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Scaling Rooftop Solar

Powering India's Renewable Energy Transition with Households and DISCOMs

Report | June 2018

NEERAJ KULDEEP, SELNA SAJI, AND KANIKA CHAWLA

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A report on 'Scaling Rooftop Solar: Powering India's Renewable Energy Transition with Households and DISCOMs.'

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About CEEW

The Council on Energy, Environment and Water (http://ceew.in/) is one of South Asia's leading not-for-profit policy research institutions. The Council uses data, integrated analysis, and strategic outreach to explain – and change – the use, reuse, and misuse of resources. The Council addresses pressing global challenges through an integrated and internationally focused approach. It prides itself on the independence of its high-quality research, develops partnerships with public and private institutions, and engages with the wider public.

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Neeraj Kuldeep is a Programme Associate at the Council on Energy, Environment and Water (CEEW), India. As part of the Renewable Energy team, he has extensively worked on and published multiple policy briefs on the impact of the goods and services tax (GST), the skills gap in the solar and wind energy segment, assessed the employment potential in the renewable energy market, examined the applications and economics of energy storage technologies, and analysed the long-term view on grid electricity tariffs, etc. He currently leads The Council's work in designing and developing new business models for the Delhi region to proliferate the deployment of rooftop solar.

Neeraj holds an M.Tech, in Energy Systems and a B.Tech. in Energy Science and Engineering from the Indian Institute of Technology (IIT), Bombay.

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Selna Saji is a research intern at CEEW. She is pursuing a European Joint Masters in Management and Engineering of Environment and Energy (ME3) from Queen's University Belfast (QUB) and Universidad Politécnica de Madrid (UPM). During her tenure at QUB, she conducted a research project on "Regulatory barriers and drivers for circular economy in Northern Ireland." Her research interests include renewable energy technologies, energy policy, circular economy, and sustainability. Prior to her masters, she completed the two-year Teach for India (TFI) fellowship in Mumbai.

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Kanika Chawla is a policy specialist working at the intersection of two revolutions in India: in renewable energy and in financial markets. As Senior Programme Lead at CEEW, Kanika manages The Council's research and outreach in renewable energy policy, finance, and jobs and skills. Her current responsibilities include: analysing financial risks affecting renewable energy investments in India; analysing changing market conditions and tax regimes and their impact on renewable energy; managing The Council's periodic surveys on renewable energy jobs; and convening a high-level working group on renewable energy finance. She is actively engaged with private and public enterprises within and outside India to design and develop new financial de-risking instruments and new financial institutions such as green banks.

Kanika has an M.Sc. in Economics and Development Economics from the University of Nottingham and an undergraduate honours degree in Economics from Miranda House, University of Delhi.

List of Abbreviations

AD	accelerated depreciation
APPC	average power purchase cost
ARR	aggregate revenue requirement
BYPL	BSES Yamuna Power Limited
CAGR	compound annual growth rate
CAPEX	capital expenditure
CFA	Central Financial Assistance
CUF	capacity utilisation factor
DERC	Delhi Electricity Regulatory Commission
DISCOM	distribution company
EMI	equated monthly instalments
EPC	engineering, procurement and construction
GBI	generation-based incentive
GHS	group housing societies
GNCTD	Government of National Capital Territory of Delhi
IRR	Internal Rate of Return
kW	kilo watt
kWh	kilo watt hour
LCOE	levelised cost of electricity
MNRE	Ministry of New and Renewable Energy
MSME	micro, small and medium enterprises
MUs	million units
MW	mega watt
NBFC	non-banking financing company
NCT	National Capital Territory
OPEX	operational expenditure
PPA	power purchase agreement
PV	photovoltaic
REC	renewable energy certificate
RESCO	Renewable Energy Service Company
ROE	return on equity
RPO	renewable purchase obligation
RTS	rooftop solar
RWA	residents' welfare association
SECI	Solar Energy Corporation of India Limited
SRISTI	Sustainable Rooftop Implementation for Solar Transfiguration of India
T&D	transmission and distribution


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Photo: pixabay

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Executive Summary

Given the low rate of deployment of rooftop solar in the residential sector in India, it has become imperative to develop innovative business and financial interventions to accelerate its adoption among households. Bringing the utilities to the forefront and incentivising them to take the lead would go a long way in improving the situation. In this context, the Council on Energy, Environment and Water (CEEW) in partnership with the Delhi electricity distribution company (discom), BSES Yamuna Power Limited (BYPL), has developed three innovative utility-led business models that can accelerate the deployment of rooftop solar systems in the residential sector.

DISCOM-led business models

1. Utility-led community solar model

Community solar is ideal for consumers who wish to benefit from solar power but do not have access to suitable roof spaces, like households within high-rise and multistory buildings. Through this model, a group of consumers could either own the solar photovoltaic (PV) system jointly or buy the solar electricity from community solar PV plants at a predetermined tariff. Individual consumers can subscribe to a share of the system by one of the two subscription options – **upfront payment** or **subscription fee.**

2. On-bill financing model

The on-bill financing model allows individual consumers with roof ownership to install rooftop solar systems while not having to pay a huge upfront amount. This is made possible by offering the capital cost as a loan which the consumers would repay through their monthly electricity bill. The average savings achieved through reduced grid electricity consumption or a part of the savings would then be used to make the monthly loan repayment. The repayment collection on the bill with a threat of disconnection on non-payment, reduces the risk of loan default.

3. Solar partners model

Solar partners model mimics the reverse auction model deployed for utility-scale large solar plants. DISCOMs play the role of a demand and supply aggregator. At the supply end, DISCOM aggregate rooftop owners in their license area, tender the capacity through reverse auction and sign power purchase agreements (PPAs) with developers who would install systems on the aggregated rooftop space.

Solar electricity from these rooftop solar plants would be made available to residential consumers through electricity exchange platform. This model allows tenants as well as flat owners (without roof access) to avail solar electricity by paying an annual subscription fee.

Table 1. Business models at a glance

	Utility-led community solar (on-site) model	Utility-led community solar (off-site) model	On-bill financing model	Solar partner model
Target consumer segments	• Residents in high rises and multi-unit buildings with shared roofs • Consumers with no access to suitable roof spaces	• Residents in high rises and multi-unit buildings with shared roofs • Consumers with no access to suitable roof spaces	Individual consumers with exclusive roof ownership but cannot finance upfront	• Renters and owners without roof access • Consumers sceptical of installing and owning a rooftop solar system
Location	Common areas and rooftop within a society's premises	Government buildings, commercial buildings, institutions	Consumer's rooftop	Public, commercial and industrial buildings, community spaces and other available roof spaces
Ownership	• Community, (society or group of consumers) if payment is upfront • Third-party, if payment through monthly subscription fee	• Community (society or group of consumers), if payment is upfront • Third-party, if payment through monthly subscription fee	Ownership transferred to consumers after loan repayment	Developers, DISCOMs, municipalities
Metering arrangement	Virtual net-metering	Virtual net-metering	Net-metering	Virtual net-metering

Source: CEEW analysis

Economic viability

The economic viability of the business models varies with several parameters like consumer consumption slab, system size, ownership and mode of financing. Techno-economic analysis of the models indicate that they could be made financially attractive to consumers who are in the high consumption slabs (>400 units/month) while lower consumption slabs (<400 units/ month) would need customised solar tariff design for it to be feasible. This is mainly because of the 50% subsidy on energy charges given to the domestic consumers under the 400-unit slab in Delhi. For BYPL, this category accounts for 84% of its total domestic consumers.

The solar subscription programme design would be one way to make benefits from solar rooftop system accessible to consumers in the low consumption category. It is possible to develop such programmes under community solar - subscription and solar partners models. This way, a certain proportion of the subscription will be reserved for consumers below the 400-unit slab at a lower tariff which will be adjusted by the higher tariff for the consumers in other slabs.

Table 2 compares the different business models in terms of the different financial parameters that determines its economic viability. Given the results, the DISCOM can choose combinations of two or more of these models and devise deployment strategies tailored to the needs of its domestic consumer segments.

Table 2. The economics at a glance

	Community solar: Upfront payment	Community solar: Subscription payment	On-bill financing	Solar partners: Large roof cluster	Solar partners: Small roof cluster
LCOE (INR/kWh)	2.73	5.6	5.89	5.06	6.27
Savings on electricity expenditure over system life (%)	74%	58%	70%	49%	46%
Payback period (years)	7 - 10	-	-	-	-
Revenue for DISCOM (INR/kWh)	0.1	0.35	0.26	0.5	0.5
All comparison shown are for a consumer with average monthly consumption 1200 units. Other assumptions regarding system size, interest rate, etc. are same as indicated in the respective sections.					

Source: CEEW analysis

Recommendations

The DISCOMs should initiate rooftop programmes that will address the various market challenges and cater to its consumer segments. Some of the key recommendations based on the business model analysis and stakeholder consultation are:

Table 3: Key recommendations at a glance

	Key recommendations
Community solar model	• DISCOMs should introduce community solar programmes in strategic locations, given the high proportion of consumers who live in apartments. It is also important that DISCOMs ensure timely project development and implementation by actively taking the lead role. • Subscription payment option along with upfront payment method would encourage more consumers to take an interest in the programmes as it eliminates any financial burden on them. • Differentiated subscription tariff is necessary to make the model financially viable to all domestic consumer segments.
On-bill financing model	• Through the on-bill programme, DISCOMs should aggregate consumers and partner with financial institutions who can offer loans below market rates • Collecting repayment on the electricity bill would reduce the risk of defaulting and this should make it possible for the banks to offer better terms of debt
Solar partner model	• DISCOMs aggregating large roof spaces and tendering them out would reduce the overall system installation cost which can bring down the solar tariff • DISCOMs can also procure systems at lower prices and install them in their office buildings as well as in other public or private buildings in their area with large roof areas
Regulatory challenges	• Virtual net-metering would help consumers benefit from solar energy generated from shared systems and systems located off-premises. It is an unavoidable regulatory provision that needs to come into force as a high proportion of the residential consumers in Delhi do not have access to exclusive roof spaces

Source: CEEW analysis

Conclusion

Involvement of DISCOMs with well-planned rooftop programmes and business interventions that can eliminate the various market challenges could provide the momentum that the sector is currently lacking. While not being an exhaustive list, the three business models discussed here have the most potential in effectively addressing the challenges and catering to all the domestic consumer segments. With the anticipated year-on-year price drop in solar panels and the potential cost reduction with DISCOM involvement in aggregation and facilitation, the models could prove to be quite attractive in the coming years.

1. Introduction

Solar electricity tariffs in India have declined significantly in recent years, making rooftop solar (RTS) an attractive investment for commercial and industrial consumers. This has led to increased deployment of RTS systems among consumers in these categories, primarily to hedge the risk against increasing tariffs of grid electricity. However, in the residential category, even though RTS systems are economically viable for higher-tariff consumption slabs, adoption has been minimal, with scale-up not growing as expected.

In the residential category, even though RTS systems are economically viable for higher-tariff consumption slabs, adoption has been minimal

Approximately 49 per cent of the total RTS potential in the National Capital Territory (NCT) of Delhi is in residential buildings, followed by the industrial, commercial, and government building sectors.[1] This presents a huge market opportunity, especially with RTS systems becoming cheaper year-on-year. In addition, the rising trend of electricity tariff and a conducive policy landscape make the RTS option quite attractive.

Recognising this context and the role of RTS in increasing the share of renewables in the city, the Delhi government has implemented a much-needed solar policy that focuses on RTS above 1 kW. The policy has set a target of 2 GW cumulative installed capacity by 2025 which would cover 21 per cent of the city's peak load.[2] Besides including unique provisions like group and virtual net-metering, the policy also offers generation-based incentives (GBIs) for a limited period of time and mandates all government buildings with roof area greater than 500 m^2 to deploy rooftop systems within five years. In addition, the policy also calls for exemptions related to various transmission, open-access, and cross-subsidy charges. Another notable feature of the policy is its emphasis on the role of electricity distribution companies (DISCOMs) in facilitating the adoption of RTS in the city. The policy requires DISCOMs to take measures to ensure smooth and streamlined net-metering connection and system integration for consumers.

At the national level too, the Ministry of New and Renewable Energy (MNRE) is implementing the Grid Connected Rooftop Solar Power Programme which is intended to encourage the DISCOMS to facilitate the faster adoption of RTS by incentivising them to increase deployment in their license area. The scheme, which is named SRISTI (Sustainable Rooftop Implementation for Solar Transfiguration of India), is being reviewed after stakeholder consultation. Once it is implemented, it will provide incentives to the DISCOMs to install incremental RTS capacity from a base year, through the INR 14,450 crore (USD 2.2 billion) earmarked for this purpose from the central financial assistance (CFA) scheme.[3]

1 Bridge to India (2013) *Rooftop Revolution: Unleashing Delhi's Solar Potential*, GREENPEACE India, June, pp 23-24.
2 Department of Power, GNCTD (2016) "Department of Power Notification - Delhi Solar Energy Policy, 2016," Government of NCT of Delhi, September.
3 MNRE (2017) "SRISTI (Sustainable Rooftop Implementation for Solar Transfiguration of India)," Concept note for stakeholder consultation, 318/331/2017-GCRT, 18 December.

Despite the favourable policy environment, the rate of adoption of RTS remains very low due to several market challenges. Even though the market is becoming increasingly favourable for most consumer categories, it has yet to reach a point where RTS gains a commodity status. RTS continues to be viewed as an investment, and the falling prices of solar, the longer payback periods, and the lack of confidence in the 25-year life of RTS stand in the way of higher penetration, especially in the residential sector. There is also a supply gap in this sector created by the major solar players who target niche markets with high credit ratings, leaving out a large proportion of consumers.

The conventional rooftop business offerings are ineffective in addressing the challenges that exist in the market and hence there is a need for innovative business interventions to make RTS a viable option for all consumer segments. Indian DISCOMs could potentially play an important role in the RTS market by leveraging their close relationship with consumers and institutions, thereby maintaining their position in the market while addressing several of the challenges faced by the stakeholders.

The Council on Energy, Environment and Water (CEEW), in partnership with the Delhi electricity distribution company, BSES Yamuna Power Limited (BYPL), has developed three utility-led business models to address the existing market challenges and to create a conducive environment for DISCOMs, consumers, and developers. Thus, the main objectives of the business models are to address the market challenges faced by stakeholders, make rooftop solar a viable option to all domestic consumer categories and thereby accelerate the RTS deployment in the BYPL licence area. The following section explores the market challenges, examines the business models, and assesses their economic viability.

2. Market Challenges for Stakeholders

All stakeholders in the RTS industry face various challenges that need to be addressed by any intervention that is being planned. The different market challenges faced by the stakeholders are as follows.

2.1 Consumers

Consumers who wish to install RTS face issues like higher upfront cost and lack of access to finance. The majority of consumers still lack awareness about the benefits of, and the processes involved in, installing rooftop systems. There are also consumers who do not have roof ownership or lack access to suitable roof spaces. The long roof lock-in period of 25 years is a major concern for some consumers.

2.2 Developers

For developers, the smaller size of the rooftop system, the non-uniform characteristics of rooftops, and the fragmented distribution of installations contribute to higher costs of procurement and installation of the systems. For the same reason, access to finance for small rooftop developers becomes a challenge. Delay in approvals and other regulatory processes, the cap on solar system sizes due to limitations on transformer capacity and sanctioned load, and consumer inertia are some of the other challenges faced by developers. The collection of payments from a decentralised consumer base also presents a high transaction cost for developers.

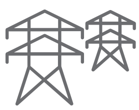
2.3 Financiers

The creditworthiness of solar developers and consumers is a major concern for financiers when it comes to RTS owing to its small and distributed nature. It also requires disproportionately high transaction costs and is an administrative hassle for banks, due to which the latter are reluctant to undertake large-scale RTS financing for the residential sector.

2.4 DISCOMs

DISCOMs face a major risk of revenue loss because most early adopters are high-paying consumers. This also affects the cross-subsidy because the tariff collected from the high-end consumers is insufficient to cover the subsidies to the subsidised consumers and the burden eventually falls on all segments of the consumers as the overall tariff increases.

Table 4 summarises the various challenges faced by different stakeholders in installing and operating solar rooftop systems.



DISCOMs face a major risk of revenue loss because most early adopters are high-paying consumers

Table 4. Market challenges for stakeholders

Consumers	DISCOMs	Developers	Financier
Lack of awareness	Loss of revenue from RTS system owners (primarily high-paying consumer categories)	Lack of access to finance	Credit worthiness of consumers
High capital cost	Lack of trained staff	Fragmented distribution of installations	Small size of rooftop projects
Lack of access to finance	Higher variability at distribution transformer level	Ownership of rooftop	Lack of legal enforceability
Issues with roof ownership and access	Lack of incentives to promote RTS (transmission charges, capacity charges, etc. are exempted)	Delay in regulatory approvals	Transaction cost
Roof lock-in for 25 years	Grid integration, load management, unscheduled request of commissioned capacity for peak load	Availability of shadow free area	Access to consumers
Quality of installations – lack of reliable developers	Lack of awareness at operating level (Junior Engineer / Assistant Engineer)	Cap on size of solar system	
Need for regular operations and maintenance		Cap on transformer capacity	
Delay in getting approval for net-metering		Cap on sanctioned load	
Solar tariffs – decreasing trends		Credit worthiness of consumers	
Cap on sanctioned load			
Grid integration – grid standards, anti-islanding protection etc.			
Long payback period			

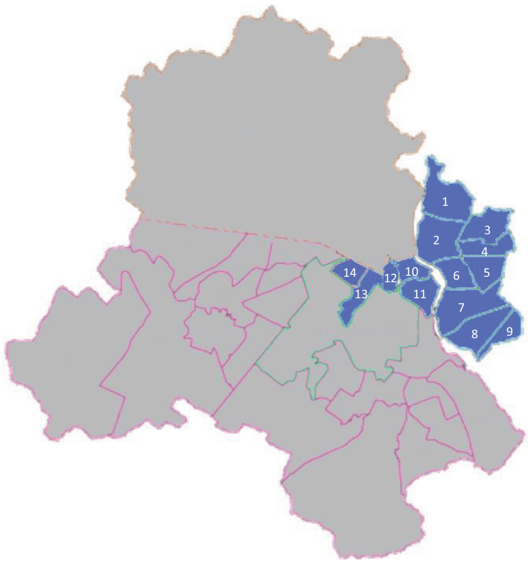
Source: CEEW analysis

3. BSES Yamuna and Solar Rooftops

BSES Yamuna Power Limited (BYPL) serves the central and eastern districts of the NCT of Delhi and has one of the highest consumer densities among DISCOMs in India.[4] The BYPL license area has the highest population density and a higher proportion of built area in the city.[5] BYPL also has a unique consumer mix compared to its counterparts in Delhi, with 76 per cent of its consumers in the domestic sector, 24 per cent in the commercial sector, and less than one per cent in other sectors.[6] The DISCOM sold 6114.82 million units (MUs) of electricity in fiscal year 2016–17, of which 58 per cent was in the domestic category. It faced a peak demand of 1493 MW in the same year which it met successfully.[7]

BYPL has a unique consumer mix compared to its counterparts in Delhi, with 76 per cent of its consumers in the domestic sector, 24 per cent in the commercial sector, and less than one per cent in other sectors

Figure 1. BSES Yamuna license area in NCT of Delhi



Source: BSES, 2017

BYPL has been actively engaged in energising net-metered rooftop systems across its license area and has achieved 13 MW of installed capacity as of 31 March 2018.[8] Given the higher proportion of its consumers in the domestic sector, the DISCOM will require higher rates of

4 BSES (2017) "BSES at a Glance," available at http://www.bsesdelhi.com/HTML/wb_bsesataglance.html; accessed 18 June 2018.
5 Government of NCT of Delhi (2016) *Statistical Abstract of Delhi 2016*, New Delhi: Directorate of Economics and Statistics.
6 BSES Yamuna Power Limited
7 BYPL (2018) *Tariff Order FY 2018 – 19*, Delhi Electricity Regulatory Commission.
8 BSES Yamuna Power Limited

adoption of RTS among domestic consumers to achieve accelerated deployment of solar in its license area.

