That aspect can be especially important for commercial and industrial (C&I) consumers who have an additional incentive to reduce their emissions intensity. Retail tariff of C&I consumers is high and that provides additional motivation to these consumers to save on electricity input costs via self-generation. Though reliability of supply from distribution companies' (Discoms) has improved over the years, it is common for consumers in several states to rely on high-cost, polluting and expensive diesel generators. RTPV offers these consumers an alternative whose cost is cheaper and predictable.

Even from a discom's point of view, sourcing from RTPV could be beneficial. First it requires lesser investments in securing transmission interconnections given the generation is closer to consumption. That also helps in reducing the local transmission and distribution losses. Having a good mix of RTPV increases the local distribution grid's resiliency and reliability. However, the key concern of discoms is with respect to the loss of revenues from the exit of cross-subsidizing C&I consumers, further impacting their financial viability.

Despite several efforts and schemes initiated by central and individual state governments, against a national target of 40 GW, the current installed RTPV capacity is less than 10 GW. Reportedly within this 10 GW about half of the installations have been done by industrial consumers, while between the rest about 20% are done by commercial consumers, 15% by public sector establishments and the remaining 15% by residential consumers or households.

The Ministry of New and Renewable Energy (MNRE) launched the first phase of rooftop solar programme in December 2015. Under the same, incentives and subsidies were announced for RTPV investments by all types of consumers, including achievement-linked incentives to public sector establishments. Installation on public sector establishments has been carried out through consolidated tenders issued by the Solar Energy Corporation of India (SECI). As per MNRE, during FY21 SECI awarded tenders worth 97.5 MW for this category.

This was followed by phase two of the programme launch in March 2019. Renewed focus was made on installations by the residential consumers, and therefore a new interim target of 4 GW was set to be achieved by FY22. Central Financial Assistance (CFA) is provided to residential consumers under a graded scheme based on project size. This includes advance incentives up to 40% of project benchmark costs for system size up to 3 kW, and 20% of costs for system size between 3 to 10 kW. In case of group housing societies and residents' welfare associations the incentive is fixed at 20% of benchmark project costs for system size up to 500 kW and supply of power to common facilities. In addition, discoms are provided performance-based incentives for achieving higher installation than their baseline. They get an incentive equal to 5% of benchmark costs for capacity addition beyond 10% and up to 15% of the baseline; beyond which the incentive equals 10% of the benchmark costs. This incentive is primarily meant to cover for additional expenditure incurred by discoms in providing for supporting infrastructure, capacity building of discom staff, any additional manpower and creating consumer awareness. RTPV capacity as on March 31, 2019 is considered as baseline capacity for individual Discom for this programme.

[11] See Annexure A for state-wise RTPV target installation by FY22 (Source: Ministry of New and Renewable Energy https://solarrooftop.gov.in/notification/Notification-08112016901.pdf)

[12] Operational Guidelines for implementation of Phase-II of Grid Connected Rooftop Solar Programme for achieving cumulative capacity of 40,000 MW from Rooftop Solar (RTS) Projects by the year 2022. Ministry of New and Renewable Energy, August 20, 2019. Budget Outlay 11,814 INR Cr. https://mnre.gov.in/img/documents/uploads/7ccd3b4b3bb94a51af516e2ee4fdede3.pdf

[13] In addition to these, for a state level compendium of policies and charges etc. see https://www.itsmysun.com/solar-state-wise-policy/

It was believed that the success of the programme can be guaranteed by making the discoms an integral part of the programme implementation along with offering them incentives for going beyond targets. Also, a 40% advance capital grant was supposed to persuade residential consumers for self-generation at lower costs and as a counter to highly subsidized electricity especially at lower consumption slabs. However as of end-FY22 the programme has not had the desired success and only 1.1 GW of capacity has been added. Of this new addition, about 87% comes from a single state – Gujarat – and thus the Phase-II of MNRE programme cannot be termed a nation-wide success. See Table 1 below for top ten states in terms of installed capacity.

Several studies have dissected the reasons for slow uptake of RTPV investments in India. Note that many of these reasons are not specific to India or the way India's power system is structured but apply almost globally. Different geographies have achieved progress through different targeted interventions. For a brief overview of select geographies and factors responsible for growth in those markets, see Annexure B.

State	Residential RTPV Capacity Installed as on 13.12.2021 (MW)
Gujarat	991.86
Rajasthan	33.99
Uttar Pradesh	22.69
Haryana	21.86
Punjab	14.31
Telangana	14.30
Madhya Pradesh	11.75
Uttarakhand	10.29
Chandigarh	3.24
Delhi	2.12

Broadly residential consumers shy away from RTPV investments for a variety of reasons, including – inability to afford upfront installation costs, costs and time incurred in arranging finance, free and/or highly subsidized retail tariff for lower consumption domestic usage which reduces the financial viability of self-generation, principal-agent challenge in rented homes, and information asymmetry led confusion. On the other side, rooftop project developers find it expensive to aggregate demand from small residential consumers. Long gestation periods in closing sales cycle, including processing approvals from discoms for multiple locations, is one of the primary reasons for higher soft costs incurred by these developers, which at times can be prohibitive for local and smaller players.

In case of C&I consumers, confusion and frustration with policy and regulatory changes can reduce the attractiveness even when for such consumers self-generation is definitely cheaper than discom supply. A major driver of frequent changes to policies and regulations surrounding rooftop solar comes from discoms' apprehension with the growth of prosumers. In India (and mostly globally too) retail tariffs are volumetric in nature and are telescopic. That means that the higher usage consumers pay disproportionately more for their usage as compared to lower usage consumers. Usually C&I consumers use more electricity. On top of it, cross-subsidies built-in retail tariffs ensure that higher revenue per kWh consumed is recovered from sale to C&I consumers than to residential and agriculture consumers. The net effect is that discoms get concerned with loss of sale – and hence revenue and cross-subsidy – when a C&I consumer switches part of its supply to self-generation.

