

Unlocking the Economic Potential of Rooftop Solar PV in India

A report based on IEA-CEEW-MNRE rooftop solar workshop held on 12 October 2020

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Executive summary

The rooftop solar photovoltaic (RTS) sector plays a crucial role in achieving India's ambitious renewable energy targets by 2022 and beyond. However, the progress of residential, commercial and industrial applications has been slow compared with utility-scale solar PV and onshore wind power. Policy, regulatory and administrative challenges at both central and state levels, as well as limited financing options and reluctance of utility distribution companies (DISCOMs), hamper the faster expansion of rooftop installations. To discuss and address some of these challenges, the International Energy Agency (IEA), in collaboration with the Council on Energy, Environment and Water (CEEW) and the Ministry of New and Renewable Energy (MNRE) of India, organised an [online workshop titled "Unlocking the economic potential of rooftop solar energy in India"](#) on 12 October 2020. The workshop brought together the central and state-level policy makers of India, business communities, regulators, and DISCOMs, along with international experts from Australia, Brazil, Germany and the United States.

This report is based on the insights of the workshop's participants, supplemented by the outcome of additional analysis by IEA and CEEW. It aims to answer six key questions regarding the acceleration of RTS expansion in India, and offers detailed policy options, business solutions and administrative modifications for the rapid deployment of RTS. Most of the proposed solutions could accelerate the deployment of RTS in the next one to two years, and do not require the implementation of structural changes in the central or state regulatory frameworks. These quick-effect solutions are presented below.

- **Enhancing economic incentives for DISCOMs to support RTS deployment:** Includes promoting DISCOM-led business models focused on aggregating demands for RTS systems by taking advantage of the existing relationships of DISCOM with customers, developing methodologies for the assessment of RTS benefits in DISCOMs' grids and enhancing central performance-based incentives for DISCOMs.
- **Improving access to finance options for consumers interested in RTS investment:** Includes increasing the involvement of private and public institutions in providing affordable loans and guarantees, standardising RTS loan applications and their appraisal and assessment processes, and simplifying the rules of sectoral lending programmes.
- **Optimising net and gross metering rules regarding system integration and remuneration:** Includes increasing the limits on the allowed system capacity without jeopardising grid stability, balancing revenues of RTS owners, and levies

for grid utilisation. The objective is to ensure an attractive return of investment in all consumer segments, and promote self-consumption through designing new remuneration rules.

- **Streamlining disbursement of subsidies and the overall investment process for small RTS:** Includes relaxing requirements to avail subsidy schemes for residential consumers, reducing responsibilities of DISCOMs in promoting RTS, disbursing subsidies and simplifying the investment process from the consumer's perspective.
- **Expanding promotion of RTS among residential and small and medium-sized enterprise (SME) consumers and boosting their confidence in RTS:** Includes expanding education campaigns, simplifying administrative procedures, increasing the availability of information on the RTS market, and promoting high-quality equipment and services.

The above-mentioned proposed actions result in benefits for both DISCOMs and RTS owners. DISCOMs would be rewarded for fully engaging in RTS adoption in their area of operation. On the consumers' side, policies facilitating the implementation of existing rules and access to affordable financing would increase their interest. Overall, policy design should offer attractive remuneration to RTS owners, while providing enough revenues to DISCOMs for the maintenance of distribution grids and preparation of necessary infrastructure for rapid expansion of RTS.

In addition, this report also includes guidelines on how the regulatory and market environment could evolve in India to support the RTS sector over the medium and longer terms. Implementation of these solutions is more demanding, although necessary to achieve a sustainable growth of RTS and reach the long-term renewable energy and climate targets:

- **Adopting new approaches towards system operation, electricity market design and energy policy:** Includes harmonisation of rules for supporting RTS across the country, facilitating open-access power procurement for RTS systems, stimulating the demand for rooftop projects through suited building codes and city-planning procedures, and reducing cross-subsidies in electricity tariffs while providing protection to vulnerable consumers through other channels.

Long-term electricity market reforms in India should take a comprehensive approach, aiming to efficiently integrate all distributed energy resources (DERs) and prepare the Indian electricity system for significantly larger roles of electric vehicles and battery storage. Experiences from highly advanced power markets suggest that reaping the full benefits of DERs requires changes in the structural system such as implementation of dynamic tariffs and market-based, demand-

oriented management techniques, and enabling participation of DERs in short-term balancing markets. Long-term policy should also support grid investments; digitalisation; widespread deployment of smart, real-time metering; and development of advanced capabilities for dynamic system control, analysis, modelling and forecasting. Supporting further integration of DERs will enable India to create an efficient power system of the future.

India has already made significant efforts in creating a favourable policy and regulatory environment for development of RTS. The introduction of only limited changes in the existing policies and regulations, and their implementation, could allow significant and rapid acceleration in the growth of RTS capacity, as observed in several other countries. Success in enhancing the adoption of RTS could be a cornerstone of building policy and technical framework for a new, sustainable, reliable, secure and more efficient Indian power system driven by DERs.