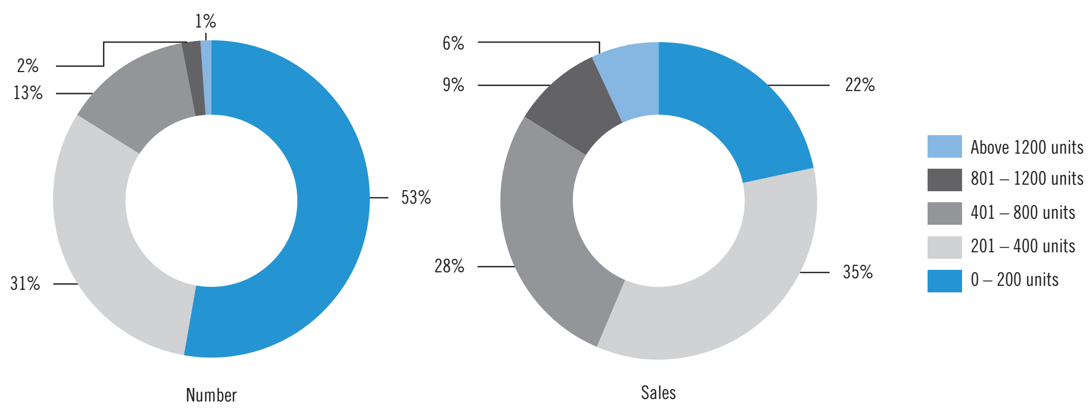
3.1 Consumer segments

In the residential sector, there are different segments of consumers in the BYPL license area. They can be broadly classified on the basis of their average monthly electricity consumption and dwelling type. The characteristics of each of these consumer segments vary widely and so do the challenges in deploying RTS.

a. Average monthly consumption: The Delhi Electricity Regulatory Commission (DERC) prescribes the variable tariff for domestic consumers based on their monthly electricity consumption. Consumers pay an incremental tariff based on slab-wise consumption. Hence, those who consume fewer units will have lower average per unit energy charges compared to those who consume more. In addition, the Delhi government has subsidised the final energy charges by 50 per cent if the total monthly consumption does not exceed 400 units.

As seen in Figure 2, 84 per cent of BYPL domestic consumers consume less than 400 units a month on average, which account for 57 per cent of the utility's total energy sales.

Figure 2. Consumer slab-wise consumption in BYPL license area



Source: CEEW; BSES Yamuna

b. Dwelling type: The BYPL license area has the highest proportion of built area in the NCT of Delhi, around 70 per cent, compared to the other regions of the city.[9] This adds up to roughly 140 sq. km.[10] While this figure indicates more buildings and thus more roof spaces, the viability of installing rooftop systems depends on several other factors.

The type of dwelling plays an important role in determining the consumer's ownership of, and access to, roof spaces. Broadly, the BYPL license area has three building types owned or used by consumers in the domestic sector:

i. Independent houses
ii. High-rise apartments
iii. Four-five-floor multifamily building units

9 Government of NCT of Delhi (2016) *Statistical Abstract of Delhi 2016,* New Delhi: Directorate of Economics and Statistics

10 BSES (2017) "BSES at a Glance," available at http://www.bsesdelhi.com/HTML/wb_bsesataglance.html; accessed 18 June 2018

Only around 51 per cent of Delhi's population lives in independent houses and the remaining 46 per cent lives in apartments or flats with no exclusive access to rooftops.[11] Flats include high-rise apartments and four-five-floor multi-unit buildings. East and central Delhi, which is the BYPL license area, have various clusters of high-rises, like in Mayur Vihar and Vasundhara Enclave, and independent houses, like in Karkardooma.

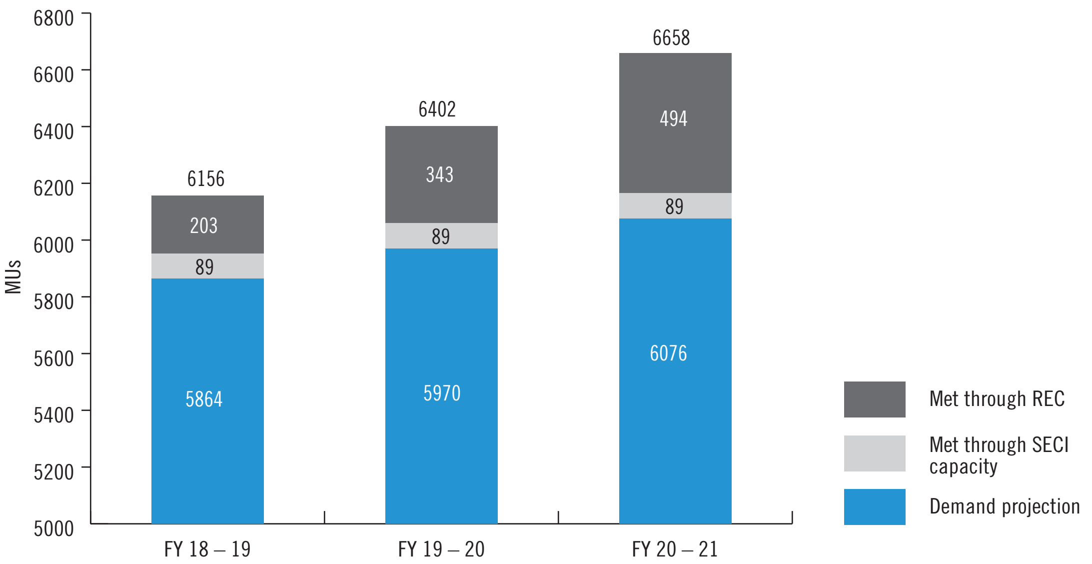
3.2 Solar renewable purchase obligation (RPO)

From the current financial year, FY 2018–19, as per the DERC Business Plan Regulations, 2017, the Delhi DISCOMs need to have a solar RPO that is 4.75 per cent of their total energy sales. As per the ARR (Aggregate Revenue Requirement) document, BYPL requires to procure about 292 MUs from renewable sources to meet its RPO targets. Current solar capacity from the Solar Energy Corporation of India (SECI) and rooftop solar generation account to around 89 MUs, and an additional 26 MUs are carried over from last year's excess. This means that BYPL needs to purchase 177 MUs as Renewable Energy Certificates (RECs), which cost around INR 1.12 /unit, adding up to INR 19.82 crore (USD 2.93 million) for the year. [12]

If the 292 MUs are to be generated from rooftop systems alone, a capacity of 208 MW (CUF: 16 per cent) is estimated to be necessary. If the same number of units are to be procured from utility-scale plants (CUF: 18 per cent), the capacity required will be 11 per cent less.

The total energy demand for BYPL is projected to increase approximately by 4 per cent each year (Figure 3). The projected RPO targets and the required solar capacity are illustrated in Figure 4.

Figure 3. BSES Yamuna energy demand and RPO target projection

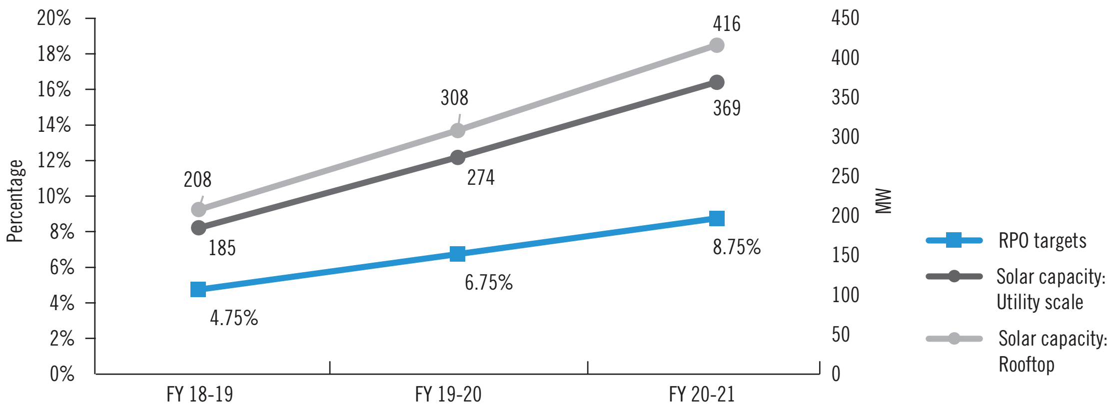


Source: BYPL, 2017; CEEW analysis

11 Government of NCT of Delhi (2012) *Housing Conditions in Delhi: Based on NSS 69th Round Survey,* New Delhi: Directorate of Economics and Statistics

12 BYPL (2017) *Petition for Truing-up upto FY 2016-17 and ARR and Tariff for FY 2018-19,* BSES Yamuna Power Limited

Figure 4. RPO targets and solar capacity required

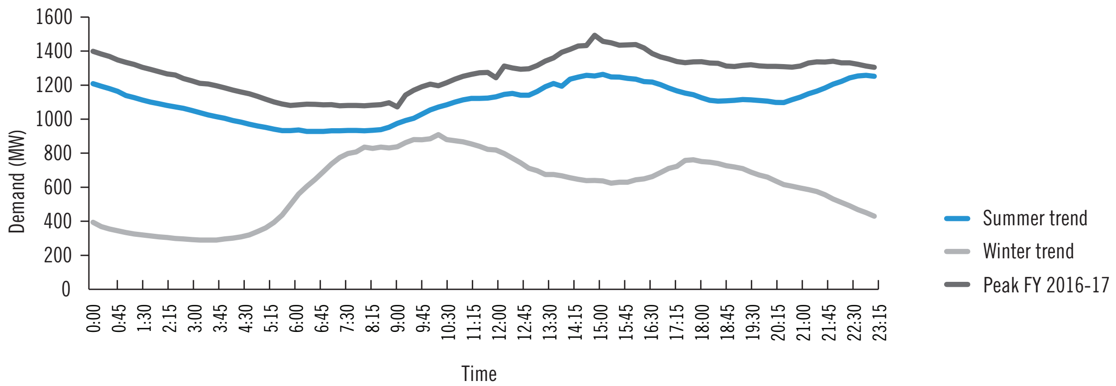


Source: BYPL, 2017; CEEW analysis

3.3 Peak load demand

For most of the year, the peak load for BYPL occurs during the day between 12:00 and 18:00 (Figure 5), which roughly corresponds to the period of solar generation in the city. The DISCOM also observed a 10 per cent increase in the peak demand between 2015 and 2016. Its load factor[13] is around 0.47, which indicates a huge variance between the average load and the peak load. Given the higher cost of procuring power from short-term markets and electricity exchanges to meet the peak demand, RTS systems across the area can go a long way in smoothening the peak curve and in reducing the overall cost for the DISCOM.

Figure 5. BSES Yamuna peak load curve



Source: CEEW; BSES Yamuna

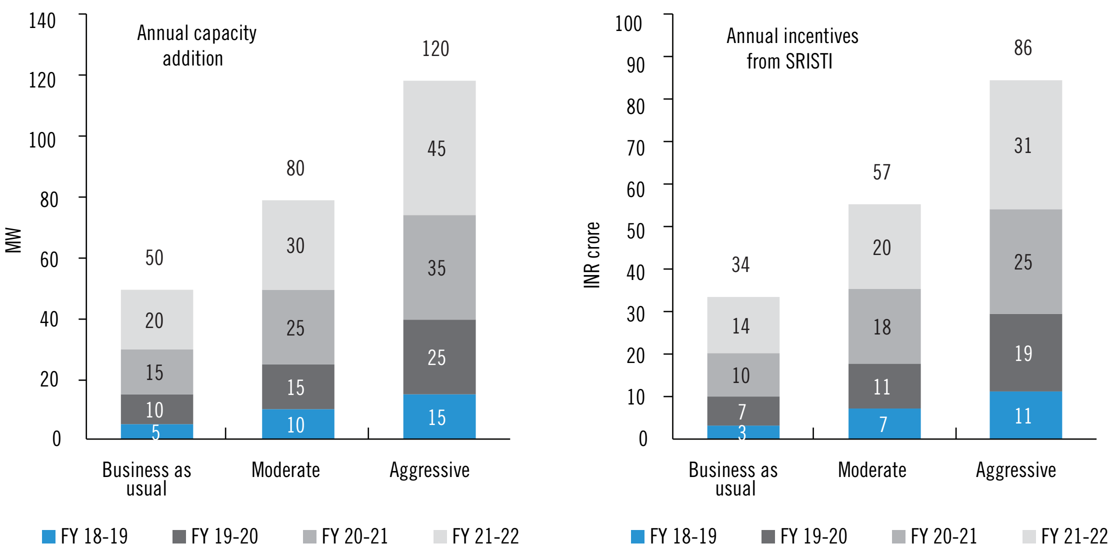
13 The load factor is the ratio between the average load and the peak load for a specified period. Here, the load factor is calculated for the year.

3.4 SRISTI scheme and avoided cost

The proposed SRISTI scheme offers incremental incentives based on the additional capacity of solar rooftop systems from a base year in DISCOM license area, the first base year being FY 2017–18. As per the scheme, higher achievement is incentivised at a higher rate and the amount can be used to implement measures that would enable an expeditious deployment of RTS systems.

Given the cumulative capacity of 13 MW as of 31 March 2018, Figure 6 demonstrates the scenarios for capacity achievement and the corresponding amounts of incentives for which BYPL could be eligible in the different scenarios. The methodology described in the SRISTI scheme document has been used to calculate the incentives.

Figure 6. SRISTI scheme's scenarios for eligible incentives

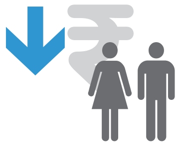


Source: CEEW analysis

In a business-as-usual scenario, BYPL will continue to see deployment in its license area at a rate that will gradually increase with the growth of the market and the anticipated price drop in RTS. In a moderate scenario, where the DISCOM actively intervenes in the market, a cumulative additional capacity of 80 MW is reasonable over the next four years. In an aggressive scenario, an aggressive capacity addition would be accompanied by DISCOM-led business and financial interventions as well as immensely favourable regulatory changes. Given the incrementally incentivising nature of the SRISTI scheme, an incremental capacity addition would maximise the benefits.

Given the incrementally incentivising nature of the SRISTI scheme, an incremental capacity addition would maximise the benefits

4. Existing Business Models



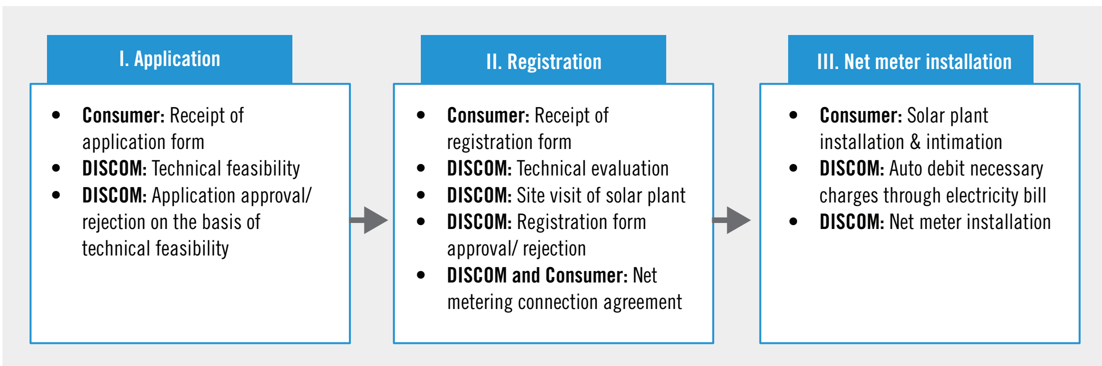
Most consumer segments are not likely to opt for RTS through the capex model because of the huge financial burden it imposes on them

The Indian RTS market still operates on the basis of the developer-led conventional capex (capital expenditure) and opex (operational expenditure) models. In the residential sector, the majority of the RTS offerings follow the capex model where consumers pay the entire cost upfront and install the system on their rooftop. Currently, the central government offers 30 per cent subsidy[14] on the capital cost which can be availed by consumers in the residential sector. Some solar developers also offer flexible payment plans depending on the consumer profile. However, most consumer segments are not likely to opt for RTS through the capex model because of the huge financial burden it imposes on them.

The RESCO (renewable energy service company) or the opex model addresses the issue of high upfront cost for consumers by letting them sign a power purchase agreement (PPA) with the developers to buy electricity generated from the system, generally at a price lower than the grid tariff with no upfront cost. While this model deals with the major challenges faced by consumers, its rate of return is lower than that of the capex model. Also, most of the issues associated with system ownership like restrictions on system size, limits on transformer capacity, and problems related to roof ownership are transferred to the developers; the collection of payments is another major risk that the developers take on. In many instances, the developers are unable to offer products under the RESCO model because the interested consumers do not have sufficient creditworthiness.

For the DISCOM, its main role in the implementation of the current model is facilitating grid connection and net-metering of the system. Figure 7 illustrates the current model for BYPL and its role in each stage of the process.

Figure 7. DISCOM as facilitator



Source: BSES Yamuna

14 There is no cap on the system size for the subsidy as of 31 May 2018.

In Delhi, one of the DISCOMs, BSES Rajdhani, has recently undertaken consumer aggregation for residential societies in Dwarka where interested consumers can reach out to the DISCOM, which, in turn, connects them to developers. However, this model also faces many challenges when it comes to implementation. Besides the issues related to gathering support from multiple parties like individual households and the building society committee, issues of financing remained unresolved. Unless the society members are able to pay upfront, it is difficult for them to acquire financing because societies cannot avail long-term debts. Under the RESCO model, many of the societies do not qualify for the necessary credit and are unable to find a guarantor.

5. DISCOM-led Business Models

To effectively accelerate the deployment of solar rooftop systems among residential consumers in the BYPL area, the DISCOM needs to deploy business models that suit each of its different consumer segments. Given the solar value chain (Figure 8), the DISCOM can take up a combination of different roles to tailor the value preposition to a target consumer segment. The DISCOM can leverage its position effectively in the solar value chain through avenues such as payment assurance and financial guarantee, energy services, consumer aggregation, and supply aggregation.

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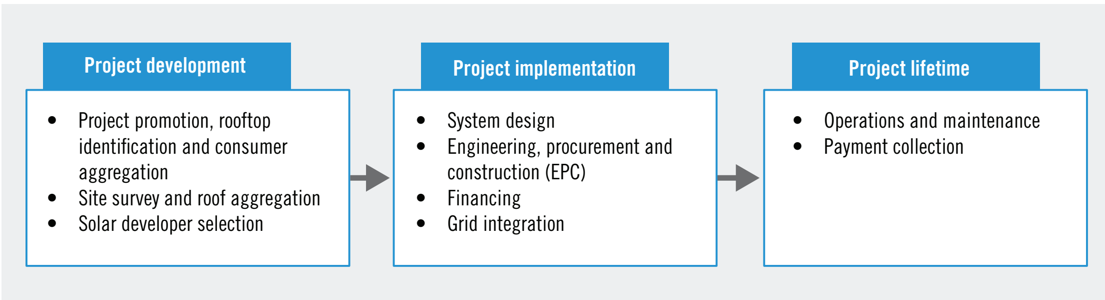
Figure 8. RTS value chain



Source: CEEW analysis

Considering the different consumer categories served by BYPL, as well as the strengths and the position of the utility, the following business models have been identified to have the most impact in increasing the adoption of RTS systems in its license area and in addressing major market challenges.

i. Utility-led community solar: on-site and off-site models

ii. On-bill financing model

iii. Solar partner model: supply and demand aggregation

While most of these models have been successfully adopted elsewhere, they have been customised to the current context through various additional mechanisms devised to address the challenges that are pertinent to the city.

Box 1: Different solar metering provisions in India

Gross-metering

In the case of the gross-metering scheme, solar electricity from the RTS photovoltaic (PV) system is fed directly into the grid. Consumers receive payment from DISCOMs for solar generation at a predetermined tariff.

Net-metering

In the case of the grid-connected RTS PV system, net-metering allows consumers to feed excess electricity into the grid which they can use in another time block. Normal meters are replaced with bi-directional meters which record electricity flow in either direction. At the end of the month, the total amount of solar generation is adjusted in the electricity bill and consumers are only required to pay for the net consumption from the grid.