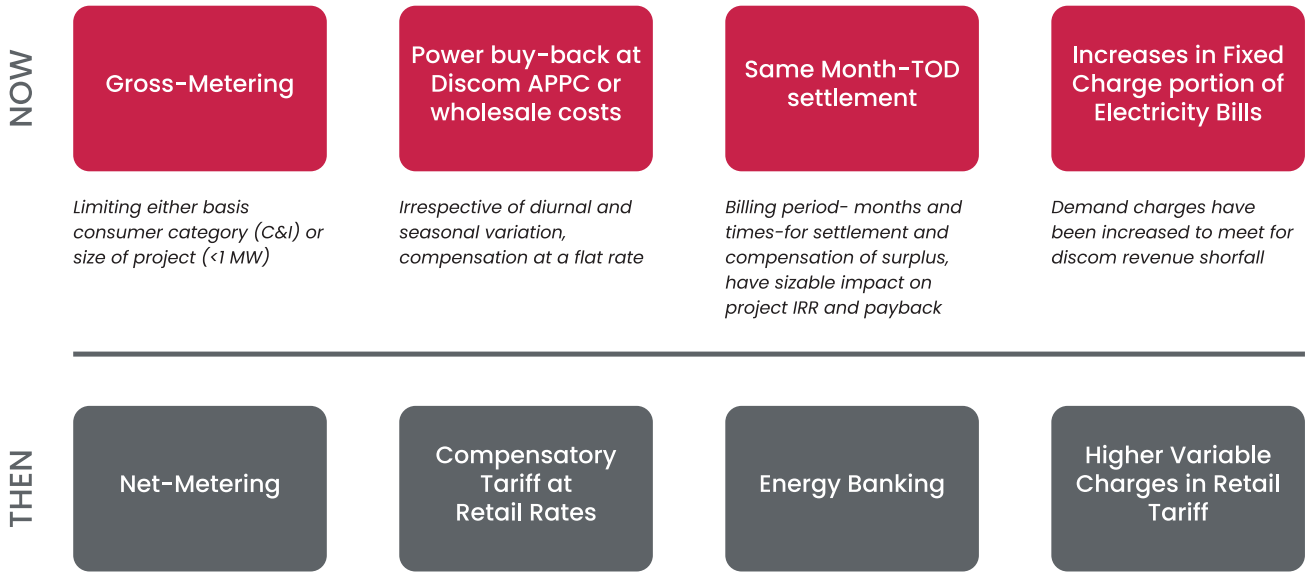


Figure 4: Policy and Regulatory Pushbacks (Source: Author)

Pushbacks from discoms have largely come in the form of lobbying for changes to rules and regulations, primarily those with respect to sale of excess energy back to the grid. For example, the majority of states have now restricted capacity size of RTPV for which net metering is allowed. In most states this capacity restriction is up to systems below 500 kW. Limiting net metering benefits lowers financial viability and increases payback period for C&I consumers who have access to larger roof areas that can accommodate system capacities that are higher than their energy requirements.

Another way of introducing hurdles is via limiting the time period of banked energy. Since irradiation differs over the year, limiting utilization of banked energy within the same month and within the same time-of-day periods, reduces the motivation to setup bigger capacity projects. Yet another tactic used by discoms is to increase the fixed charges (demand charges per kW connection) which are billed irrespective of change in consumption. See Annexure C for comparison of net-metering policies across states with highest RTPV potential.

Chapter 3: Rooftop solar Adoption for Consumer Empowerment

Electricity demand has rebounded sharply after a low consumption period during 2020 and 2021 because of nationwide lockdowns. Discoms have been facing the heat due to their inability to meet energy and demand requirements. Rooftop solar is but a necessary tool which can provide multiple benefits and should be pursued with extra vigor.

Basis outcome of the several government schemes announced in the past, it can be deduced that certain basic building blocks are vital for success of a RTPV programme. These include:

Consumer Aggregation: Solar technology costs have reduced drastically over the years. That includes the hardware part meaning the modules, inverter, cables, racking and storage units, sensors etc. However, the soft costs, that is the cost of consumer acquisition including marketing, sales etc. and overheads including permitting, financing etc. have been a concern to developers. This is especially true in case of domestic consumers with limited rooftop spaces that are geographically dispersed.

A centralized program that can provide aggregation of probable consumers, reduces the soft costs related to customer acquisition and financing. It also streamlines project approval and permitting procedures, thereby reducing gestation period and costs. Aggregated demand also provides clear directions to hardware manufacturing and sourcing suppliers, who can streamline their processes and pass on their costs savings to developers.

Discom Involvement: Soft costs are also incurred by the discoms in processing of applications and technical studies to ascertain local grid strengthening if any, required for two-way flow of power. Under a centralized

- Reduces acquisition time and costs
- Reduces transaction costs
- Shapes up sales pipeline and thereby associated manufacturing-sourcing capabilities
- Helps build clarity for discom supply planning

Consumer Aggregation

- Reduces transaction time in application processing, approval, meter installation etc.
- Facilitates targeted area investments, benefitting all ratepayers
- Reliability of power supply as a metric to ensure discom engagement

Discom Involvement

- Sale of power back to grid as an additional source of income for HHs and a poverty alleviation measure
- Standardized Net-Metering guidelines accross discom license areas
- TOD tariff to facilitate self-generation and consumption during peak periods

Enabling Policy

programme, Discom can save transaction time since they can focus on particular areas and prioritize their side of the work.