Background

In 2015, the Government of India set a target to achieve 175 gigawatts (GW) of renewable electrical energy capacity by the end of 2022, of which 40 GW is expected to be installed in rooftop solar (RTS). However, the actual RTS capacity deployed by the end of 2020 was approximately 6 GW, requiring a substantial increase in efforts to support the deployment. Accelerating RTS adoption offers significant opportunities for the economic recovery of India post-Covid-19. According to the International Energy Agency (IEA) [Sustainable Recovery Plan](#), RTS has the greatest potential of job creation among all clean energy technologies, and its costs are still declining. Stimulating the deployment of distributed photovoltaic (PV) through effective policy design and implementation, balancing social and economic interests of different stakeholders, and raising consumers' awareness will allow India to achieve its economic and renewable energy goals.

To stimulate knowledge exchange, the IEA, in collaboration with the Council of Energy, Environment and Water (CEEW) and the Ministry of New and Renewable Energy (MNRE) of India organised an [online workshop titled "Unlocking the economic potential of rooftop solar energy in India"](#) on 12 October 2020.

The workshop focused on innovative regulatory and policy options as well as various market mechanisms to scale up RTS in India. The participants were the representatives of national government, state nodal agencies, electricity distribution companies (DISCOMs), regulators, industry and international policy makers. A group of experts from Australia, Brazil, Germany and the United States shared their insights on policy, regulation and market innovations relevant for India's RTS market.

This report was created based on insights from the participants of the workshop and the outcome of additional analysis by the IEA and CEEW. It aims to answer the following important questions regarding deployment of RTS in India.

1. How can DISCOMs benefit from the rapid deployment of RTS?
2. How can an enabling financial environment for development of RTS be created?
3. How can the existing remuneration policies of RTS be improved to attract more investment and balance the interests of consumers, DISCOMs and regulators?
4. How can other RTS support schemes be improved and what new policies can be introduced in India to achieve quick acceleration of RTS deployment?

5. How can residential and small or medium-sized enterprise (SME) consumers be effectively encouraged to invest in RTS?
6. How can a holistic policy approach for all distributed energy resources (DERs) be adopted to maximise the value of RTS in combination with electric vehicles (EVs) and storage?

Answering each of the above six questions includes:

- a Outlining the “state of play” for policies and challenges relevant to each question.
- b Proposing possible solutions to the challenges, based on Indian and International examples, in combination with authors’ analysis.

The report has been summarised by providing a set of key recommendations for Indian policy makers and other stakeholders, aimed at achieving rapid acceleration in the deployment of RTS.

Question 1: How can DISCOMs benefit from the rapid deployment of RTS?

Context and challenges

The generation cost measured as the levelised cost of electricity of RTS power is already lower than the variable portion of retail electricity prices in many Indian states, enabling RTS owners to save money on their bills. Simultaneously, the increasing self-consumption of electricity from RTS has the potential to decrease revenues of DISCOMs because RTS owners purchase less electricity from the grid. Theoretically, the self-consumption of electricity benefits both the consumer and the overall power system, especially when there is a good match between solar generation and peak energy demand. RTS consumers save the most on their electricity bills by maximising self-consumption, and at the same time, they help to reduce the system's peak demand. In effect, investments in generation capacity and transmission and distribution infrastructure can be avoided or delayed, especially in the Indian states with increasing daytime power demand due to the popularisation of cooling. In addition, deployment of RTS leads to a reduction in distribution losses, as the generated energy is consumed locally.

However, due to the current rules of RTS remuneration, i.e. net metering and cross-subsidising retail tariff system, RTS deployment has resulted in adverse impact on revenues of DISCOMs. To mitigate such impacts and facilitate the adoption of RTS, MNRE has provided performance-based financial incentive to DISCOMs under Phase II of the Grid Connected Rooftop Solar Programme for progress in RTS adoption. The incentive includes yearly payments of 5% of the benchmark RTS costs for capacity additions above 10% of DISCOMs' total RTS capacity in the preceding financial year, and 10% of benchmark costs for achievement of more than 15% of the installed capacity. In addition, service charges up to 3% of the central financial assistance (CFA) are being provided to DISCOMs for implementation of solar rooftop projects in residential sectors. However, many DISCOMs consider the offered support as insufficient to cover the decrease in revenue due to growing self-consumption.

Accordingly, the most important challenges to DISCOM are as follows:

Loss of sales to the best-paying customers – The design of the current retail tariff requires DISCOMs to sell electricity to residential and agricultural customers below the actual cost of supply. Simultaneously, industrial, commercial and high-demand residential consumers are subject to higher tariff rates and cross-subsidise losses from the low-demand residential and agricultural sectors. Such highest-paying DISCOM customers have the most motivation to adopt RTS systems to save money on electricity bills, resulting in a reduction of the sales revenue of DISCOMs and an increase in the cross-subsidy deficit.

Solutions: Engagement of DISCOMs in opex financing; promoting innovative DISCOM-led business models; reduction of cross-subsidising (*details of each solution highlighted under the challenges are presented in the subsequent section*).