Virtual net-metering

In the case of virtual net-metering, consumers receive solar electricity credits in proportion to their ownership of a shared community solar system. Solar electricity credits are adjusted in the electricity bill and the consumer only pays for the net electricity consumption.

5.1 Utility-led community solar model: Suitable for consumers without roof access

The community solar model is an increasingly popular model for RTS systems around the world and is ideal for cases where there is a lack of available and/or accessible rooftop spaces for interested consumers. In this model, a group of consumers can either jointly own the solar PV system or buy solar electricity from community solar PV plants at a predetermined tariff. The RTS system could be located in a shared space like a common rooftop in their premises or in public or privately owned spaces elsewhere. Individual consumers can subscribe to a share of the system through two subscription options—subscription fee or upfront payment. The DISCOM will act as the project promoter, consumer aggregator, and payment guarantor in the case of the subscription method and also act as the one-stop contact for consumers.

While communities with enough capital can jointly own the RTS system by paying an upfront cost, communities that do not have access to finance can opt for the subscription method where the DISCOM eliminates the need for a financial guarantor by using the payment history of the electricity bill for conducting a credit check and for collecting the subscription on the bill. Thus, the developers are assured of timely repayment and the DISCOM can charge a fee for collection services as well.

5.1.1 Location and ownership

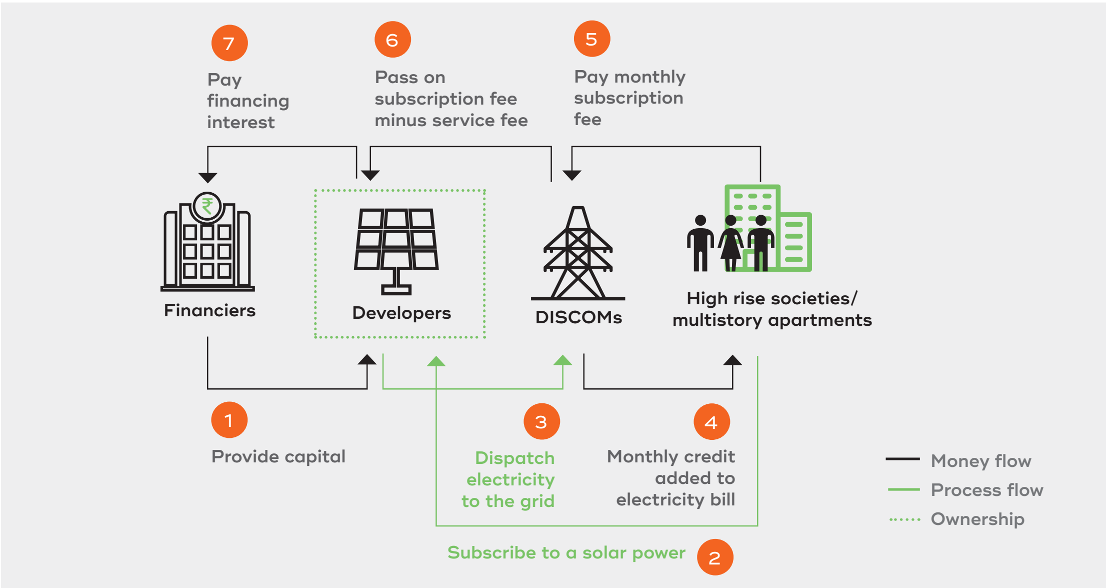
a. **On-site model:** For BYPL consumers who live in multifamily residences and residential societies, the on-site community solar model can be adopted where the RTS is located on their common roof. The model can be implemented as the capex model or as the on-bill subscription model depending on the payment capacity of the community or society members.

   If the community members are ready to make an upfront payment, the community or the residential society can jointly own the system and reap the benefits throughout the life time of the system. However, only the house owners are eligible to participate in this type of arrangement. In the case of subscription payment, the system is owned and operated by the developer and the consumers pay a monthly amount for subscribing to the energy generated from the system. The payment is designed as either a fixed amount for a specified share of the capacity or as a fixed price for a specified kWh of energy generated each month. This second method makes it possible for tenants living in rented premises to subscribe to the programme in the short term in concurrence with their landlords and to pass on the subscription to the next tenants on moving out.

b. **Off-site model:** It is possible to deploy larger solar rooftop systems on government, public, or even privately owned roof spaces within the community financed by a solar aggregator or developer. Since the system is located away from the residences of consumers, it is convenient to operate this model through a subscription programme. Consumers subscribe to a certain capacity or amount of energy generated monthly through their electricity bill. Developers, which are chosen through competitive bidding, own and operate the system.

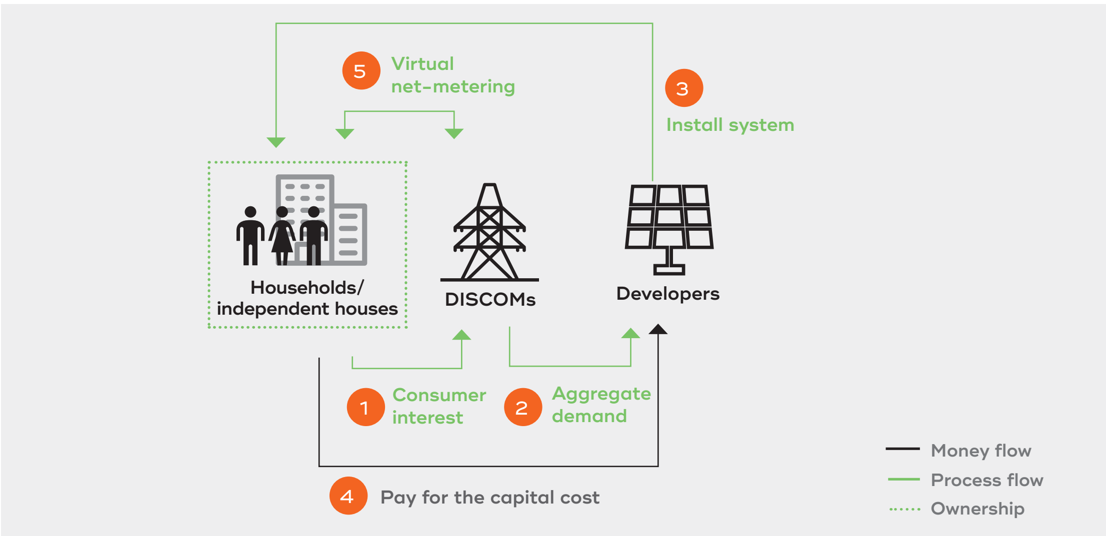
Identifying rooftop sites that have no rent or have low rent rates is crucial for decreasing the total cost of the project and for reducing the payback period. The rooftops of BYPL office buildings, government buildings, and other public buildings are ideal places for setting up solar rooftop systems through this business model. In other states, systems could be installed outside the city where ample space is available.

Figure 9. Community solar: Subscription method



Source: CEEW analysis

Figure 10. Community solar: Upfront payment method



Source: CEEW analysis

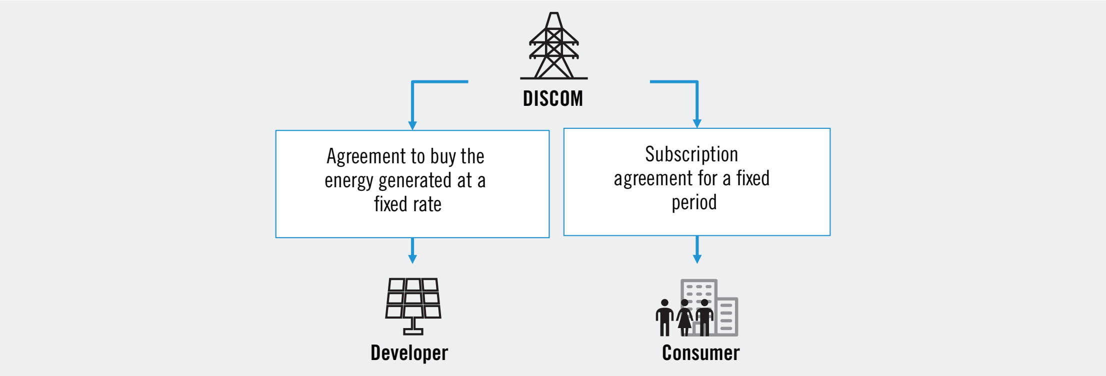
5.1.2 Metering arrangement

The electricity generated can be used for consumption on-site, say, for use in the common areas of a residential society. The members get kWh credits for any excess generation on their electricity bill through virtual net-metering. In the case of off-site systems, all the electricity generated can be credited to the consumers' bill.

5.1.3 Agreements and contracts signed

Figure 11 demonstrates the agreements and contracts signed between the stakeholders in the community solar subscription model. The DISCOM signs an agreement with the developer to buy the solar energy generated from the community plant for the lifetime of the plant (25 years) and signs subscription agreements with all the consumers for a fixed period (25 years in the case of the on-site model and for shorter periods in the case of the off-site model). In the agreement with the developer, the DISCOM also agrees to pay the developer at average power purchase cost (APPC) in the case of default of subscription payment by consumers.

Figure 11. Agreements signed between stakeholders



Source: CEEW analysis

5.1.4 Target consumers

This model is most suitable for residents of high-rises and multi-unit buildings with shared roofs because they can install a shared system on the common roof. Consumers who have no access to suitable shadow-free roof spaces can also opt for the community solar model where they can subscribe to an off-site system.

5.1.5 Role of DISCOM

As the project lead and facilitator, the DISCOM acts as the single point of contact for consumers at all stages of the project, from scouting for interest among communities to finalising the project, while continuing with the collection of monthly subscriptions. The role of the DISCOM is detailed below:

a. Promote the programme and ensure enough interest in the community and among the residents of multi-unit buildings
b. Conduct the initial site survey and calculate the system size in interested communities
c. Empanel developers through competitive bidding to ensure the supply of high-quality equipment at the lowest price
d. Connect developers with prospective consumers for the selection of system design and the finalisation of cost

e. Facilitate timely approval of net-metering and grid connection
f. Make the necessary administrative changes to include the subscription programme in the electricity bill of community members
g. Arrange and automate the transfer of subscriptions to developers

The steps for the implementation of the model are summarised in Table 5.

Table 5. Key activities for implementation of community solar model

Key activities	DISCOM	Developer	Consumer
PHASE 1: PROJECT DEVELOPMENT			
Aggregation of consumer interest in programme subscription	✓		✓
Selection of communities involved and aggregation of data on sites and site feasibility	✓		✓
Empanelment of developer(s) through competitive assessment	✓	✓	
Development of programme customised to each community	✓	✓	✓
Finalisation of complete subscription agreements with selected consumers	✓	✓	✓
Ensuring of ease in installation and performance	✓	✓	✓
PHASE 2: SYSTEM ENERGISING AND OPERATION			
Integration of subscription programme in the billing of designated consumers	✓		
Automation of accounting and information sharing	✓	✓	✓

Source: CEEW analysis

5.1.6 Addressing market challenges

a. **Benefits to consumers**
   i. Consumers with shared roof spaces or with no suitable shadow-free roofs get to avail the benefits of solar energy.
   ii. Communities that do not have access to upfront capital and that do not qualify for credit can avail the benefits of solar energy through the subscription programme wherein the DISCOM acts as the payment collector.
   iii. Empanelment of developers by the DISCOM ensures that the systems installed are reliable and meet the highest industry standards.
   iv. Communities have more trust in DISCOMs than in developers or individuals and hence the project spearheaded by the DISCOM is likely to achieve higher and faster community buy-in.
   v. Consumers achieve savings on their electricity bill.

b. **Benefits to developers**
   i. Developers can gain access to communities that are interested in solar rooftop systems and are able to install relatively larger systems compared to individual residential systems, thus reducing operations and maintenance costs through economies of scale.
   ii. The payment assurance through the on-bill subscription programme gives developers more confidence and reduces the risk of defaulting on the part of consumers.

c. **Benefits to DISCOMs**
   i. There is increased adoption of RTS systems by subsidised consumer segments through the on-bill subscription programme.

ii. There is increased outreach to consumers who do not have their own roof or who share their roof with others.

iii. It is possible to deploy the on-bill subscription programme in selected geographies.

iv. New revenue flow is guaranteed through the collection of subscription fee.

Box 2: Case study – Xcel energy's solar rewards community program[15]

The US-based utility, Xcel Energy, offers a community solar subscription programme in the state of Colorado called Solar Rewards Community Program. Residential and commercial consumers of Xcel can subscribe to a solar energy plant owned by a third-party developer located elsewhere. Once subscribed, the consumers get credits on their monthly electricity bill. In this case, the Colorado Public Utilities Commission has allocated project capacity to the utility which they can develop through third-party owners chosen through competitive bidding. Xcel manages the administration and supports the programme.

With the current design, each programme under the utility should have at least 10 subscribers with a minimum subscription size of 1 kW. It has an upper limit where no one subscriber is allowed to own more than a 40 per cent share of a single project. Subscribers are limited to subscriptions that will produce no more than 120 per cent of their annual electric usage. It also has a provision that ensures at least 5 per cent of the project capacity is subscribed by low-income consumers.

5.2 On-bill financing model: Suitable for consumers without access to credit

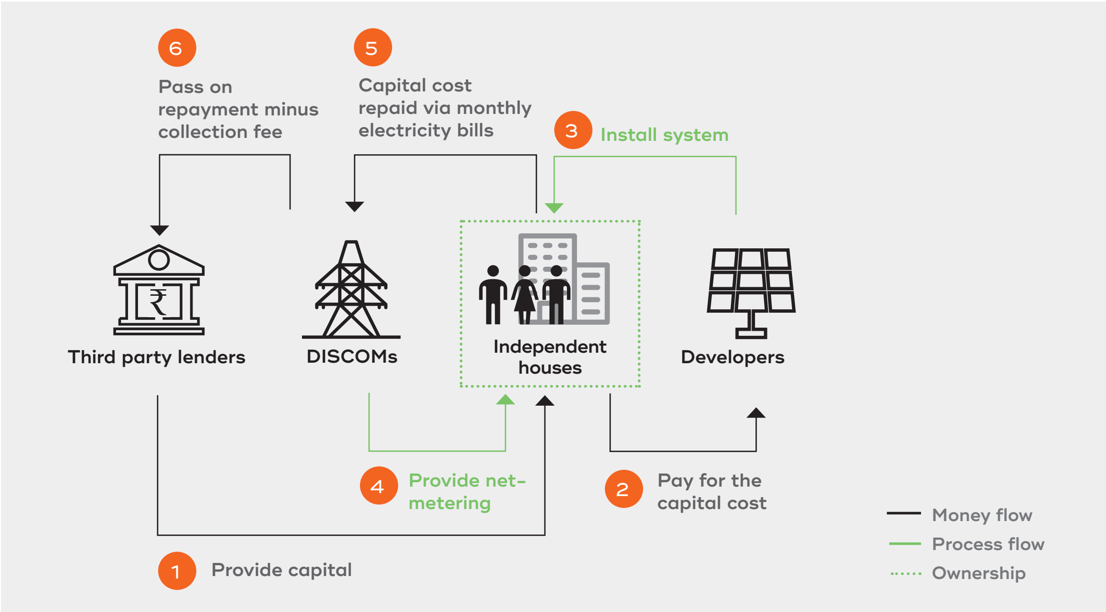
The on-bill financing model allows individual consumers to own RTS systems without having to pay a huge amount upfront. This is made possible by offering the capital cost as a loan which consumers can repay through savings on their monthly electricity bill. The loan can be sourced from (i) a third-party lender, be it a non-banking financial company (NBFC), a commercial bank, or the developer itself; and (ii) the DISCOM by facilitating lending from multilateral institutions like the World Bank, the Asian Development Bank, and the New Development Bank. The repayment equated monthly instalments (EMIs) are devised in such a way that the usual amount of the consumer's bill remains the same or is slightly lower. The average savings achieved through reduced grid electricity consumption will be equal to the monthly amount of the loan repayment. In the on-bill financing model, consumers will not feel any additional financial burden and will also be able to achieve savings from net-metering once the loan is repaid.

The on-bill financing model is also attractive to the developer because the repayment collection on the bill ensures timely repayment and a low default rate on the part of consumers. The DISCOM can further offer the provision of disconnection on non-payment. The developer now receives payment from the DISCOM under gross-metering arrangements. Based on this feature, the model is also called the payment assurance model.

An additional feature of the model is "stay with the meter", which ties the loan to the meter, thereby making it transferrable on the sale of the property. An installed rooftop system can increase the value of the property.

15 Xcel Energy (2018) "Solar Rewards Community," available at https://www.xcelenergy.com/programs_and_rebates/residential_programs_and_rebates/renewable_energy_options_residential/solar/available_solar_options/community-based_solar; accessed 16 May 2018.

Figure 12. On-bill financing model



Source: CEEW analysis

5.2.1 Location and ownership

This model is similar to the capex model in terms of location and ownership of the plant. The system is located on the consumer's rooftop and the ownership is transferred to the consumer after the repayment of the loan. The consumer is eligible to get 30 per cent of the capital as subsidy and also to receive other incentives such as GBIs offered by the state and central governments.

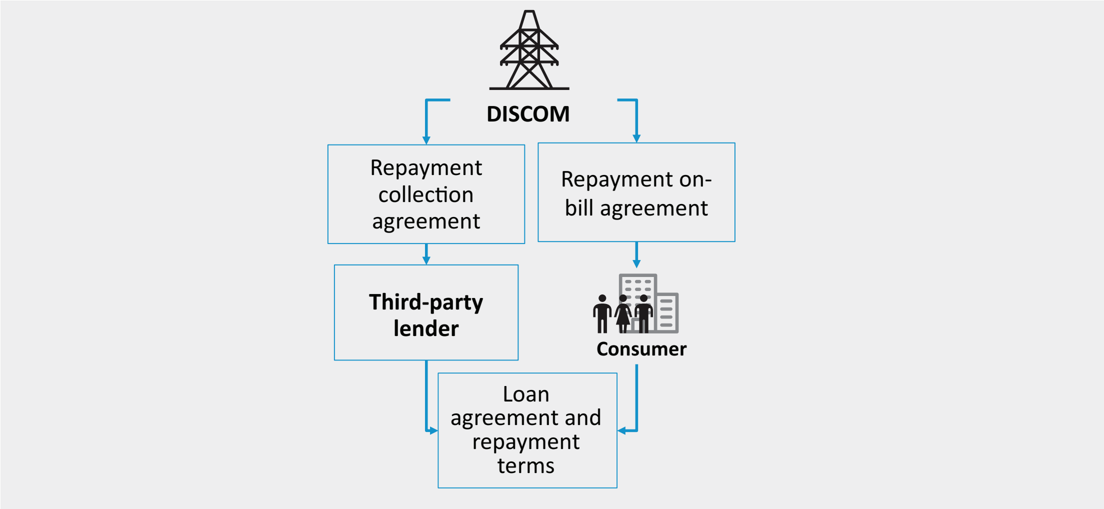
5.2.2 Metering arrangement

The system is connected to the grid through net-metering, with the consumer receiving the benefits of the system through reduced grid consumption.

5.2.3 Agreements and contracts signed

In the on-bill financing model, there is a tripartite agreement between the DISCOM, the consumer, and the lender where the lender and the consumer agree on the loan amount and the terms, the DISCOM agrees on the terms of repayment collection, and the consumer agrees on the terms of repaying the loan through the electricity bill.

Figure 13. Agreements signed between stakeholders



Source: CEEW analysis

5.2.4 Target consumers

The model is suitable for all residential consumers who have access to suitable roof space but do not want to pay the system costs upfront.

The on-bill financing model can also be a way to pay for community solar systems for single-point-connected group housing societies (GHS[16]) where the higher flat tariff makes it a feasible option. This can be an alternative option when residential societies do not qualify for long-term debt and need capital.

5.2.5 Role of DISCOM

This model is intended to increase the adoption of solar rooftop systems by facilitating loans that are easily accessible to consumers. By playing the role of repayment collector, the DISCOM insulates willing developers from the risk of loan defaulting. The bill payment history of the consumer can be used as a credit check while selecting eligible consumers.