Discoms can pick up areas for targeted intervention based on their own needs. This can be basis areas or sub-divisions that require immediate-term investments in meeting increase in load, or areas that have a high technical and commercial loss, or areas that are hard to meet service delivery requirements, such as rural places.

Enabling Policy: Sale of excess generation over and above self-consumption, is one of the key requirements for rapid RTPV adoption by consumers. Any programme that benefits residential consumers financially will generate interest and curiosity. Ease of selling excess generation from RTPV, along with clarity of rules and rewards is a must.

Net-metering regulations come under the purview of state electricity regulatory commissions. Yet there is room for common guidance from the central government on discoms' standards of performance – in terms of reliability as well as promotion of load-side efficiency measures, including self-generation during system peak load. Net-metering regulations is the right place for addressing these aspects. The incentives should be such that RTPV results in lesser unplanned peak-period purchases by discoms, thus saving on procurement costs.

Mass-scale adoption of RTPV by residential consumers, especially the low-income low-consumption consumers, can solve multiple needs in one go. It is a source of cleaner energy procurement helping discoms meet their renewable purchase obligations (RPO) targets. It is a sure shot way of hedging for inflationary pressure on wholesale electricity generation cost as a result of spikes in fossil-fuels prices. It reduces the financial burden on discoms by cutting back on free or extremely low retail tariff supply to consumers.

Consumers also get benefit of higher reliability since they are the ones who generate electricity for themselves. They do not have to suffer discomfort due to load shedding when their electricity discom is unable to supply power. And last but not least, net-metering policy can provide a new source of income and livelihood for people. Poverty alleviation via enabling them to become generators of clean energy is a win-win for everyone.

Similarly targeted support for small and medium enterprises especially those in the rural institutional sector such as municipal schools, farmer producer organisations, NGOs, tiny businesses can benefit from self-generation and sale of clean energy.

In the above context a new centralized scheme which makes risks and rewards for all stakeholders more predictable is proposed. The idea of the proposed scheme titled – **Rooftop solar Adoption for Consumer Empowerment (RACE)** – is to focus on win-win benefits to variety of consumers and discoms. Additionally, by way of consumer aggregation, this scheme provides a guaranteed business for developers and economies of scale helps in reducing the total cost of RTPV installation.

In short, the scheme design works as follows. IREDA through central government financial assistance, procures and deploys rooftop modules and assisted infrastructure via state level renewable energy development agencies (SRDAs). Bulk procurement by IREDA is expected to reduce capital costs by providing definitive sales pipeline to module and associated equipment manufacturers.

SRDAs secure a state regulatory approval on benchmark costs of RTPV. This benchmark cost consists of capital cost plus state-specific grid installation charges and a fair developer margin. Benchmark costs reflect locational and services markup on top of the capital cost discovered by IREDA.

Developers who have secured consumer interest, approach SRDAs with request for necessary modules and infrastructure. They then install the same at consumers' premises and are responsible for maintenance for at least fifteen years. They get paid a fixed installation fee and yearly maintenance fees from SRDAs for their services, in case of poor category consumers. For other consumers, the installation fees and yearly maintenance fees is paid directly by them to the developers. Such other consumers also have to pay part of the capital costs, which is fully paid for/subsidized by IREDA in case of poor consumers.

All consumers will have to agree upon their share of self-use of the electricity generated from RTPV and the balance that will be considered as sold to developers/SRDAs (unless bought by the discom), for which they will be suitably compensated.

The developers/SRDAs aggregate such balance electricity from all participating consumers and are encouraged to maximise revenue by sale of this power to other discoms, large consumers, and power exchanges. Price arbitrage opportunities - that is difference between compensation paid to participating consumers and the realised sale price for electricity sold to other parties - will determine the net financial assistance provided by the central government.

Detailed process flow for the program, broken down into financial and energy transactions aspects, can work as follows:

Financial Flows

A. Central government agencies have a proven track record of aggregating distributed demand and procuring in bulk, which reduces the overall system level costs. Past performance of such bulk procurement and deployment in the energy sector include procurement of LED lights under UJALA. The current ongoing program for procurement and installation of smart meters under the Revamped Distribution Sector Scheme is another such example.

B. For the proposed rooftop solar photovoltaic (RTPV) Program, IREDA can take up the responsibility of central administrator and nodal agency, working in conjunction with state-level renewable energy development agencies (SRDAs). IREDA will prepare a state-wise yearly purchase tender basis inputs from SRDAs. This provides a definitive future sales pipeline to module manufacturers and suppliers. It will then initiate tenders and negotiate with suppliers to drive down capital costs. Financial assistance for procurement of RTPV systems as well as for tender related activities will be sponsored directly under central government grants.

C. In addition, the central government via IREDA will have to provide further financial assistance to SRDAs to cover for state-specific grid integration costs and developer margins that cover services for installation and recurring maintenance for the poor consumers. These two costs together, minus capital cost contribution from select consumers, makes up the gross financial support from the central government. State-specific grid integration costs and developer margins will be defined by the state regulators basis application for approval filed by respective SRDA.