Insufficient savings in grid development and maintenance costs – Net metering rules do not effectively incentivise real-time self-consumption, and allow customers to use grids as long-term storage. When self-consumption is not effectively encouraged at the individual or local level, the potential savings of DISCOMs on grid expansion and equipment replacement remain limited.

Solution: Enhancement of performance-based financial incentives for DISCOMs.

Lack of integrated approach, encompassing all of the system benefits of RTS – DISCOMs might often not capture the full benefits of RTS in their analysis, such as savings in the purchase of power, reduction of distribution losses, fulfilment of renewable portfolio obligations (RPO) or avoided expenses due to deferred grid investments. DISCOMs are also often unable to take advantage of full cost savings due to fixed, long-term contracts with other stakeholders, such as generators.

Solution: Acknowledging the full system benefits of RTS.

The financial condition of many DISCOMs is poor, and the fear of additional revenue losses due to the adoption of RTS makes them reluctant to support rapid RTS deployment. Owing to their crucial role, the support and engagement of DISCOMs are required for significant acceleration in RTS deployment. Innovative

business models and improved support policies can allow DISCOMs to benefit from RTS adoption, and encourage them to support RTS actively.

Solutions

DISCOMs' engagement in opex financing

Leasing models (also referred to as opex or RESCO [for “renewable energy service company”] models) have proven to be effective in providing additional stable revenues in many countries. In this case, the consumer does not need to put significant capital up front, but pays a monthly fee, similar to paying off a loan. DISCOMs, with their central place in the power market and existing reach to consumers, are in a good position to offer such solutions. Monthly leasing or power purchase agreement (PPA) payments can provide long-term stable revenues for DISCOMs. If planned well, DISCOMs can offer lease or PPA services at a lower cost than the private sector because of synergies in marketing, sales operations and large customer base, which can lower customer acquisition costs. In addition, integrated planning can enable DISCOMs to save on future generation costs, transmission investments and distribution losses. Moreover, owing to large portfolio and regulated business, DISCOMs might have access to a lower cost of financing than the private sector.

On the other hand, structural advantages of DISCOMs create a risk of unfair competition with other RTS market participants. In order to ensure fairness of the market and protect the consumers' interests, regulators should create strong legal frameworks and monitoring procedures to detect and mitigate any abuses of power.

International example: RTS business model of DISCOM in Brazil

Brazilian DISCOM Companhia Energética de Minas Gerais (CEMIG) established a separate company called CEMIG SIM. The company offers services such as energy efficiency and RTS. CEMIG is the DISCOM in the Minas Gerais region, which has the largest RTS capacity installed in Brazil under the current net metering scheme. Thus, CEMIG was greatly affected by revenue losses driven by increasing contractual self-consumption. CEMIG SIM was established to take advantage of the growing RTS market and provide an additional stream of revenue for the utility company. CEMIG SIM installs solar PV systems and offers contracts at lower prices to consumers via a virtual net metering scheme.

Promoting innovative DISCOM-led business models

CEEW, in collaboration with BSES Yamuna Power Limited (BYPL), has developed [three innovative, DISCOM-led business models](#), which could maximise benefits from RTS adoption, not only for DISCOMs but also for customers and developers. In proposed models, DISCOMs could utilise their existing commercial relationship with consumers, economies of scale and lower financing cost.

Utility-led community solar model – A group of consumers can either own the PV system jointly or buy solar electricity from the community solar PV plants at a predetermined tariff. The system could be located in a shared space such as a common rooftop or public or privately owned spaces elsewhere, even out of the city. Individual consumers can subscribe to a shared system through one of the two subscription options, i.e. upfront payment or subscription fee.

In this model, a developer sells electricity to the DISCOM at an agreed tariff. Subsequently, the DISCOM transfers monthly credit into the consumer's electricity bill in a predetermined proportion under the virtual net metering arrangement. While a consumer pays the DISCOM a monthly subscription fee for the subscribed amount of solar electricity, the same is passed on to the project developer after deducting nominal service charges by the DISCOM.

On-bill financing model – This model is attractive to individual consumers who own roof spaces and do not want to pay the upfront investment costs. The consumer installs and operates the system on their own roof, and achieves savings through a net metering mechanism. This model offers capital cost as a loan, which consumers can repay through savings in their monthly electricity bill. Monthly repayment is devised in such a way that the amount of the consumer's bill remains the same or slightly lower. The average savings achieved in electricity bills by switching to solar power equals the amount of loan repayment.

In the contractual agreement, the lender and the consumer agree on the loan amount, the DISCOM agrees on loan recollection with a margin, and the consumer agrees on the terms of repaying the loan through their electricity bill.

Solar partners model – The DISCOM aggregates rooftop owners in their licensee area, and opens a tender for installation of PV on the identified roofs. Developers, who are selected through competitive bidding, install, own and operate the systems. Subsequently, the DISCOM agrees to buy power at the fixed tariff for the

next 25 years. The larger aggregated capacity ensures that the economies of scale lead to a better tariff. Rooftop owners are benefited by receiving either the monthly rent payments or energy credits in their electricity bills.