The steps for the implementation of the model are summarised in Table 6.

Table 6. Key activities for implementation of on-bill financing model

Key activities	DISCOM	Developer	Consumer	Third-party lender
PHASE 1: PROJECT DEVELOPMENT				
Aggregation of consumer interest in programme subscription	✓		✓	
Negotiation and finalisation of third-party lender(s)	✓			✓
Engagement by DISCOM with consumers and lender to sign a tripartite agreement between the three and thus facilitate process	✓		✓	✓
Ensuring of ease in installation and performance	✓	✓	✓	

16 Single point Group Housing Societies (GHS) connections are high rise apartments which are connected to the grid at just single point. The individual residents in the society do not get separate electricity bills from the DISCOM and are charged at a flat tariff in Delhi.

Key activities	DISCOM	Developer	Consumer	Third-party lender
PHASE 2: SYSTEM ENERGISING AND OPERATION				
Integration of programme into the billing of designated consumers	✓			
Automation of accounting and information sharing between lender and DISCOM	✓			✓

Source: CEEW analysis

5.2.6 Addressing market challenges

a. **Benefits to consumers**
   i. Consumers who otherwise would not have access to cheap credit are able to install systems through the on-bill EMI system.
   ii. Consumers are able to realise savings on their electricity bill.

b. **Benefits to developers**
   i. The risk of loan defaulting is considerably reduced because non-payment of the electricity bill can lead to disconnection.
   ii. Developers have more confidence in lending to consumers because they are insulated from the risk of defaulting.

c. **Benefits to DISCOMs**
   i. Adoption among middle-class consumers increases because they are now able to afford a RTS system.
   ii. Adoption in strategic locations can be increased through targeted offering of schemes or customised campaigns.
   iii. New revenue flow through the repayment collection fee can be achieved.

Box 3: Case study – Seattle city light's community power works program[17]

Aiming to increase energy efficiency in low-income households, Seattle City Light, a municipal utility, has rolled out a Community Power Works Programme and has financed 376 on-bill loans totalling to USD 5 million since 2011. The capital comes from third-party loans and federal grant funds and the repayment amount comes as a line item in the consumer's monthly electricity bill. The interest rates are lower than the market rates and can be repaid over a period of 20 years. The loan is attached to the meter, which makes it easier to transfer the loan in case of property sale.

For the credit check of consumers, the third-party financiers use the consumers' bill payment history as well as their credit rating. However, even consumers with lower credit rating are eligible for the programmme if they have a good bill payment history. The programme also has the provision for disconnection in case of non-payment.

5.3 Solar partners model: Suitable for all residential consumers

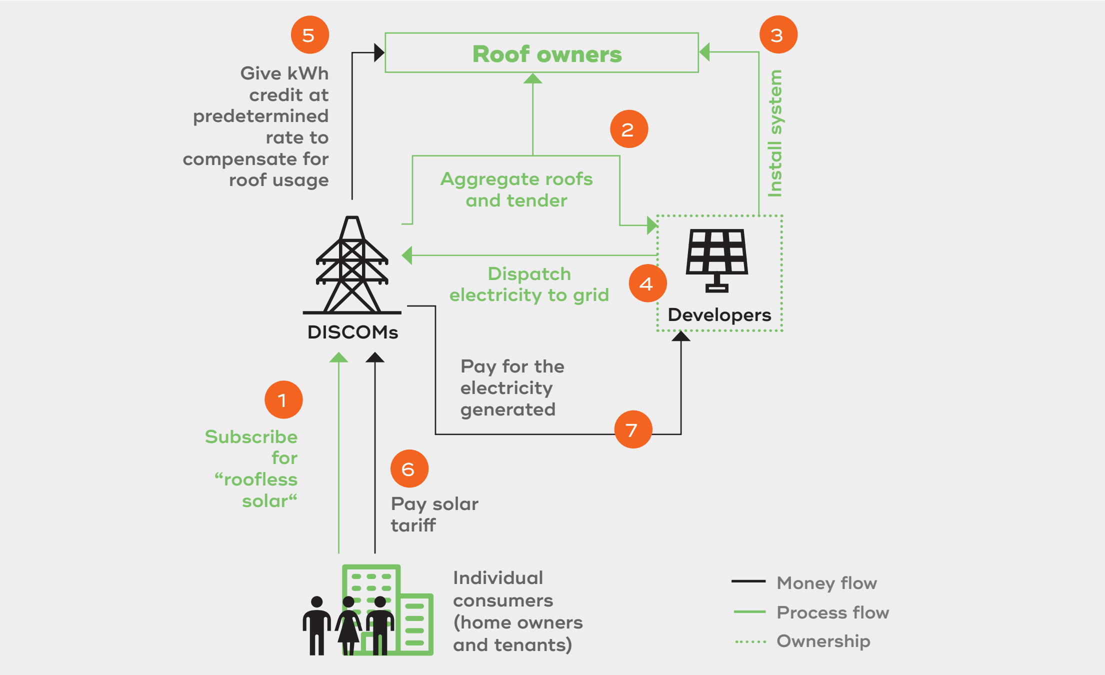
In the solar partners model, the DISCOM plays the role of a demand and supply aggregator. At the supply end, the DISCOM aggregates the rooftop owners in its license area and identifies developers who will own and install systems in the aggregated rooftop space. Developers are chosen through a competitive bidding process, which is conducted periodically, say, every quarter. Depending on the size of the capacity, one or more developers are allocated to design

17 Michigan Saves (2017) Program design considerations for developing an on-bill financing program - A Primer for Utilities in Michigan, April, pp 18-15.

and install the systems. Rooftop owners either get monthly rent for usage of their roof or a credit on their electricity bill. The DISCOM signs a tripartite agreement with rooftop owners and solar developers locking in the system for 20–25 years where developers agree to own and operate the system, roof owners agree to host the system and the DISCOM agrees to buy the power at a fixed tariff.

Simultaneously, the DISCOM aggregates the demand for solar energy among its consumers who are interested in getting 'roofless solar', that is, receiving solar energy without having a system on their rooftop. This goal is achieved through awareness-raising programmes and publicity campaigns. As a result, the interested consumers are subscribed to the programme on a yearly basis where they make a monthly payment to stay in the programme. The consumers get part of their electricity at the predetermined solar tariff based on the annual average cost of solar generation. The proportion of solar energy each consumer can subscribe is determined based on their average monthly consumption.

Figure 14. Solar partners model



Source: CEEW analysis

Box 4: Annual average cost of solar generation

In the solar partner model, the DISCOM issues multiple tenders on a regular basis to achieve the installation of new roof clusters. The solar bid tariff (LCOE) from developers is expected to be different for different roof clusters based on the cost of the system (at that given point of time) and on the site parameters. However, subscribers (residential consumers) are offered solar electricity at par with the annual average cost of solar generation which is the aggregate of all individual solar bid tariffs.

The bundling of all the solar bids over the years in this way brings down the average cost of solar generation each year while the grid tariff continues to increase. Hence, consumers do not have any incentive to wait for a fall in the solar price in the future and instead can maximise savings by subscribing right away.

Example: 50 MW capacity is tendered in three tranches; 10 MW, 15 MW, and 25 MW. The solar bid tariff is INR 5.5/kWh, INR 5/kWh, and INR 4.5/kWh respectively.

The average cost of solar generation is: INR 4.85/kWh (weighted average)

5.3.1 Location and ownership

The systems are located in roof clusters on the roofs of individual consumers who have access to eligible roof spaces and on the rooftops of public and government buildings. The roof owners are compensated for the roof rent in the form of kWh credits on their electricity bill or as rent payments. After the completion of the site survey and assessment, the DISCOM aggregate the roofs and tender them out to interested developers who then own and operate the system, as in the RESCO model.

Solar subscribers, on the other hand, will neither own nor host a system on their rooftop, but will get solar energy credits on their electricity bill netted against their total consumption.

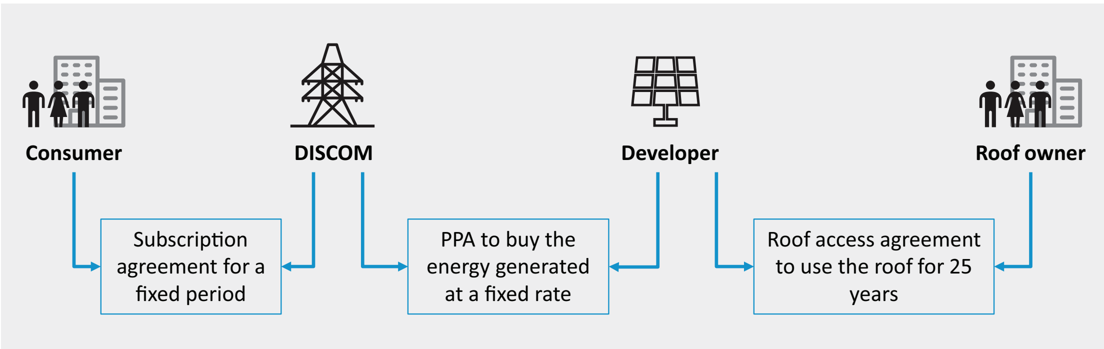
5.3.2 Metering arrangement

The electricity generated will be fed into the grid through gross-metering as per the PPA signed between the developer and the DISCOM. At the consumer end, the exchange will be through virtual net-metering where the consumers gain kWh credits on their electricity bill.

5.3.3 Agreements and contracts signed

On the supply side, the DISCOM signs a PPA with the developer, which, in turn, signs a roof-access agreement with the roof owners. On the demand side, the consumers sign short-term subscription contracts, which can be between one and five years, with the DISCOM to subscribe to solar energy. Figure 15 demonstrates the agreements and contracts signed between the stakeholders in the solar partner model.

Figure 15. Agreements signed between stakeholders



Source: CEEW analysis

5.3.4 Target consumers

The solar partners model is ideal for consumers with no roof access, consumers who are tenants, and consumers who are sceptical of installing and owning solar rooftop systems on their roofs.

5.3.5 Role of DISCOMs

DISCOMs play an important role in the solar partner model, as they are required to coordinate activities at both the demand and supply ends. The DISCOMs first aggregate interest from roof owners, conduct site surveys, assess the potential, and form roof clusters with potential for a higher total capacity. Once the sites and sizes are confirmed and the initial agreements have been signed with roof owners, the DISCOMs tender out each cluster to interested developers.

While the tenders are being evaluated and finalised, the DISCOMs should elicit interest among their consumers for roofless solar subscription through awareness-raising campaigns. Subscribers are finalised either based on a first come, first-served basis or through predefined selection criteria to ensure that the benefits are well spread out among the entire spectrum of residential categories.

The DISCOMs also facilitate smooth installation and grid connection after the signing of the tripartite agreements between the consumers, the developer, and themselves.

They also coordinate regulatory and administrative changes with the regulators.

The steps for the implementation of the solar partner model are summarised in Table 7.

Table 7. Key activities for implementation of solar partner model

Key activities	DISCOM	Developer	Consumer	Roof owner
PHASE 1: PROJECT DEVELOPMENT				
Aggregation of roof spaces	✓			✓
Aggregation of consumer interest for programme subscription	✓		✓	
Selection of developer(s) through competitive bidding	✓	✓		✓
Engagement by DISCOM with roof owners and developer(s) to sign a tripartite agreement between the three and thus facilitate process	✓	✓		✓
Completion of subscription to cover entire capacity of plant(s)	✓		✓	
Ensuring ease in installation and performance	✓	✓		✓
PHASE 2: SYSTEM ENERGISING AND OPERATION				
Integration of programme into billing of designated consumers	✓			
Automation of accounting and information sharing	✓	✓	✓	

Source: CEEW analysis

5.3.6 Addressing market challenges

a. **Benefits to consumers**

   i. Consumers who do not have access to a rooftop or who live in rented property can benefit from solar electricity through the subscription programme.

   ii. Consumers can agree to be a solar host without having to pay any money and without any credit checks, conditions that are usually required for other RESCO models, thus eliminating all investment-related market challenges associated with solar rooftop systems like high capital cost and limited access to finance.

   iii. There are no operations and maintenance costs nor any obligations for consumers.

   iv. Consumers achieve savings on their electricity bill.

b. **Benefits to developers**

i. Developers get access to clustered rooftops, which can reduce their sales expenses.

ii. Roof clusters can help developers achieve economies of scale and save costs on the logistics of design, installation, and maintenance.

iii. Developers do not have to worry about the creditworthiness of consumers because the electricity is sold to the DISCOM directly.

iv. Since the project is facilitated by the DISCOM, the processes for regulatory approval can be streamlined further and can reduce the overall time for implementation.

c. **Benefits to DISCOMs**

i. More residential consumers in the low- and medium-level consumption segments are encouraged to pay for solar electricity through a differentiated solar tariff design.

ii. By increasing residential adoption, DISCOMs can prevent loss of revenue through cross-subsidy.

iii. Through the strategic identification of roof clusters, DISCOMs can reduce transmission and distribution (T&D) losses, minimise, grid congestion, and manage the adoption of solar rooftop systems based on the capacity of the distribution transformer.

iv. DISCOMs also benefit from the avoided cost for power procurement, especially for peak load, and from the profit from reselling of solar energy.

Table 8. Business models at a glance

	Utility-led community solar (on-site) model	Utility-led community solar (off-site) model	On-bill financing model	Solar partners model
Suitable for	Residents in high-rises and multi-unit buildings with shared roofs. Consumers with no access to suitable roof spaces.	Residents in high-rises and multi-unit buildings with shared roofs. Consumers with no access to suitable roof spaces.	Individual consumers with exclusive roof ownership but who cannot provide finance upfront.	Tenants and owners without roof access. Consumers sceptical of installing and owning a RTS system.
Location	Common areas and rooftops within the premises of a society.	Government buildings, commercial buildings, institutions.	Consumer's rooftop.	Public, commercial, and industrial buildings, community spaces, and other available roof spaces.
Ownership	Community (society or group of consumers), if payment is upfront. Third party, if payment is through monthly subscription fee.	Community (society or group of consumers), if payment is upfront. Third party, if payment is through monthly subscription fee.	Ownership transferred to consumers after loan repayment.	Developers, DISCOMs, municipalities.
Metering arrangement	Virtual net-metering.	Virtual net-metering.	Net-metering.	Virtual net-metering.

Source: CEEW analysis

5.4 Regulatory hurdles

While the business models can successfully address the existing market challenges, it would require certain regulatory changes for its implementation.

Since two of the business models are designed to eliminate the need for physical access to roof spaces, the provision of virtual net-metering is essential. The Delhi solar policy briefly describes the provision and calls upon the relevant state government departments and DERC to develop a framework to achieve its policy objectives.[18] However, as of 31 May 2018, the policy has yet to be brought under any regulatory framework.

For on-bill financing, while the repayment collection on the bill significantly reduces the risk of defaulting, it still necessitates provisions to safeguard the developers and lenders from the risk. There needs to be regulatory frameworks that will incorporate these aspects and give clarity regarding DISCOM's right to disconnect or recover the dues in cases of payment default.

Another major regulatory change that should be brought about is the provision of solar tariff. In the solar partner model, consumers who subscribe to the programme pay a special solar tariff for a certain proportion of their total grid consumption. This tariff varies for consumers in different consumption slabs. To implement this, the DISCOMs in Delhi will need the DERC to approve the solar tariff under the purview of the Electricity Act, 2003, according to which the tariff can be differentiated based on the nature of supply and the consumer's total consumption.[19]

18 Department of Power, GNCTD (2016) "Department of Power Notification - Delhi Solar Energy Policy, 2016," Government of NCT of Delhi, September.
19 Electricity Act, 2003, Section 61 "Tariff Regulations."

6. Assessing Economic Viability of the Models

The deployment of solar rooftop systems through these business models can bring considerable economic benefits to consumers as well as DISCOMs through effective facilitation and implementation. The economics of the business models is assessed by considering the following main factors:

a. **Grid parity:** For each business model to be feasible for different consumer segments, its levelised cost of electricity (LCOE) or the subscription rate for solar energy, as in the case of some of the models, needs to be less than the grid tariff. The LCOEs for each model were estimated using the discounted cash flow method, and all the relevant data and assumptions were considered in consultation with industry stakeholders (Table 9).

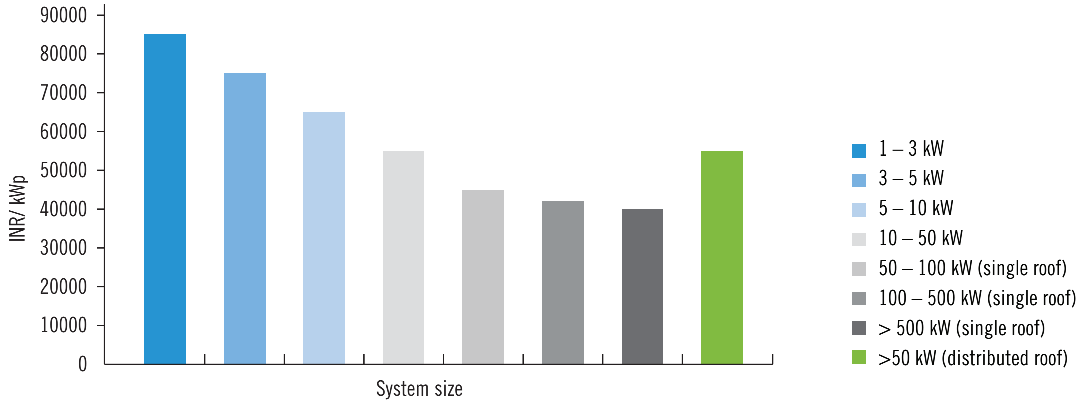
Table 9. Data and assumptions regarding technical and economic analysis

Parameters	Values
Capacity utilisation factor (CUF)	16%
System useful life	25 years
Operations and maintenance cost	1.5% of initial capital expenditure with 3% increase per year
Terms of debt for developers (interest rate and tenure)	11% (10 years)
Required return on equity for developers	16%
Taxes	34.61%
Debt–equity ratio for developers	70:30
Discount rate for developers	9.24%
Discount rate for consumers	6%
System degradation rate	0.5%
Profit margin for developers	10% of system installation cost per kW
Grid electricity tariff escalation rate[3]	5%

Source: CEEW analysis

The unit cost of the RTS system decreases with an increase in the plant size. This is mainly because of two reasons: (a) economies of scale; and (b) the cost of the inverter and other ancillary components. Figure 16 demonstrates the unit cost for different plant sizes. When the plant is not installed on a single roof, but on multiple roofs within a housing society complex, the cost does not decrease with size because each roof needs separate ancillary devices.

Figure 16. Installation cost of rooftop solar system without subsidy



Source: CEEW analysis

b. **Savings on electricity bill:** The monthly energy savings that can be achieved by consumers through each of the models is another determining factor in the success of the given model. These savings are the result of reduced grid consumption owing to generation from the RTS system. The potential for savings varies considerably with the average consumption level of the consumers. Differentiated solar tariff can be considered to maximise savings for all consumer categories.

c. **Financial feasibility:** The financial feasibility of the model is essential to ensure financial returns to consumers, developers, and financiers. The net present value, the payback period, and the internal rate of return (IRR) were considered for a system life of 25 years for each model through the discounted cash flow method. For residential consumers, a payback period of less than seven years and IRR greater than 15 per cent were considered to make the model financially attractive.[20]

d. **Average consumption and tariff slabs:** The average electricity consumption of a consumer in a particular consumer category is a major factor in determining the feasibility of each model for that category. The energy charges in the electricity tariff for domestic consumers are calculated on consumption-based slabs (Table 10). Therefore, consumers in the higher slabs who have higher average tariff per unit save more with RTS than those in the lower slabs.

   The consumer receives the savings through reduced grid consumption as well as from move to lower consumptions slabs due to lower net grid consumption. When the consumer moves down one slab, the average per unit energy charge can decrease by up to 15 per cent. Also, consumers below a consumption level of 400 units a month get an additional subsidy of 50 per cent in their energy charges. Rooftop systems can also lead to consumers being able to avail the 50 per cent tariff subsidy through lower net consumption.

20 An IRR of 15 per cent is reasonably higher than the alternative risk-free investment options available to households in Delhi. Also, a payback period of five to seven years should be a reasonable time to get an investment return.