D. Capital cost contribution from select consumers is determined basis current rooftop subsidy programs run by MNRE, which require consumers to bear about 60% of total costs. For this program it is envisaged that consumers will be grouped into two distinct categories - one is poor/low income households; and the other one include social institutional/ small businesses such as municipal schools & hospitals, NGOs, Farmer Produce Organisations, SME or micro-

SME businesses as well as average/rich households. It is proposed that the poor/ low income households get full capital grant, that is they do not have to pay any share of the costs for RTPV installation and maintenance. While the other category - non-poor consumers - will bear 60% of the capital costs along with 100% of installation & developer margins, which is as per the current practice. Definition of poor consumers for this program can be kept similar to the one being used in case of other similar mass-scale central government schemes such as the Ayushman Bharat Yojana . Further the SRDA will assist in providing finance to the non-poor consumers to fund for their share of capital costs, installation costs and developer fees. This can be arranged via lending support through PFC/REC or other banking and financial institutions at attractive rates of interest.

E. Developer(s) have the onus to market the program benefits to consumers and gather interests. Once the consumer puts in his/her contribution (as per set guidelines), the Developer installs the requisite RTPV on consumers' premises. The developer gets paid a fixed installation fee and yearly maintenance fees from SRDAs for its services.

F. Consumers will have to agree upon their share of self-use of the electricity generated from RTPV system. The consumer can get paid for any excess generation which is not self-consumed and injected into the discoms' network. Otherwise, the consumer may opt for sale of excess generation - an agreed quantum per month - to the SRDA at a set rate. The set rate is similar for all types of consumers, irrespective of the quantum that is on offer.

G. SRDAs will aggregate such balance electricity bought from all participating consumers, who are willing to sell it to them. They can sell this power to other discoms, large consumers, and power exchanges, such that revenue from sale of power can be maximised. Price arbitrage opportunities - that is difference between compensation paid to participating consumers and the realised sale price for electricity sold to other parties - can give boost to the overall program. SRDAs will share 50% of the net benefit thus realised with IREDA, while keeping the balance 50% which makes good their costs to set up power trading responsibilities etc. The net financial support from the central government will be calculated basis this quantum of benefit earned and shared by SRDAs. IREDA will frame the charter for seeking financial assistance from the central government basis gross and net financial support calculations.

H. Model contract agreement detailing roles and responsibilities and financial obligations shall be drafted by IREDA. There will be one umbrella tripartite agreement, signed by the consumer and the developer, and kept on records by the SRDA. Any transactions between the consumer and discom will be guided by existing regulations and model PPA for injection of excess RTPV generation into the grid (which form part of net-metering regulations).

Energy Flows

I. A consumer has to decide and agree on how much electricity will be self-consumed. The balance is deemed to be sold to the SRDA. The developer will pass on the information about the SRDA to the consumer and vice versa.

[14] National Health Authority, Government of India https://nha.gov.in/PM-JAY

Technical and commercial interlinkages between the various stakeholders are pictorially described in Figure 6.

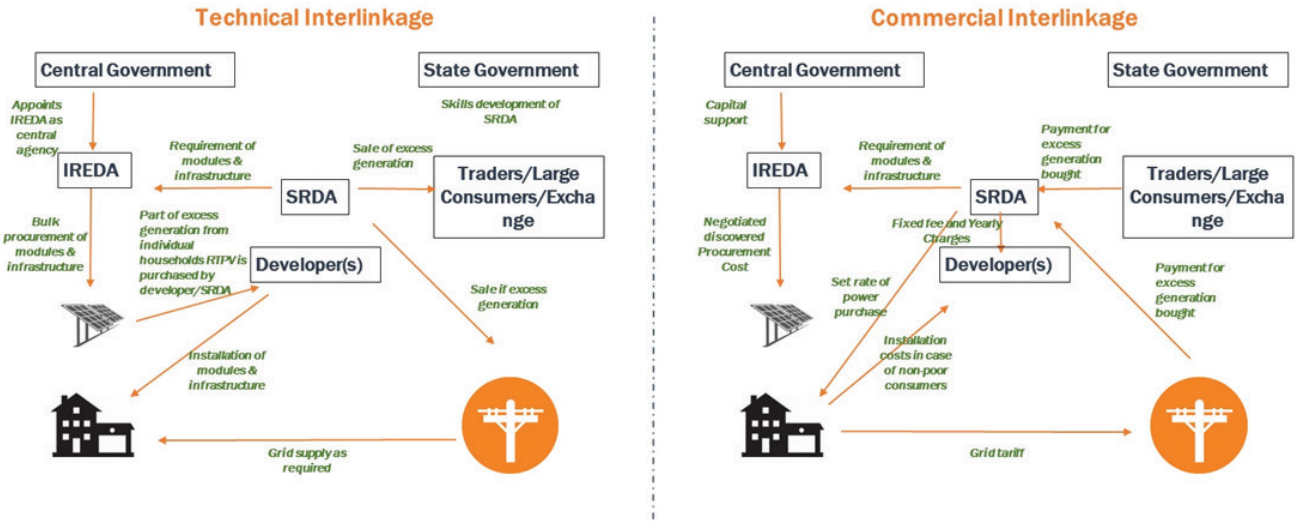


Figure 6: Implementation Structure and Economics (Source: Author)

J. The SRDA will have to aggregate all such available excess generation and compensate the consumers at set rate. It will have to develop the capabilities to plan for sale of aggregated power at the available times matching the need of third-party buyers such as other discoms, large consumers and power exchanges. To assist SRDAs with sales, one of the policy recommendations is to accord priority to solar energy accumulated through this program for delivery in the Green Day Ahead Market on power exchanges.