The DISCOM also meets the demand for solar energy from interested consumers, who may not have suitable roof space and access to cheap capital. These consumers can subscribe to the part of electricity generated from PV systems, sold by the DISCOM with a margin.

New business models would ensure equitable sharing of the benefits of solar PV by DISCOMs and consumers, by creating additional revenue streams for DISCOMs and addressing market challenges faced by consumers. A study by CEEW in BYPL's DISCOM area found that by utilising the DISCOM-led business models, consumers can achieve 40-70% savings on electricity expenditure over the RTS project's lifetime (depending on electricity consumption level). Additionally, the DISCOM also realises additional revenue.

These findings are based on the analysis of three RTS pilots using virtual net metering with various specific assumptions regarding local power markets and can significantly vary across other DISCOMs. The study shows that DISCOMs can benefit from engaging in RTS development. However, before implementation, each business model should be carefully evaluated, taking into consideration local conditions.

As described in the previous solution, increased engagement of DISCOMs in the RTS market creates a risk of unfair competition due to the structurally central role that DISCOMs have in many areas of the power market. In order to mitigate that risk and protect consumers' interests, regulators should develop effective market monitoring and control mechanisms to ensure fair competition between utilities and other market participants.

Acknowledging full system benefits of RTS

RTS deployment brings many benefits to DISCOMs that often are not taken into consideration. Such benefits include reduction in capacity and power procurement, savings on transmission charges, reduction of distribution losses, and savings in grid investment and maintenance.

With proper methodology, DISCOM should be able to identify the most beneficial approach to deploy and support RTS systems in their grids. To assist DISCOMs in estimating the actual outcomes, CEEW has developed a [Valuing Grid-](#)

[Connected Rooftop Solar \(VGRS\)](#) framework taking into account various cost and benefit parameters involved in RTS. Accordingly, CEEW conducted a case study with BSES Rajdhani Power Limited (BRPL), a Delhi-based DISCOM in India.

List of benefits and cost parameters considered in the VGRS framework

Benefit parameters	Generation system	Avoided generation capacity costs
		Avoided power purchase costs
	Transmission system	Avoided transmission charges
	Distribution system	Avoided distribution capacity costs
	Externalities	Avoided renewable energy certificate costs
Reduced working capital		
Cost parameters	Programme administration costs	
	Additional distribution services costs	
	Revenue loss from reduced retail electricity sales	

The results of the case study demonstrate that DISCOMs should promote RTS among their low-tariff residential consumers to reduce the overall cross-subsidy requirement. BRPL saw a maximum net benefit of up to 0.75 rupees (INR) per kilowatt-hour as the residential consumers switched to RTS power. Moreover, DISCOMs should target overloaded distribution transformers to install RTS as it will relieve the load on the network and enhance system life, thereby deferring necessary investments. BRPL could witness a reduction in peak demand of 13% owing to the uptake of RTS in its licensee area. Finally, DISCOMs should prioritise the export of solar electricity generated in the area as it will assist their grid operation and reduce power procurement from expensive sources. Apart from adopting proper methodology, improving data collection and analysis capabilities will be necessary for DISCOMs to quantify and access full benefits of RTS adoption in their grids. It is important for DISCOMs to include full analyses of costs and savings in their operational strategy to maximise the benefits of RTS adoption. As a subsequent step, DISCOMs could also incorporate supporting the deployment of energy storage and EVs into analysis, as they can further increase achievable savings.

Achieving savings in power procurement might be easier for DISCOMs with strong demand growth, and more challenging for utilities with overcapacity that cannot easily decrease their previously contracted energy amounts. Allowing more

flexibility in the power procurement contracts could significantly enhance the cost reduction potential of RTS for DISCOMs.

Enhancement of performance-based financial incentives for DISCOMs

Increasing support schemes for DISCOMs, such as performance-based financial incentives included in Phase II of the Grid Connected Solar Rooftop Programme by MNRE, can encourage DISCOMs to support RTS adoption more actively. The calculation of support value should resemble the actual revenue losses and costs incurred by DISCOMs due to RTS adoption. The support value should also provide compensation for necessary investments in infrastructure upgrades, digitalisation and data analysis. Enhancement of the offered incentives might be a solution that would allow DISCOMs to retain the necessary level of revenues in the transition period, before new, sustainable market solutions could be implemented.

Reduction of cross-subsidising

The current tariff design creates a significant disadvantage for DISCOMs. It creates the biggest incentive to adopt RTS for commercial, industrial and high-demand residential consumers, who are the main source of capital for subsidising low-demand residential and agricultural users. A progressive reduction of subsidies and a tariff reform would remove the main reason for resistance from DISCOMs to promote RTS. Residential customers faced with cost-reflective electricity tariffs would have higher economic incentive to install RTS. Simultaneously, commercial and industrial consumers would face less opposition from DISCOMs to connect RTS.

However, policy makers should carefully weigh the impact of tariff reform on the ability of low-income customers to afford electricity. Subsidies for the most vulnerable consumers could be still disbursed through other channels, independent of DISCOMs.