Table 10. Delhi electricity tariff schedule, 2018–19

Fixed charges (INR/kW/month)		Energy charges (INR/kWh)				
Connected load/Tariff slab		0–200 units S1	201–400 units S2	400–800 units S3	800– 1200 units S4	> 1200 units S5
Up to 2 kW	125	3.0	4.5	6.5	7	7.75
2–5 kW	140	3.0	4.5	6.5	7	7.75
5–15 kW	175	3.0	4.5	6.5	7	7.75
15–25 kW	200	3.0	4.5	6.5	7	7.75
> 25 kW	250	3.0	4.5	6.5	7	7.75
Single delivery point for GHS	150			4.5		

Source: BYPL, 2018

Therefore, for the purpose of this analysis, different consumption slabs are considered and the results vary considerably based on the slab. Only savings in the energy charges are considered because consumers have to pay the fixed charges irrespective of the amount of solar energy generated from RTS. The different consumption slabs of BSES Yamuna and its electricity tariff for the year 2018–19 are given in Table 10. The reference for each consumption slab (S1, S2, etc.) that will be used henceforward is also indicated.

Box 5: Components of a Delhi electricity bill

In Delhi, the electricity tariff is determined each year by the Delhi Electricity Regulatory Commission (DERC). For the domestic consumer category, the monthly electricity bill has two components, fixed charges and energy charges. The fixed charge is determined by the consumer's sanctioned load. The different slabs and their charges are illustrated in Table 10. The energy charge is calculated on the basis of the consumer's monthly energy consumption, and the per unit rates increase with each slab of consumption (Table 10).

e. **Revenue for DISCOMs:** Given the various roles undertaken by DISCOMs in the various business models, they can cover their costs and gain benefits through intermediary charges on the final tariff. The assumptions regarding DISCOM charges are summarised in Table 11.

Table 11. Assumptions regarding DISCOM charges

Business model	Aggregation and administrative	Payment collection (INR/person/ month)	Loan arrangement	Transmission, supply, and other DISCOM charges (INR/ kWh)
Community solar – upfront payment	3% of capital expenditure			
Community solar – subscription	5% of capital expenditure	100		0.15
On-bill financing	1% of capital expenditure	100	2% of capital expenditure	
Solar partners	1% of capital expenditure			0.35

Source: CEEW analysis

Aggregation and administrative charges: This is a one-time expense that covers the cost of consumer aggregation, roof aggregation, and other administrative and billing changes that are needed in the beginning. This expense is assumed to be the highest for the community solar subscription model because the DISCOM engages in aggregating consumers from a community, empanelling developers, adding subscriptions to the billing system, and automating subscription transfer to the developers. In the community solar upfront payment business model, the role of the DISCOM ends with the initial aggregation and the empanelling of the developers. The on-bill financing business model only involves consumer aggregation and billing changes at the beginning. In the solar partner business model, the major role of the DISCOM is roof aggregation.

Payment collection charge: This is a recurring monthly charge for subscription and for EMI collection in the community solar subscription model and in the on-bill financing model respectively.

Loan arrangement charge: This charge is incurred in partnering with third-party lenders and arranging loans for aggregated individual consumers.

Transmission, supply, and other DISCOM charges: Additional charges are considered as part of the solar tariff in case the RTS PV system is installed away from the consumer's premises.

6.1 Community solar model

In the community solar subscription model, the major cost reduction comes from economies of scale. With multiple subscribers or owners and with larger roof spaces, it is possible to install larger systems (25–500 kWp) compared to individually owned systems (1–10 kWp), which reduces the per kWp cost of the system (Figure 16).

More than 49 per cent of consumers in the BSES Yamuna license area live in multi-storey buildings with no exclusive access to a roof space and around 0.4 per cent of the residential consumers live in GHS with single-point connection.[21,22] This 50 per cent of the total consumers could be the target segments for the community solar subscription model.

We have considered two different ways of financing the community solar model – upfront capital payment and subscription payment. In the upfront payment method, all consumers who are part of the community solar system pay their share of capital upfront and gain a share of ownership of the system proportional to their contribution. In the subscription method, the consumer becomes a part of the programme and owns the right to utilise solar energy from the system by paying a monthly subscription fee.

The following parameters, values, and assumptions were used for the analysis:

Table 12. Data and assumptions used for analysis

Parameters	Values
System size	25 kWp
Debt–equity ratio for consumer (upfront payment)	70:30
Interest rate for consumers (upfront payment)	12.5%

Source: CEEW analysis

21 Government of NCT of Delhi (2012) *Housing Conditions in Delhi: Based on NSS 69th Round Survey,* New Delhi: Directorate of Economics and Statistics
22 BSES Yamuna Power Limited

6.1.1 Findings

The cost calculation and the feasibility assessment are conducted for the two payment methods and for different scenarios. The scenarios considered are:

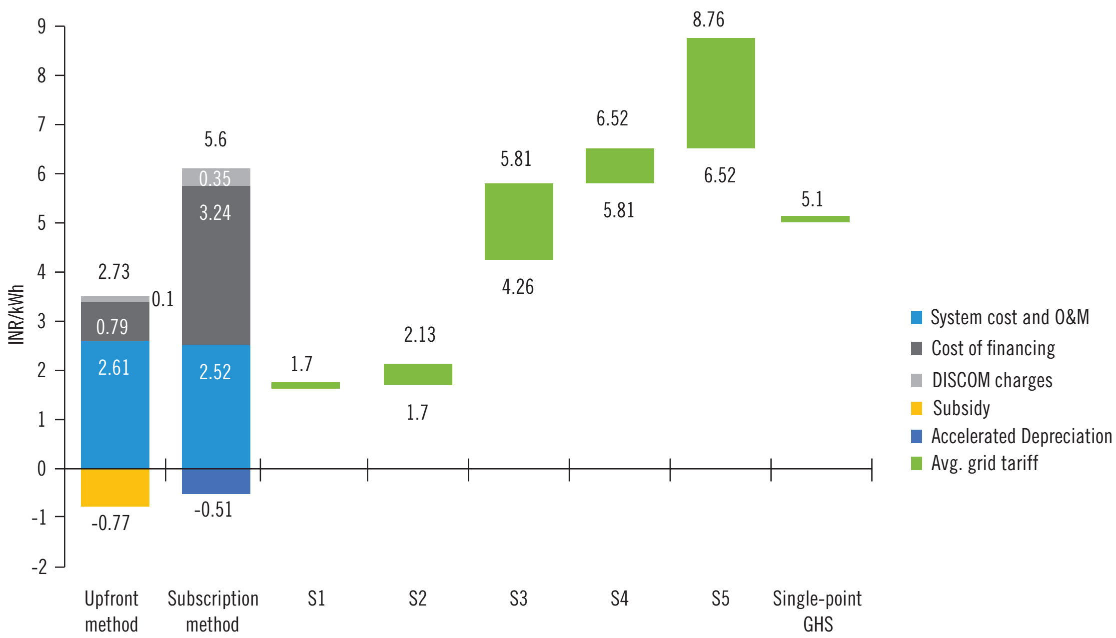
a. Various consumer consumption slabs
b. With and without subsidy

The section summarises the critical outputs obtained from the analysis.

a. **Grid parity:** The consumption level of the consumer is a major factor in determining the feasibility of the model. The community solar subscription model achieves grid parity in subscription payment if the subscribed consumers have an average monthly consumption of more than 700 units, which is around 6 per cent of BYPL residential consumers (Figure 17). The tariff needs to be reduced by around 25 per cent for the model to achieve grid parity with consumers who consume as little as 400 units a month and by 9 per cent for single-point-connected GHS consumers. For consumers in consumption slabs below 400 units, who constitute 84 per cent of the BYPL consumer mix, the model will not achieve parity even with a 50 per cent reduction in the subscription rate because of the additional subsidy on energy charges. Therefore, there should be a differentiated tariff mechanism for solar subscription that can counter the effects of subsidy in the lower consumption slabs.

   For the upfront payment method, the model achieves grid parity for consumers in slabs above 400 units and for single-point-connected GHS consumers. The feasibility for these consumers is discussed in the following section.

Figure 17. Comparing LCOE with average energy charges[23] for each consumption slab

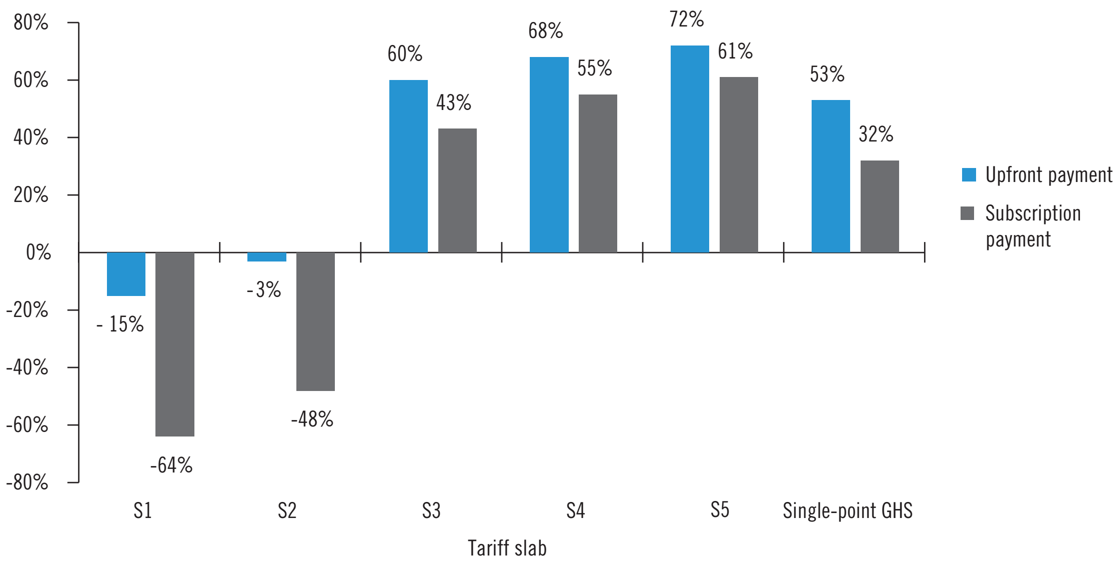


Source: CEEW analysis

23 Average energy charges are calculated using the slab-wise energy tariff calculation method in Delhi for domestic consumers. Surcharges and electricity duty at 8 per cent and 5 per cent respectively are also added to the tariff. The rates for each slab of consumption are given in Table 10.

b. **Energy savings:** As demonstrated in Figure 18, consumers in higher consumption slabs save more than consumers in lower consumption slabs. This is due to the following reasons: (a) With higher consumption, the cumulative cap on accounted energy generations will be higher, and hence consumers are able to avail benefits from a larger share of the solar system; (b) Consumers in higher consumption slabs pay more per unit consumed: and (c) Consumers also move to lower consumption slabs with lower net grid consumption, thereby reducing their average energy tariff per unit.

Figure 18. Savings on electricity expenditure over system life for each consumption slab

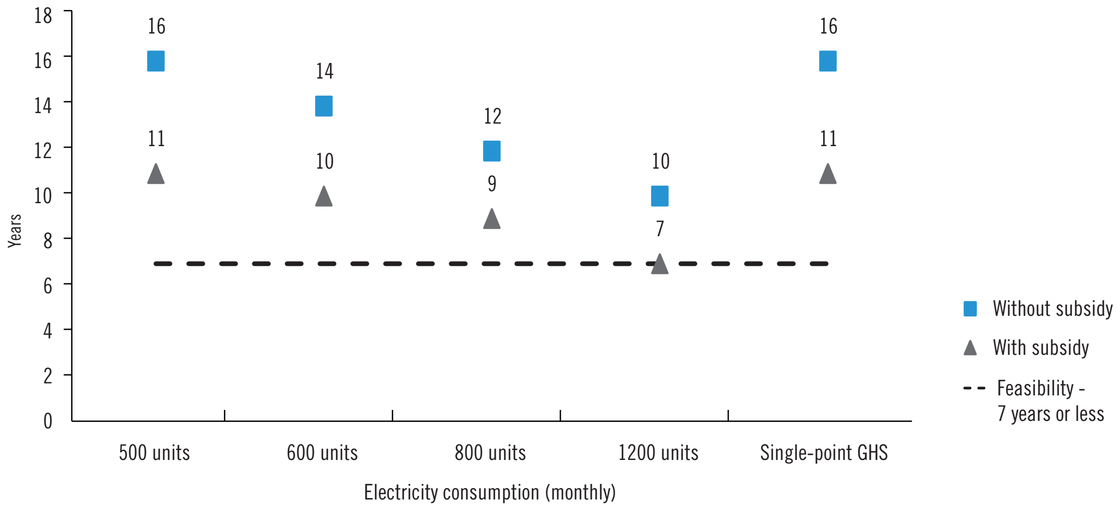


Source: CEEW analysis

c. **Financial feasibility:** Availability of 30 per cent capital subsidy for community projects might become ambiguous after the proposed policy is implemented as the subsidy will be limited to residential systems under 10 kWp. However, in the community solar upfront payment method, individual consumers will own system shares less than 10 kWp, and hence should be considered eligible for the subsidy. Capital subsidy can make the model viable for consumers in the lower consumption slabs as well.

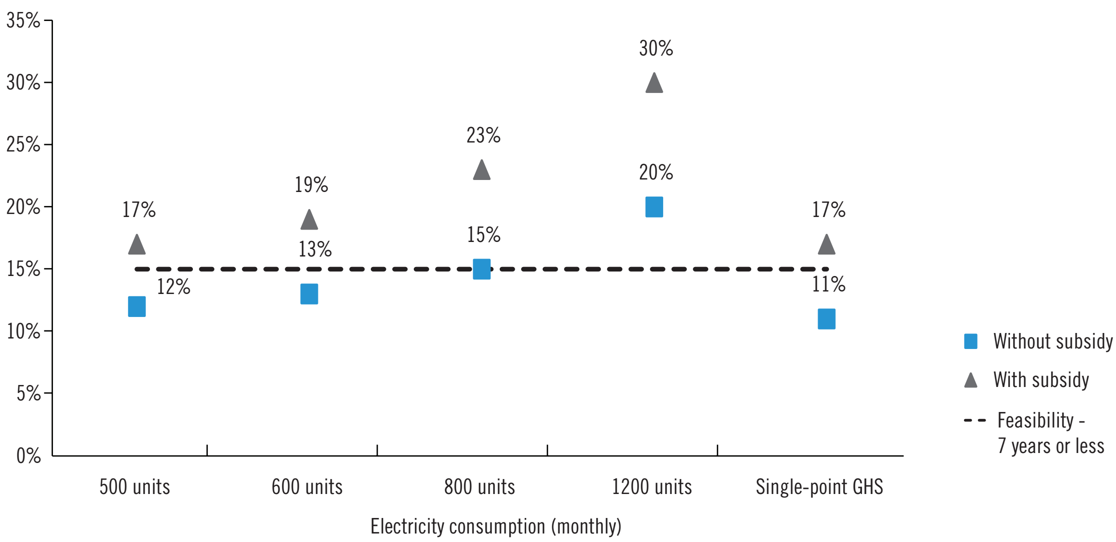
For the upfront payment method, the model is financially very attractive for consumers in consumption slabs higher than 1200 units with capital subsidy. The method provides high returns to consumers in the 400–800 unit consumption slabs with slightly longer payback periods. Without subsidy, it can be a reasonable investment for consumers in the consumption slab above 800 units with IRR greater than 15 per cent and a payback period of 10–12 years (Figure 19 and Figure 20).

Figure 19. Payback period for upfront payment method



Source: CEEW analysis

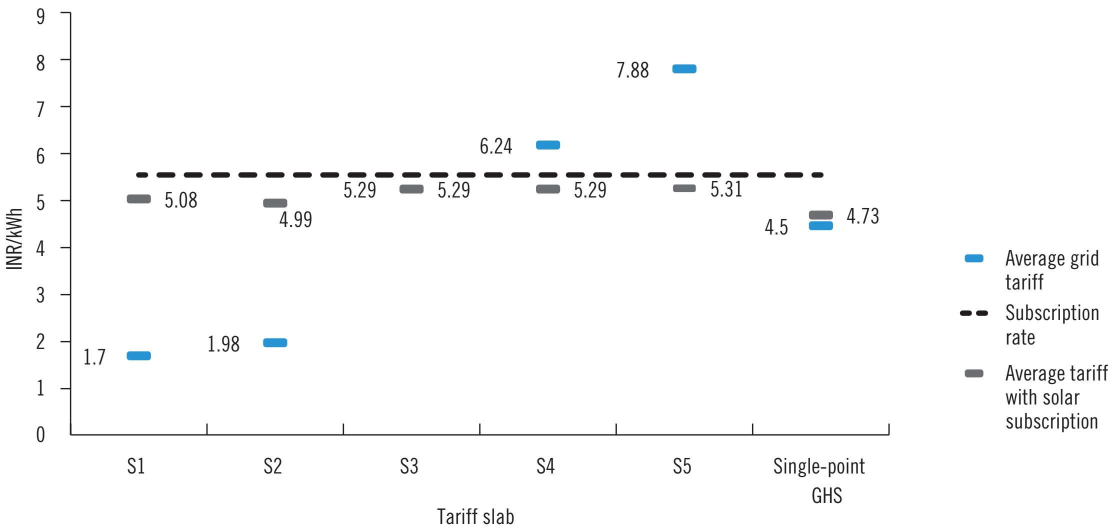
Figure 20. Internal rate of return (IRR) in % for upfront payment method



Source: CEEW analysis

For the subscription method, solar subscription brings down the average per unit tariff of consumers in the consumption slabs above 400 units because the reduced grid consumption in turn places them in a lower consumption slab. This makes the model financially feasible for those consumer segments (Figure 21).

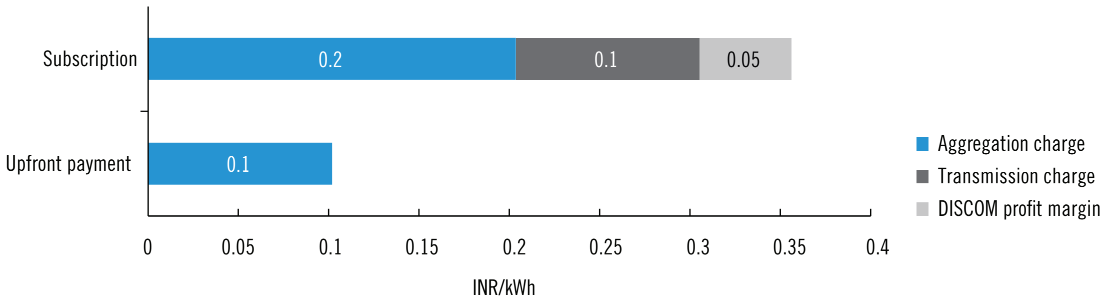
Figure 21. Average per unit tariff reduction with solar subscription



Source: CEEW analysis

d. Revenue for DISCOMs: Since the involvement of the DISCOM is limited to consumer aggregation in the upfront payment method, the charges are also minimal. However, in the subscription method, the DISCOM is involved in subscription collection as well as in transferring the subscription to the developer.

Figure 22. DISCOM charges for community solar



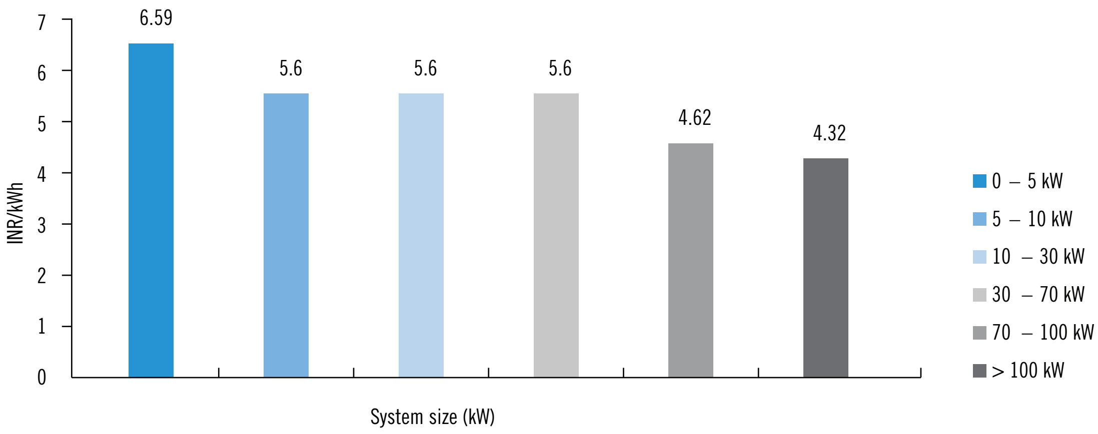
Source: CEEW analysis

6.1.2 Design of subscription programme

At a flat solar subscription rate, the subscription payment method of the community solar model is not viable for consumers in the lower consumption slabs. A well-designed heterogeneous subscription programme can make the model viable for all consumer categories. System size and consumer mix are the two factors that need to be considered while designing a subscription programme.