System Capacity Range	Benchmark Cost (Rs./kW)
Up to 1 kW	51,100
>1 kW up to 2 kW	46,980
>2 kW up to 3 kW	45,760
>3 kW up to 10 kW	44,640
>10 kW up to 100 kW	41,640
>100 kW up to 500 kW	39,080

Basis the existing rooftop solar capacity and government past targets, the proposed centralized scheme is expected to add a total of 20 GW residential RTPV capacity over a five-year period. The central sector budgetary support required could for procurement will be approximately 52,000 Rs. Crores. This has been arrived at assuming benchmark capital cost of 40,000 Rs/kW.

Reduction in cost of capital is assumed to account for economies of scale-based discounts, as well as passing over of benefits that can be achieved via aggregation of excess generation and sale through traders at competitive prices. Current benchmark costs notified by MNRE are as follows.

For the proposed addition of 20 GW of capacity and for capacities ranging 1 kW to 5 kW, this scheme can target approximately 120 lac households and 8 lac institutional or micro-small business enterprises.

At its full capacity the projects will generate approximately 29,200 GWh/Yr, at an average generation potential of 4 units/kW/day. If 50% of this energy is self-consumed by the

[15] Benchmark costs for grid-connected rooftop solar photo-voltaic systems for the financial year 2021-22 reg. MNRE Order dated August 18, 2021. https://solarrooftop.gov.in/notification/122_notification.pdf

participating consumers, that amounts to consumption of 14,600 GWh/Yr. This means a low-income household gets to use 61 units per month free of cost, a regular income household gets to use 183 units per month free of cost, and a micro-small enterprise/institutional consumer gets to use 304 units per month free of cost. Defining low-income household is important to take the program's benefit to mass-scale and has been discussed in Annexure E.

The balance, i.e. 14,600 GWh/Yr would be available for sale to the SRDAs for sale to other discoms, traders, large consumers or at the power exchanges at market prices. Depending upon the sale realisation by SRDAs, and after 50% benefit sharing, the net capital support from the central government reduces.

Following tables presents the broad set of assumptions and calculations, along with expected outcomes of the program.

Part I: Installed Base			**Category 1: Poor Consumers**	**2: Non-poor Consumers**		
Sl. No.	Particulars	Units	Low Income Households (LI)	Regular Income Households (HI)	Institutional/MSME Business (IB)	Total
A	Type of Consumer	Lacs	100	20	8	128
B	Installed Solar Capacity per Consumer	kW/Con	1	3	5	
C	Total Installed Capacity	GW	10	6	4	20
India's RTPV target is 40 GW. Out of this about 10 GW has been installed. Of the remaining 30 GW, this scheme will target for 20 GW, and the balance 10 GW is assumed to be taken up by profit-making enterprises C&I consumers, who do not require any government support.						

Part II: Energy Generated and Consumed (Assumption for electricity generation by RTPV 4 kWh/kW/day)						
D	Per Consumer Generation Per Month	kWh/mth	122	365	608	
E	Self-Consumption Per Consumer	%	50.0%	50.0%	50.0%	
F	Self-Consumption Per Consumer	kWh/mth	61	183	304	
G	Surplus Available for Sale to Developer/SRDA Per Consumer	kWh/mth	61	183	304	
H	Total Generation: All Consumers / Year	GWh pa	14,600	8,760	5,840	29,200
I	Self-Consumption by All Consumers / Year	GWh pa	7,300	4,380	2,920	14,600
J	Surplus Available for Sale to Developer/SRDA / Year	GWh pa	7,300	4,380	2,920	14,600
Depending upon their usage patter, consumers will have to commit to how much generated energy they will self-consume and how much they would be able to inject into the grid. Energy injected into the grid can be purchased by the Discom. If not, it will be considered to be purchased by the SRDA. For energy purchased by the Discom, payment shall be in-line with net metering regulations and will be via adjustments into the consumers' monthly bill. Payment for energy deemed to be purchased by the SRDA, will be paid directly by the SRDA to the consumer. This payment shall be at a set rate as defined in the contract between the consumer and the SRDA.						

Part III: Capital Cost of Installation & Subsidy (Assumption for RTPV Installation Benchmark Cost = capital cost+grid integration+developer margin 40,000 Rs./kW (Assumption that full capacity subsidy is provided to poor consumers, and only 40% of 'capital cost' subsidy is provided to non-poor consumers)						
K	Capital Subsidy	%	100%	40.0%	40.0%	
L	Capital Subsidy Provided by IREDA	Rs. Cr	40,000	7,200	4,800	52,000
M	Capital Contribution self-paid by the Consumer	Rs. Cr	0	16800	11200	28,000
Capital Cost assumption here is the Benchmark Cost as approved by state regulator. This assumes that the Benchmark Cost includes capital cost + grid interconnection charges + developer fees (one time for installation and yearly for maintenance for 15 years). At 40,000 Rs./kW the Benchmark Cost equals 80,000 Rs. Cr - wherein the central government funding equals 52,800 Rs. Cr and the participating consumers pay 27,200 Rs. Cr. This also means that the capital cost alone equals 60,000 Rs. Cr (at assumption of 30,000 Rs./kW) and the balance 20,000 Rs. Cr is for grid integration and developer margins. In other words about 75% of the Benchmark Cost is capital cost, and balance 25% is the grid integration charges + developer fees.						