Question 2: How can an enabling financial environment for development of RTS be created?

Context and challenges

The following two financing models are predominantly used in India for RTS deployment:

Capex model – Consumers purchase the system up front and benefit from savings on electricity bills or from selling electricity to DISCOM. The capex model is challenging for residential and small commercial consumers, since the upfront cost is relatively high, making it difficult to make an investment without access to affordable financing. In this model, the consumers are responsible for risks associated with the performance of the RTS system as well as its maintenance.

Opex model – Customers lease their roof to a third-party vendor to install PV systems. In this case, the developer makes the initial investment, which is later paid by consumers in the form of a monthly charge, often sourced from savings on the electricity bill or electricity sales to discoms. In the opex model, the developer is responsible for ensuring uninterrupted operation of the RTS system and its maintenance.

Most of the RTS capacity in India has been installed by large commercial, industrial and institutional consumers. Larger entities usually have more equity to invest and maintain relationships with the financial sector, which makes it easier to secure a loan. It is also easier for such consumers to enter the opex agreements because of relatively high payment credibility compared with residential and small commercial consumers, who often cannot demonstrate multi-year credit histories or credible projections of future revenues.

There are several support mechanisms in place for the capex model of RTS financing, i.e. subsidies for residential consumers and low-interest loans under the Priority Sector Lending initiative by the Reserve Bank of India. In addition, multilateral banks such as the World Bank and the Asian Development Bank have provided dedicated lines of credit to the state-owned banks such as the State Bank of India (USD 625 million) and Punjab National Bank (USD 100 million) for on-lending to RTS projects. Loans from these channels were successful in kick-

starting the RTS sector in India. However, they have been mostly limited to projects developed by large, creditworthy entities due to the restrictive conditions that borrowers need to fulfil and high minimum amount requirements.

Despite the growing commercial viability of RTS and multiple support policies, there are still significant difficulties in obtaining finances for smaller projects due to the following challenges:

High transaction costs – The small size and disaggregated nature of RTS projects make them unattractive for commercial banks due to the relatively long loan application processing time, compared with the loan amount. In addition, differences in remuneration rules and incentives across states, along with often limited understanding of the RTS sector at the branch level of banks, make it difficult to conduct due diligence.

Solutions: Encouraging RTS demand aggregation business models; standardisation of the RTS loan application assessment process and financial products (*details of each solution highlighted under the challenges are presented in the subsequent section*).

Difficulty in assessing creditworthiness of borrowers – Residential consumers, SMEs and local developers often do not possess significant credit histories allowing financial institutions to assess their creditworthiness. Due to this, banks often demand collateral, which the RTS system itself cannot provide because of high removal costs and low value of used equipment. Such requirements make it much more challenging for consumers to invest in RTS.

Solution: More involvement of public institutions in providing affordable loans or guarantees.

Complicated procedures required to participate in sectoral programmes – As mentioned above, participation in the preferential lending programmes introduced by public or multilateral institutions requires conducting complicated processes and is mostly restricted to large projects.

Solution: Simplification of rules of sectoral lending programmes.

Improving the availability of financing, especially for residential consumers and SMEs, could enable many interested consumers to invest in RTS, thereby significantly accelerating the capacity growth, helping to build a strong supply market and creating quality employment.

Solutions

Encouraging RTS demand aggregation business models

The solution to challenges resulting from the small size of RTS projects is to aggregate them in large quantities, so that the entire portfolio can apply for financing. Such aggregators should be able to receive better terms from financial institutions owing to lower transaction costs and more attractive offers from system installers.

Currently, DISCOMs are the main entities responsible for supporting development of RTS, chosen as the main point of contact for consumers interested in RTS. They engage with consumers on almost every step of investment, apart from financing. There is an enormous potential for facilitating financing for smaller projects if DISCOMs engage in aggregation of interested consumers. DISCOMs also possess good knowledge about the potential of project portfolios and the expected revenue streams. Through business models such as the utility-led community solar model, on-bill financing model and solar partner model (described in Question 1), DISCOMs could facilitate investments and benefit from it. The entire process would also become easier for consumers as they would need to contact just a single entity throughout the entire investment process.

Apart from DISCOMs, local governments, nodal agencies, other public entities, and private companies and developers could also engage in aggregation business models and benefit from economies of scale. Again, to ensure fair competition between public and private entities, regulators should enforce equal rules for all market participants, preventing DISCOMs or any other entities from excessively leveraging their dominant market position.

Indian example: Project aggregation in Madhya Pradesh

Urja Vikas Nigam, a state nodal agency in Madhya Pradesh, conducted aggregation of RTS projects among public institutions and government buildings in the state. Projects were tendered in the opex model, and aggregation allowed the reduction of off-taker risks for RTS developers, leading to easier access to financing. In result, achieved rates were as low as INR 1.38 per kilowatt-hour (kWh) including subsidies from both central and state government, and INR 4.13/kWh without subsidies (with an annual escalation of 3% per year in both cases). RTS systems were implemented under net metering arrangements, which should allow consumers to achieve an attractive return on investment. In addition, intermediation of the state entity helped in streamlining the process of signing PPAs. A unique projects data room has also been created to facilitate design and construction for developers.