System size: The subscription rate is largely based on the size of the system. It can vary from 20 to 30 per cent depending on the size of the system (Figure 23). Hence, identifying roof areas to accommodate larger systems is key to a successful programme design.

Figure 23. Subscription rate versus system size



Source: CEEW analysis

Consumer mix: Reserving the proportion of consumers from each slab in the subscription programme is one way of extending the model to all consumer categories. It is possible to design differentiated subscription rates for each slab in proportion to the average per unit grid tariff of the given slab.

Table 13 presents details about a sample subscription programme where there are subscribers from various consumption slabs. A higher number of subscribers from the higher slabs are required to cross-subsidise the solar tariff for consumers in the lower consumption slabs.

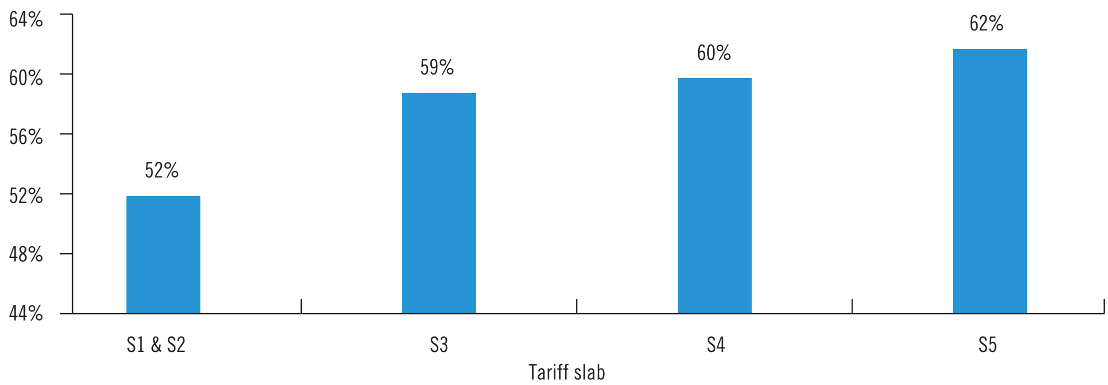
Table 13. Example of a subscription programme design

Tariff slab	Number of subscribers in each slab	% of consumers in slab	Average per unit price/kWh	Flat solar subscription rate (INR/kWh)	Subscription rate under differentiated tariff design (INR/kWh)	% of monthly savings on electricity bill
S1 & S2	5	20%	2.38	4.32	1.91	20%
S3	5	20%	5.29		4.24	26%
S4	10	40%	6.24		5.00	27%
S5	5	20%	6.84		5.48	31%

Source: CEEW analysis

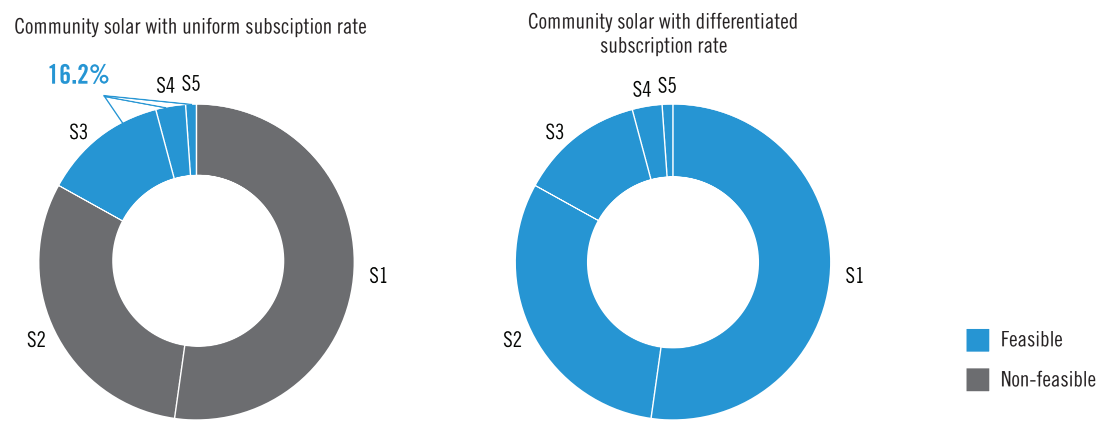
With the above rates, consumers in all consumption slabs achieve savings from year one, with the savings in the following years increasing as the grid tariff escalates over the system life. Figure 24 shows the yearly savings achieved by consumers in each consumption slab.

Figure 24. Savings on electricity expenditure over system life



Source: CEEW analysis

Figure 25. Feasibility of business models for BYPL domestic consumers



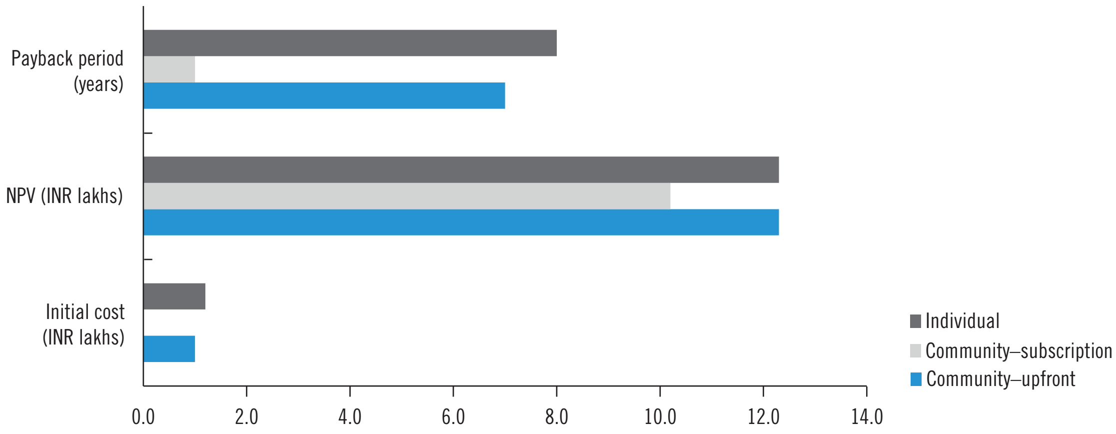
Source: CEEW analysis (based on data from BSES Yamuna)

6.1.3 Recommendations

- From the perspective of an individual consumer, the community model systems are more beneficial than the individual systems.

  Figure 26, compares the benefits to individual consumers from the individual installation of a RTS system as against getting a share of similar capacity in a community model. In the case under consideration here, for a consumer whose average consumption is 1200 units per month and requires a 9kW system, the community model gives shorter paybacks and higher future returns at a lower initial cost. This is because the community systems are larger in size than an individual system and hence the unit cost of the system is significantly lower.

Figure 26. Individual solar systems versus community solar systems



Source: CEEW analysis

- The community model should be executed for single-point-connected GHS buildings and for individual consumers in the medium to high consumption slabs.
- Capital subsidy, in the case of the upfront payment method, will benefit consumers in the lower consumption slabs, and hence it is necessary to make the model viable for them.
- The careful design of a subscription programme and an affordable subscription tariff can make the model viable for all consumer segments. The off-site community solar model is an attractive model for utilising the roofs of government and public buildings.
- The provision of virtual net-metering is essential for implementing this model.

6.2 On-bill financing model

The main determining factor of the on-bill financing model is the interest rate. This will determine to a very large extent the LCOE, the EMI amount, and the payback period for the model. The involvement of the DISCOM in repayment collection reduces the risks considerably, and hence lenders should be able to offer loans at below-market rates. The analysis considers different interest-rate scenarios, ranging from 8 to 14 per cent.

The following assumptions were made in calculating the loans available for consumers (Table 14).

Table 14. Data and assumptions regarding calculation of consumer loan servicing

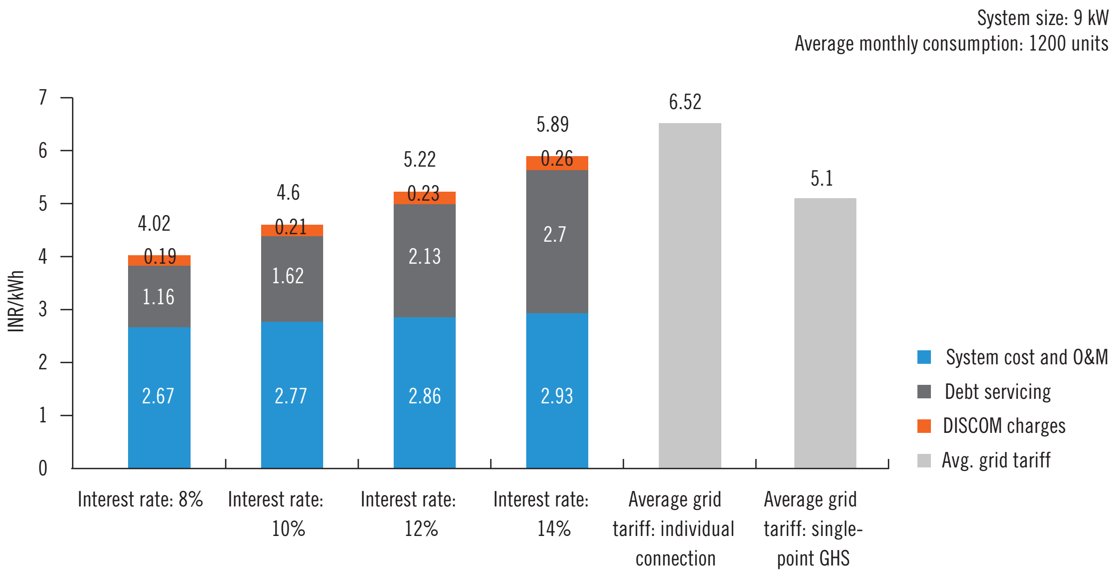
Parameters	Values
Interest rate	8%–14%
Tenure	10 years
System size	Capacity equivalent to 90% of consumer's average consumption
Capital subsidy	30%

Source: CEEW analysis

6.2.1 Findings

a. **Grid parity – LCOE versus grid tariff:** Comparing the LCOE of the model with the average per unit grid tariff, for a consumer with an average monthly consumption of 1200 units, the on-bill financing model achieves grid parity for interest rates 14 per cent and lower (Figure 27). However, the LCOE will increase by 22 per cent when a consumer with half the average consumption is considered.

Figure 27. Tariff comparison with LCOE



Source: CEEW analysis

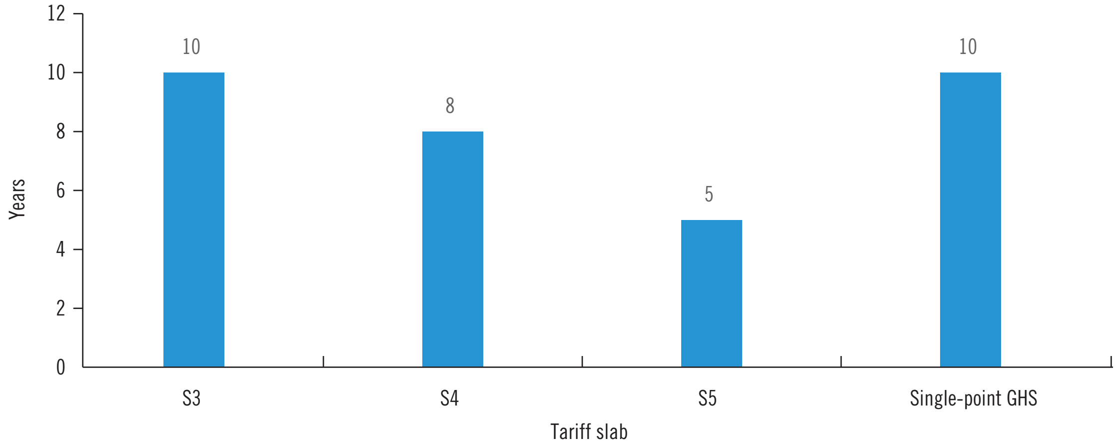
The LCOE is calculated with 30 per cent capital subsidy because residential consumers would be able to avail it. However, if the subsidy is not available, the LCOE will increase by around 35 per cent, making it less attractive to consumers.

For single-point-connected GHSs, the interest rates need to be 10 per cent or less for the LCOE to be at par with the grid tariff, given the flat tariff of INR 5.1/kWh (taxes included) for such connections.

b. **Bill-neutral payment:** The key to the success of the model is the design of the loan terms in such a way that the EMI payment balances the average monthly generation from the system, thus making the consumer's electricity bill the same as before ("bill-neutral").

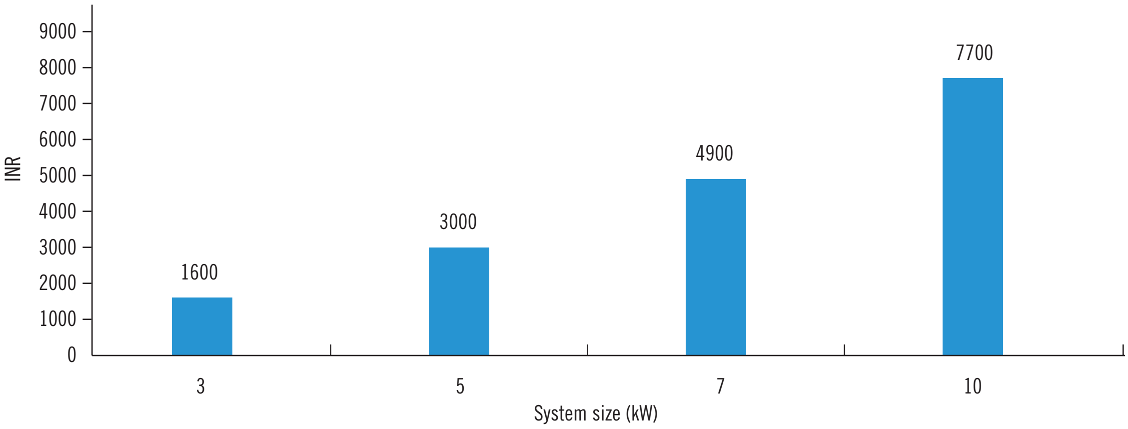
Loan tenures between 5 and 10 years can provide bill-neutral EMI plans for consumers in the consumption slabs above 400 units given the interest rate is 8-10 per cent. If the interest rates are higher, the tenure will have to be longer for the model to be bill-neutral from the first year. For single-point-connected GHSs, the tenure should be between 8 and 10 years (Figure 28).

Figure 28. Loan tenure for bill-neutral EMI at 10% p.a.



Source: CEEW analysis

Figure 29. Bill-neutral EMI for different system sizes at 10% p.a.

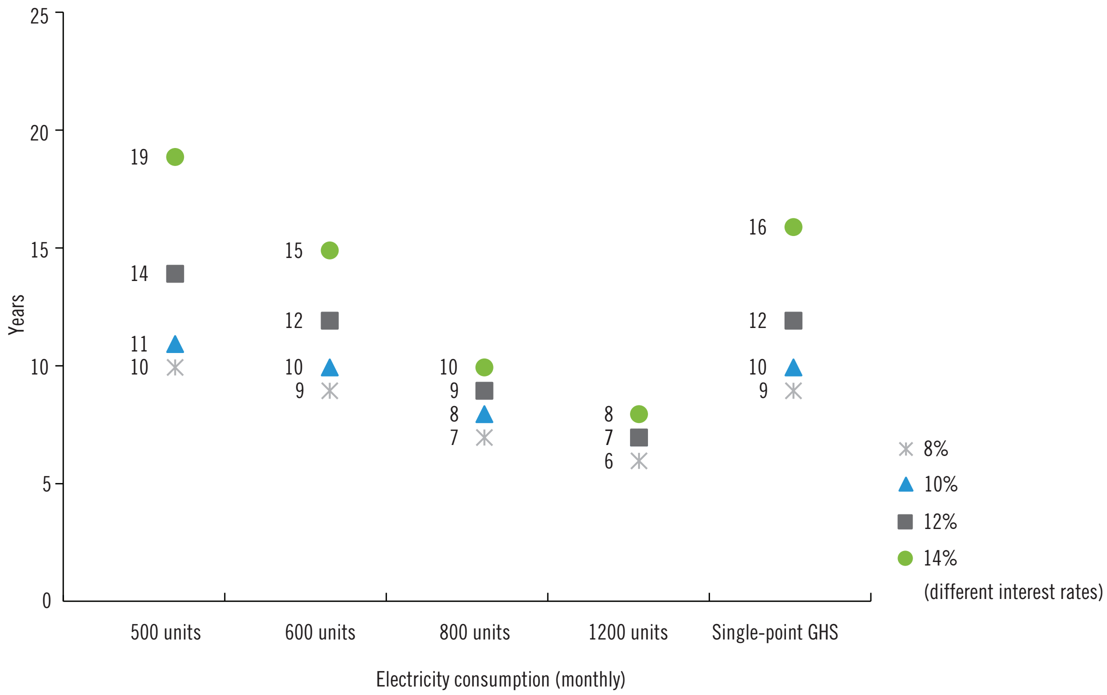


Source: CEEW analysis

c. **Financial feasibility:** Loan tenure for bill-neutral EMI is the year by which the consumer repays the loan and acquires the ownership of the system through monthly bill-neutral payments on the electricity bill. Loan tenure can be seen as a proxy to check financial feasibility for the consumer as they would start making savings after this year. Figure 30 indicates the loan tenures for bill-neutral EMI for consumers in different slabs at different interest rates.

The model will be feasible only to consumers in the higher consumption slabs at the current market rates. Interest rates between 8-10% would make it a reasonable investment for consumers in the 400-800 units slab.

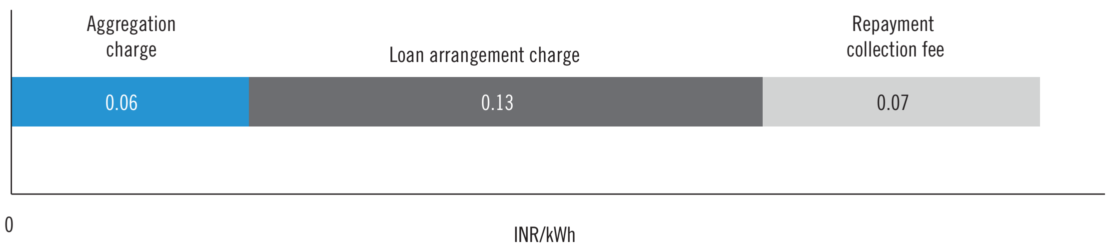
Figure 30: Loan tenures for bill-neutral EMI



Source: CEEW analysis

d. Revenue for DISCOMs: In the case of the on-bill financing model, DISCOMs aggregate consumers, partner with third parties for arranging loans for the aggregated consumers, and also collect the repayment every month on the consumer electricity bill. Around 4 to 6 per cent of the cost of each unit generated is the revenue that goes to the DISCOM.

Figure 31. Revenue for DISCOMs in on-bill financing model



Source: CEEW analysis

6.2.2 Recommendations

- On-bill loan financing for conventional personal loan products in the market will increase the overall cost to consumers significantly, as the intermediary roles played by the third-party lender and the DISCOM in repayment collection add to the cost of availing the capital loan. However, the payment assurance nature of the loan repayment reduces the risk of defaulting considerably, which, in turn, reduces the risk premium that is charged as part of the loan interest.
- At the current market levels, on-bill loan financing may not be a feasible option for all consumer segments. Hence, there is a need for customising loan products with softer terms that consumers can avail through the on-bill repayment method.