Part IV: Benefit to Discom Per Annum (Assumption Discom does not purchase anything from consumers directly)						
N	Discom Average Power Purchase Cost (APPC)	Rs./ kWh				4.25
O	Discom Offered Price for excess RTPV generation	Rs./ kWh				-
P	Discom Retail Tariff charged to Consumers	Rs./ kWh	3.00	5.50	5.50	
Q	RTPV generation purchased by Discom from Consumers	GWh pa	-	-	-	-
R	Purchase consideration by Discom to Consumers	Rs. Cr	-	-	-	-
S	Discom Sales Revenue Loss due to Consumers self-consumption	Rs. Cr	2,190	2,409	1,606	6,205
T	Discom Savings due to lower Power Purchase for Consumers	Rs. Cr	3,103	1,862	1,241	6,205
U	Overall Saving By Discom	Rs. Cr	913	(548)	(365)	-
Total cost to the Discom is the loss of sales revenue (consumer is self-generating and consuming). If this cost is lower than the savings to the Discom because they have to purchase lesser energy, then only there is a net saving. In other words this is true only in case the retail tariff charged to consumers is less than what is spend on supplying electricity to them - for instance in case of low-income households and agriculture consumers. For other categories which are generally cross-subsidising categories, loss of sales revenue is much higher than any savings from lower power procurement.						

Part V: Benefit to Developer (Assumption Developer gets fixed fee for installation and recurring maintenance fees)						
V	Fixed Fee for RTPV Installation	Rs./ Consumer	1,000	1,000	1,000	
W	Fixed Fee earned by Developer	Rs. Cr	1,000	600	400	2,000
X	Yearly Maintenance Fee for RTPV Upkeep	Rs./ Consumer	300	300	300	
Y	Yearly Maintenance Fee earned by Developer (for life i.e. 15 years)	Rs. Cr	4,500	2,700	1,800	9,000
The Developers total fees for life of the project equals ~11,000 Rs. Cr, which comes out of the total benchmark cost of the Program - which is 80,000 Rs. Cr. This leaves 9,000 Cr for grid integration costs which would mean 4,500 Rs./kW for grid integration.						

Part VI: Benefit to SRDA Per Annum (Assumption SRDA sale price is 5 Rs./kWh)						
Z	RTPV generation purchased by SRDA from Consumers	GWh pa	7300	4380	2920	14,600
A1	SRDA Offered Price for excess RTPV generation	Rs./ kWh				2.00
A2	SRDA Price paid to Consumers	Rs. Cr	1,460	876	584	2,920
A3	SRDA Revenue earned from sale of power in open market	Rs. Cr	3650	2190	1460	7,300
A4	Overall Saving by SRDA	Rs. Cr	2190	1314	876	4,380
Depends heavily on how much sales price the SRDA is able to get for all accumulated power it receives from disaggregated consumers spread across location and how much it has to spend on creating capability to trade such power, including charges for power exchange fees etc.						

Part VII: Benefit to Central Government-IREDA (Assumption life of project 15 years; SRDA keeps 50% of net income and shares rest with Central Government)						
A5	Savings realised by SRDA over Program Life	Rs. Cr				65,700
A6	Net Capital Subsidy Provided by IREDA	Rs. Cr				19,150

Part VIII: Benefit to Consumers Per Annum (Assumption)						
A7	Income earned from sale of excess RTPV generation	Rs. Cr	1,460	876	584	2,920
A8	Income earned (notional) free self-gen-usage due to RTPV	Rs. Cr	2,190	2,409	1,606	6,205
A9	Net Income earned or Savings to Consumers	Rs. Cr	3,650	3,285	2,190	9,125
A 10	Net Income earned per Consumer	Rs./ Year	3,650	16,425	27,375	
		Rs./ mth	304	1,369	2,281	
Notional earning is way higher than actual earning. Program should be advertised such that the consumers are clear of how much actual income they will earn versus actual savings due to the ability to self-generate and consume.						
Sensitivity Analysis			**Base Case**	**Lower than**	**Higher than**	
			A1. SRDA sale price and Offered Price for excess RTPV generation			
				5 and 2	3.5 and 1	6.5 and 3
A5	Savings realised by SRDA over Program Life	Rs. Cr	65,700	54,750	76,650	
A6	Net Capital Subsidy Provided by IREDA	Rs. Cr	19,150	24,625	13,675	
A10	Net Income earned per Consumer (poor household category)	Rs./ mth	304	243	365	

Chapter 4: Policy and Regulatory Levers

For achieving the desired goals of a large-scale programme, the necessary policy and regulatory level support is a must. Identification of support required and the levers necessary to get the same is a good starting point.

Budgetary support from the central government will be required to fund for capex subsidy. Administrative support and funding shall be required to fund tasks to be performed by IREDA and SRDAs including to conduct auctions for selection of module suppliers and transactions between the consumers and developers. State governments are not required to fund any subsidy upfront.

Support will also be required for sale of power by SRDAs to discoms or other third parties. Policy level directives for introduction and recognition of community-based aggregation projects will help in participation from consumers who either have limited/nil rooftop space or who are not owners but renters.

Regulatory support is required on several fronts for a successful run of this scheme. First and foremost, a regulatory nudge is required so that discoms plan for RTPV installations are reflected in their reporting on standards of performance (supply reliability, outage hours) and petitions for approval of short-term seasonal power demands. These will force discoms to prioritize areas such that the impact of the scheme can be maximized.

Secondly state regulators will have to formalize and support mechanisms for Virtual Power Plants (VPPs). This allows the SRDAs to aggregate excess generation from individual homeowners RTPV systems and sell the aggregate output to traders/exchanges. The entire generation, including units that are self-consumed can be counted towards meeting discoms' RPO targets. Time of Day tariff for residential consumers will further help in signaling storage and sale of excess generation during the times when it is valued most by the discoms.

Lastly, significant capacity development of all stakeholders involved, especially SRDAs, is necessary for the successful implementation of the programme.