More involvement of public institutions in providing affordable loans or guarantees

Public institutions could engage more in stimulating financing of RTS projects by providing special purpose loans and guarantees. Public entities could provide standardised loans for residential and SME consumers, who are constrained in proving their creditworthiness, and cannot receive loans from private banks. Based on known revenue streams from RTS support schemes and the standardised approach, public institutions would be able to correctly assess the risk and fill the gaps in financing availability.

Guarantees could be especially helpful in the case of RTS investments on government and public institution buildings. It would decrease the risk of payment delays in opex financing and encourage developers to participate in empanelment auctions.

Payment security mechanisms are already successfully utilised by the Solar Energy Corporation of India for utility-scale projects. The approach consists of multiple levels of payment security in PPAs such as letter of credit, default escrow agreement, payment security fund, tripartite agreement and state government guarantee. Similar solutions could be devised for RTS projects on government buildings, with engagement of state and national agencies.

International example: Public-private co-financing in the United States

Many state authorities in the United States, such as Iowa, Montana and Nebraska, introduced co-financing programmes dedicated to small consumers who are interested in renewable energy and energy efficiency investments. Introduced schemes include: 1) loan loss reserve, where the government co-ordinates and supports the creation of a reserve fund, supplied by lenders, which guarantees a part of the loan in case of borrower's default; 2) subordinated debt programme, where the government provides a loan subordinated to a loan from the private sector, which is used to absorb first losses in case of default; and 3) interest rate buy-down, where the government covers part of the interest rate offered by the private lender. All of the presented incentives aim to decrease the risk of private lenders, resulting in lower interest rates, longer tenors and higher availability of loans. In order to control costs of such support programmes, they were designed as revolving loans, which means that the initial funds are provided by the government and later replenished by payments from lenders.

Standardisation of RTS loan application assessment process and financial products

Financial institutions should be encouraged to develop standard rules and procedures for assessment of RTS projects. Additionally, banks should be encouraged to develop standardised products based on RTS policy and regulation regimes of each state. A standardised approach should be used to automatically design details of such products, such as tenor and monthly payment based on customer type, system size, remuneration policy, subsidies, tax benefits and other existing incentives. Such products targeted for residential and SME consumers should be as simple as possible to encourage participation.

Public institutions should encourage digitalisation of the assessment and product design process based on standard forms to accelerate the processing of applications. Banks could create central organisational units or task forces specialising in processing RTS applications to improve the efficiency and reduce the cost of the individual process.

Simplification of rules of sectoral lending programmes

Small projects should be allowed to receive preferential loans through sectoral programmes of public and multilateral development banks. These could be achieved by decreasing the minimum expenditure, streamlining and digitalising

the application process, and facilitating participation of aggregators. Such programmes should be aimed to provide financing to market segments with limited possibilities of obtaining finances from private banks.

Large companies, which are currently the main target of lending programmes, often prefer to seek funds in bilateral agreements with private banks due to fewer restrictions and faster processes. This leaves the available public funds largely untapped. Allowing the participation of smaller investors, standardising procedures, and outsourcing customer acquisition to DISCOMs, state agencies or other third-party developers serving as intermediaries would increase the effectiveness of such programmes without a significant increase in processing capacity on lender's side.

Indian example: The World Bank RTS financing programme for India

In 2016, the World Bank, in co-operation with the State Bank of India, started the Grid Connected Rooftop Solar Programme in India. The aim of the project is to finance the installation of at least 400 megawatts (MW) of RTS systems with funds made available amounting to USD 625 million. It required the individual RTS projects eligible under this programme to have at least 100 kilowatts (kW) of installed capacity, or the aggregated capacity should be at least 1 MW in case of the opex model. The World Bank programme kick-started the Indian RTS market by reducing the interest rates from 14-16% offered in 2016 to lower than 10%. It greatly increased the economic feasibility of early Indian RTS investments and mobilised many other financing entities to engage in the RTS market.

Question 3: How can existing RTS remuneration policies be improved to attract more investment and balance the interest of consumers, DISCOMs and regulators?

Context and challenges

In 2013, Indian states started introducing RTS remuneration policies, and currently all of them have such regulations in place. The enacted rules determine various aspects of installing RTS systems, including technical requirements and limitations, administrative procedures and how consumers are compensated for the electricity production. The introduced policies are net metering, gross metering or a combination of both, with large differences in rules between the states. The Electricity (Rights of Consumers) Rules were introduced in December 2020 in an attempt to unify a part of the state-level incentive schemes. It allowed net metering only for installations with capacity up to 10 kW, and gross metering for larger systems. Although new rules facilitating further unifications of incentive schemes are under consideration, many differences are expected to remain. The general rules of net and gross metering in India are as follows:

Net metering – RTS owners self-consume the electricity they generate, which reduces their consumption from the grid. Consumers receive energy credit for any surplus generation exported to the power system, which allows them to import electricity from the grid at another time without additional cost.