- The capital subsidies need to be retained until the costs of the smaller systems come down further for the on-bill loan financing model to be financially viable and for the electricity bills to be 'bill-neutral'.
- On-bill loans should be designed for housing societies with single-point connections because the resident welfare associations (RWAs) are not eligible to avail usual long-term debt from banks.
- On-bill financing should be considered for government departments and other commercial entities, including small-scale industries and micro, small, and medium enterprises (MSMEs).

6.3 Solar partners model

The economics of the solar partners model is primarily determined by the final per unit subscription rate at which solar energy can be made available to the consumer. This solar tariff is mainly dependent on system size and cost.

While aggregated roof clusters can bring down the logistical costs of system installation, economies of scale will not apply if the individual roofs are small. This is because separate ancillary equipment, mainly inverters, is required for each individual roof. Large roof clusters are the roofs of institutions and public buildings and can host systems as big as 200 kW. In this analyses, roofs are categorised as small and large roof clusters with individual system sizes of 10–25 kW and 50–200 KW respectively.

6.3.1 Findings

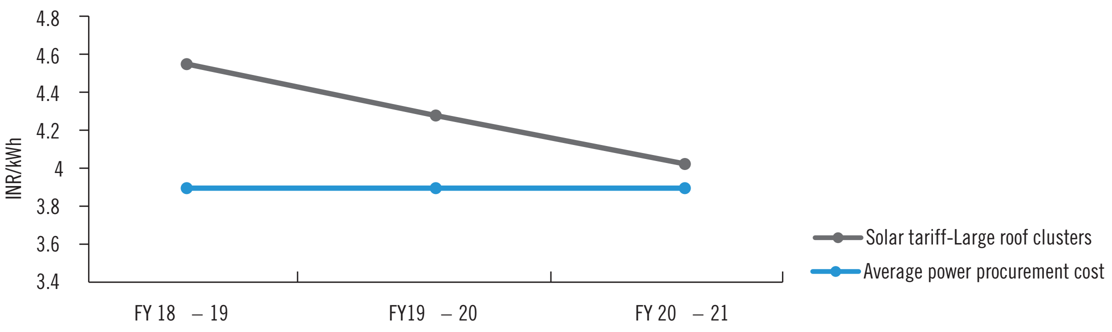
a. **Grid parity:** Given the current grid tariff, solar tariffs from a small roof cluster will not achieve grid parity for consumers with monthly consumption below 1000 units. For large roof clusters, consumers with lower consumption slabs will not find the model feasible at a flat solar tariff either.

Figure 32. Solar tariff compared with average grid tariff for each consumption slab

Source: CEEW analysis

However, the solar partners model emulates the utility-scale solar power plants and other sources of generation from where the DISCOMs procure electricity. The procurement rate of solar energy will be around INR 4.56/kWh from large roof clusters. This is comparable to the average rate at which BYPL procures power (INR 3.9/kWh for FY 2018–19) (Figure 33).[24] The yearly drop in solar partners procurement rate is estimated in conjunction with the anticipated solar panel price drop.

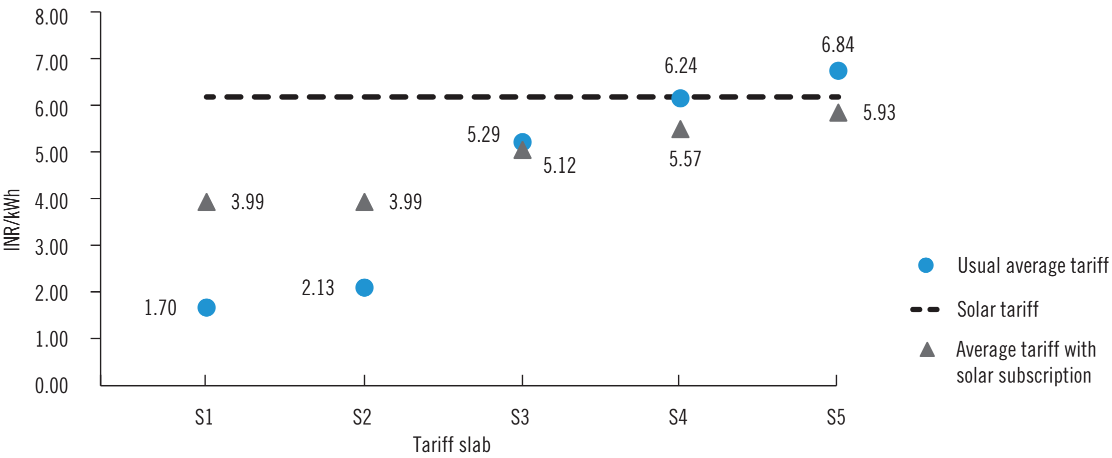
Figure 33. DISCOM power procurement cost versus solar partners tariff



Source: BYPL, 2018; CEEW analysis

a. Weighted average grid tariff: An interesting outcome of the differentiated tariff slabs in Delhi is that consumers gain additional savings by moving to the lower slabs as a result of solar subscription. Assuming a subscription that would supply 50 per cent of the total demand, the final average per unit tariff falls below the solar tariff (Figure 34). Therefore, even with a solar tariff that is higher than the average grid tariff, if the solar tariff is lower than the unit price for the higher consumptions slab, the model will be viable.

Figure 34. Average per unit tariff with solar subscription – small roof clusters



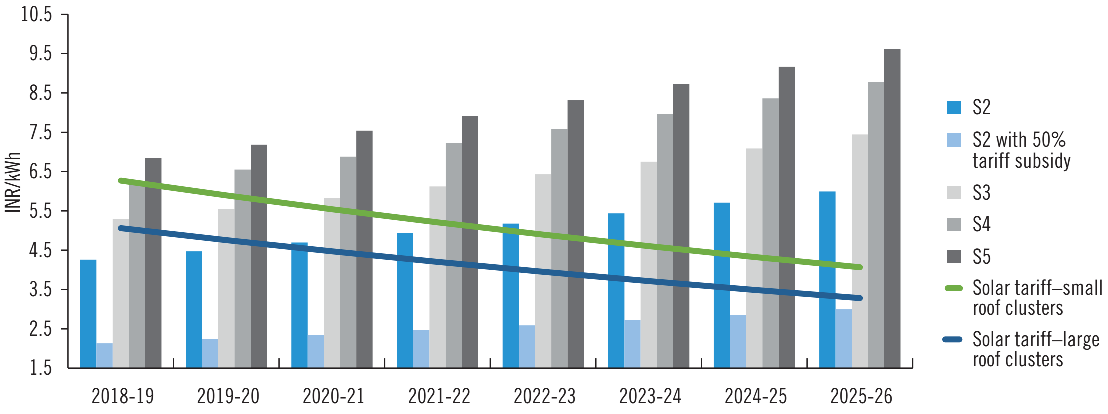
Source: CEEW analysis

Tariff projections: With an estimated annual grid tariff escalation rate of 5 per cent and a solar tariff drop rate of 6 per cent, the solar tariffs can reach parity with the grid tariff of the lower consumption slabs within two to five years without the additional 50 per cent subsidy given by the Delhi government. However, if the subsidy continues to be extended in the coming years, the solar tariff will continue to be higher for the subsidised segments even after six or seven years.

24 BYPL (2018) *Tariff Order FY 2018 – 19*, Delhi Electricity Regulatory Commission

For consumers in consumption slabs above 400 units, the solar tariff will reach parity in a year or two even with the current projection for small roof cluster systems.

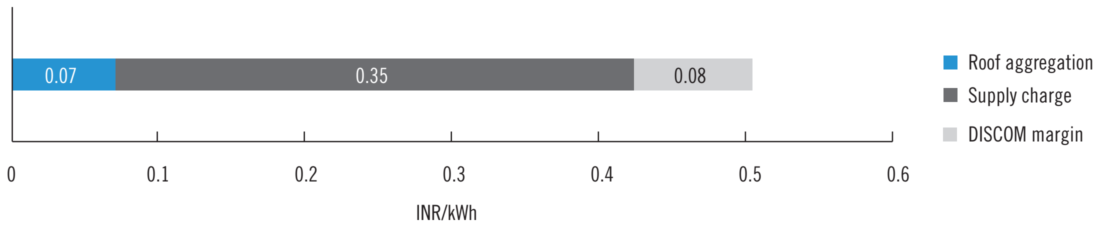
Figure 35. Tariff projections until 2025



Source: CEEW analysis

a. **Revenue for DISCOMs:** In the solar partners model, DISCOMs play a major role in aggregating roofs and supplying the solar energy generated to the subscribed consumers through virtual net-metering. Based on the assumptions considered here, DISCOM charges account for 9 to 10 per cent of the final solar tariff.

Figure 36. Revenue for DISCOMs in solar partners model



Source: CEEW analysis

6.3.2 Solar subscription programme design

As is evident from the previous section, the solar partners model will not be feasible for all consumer slabs with only a flat solar tariff. However, it can be developed into a feasible subscription programme with careful calculations of solar tariff that would correspond with the average per unit grid tariff of each consumer slab by determining the optimum proportion of consumers from each slab in the subscription plan.

The following section describes a subscription programme that could be feasible for all consumers.

Table 15. Solar subscription programme design

System Size	200 kW (large roof cluster)			
Tariff Slabs	S1 & S2	S3	S4	S5
Proportion available for subscription	5%	35%	30%	30%
LCOE – collected by developer (INR/kWh)	3.89			
Subscription rate for roofless solar (INR/kWh)	5.06			

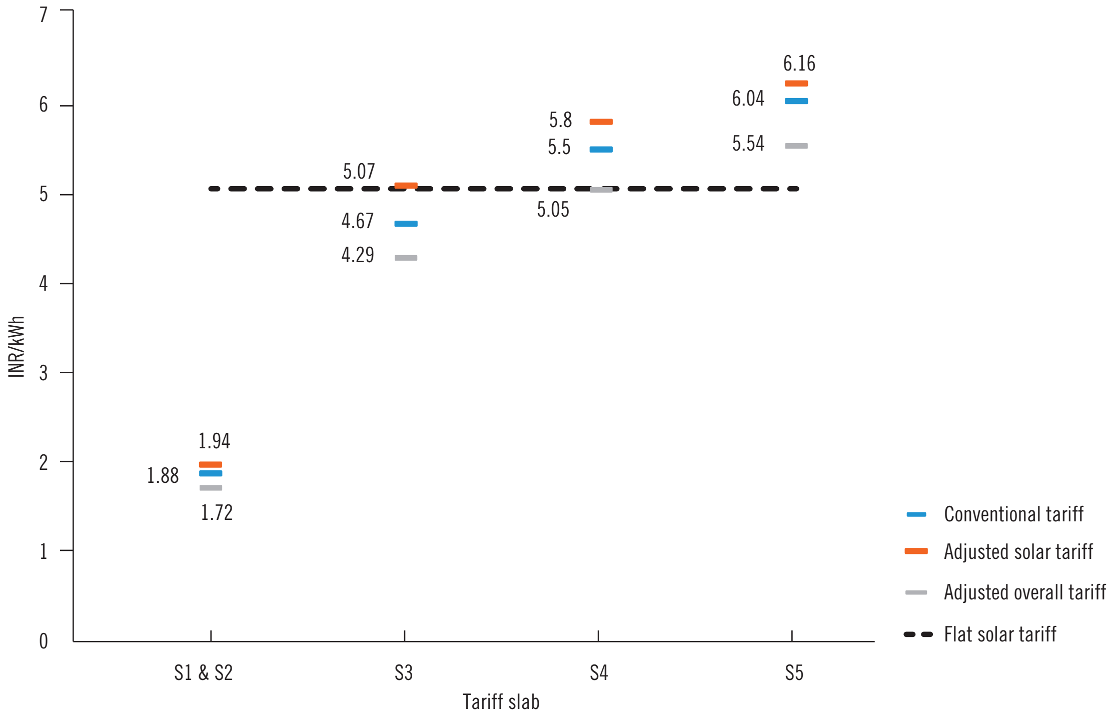
Source: CEEW

Table 16. Differentiated solar tariff

Tariff slab	Conventional tariff (INR/kWh)	Adjusted solar tariff for each slab	Adjusted overall tariff	Average monthly savings
S1 & S2	1.88	1.94	1.72	28%
S3	4.67	5.07	4.29	28%
S4	5.5	5.80	5.05	28%
S5	6.04	6.16	5.54	28%

Source: CEEW

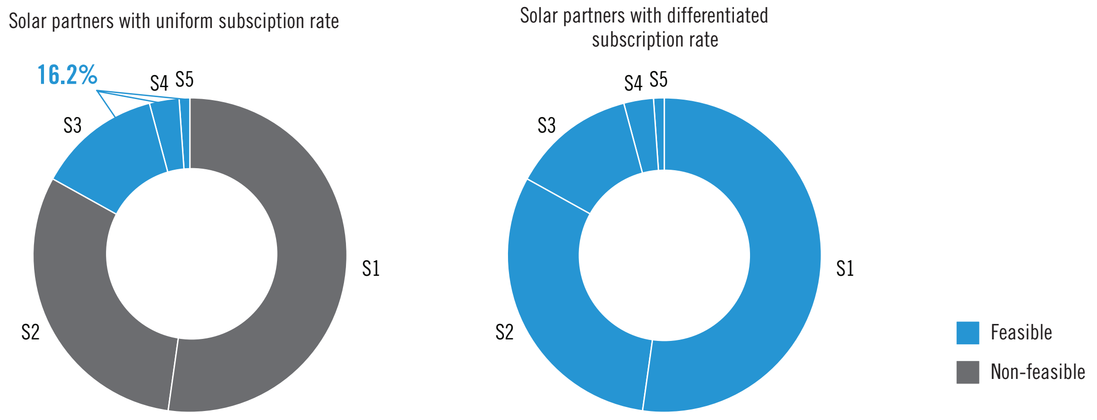
Figure 37. Average per unit tariff with solar subscription



Source: CEEW analysis

Through the subscription programme, each consumer slab achieves a certain level of savings on its monthly electricity bill in proportion to its consumption level. As the difference between the grid tariff and the solar tariff increases, the monthly savings for the individual consumer also grow.

Figure 38. Feasibility of business models for BYPL domestic consumers



Source: CEEW analysis (based on data from BSES Yamuna)

6.3.3 Recommendations

- The optimum way to execute this model is for the DISCOM to aggregate the large roof spaces of public and private buildings, including the office buildings of BYPL in Delhi, and to install RTS systems while retaining ownership. The lower cost of RTS systems, thanks to the availability of capital at lower costs to the DISCOM, can considerably reduce the solar tariff.
- It is also necessary to execute carefully designed subscription plans that will nullify the effect of cross-subsidy through differentiated solar tariff. In this way, consumers with low grid tariff can subscribe to solar energy, with virtually no expense to higher-paying consumers.
- This model also requires the provision of virtual net-metering for its implementation.

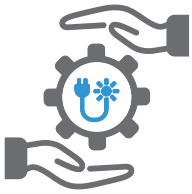
Table 17. The economics at a glance

	Community solar: Upfront payment	Community solar: Subscription payment	On-bill financing	Solar partners: Large roof cluster	Solar partners: Small roof cluster
LCOE (INR/kWh)	2.73	5.6	5.89	5.06	6.27
Savings on electricity expenditure over system life (%)	74%	58%	70%	49%	46%
Payback period (years)	7–10	-	-	-	-
Revenue for DISCOM (INR/kWh)	0.1	0.35	0.26	0.5	0.5
All comparisons shown here pertain to a consumer with an average monthly consumption of 1200 units. Other assumptions regarding system size, interest rate, etc. are the same as indicated in the respective sections.					

Source: CEEW analysis

7. Conclusion

BSES Yamuna Power Limited, with its large share of residential consumers, has found that it needs to make innovative business interventions to increase the pace of solar deployment in its license area. Given its consumer mix and the dominant building types in its license area, the community solar model, the on-bill financing model, and the solar partners model are the three business models that could aid the utility in achieving this objective by addressing the market challenges in the sector.



The business models that are quite feasible for consumers in the higher consumption slabs in the present market conditions will need additional provisions like differentiated solar tariff to ensure that they are feasible for all consumer segments.

While the community solar model provides a way for households living in apartment buildings with shared roofs or with no roof access to receive the benefits of a RTS system through a shared system, the solar partners model allows even tenants to subscribe to solar energy for shorter periods. Both models benefit from the availability of large roof spaces in public and private buildings and pass on the benefit to residential consumers. The on-bill financing model, on the other hand, targets consumers with roof access and who need access to easy financing. Thus, the combination of the three models extends the rooftop market to all the residential consumer segments.

The business models that are quite feasible for consumers in the higher consumption slabs in the present market conditions will need additional provisions like differentiated solar tariff to ensure that they are feasible for all consumer segments. The current tariff structure for the domestic consumers in Delhi play an important role in determining the economic viability of these business models to different consumer segments. The recent tariff revision and the existing 50 per cent additional subsidy on energy charges for consumers under 400 units slab are two factors that have deemed solar rooftop unattractive for the consumers in those slabs. In the revised tariff structure for the financial year 2018-19, the fixed tariff was increased up to 2 - 5 times while the energy charges were reduced by 11-25 per cent for various slabs. This would help the DISCOMs reduce their losses from consumers switching to solar as they are now able to recover more money through the fixed tariff which the consumers pay irrespective of solar generation. But the reduced energy charges have considerably reduced the savings consumers could have gained with net-metered RTS. Additionally, the 50 per cent energy tariff subsidy reduces the per unit average tariff of the consumers to as low as INR 1.7/kWh (including tax and surcharges) which are incomparable with the rooftop solar tariffs.

Ideally, the involvement of DISCOMs through the business models discussed here should help in bringing considerable system cost reduction. When the DISCOMs undertake consumer and site aggregation, the developers would be able to save on their sales and consumer acquisition cost which should reflect in the final prices. DISCOMs conducting reverse auctions in community solar subscription or solar partners model can also help in realising lowest possible subscription tariffs. Therefore, with the trend of decreasing prices of solar systems and the possible cost reduction that could be achieved through economies of scale and interventions by the utility, the financial attractiveness of the business models will only improve.

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Annexures

Annexure A: Sensitivity analysis

This section illustrates a sensitivity analysis of the LCOE for each of the business models. For community solar upfront method and on-bill financing model, the sensitivity for consumer debt-equity ratio and CUF are assessed. For community solar subscription model and solar partners, the sensitivity of LCOE on ROE and CUF is analysed.