Key highlights of the proposed RACE program can be summed up as follows:

From a consumer point of view, this program ensures they get electricity at least during the day-time. So, this program ensures day time supply and provides additional income from sale of surplus electricity for utilisation of their rooftop space.

From a Discom point of view, this program assists in RPO fulfillment, by way of using clean energy generated at distributed level, and thereby savings in terms of network augmentation costs. Focus of the programme on low-income households also leads to reduction in losses for the discoms on account of reduction in sale of electricity below the average cost of supply.

From a State Government point of view, this program leads to local jobs and economic

activity within the state. Rural entrepreneurship will get a boost from this program and small-scale developers who can serve the local consumers will get a chance to build skills and income from the clean energy economy. It is important to leverage the Surya Mitra programme, which has anticipated such a demand and helped create a workforce with strong skills in solar systems installation, maintenance and entrepreneurship.

From a Central Government point of view, this program assists in energy transition and solar capacity addition goals.

From a programmatic perspective, it is also essential to establish a clear and transparent framework from an institutional and contractual perspective that sets out the roles and responsibilities of each stakeholder to ensure the successful implementation of the programme.

Together these measures can make the risks and rewards more predictable for all, thereby reducing the total system costs and an assurance of consumer interest.

Last but not the least, mass-scale deployment of rooftop solar has the potential to uplift local economy and create local jobs, in addition to being a recognized poverty alleviation measure. Such deployment will create new age clean energy entrepreneurs who will provide technology skills-based jobs to the local youth. Finally, the regular domestic consumer will not only get to consume, but also contribute towards clean energy transition of India.

Next Steps

While we recognise that there are several operational aspects of this proposed scheme that need to be addressed, we believe that it is important to initiate a dialogue towards understanding and addressing the current barriers to tapping our RTPV potential, which is a critical element of our clean energy transition. Some of these challenges, which we have mentioned above, include (but not comprehensive)

- Capacity building of institutions such as IREDA for technical assessment/ due diligence, bulk procurement, etc.
- Capacity building of SRDA for aggregation of customers, trading of surplus electricity, etc.
- Price discovery/negotiation for purchase price of surplus electricity from customers
- Creation of a strong installation & service network to address the needs of such a large programme; can tap into the people trained under the Surya Mitra programme
- Well-structured agreements between the customer, SRDA, equipment supplier and installer/O&M service provider to ensure performance of the system
- Check on rooftop area availability and strength to support a 1 kW + rooftop PV system in the case of low income households

Annexure A: State-wise RTPV Target

State	RTPV Target by FY22 (MW)
Maharashtra	4,700
Uttar Pradesh	4,300
Tamil Nadu	3,500
Gujarat	3,200
Karnataka	2,300
Rajasthan	2,300
Madhya Pradesh	2,200
West Bengal	2,100
Telangana	2,000
Andhra Pradesh	2,000
Punjab	2,000
Haryana	1,600
Delhi	1,100
Bihar	1,000
Odisha	1,000
Jharkhand	800
Kerala	800
Chhattisgarh	700
Jammu & Kashmir	450
Uttarakhand	350
Himachal Pradesh	320
Assam	250
Dadra & Nagar Haveli	200
Goa	150
Chandigarh, Daman & Diu, Puducherry	100 (each)
Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura	50 (each)
Andaman & Nicobar, Lakshadweep	30

Annexure B: Success Factors for RTPV Growth in Select Countries

Australia: Australia is the global leader in rooftop solar PV penetration. More than one in three households in Australia are powered by rooftop PV. RTPV accounted for 8.1% of total electricity generation in 2021. Growth has been driven by several factors including feed-in tariff (FiT) and auctions. FiT in the Queensland region for FY23 is set at 9.3 cents/kWh. A federal capex incentive scheme (Small-Scale Renewable Energy Scheme) offers discount on installation costs of solar panels. Residential consumers are charged higher retail tariff than commercial and industrial consumers. That along with excellent solar resource potential, falling energy storage costs improves the economics of self-generation and consumption. Steep growth has more recently led to reliability concerns and the Australian Energy Market Commission in 2021 has worked out new rules allowing distribution utilities to limit/ disconnect or charge consumers who wish to export power to the grid during certain times.

China: RTPV installations in China have picked up pace since 2017. Last year it stunned the world with a surge in capacity addition, which as of end-2021 stands at 27.3 GW. Rise in adoption by residential consumers has been attributed to favorable feed-in-tariff policies introduced lately as a means for faster energy transition for the country. Previously offered capex subsidies have been rolled back reportedly from 2022, while a feed-in-tariff of 0.03 RMB/kWh is proposed to be offered for all exports to the grid. RTPV has also been a part of China's solar energy for poverty alleviation program (SEPAP) announced in 2014, which aimed to benefit 2 million citizens in rural areas by 2020.

Germany: Germany was the original mecca of rooftop PV growth and remained so till around 2015 by which time the market has been reportedly saturated. It was the first country to launch mass-scale schemes such as 100,000 Roofs Programme in 1999. Higher energy costs for residential consumers in Germany is the biggest driver for rooftop PV installations. As of 2020, average retail tariff for households was 31.89 Euro cents/kWh while the cost of self-generation by RTPV was about 10 Euro cents/ kWh.

United States: Higher residential retail electricity tariff coupled with reliability concerns due to extreme weather events have resulted in residential RTPV demand picking up in the US. The biggest driver though has been the federal solar Investment Tax Credit policy first introduced in 2006. Aggregate residential RTPV capacity as of 2020 was around 18 GW.