Gross metering (or buy-all-sell-all) – Electricity generated by the PV system is fully injected into the grid, and the consumer imports all of their electricity from the grid for consumption. At the end of settlement period, the consumer is compensated for electricity exported to the grid at the tariff determined by the electricity regulatory commission of the concerned state.

The main reason for introducing the above-mentioned incentives is a lack of exact match between the generation of electricity from PV and consumption, with limited possibilities to store energy on site. Net metering uses the power grid as long-term

storage, with the possibility to draw stored electricity from the grid without any additional fees at any time. In gross metering, RTS acts as a small independent power plant. It is also possible for consumers to install RTS in behind-the-meter arrangements, without exporting surplus generation to the grid. However, achieving economic feasibility of such a solution requires a very good match between energy generation and demand, or a significant decrease in the costs of energy storage.

Both net and gross metering schemes have been successful in propelling dynamic growth of RTS in many markets such as Brazil, California (United States) and the Netherlands in the case of net metering, and the People's Republic of China, Germany and Japan in the case of gross metering (in all cases with generous tariffs for exported electricity, significantly above the wholesale market price).

Despite extensive remuneration policies, RTS deployment in India has been relatively slow, even in states where the rules are relatively attractive to consumers. The reluctance of DISCOMs, inefficient administrative procedures and limited financing availability can often be the main reasons for sluggish deployment. All of above-mentioned hurdles seem not to be directly connected with remuneration policy. However, in reality, many of these challenges can be tackled through eliminating the inefficiencies in the design of current remuneration schemes.

Inconsistency in regulatory rules across states – The lack of consistent guidelines on the design of RTS support policies across states may lead to implementation of suboptimal regulatory solutions. Variations and changes in technical requirements and pricing mechanisms at the state level also create confusion among users, and make it more challenging for installers and other RTS service providers to develop their businesses throughout the country.

Solution: Creating more consistent national guidelines for RTS remuneration policies and regulations (*details of each solution highlighted under the challenges are presented in the subsequent section*).

Restrictive rules on system size and grid integration – Limits on the size of RTS systems to be eligible for support schemes are too low in some states, which leads to underutilisation of RTS potential in larger households, commercial buildings and industrial plants. In addition, limits set with respect to connection

voltage, sanctioned load in connection agreement, and transformer capacity are often too conservative, slowing down adoption of RTS in residential and commercial segments.

Solution: Optimising restrictions on system size and grid integration.

Inadequate compensation rules – Remuneration rules and financial incentives for RTS in many states are not attractive enough to drive investment. In addition, the rules often do not encourage self-consumption, leading to additional strain on the power grid. Finally, a lack of balance in levies for grid maintenance for RTS users can lead to unjustified burdens on non-RTS consumers and DISCOMs, who may be forced to cover full grid costs, also on behalf of RTS owners.

Solution: Optimising remuneration and levies for RTS systems.

Relatively small changes in the existing gross and net metering regulations can lead to much more balance among all stakeholders, including RTS owners, non-RTS consumers, DISCOMs and regulators. With improved regulations and technology, flexibility in installing RTS systems can be significantly increased without compromising power system security, leading to faster and sustainable deployment of RTS.

Solutions

Creating more consistent national guidelines for RTS remuneration policies and regulations

Introducing stricter RTS policy guidelines on the national level could lead to more consistent RTS rules and proliferation of the most successful policies across Indian states. Because of the differences in states' electricity markets, some flexibility in setting rules is always needed. However, the central and state governments should co-operate more closely to ensure that the introduced regulations fit the state's requirements and are within the boundaries of optimal policy design. Central agencies could also put more efforts in awareness-raising campaigns and knowledge sharing with state regulators to promote the most effective regulatory solutions.

With more uniform rules regarding tariffs, levies, the administrative process, capacity limits and technical requirements, consumers and developers in India

would have a greater chance of obtaining stable and efficient regulations, resulting in higher confidence and faster growth of RTS capacity.

Optimising restrictions on system size and grid integration in net and gross metering

It is usually the most profitable for consumers to install RTS systems that cover as much of their annual electricity demand as possible. However, due to the current system size limits eligible for net or gross metering schemes, many consumers cannot invest in larger RTS systems that would cover a bigger portion of their actual demand, leading to underutilisation of existing potential. Increasing the caps of maximum RTS system capacity for low-voltage connections would lead to faster RTS deployment among high-demand households, and increasing the total caps would lead to the installation of larger systems in big industrial plants.

In the case of grid integration rules, more individual approaches should be introduced, with more advanced procedures for determining the technical limits. In grid areas with a large correlation between demand and RTS generation profiles, it is often unnecessary to set strict limits on the transformer capacity usage, as additional local RTS capacity lowers the load on transformers. The same applies to limits on maximum capacity with respect to sanctioned load. Additional technical solutions, including grid digitalisation, batteries and smart inverters, allow dynamic regulation of RTS generation exported to the grid and could act as a security mechanism, while liberalising limits would allow RTS to expand faster in suitable locations.