The range of variation considered for ROE and CUF is +/- 25%. Debt-equity ratio is varied from 100% equity to 100% debt. The unit of LCOE is in INR/kWh.

a. Community solar – upfront payment method

CUF/Debt-equity ratio	0:100	30:70	50:50	70:30	100:0
12%	2.89	3.21	3.42	3.63	3.95
14%	2.48	2.75	2.93	3.11	3.38
16%	2.17	2.41	2.56	2.72	2.96
18%	1.93	2.14	2.28	2.42	2.63
20%	1.74	1.93	2.05	2.18	2.37

b. Community solar – subscription payment method

CUF/ROE	12%	14%	16%	18%	20%
12%	6.77	7.09	7.41	7.72	8.04
14%	5.83	6.10	6.38	6.65	6.91
16%	5.12	5.36	5.60	5.84	6.07
18%	4.57	4.79	5.00	5.21	5.42
20%	4.13	4.33	4.52	4.71	4.89

c. On-bill financing model

CUF/Debt-equity ratio	0:100	30:70	50:50	70:30	100:0
12%	2.18	3.42	4.28	5.17	6.56
14%	1.87	2.94	3.67	4.43	5.63
16%	1.94	3.04	3.80	4.59	5.89
18%	1.73	2.71	3.39	4.09	5.18
20%	1.57	2.45	3.06	3.69	4.68

d. Solar partners model

CUF/ROE	12%	14%	16%	18%	20%
12%	6.14	6.36	6.59	6.81	7.02
14%	5.33	5.53	5.72	5.90	6.09
16%	4.73	4.90	5.06	5.23	5.39
18%	4.26	4.41	4.56	4.70	4.85
20%	3.88	4.02	4.15	4.28	4.41

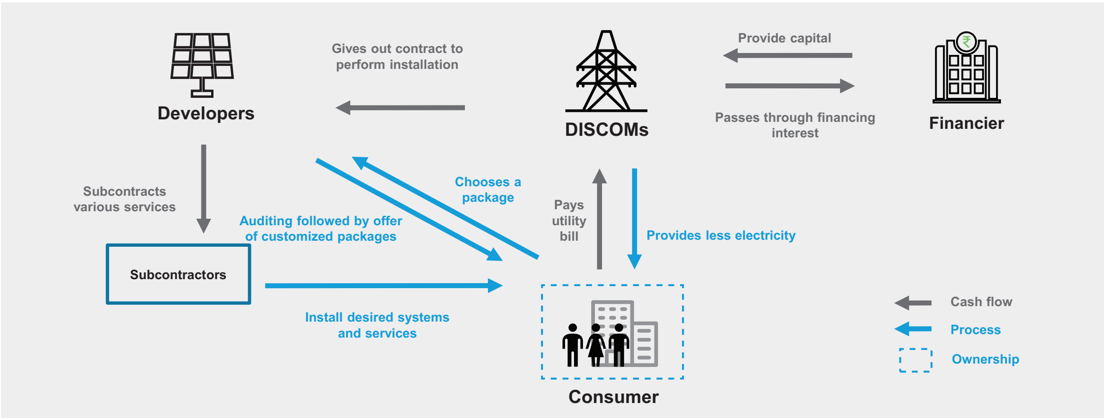
Source: CEEW analysis

Annexure B: Other rooftop solar business models considered

a. Integrated utility services (IUS) model

In an integrated utility services model, the DISCOMs offer other services like energy efficiency measures along with rooftop solar to the consumers and a tariff is collected on the monthly electricity bill for a predetermined period of time to cover the capital costs incurred by the DISCOM. DISCOMs can design basic packages which offer rooftop solar and energy efficiency measures. The billing can be made 'bill-neutral[25]' for basic packages with options for premium packages where the additional tariff will exceed the savings due to reduced electricity consumption.

Figure 39. Integrated utility service model



Source: CEEW analysis

The following table summarises the role of each stakeholders in an IUS model: -

Table 18. Stakeholder roles (Integrated utility service model)

Stakeholder	Role
DISCOMs	• Offer basic and premium green energy packages which are rooftop solar bundled with various energy efficiency measures to the consumers and collect monthly service tariff through the electricity bill • Outsource auditing, design, procurement and installation to developers/contractors through competitive bidding processes • Obtain capital financing from financiers to supplement own capital funds
Consumers	• Subscribe to DISCOMs' basic or premium green energy customized packages and pay the tariff on electricity bill • Own the rooftop system and other building enhancements which is tied to the property and hence it can be transferred upon sale of property
Developers	• Conduct auditing, site survey, design, procurement and installation of solar rooftop and other measures as decided after auditing for consumers and collect the capital cost from the DISCOM
Financiers	• Provide financing to DISCOMs • Collect repayment from DISCOM

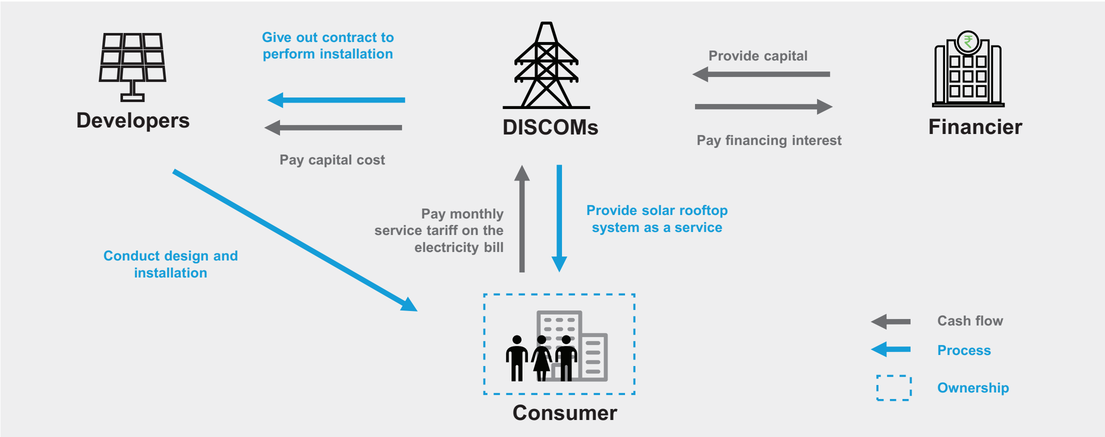
Source: CEEW analysis

25 Bill-neutral refers to billing arrangement where the additional tariff collected for the green energy package is equivalent to the savings from reduced grid consumption.

b. On-bill tariff model

In an on-bill tariff model, the customers pay a tariff or service charge to the DISCOMs for providing rooftop solar systems as a service. Therefore, DISCOMs manage the installation of the system through a developer. This model assigns a financial obligation to the rooftop system installed and the ownership remains with the consumer. The tariffs can be structured in a way that the reduction in grid energy consumption due to the solar rooftop covers the additional charge, resulting in a bill-neutral[26] or bill-positive[27] method. DISCOMs obtain the necessary capital cost through their own capital fund supplemented by low-cost financing options available. Tying the obligation to the system, rather than the individual, can facilitate extending the option to rental houses as well.

Figure 40. On-bill tariff model



Source: CEEW analysis

The following table summarises the role of each stakeholders in an on-bill tariff model: -

Table 19. Stakeholder roles (On-bill tariff model)

Stakeholder	Role
DISCOMs	• Facilitate solar rooftop installation at the customer household as a service and collect a service charge on the electricity bill over a pre-determined period of time which will cover the capital cost • Outsource design, procurement and installation of solar rooftop systems to developers and pay the capital cost • Obtain capital financing from financiers to supplement own capital funds
Consumers	• Subscribe to DISCOMs' rooftop installation service and pay the tariff on electricity bill • Own the system which is tied to the system and hence it can be transferred upon sale of property
Developers	• Conduct site survey, design and installation of system for consumers as directed by the DISCOM and collect the capital cost from the DISCOM
Financiers	• Provide financing to DISCOMs • Collect repayment from DISCOM

Source: CEEW analysis

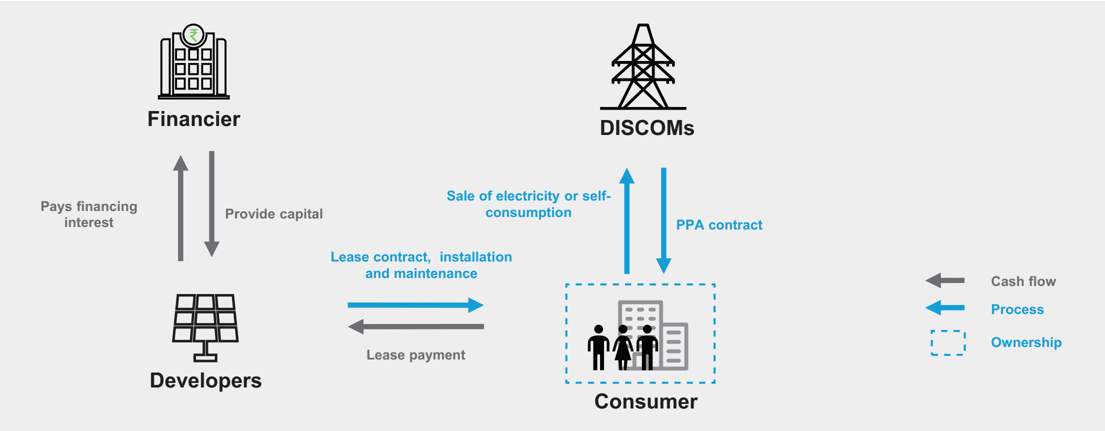
26 Bill-neutral refers to the billing when the net bill amount remains the same as before with the additional service tariff being equivalent to the savings achieved through reduced grid consumption.

27 Bill-positive is when the additional tariff is charged at a rate less than the savings achieved through reduced grid consumption, thereby reducing the net electricity bill from before.

c. Solar leasing model

Solar leasing model allows consumers to receive benefits of rooftop solar power generation without owning the system and hence, considerably reducing the high upfront cost. The developer or a leasing company own, install and operate the rooftop solar system on the consumer's roof and collects a down payment and monthly lease from them. The consumer can use it for self-consumption or send it to grid and hence, benefits from net savings and or/ FiTs.

Figure 41. Solar leasing model



Source: CEEW analysis

The following table summarises the roles of each stakeholder:

Table 20. Stakeholder roles (Solar leasing model)

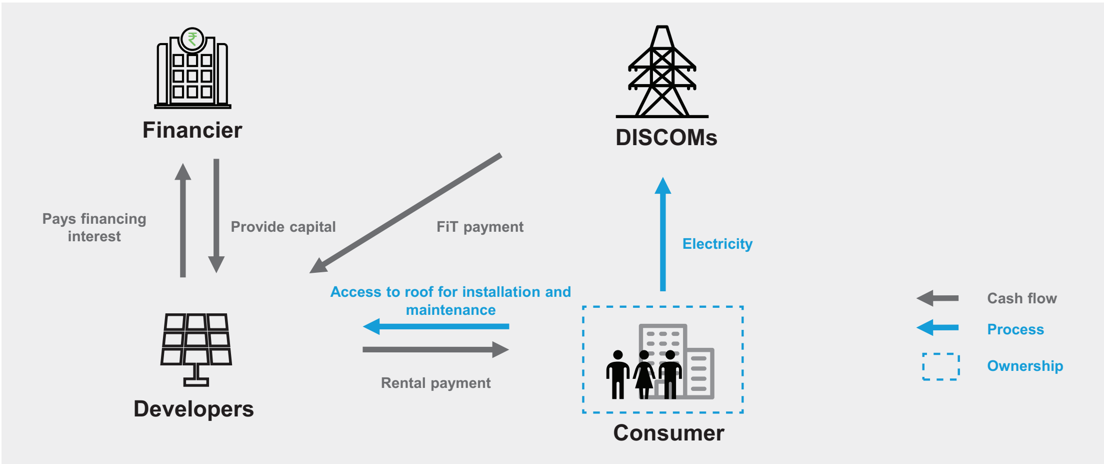
Stakeholder	Role
Developers	• Sign a leasing contract with the consumer and receives monthly lease payment and down payment • Conduct site survey, design and installation of system on consumer's roof • Owns, operates and maintains the system
Consumers	• Sign the lease agreement with developer and pays the upfront lease down payment and monthly instalments • Provide access to the roof for installation and maintenance by the developer • Consume or send the electricity to the grid and benefit from generation based incentives or net savings
DISCOMs	• Provide grid connection to the consumer • Provide FiTs, if any, to the consumer
Financiers	• Provide financing to developers • Collect repayment from developers

Source: CEEW analysis

d. Roof rental model

In roof rental model, the developers rent the rooftop from consumers paying monthly rent. Ownership and maintenance of the system remains with the developer. Developer connects the system to the grid and receives the benefits of generation from the DISCOM.

Figure 42. Roof rental model



Source: CEEW analysis

The following table summarises the roles of each stakeholder:

Table 21. Stakeholder roles (Roof rental model)

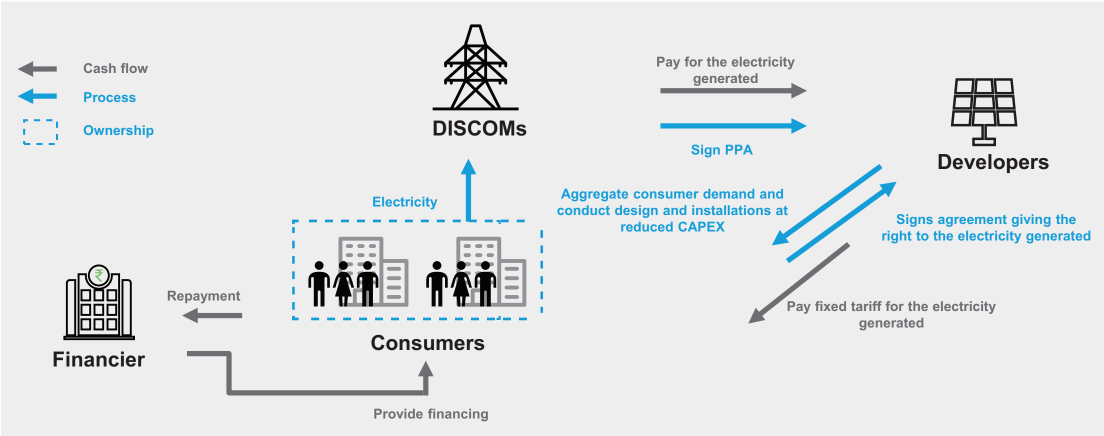
Stakeholder	Role
Developers	• Rent the rooftop from consumers • Conduct site survey, design and installation of system in the rented space • Owns, operates and maintains the system • Sell the electricity to the grid and receive any generation based incentive like FiTs
Consumers	• Sign the rent agreement with developer • Provide access to the roof for installation and maintenance by the developer
DISCOMs	• Provide grid connection • Provide FiTs, if any
Financiers	• Provide financing to developers • Collect repayment from developers

Source: CEEW analysis

e. Virtual power plant or aggregator model

In aggregator model, the aggregator aggregates consumers who wish to install solar rooftop systems and provides the installation through aggregated procurement at a lower capex. The role of aggregator can be performed by the DISCOM, developer or an individual entity. The aggregator signs a PPA with the consumers. While the electricity generated is directly connected to the grid, the consumers receive a fixed tariff/kWh generated from the aggregator as determined in the PPA. When the aggregator is not the DISCOM, the aggregating entity also signs a PPA with the DISCOM and receive a fixed tariff/kWh generated by the consumers.

Figure 43. Virtual power plant model



Source: CEEW analysis

The following table summarises the roles of each stakeholder.

Table 22. Stakeholder roles (Virtual power plant model)

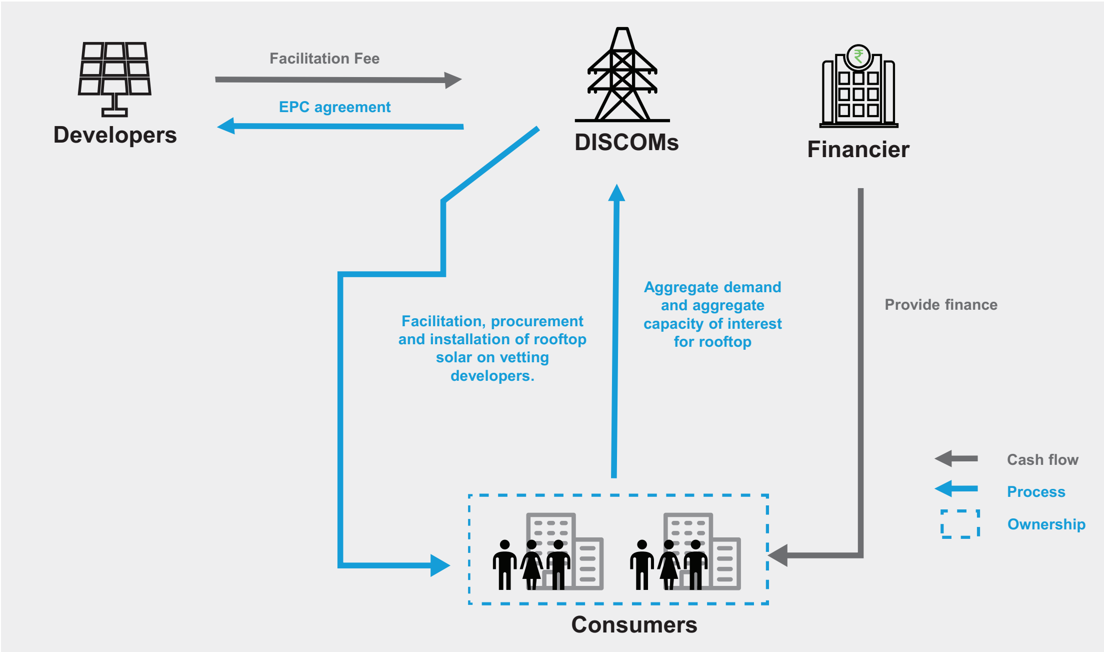
Stakeholder	Aggregator: DISCOM	Aggregator: Developer	Aggregator: Individual entity
Aggregator			• Aggregate consumer demand for solar rooftop systems • Contract to developer to conduct aggregated site survey, design, procurement and installation of system for the consumers • Sign PPAs with consumers • Sign PPAs with the DISCOM
DISCOMs	• Aggregate consumer demand for solar rooftop systems • Contract developer to conduct aggregated site surveys, design, procurement and installation through competitive bidding • Sign PPAs with consumers • Provide grid connection	• Sign PPA with the developer • Provide grid connection	• Sign PPA with the aggregator • Provide grid connection
Consumers	• Subscribe to DISCOM's aggregated rooftop installation offer • Own and maintain the system • Sign PPA with aggregator and receive fixed tariff for generation or credit points on utility bill	• Subscribe to the developer's aggregated rooftop installation offer • Own and maintain the system • Sign PPA with aggregator and receive fixed tariff for generation	• Subscribe to the developer's aggregated rooftop installation offer • Own and maintain the system • Sign PPA with aggregator and receive fixed tariff for generation
Developers	• Conduct aggregated site survey, design, procurement and installation of system for the DISCOM contract	• Aggregate consumer demand for solar rooftop systems • Conduct aggregated site survey, design, procurement and installation of system for the consumers • Sign PPAs with consumers • Sign PPAs with the DISCOM	• Conduct aggregated site survey, design, procurement and installation of system for the aggregator
Financiers	• Provide financing to individual consumers • Collect repayment from individual consumers	• Provide financing to individual consumers • Collect repayment from individual consumers	• Provide financing to individual consumers • Collect repayment from individual consumers

Source: CEEW analysis

f. Anchored procurement

This model requires consumers to finance the rooftop solar system themselves under the CAPEX model. The distribution company plays a role to help facilitate the installation of the solar system by aggregating the demand and capacity of rooftop solar on collective basis. On this aggregate basis, the utility contracts and procures rooftop solar systems from developers after vetting and evaluating them. Lot of consumers are more comfortable to procure rooftop solar services through the DISCOMs because of long standing relationship established over the years.

Figure 44. Anchored procurement model



Source: CEEW analysis

Role of stakeholders

Table 23. Stakeholder roles (Anchored procurement model)

Stakeholder	Default functions	Case A – DISCOM: A single point stop	Case B – Back-to-back contractual model
DISCOM	• Realizes the aggregate demand of rooftop solar among interested consumers. • Aggregates the capacity of rooftop solar • Identifies solar developers by vetting and evaluating them • Procures solar systems from the developers • Helps to bring solar systems to each consumer's rooftop and installs them.	• Executes an EPC agreement with developer outlining the bidding process, O&M services, terms and conditions. • On behalf of the consumers, DISCOM runs competitive bidding process for the aggregated capacity • DISCOM charges facilitation fee from the developer • Ensures quality and monitors the project.	• Executes an EPC agreement with consumers for design, supply, engineering, installation and commissioning the systems. • Executes another agreement with the developer • Runs competitive bidding process for the aggregated capacity • Ensures quality and monitors the project • Charges the consumer for facilitating solar • Vendor payment to the developer.
Consumer	• Expresses interest or submits an application for rooftop solar to the DISCOM. • Finances upfront capital required to install the solar system	• Submit application of interest to DISCOM • Arrange access to finance the solar system	• Submit application of interest to DISCOM • Arrange access to finance the solar system • Sign agreement with DISCOM • Pay facilitation fee to DISCOM
Developer	• Conducts rooftop survey and installation on the instruction of the DISCOM	• Survey and installation • Sign agreement with DISCOM • Pay the facilitation fee to the DISCOM	• Survey and installation • Sign agreement with DISCOM • Charges the DISCOM vendor payment

Source: CEEW analysis

Photo: pixabay

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