[16] Australia passes 25 GW of installed PV capacity, leading world with almost 1 kW per person. PV Magazine published February 15, 2022. https://www.pv-magazine-australia.com/2022/02/15/australia-passes-25gw-of-installed-pv-capacity-almost-1kw-per-person/

[17] Rooftop solar energy to power nation's green development. China Daily published March 30, 2022. https://global.chinadaily.com.cn/a/202203/30/WS6243b41aa310fd2b29e5416d.html#:~:text=The%20increased%20adoption%20of%20rooftop,global%20solar%20capacity%2C%20it%20said.

[18] Zhang, H. (2020). Solar photovoltaic interventions have reduced rural poverty in China. Nature Communications. https://www.nature.com/articles/s41467-020-15826-4

[19] Solar Investment Tax Credit. SEIA Factsheet. https://www.seia.org/initiatives/solar-investment-tax-credit-itc

Annexure C: Comparing Net-metering Regulations

State	MH	UP	TN	GJ	KA
Limit on loading capacity at distribution transformer level	70%	100%	90%	100%	80%
Capacity of RTPV as compared to the consumer's sanctioned load or contract demand	100%	100% (from 1 kW to 2 MW)	100%	100%	100% (from 1 kW to 1 MW)
Limit on energy banking					
Settlement period Compensation period Rate for such compensation for energy unutilized at the end of period	Monthly (within same TOD; if excess, during off-peak hours) Financial Year Generic tariff approved by MERC	Monthly (within same TOD; if excess, during off-peak hours) Financial Year 2 Rs./kWh	Monthly (within same TOD; if excess, during off-peak hours) Financial Year Units unutilized get lapsed	Monthly (within same TOD; if excess, during off-peak hours) Financial Year 2.25 Rs./ kWh for first 5 years; 75% of GUVNL contracted at non-solar park	Monthly (within same TOD; if excess, during off-peak hours) Financial Year PPA rate as negotiated
Rate for export in case of gross metering	APPC	Solar Injection Compensation	Feed-in-tariff	GUVNL discovered price under competitive bidding + 0.20 Rs./kWh	Retail supply tariff

Annexure D: State-wise APPC for FY21

State	APPC for FY21 (Rs./kWh)
Maharashtra	4.00
Uttar Pradesh	4.45
Tamil Nadu	3.73
Gujarat	3.67
Karnataka	4.38
Rajasthan	3.94
Madhya Pradesh	3.43
West Bengal	3.55
Telangana	3.92
Andhra Pradesh	4.71
Punjab	3.65
Haryana	3.99
Delhi	4.11
Bihar	4.26
Odisha	2.46
Jharkhand	4.04
Kerala	2.87
Chhattisgarh	3.07
Jammu & Kashmir	2.77
Uttarakhand	3.47
Himachal Pradesh	2.57
Assam	5.14
Dadra & Nagar Haveli	3.85
Goa	2.83
National Average	3.85

Annexure E: Electricity Consumption and Energy Poverty

Defining poverty has been a difficult and complex task. It appears that there is no one single definition of a poor household. National poverty line estimates as reported by the Tendulkar committee in July 2013, were being used for several years. According to the Tendulkar committee the national poverty line was estimated at Rs. 816 per capita per month for rural areas and Rs. 1,000 per capita per month for urban areas for 2011-12. Accordingly, the official estimate of the number of poor in the country was 269.8 million (Poverty Measurement in India: A Status Update, Ministry of Rural Development, Working Paper No.1/2020).

Recently the NITI Aayog having recognized the limitations of poverty measurements based on consumption alone , has released its first analysis on poverty estimates basis multi-dimensional criteria. Its National Multidimensional Poverty Index: Baseline Report 2021 , has identified ~25% of India's population as poor basis assessment on three core dimensions (health, education, standard of living) followed by further twelve sub-dimensions (nutrition, child and adolescent mortality, antenatal care, years of schooling, school attendance, cooking fuel, sanitation, drinking water, electricity, housing, assets and bank accounts).

Discoms at the time of tariff setting create multiple categories of domestic consumers, basis their consumption per month and requirement of subsidy support sought/offered by the state government. At the bottom of the consumption-based pyramid are generally two categories:

- those who consume less than 30 units (kWh) per month, referred to as BPL consumer
- those who consume either less than 100 or in some states 200 units per month, referred to as lifeline consumers

[20] "Poverty line estimation in India has been based on the consumption expenditure and not on the income levels due to difficulties in assessing incomes of self-employed people, daily wage laborers etc., large fluctuations in income due to seasonal factors, additional side incomes as well as data collection difficulties in largely rural and informal economy of India. Since households may be able to access credit markets or household savings and thereby smooth their consumptions to some degree, consumption expenditures may be able to provide a better basis for determining a household's actual standard of living. Hence, most of the Poverty Estimation Committees proposed that per capita consumption expenditure or household expenses were the right statistical choice for calculating poverty in India." Poverty Measurement in India: A Status Update, Ministry of Rural Development, Working Paper No.1/2020

[21] NITI Aayog https://www.niti.gov.in/sites/default/files/2021-11/National_MPI_India-11242021.pdf

Annexure F: Abbreviations

aka also known as

ARR Aggregate Revenue Requirement

APPC Average Power Procurement Rate

C&I Commercial and Industrial

CERC Central Electricity Regulatory Commission

Discom Distribution Company (Licensee)

GW GigaWatt

GWh GigaWatt Hour

MW MegaWatt

MWh MegaWatt Hour

NSM National Solar Mission

PPA Power Purchase Agreement

PV Photovoltaic

RTPV Roof Top Photovoltaic

SRDA State Renewable Development Agency

TOD Time of Day

USD United States Dollar