Regulation should also encourage DISCOMs to perform technical studies to assess RTS hosting capabilities in their grids. Results of such periodic studies should be made available to the public, allowing consumers and developers to make informed investment plans.

International example: Net metering system size limits in Brazil

Brazil introduced a net metering scheme in 2012, allowing PV installations of up to 1 MW to participate. In 2015, rules were amended, and the eligible PV system size was increased to 5 MW. In addition, virtual net metering was also implemented, creating new business models that reduced the cost of installers and consumers. The policy resulted in a boom in RTS capacity, with annual additions increasing from 157 MW in 2017 to approximately 2.5 GW in 2020. Although about 80% of installations are low-voltage and with capacity below 75 kW, the increased capacity limit added important drive to RTS deployment in the industrial sector. A favourable support policy led to the rapid increase of RTS and of the distributed ground-mounted solar PV capacity, which have far exceeded regulators' expectations. This sudden success has triggered regulators' actions for replacement of net metering with net billing to balance the burden of PV and non-PV consumers in maintaining the power grid.

Optimising remuneration and levies for RTS systems

Remuneration schemes are usually the main drivers of RTS capacity growth, and are the most important aspect of RTS policy. They determine the attractiveness of investment, along with the balance between interests of RTS owners, other electricity consumers and utilities. There are three main goals that should be achieved when designing such rules: to provide a reliable revenue stream for RTS owners, allowing them to achieve investment payback in a maximum of approximately five years (taking other incentives into account); to incentivise self-consumption; and to ensure fair distribution of RTS benefits among all users and operators of the power system.

Net metering schemes – Most Indian states allow an annual or monthly compensation period for surplus generation, with remuneration for outstanding credit beyond the settlement period varying between zero and the feed-in tariff determined by state regulatory commissions. The attractiveness of such a solution depends on the electricity tariff, and is limited for residential consumers, who need additional subsidies to make investment attractive. However, such a system does not encourage real-time self-consumption, as surplus generation can be recovered from the grid during any subsequent period throughout a year without penalty, creating an additional burden for DISCOMs. Possible improvements would be to shorten the period in which generation credits can be redeemed, introduce levies for banking and wheeling of electricity in the power grid, or provide

different amounts of credit depending on whether surplus electricity is injected to the system in peak or off-peak hours.

For example, in Poland, the credit is granted only for 70-80% of surplus electricity generation exported to the power grid, with the rest being transferred to the utility company without any benefit for the consumer. Such an arrangement creates an additional incentive for self-consumption, and enables utility companies to recuperate part of the expenses associated with the distribution grid.

Gross metering schemes – The tariff offered by DISCOMs for electricity injected to the grid is often at the level of the wholesale price, which is too low to encourage investment in RTS, especially in opex models. In setting such a price level, the full benefits of RTS should be taken into account, including savings in power procurement, RPO fulfilment, deferred distribution grid investments, avoided transmission losses and even externalities such as lower pollution. If the resulting price does not assure reasonable return on investment, additional subsidies should be offered. Rules of price setting should be transparent and stable, providing RTS owners with long-term confidence of revenues, lowering financing costs and encouraging investment.

Also, to ensure fair participation in covering the distribution system costs among all consumers and provide DISCOMs with the necessary means to maintain and expand the grid, RTS owners should be subjected to certain fixed grid charges. When designing rules for RTS remuneration and levies, it is important to take a holistic approach of balancing the levels of all costs and revenues to ensure the attractiveness of RTS deployment for all stakeholders, and encourage behaviours mitigating grid integration challenges. Providing consumers with incentives attractive enough to make an investment decision while simultaneously providing DISCOMs with enough revenue to support deployment of RTS requires careful, long-term planning, which should also take into consideration the eventual phase-out of the incentives.

Net billing remuneration schemes can allow high flexibility in setting rules and balance interests of consumers and utilities. It includes part of a net metering scheme, allowing consumers to self-consume electricity generated by their RTS system, and part of a gross metering scheme, providing remuneration for surplus generation at a predetermined price.

International example: Net metering rules in Poland

Poland introduced a net metering scheme in 2016, and the current policy allows residential and commercial consumers to install PV systems with capacity of up to 50 kW. Surplus generation is injected to the power grid, which is treated as long-term battery storage. Simultaneously, consumers are rewarded with credit allowing them to consume electricity from the grid at any time within the year without any fees. However, to provide distributors with necessary revenue and incentivise self-consumption, credit is granted only for 70-80% of electricity injected to the grid. The remaining amount is transferred to distribution company without any remuneration. In addition, RTS system owners remain subjected to the fixed part of distribution and transmission fees, preventing an unjustified transfer of the cost burden for grid maintenance to the non-RTS consumers. The balance of benefits, costs and fees allows for a return on investments in approximately seven to ten years, depending on the availability of additional capex subsidies, which resulted in an increase in annual installations from 0.1 GW in 2017 to 1.5 GW in 2020.

Question 4: How could other RTS support schemes be improved and what new policies could be introduced in India to achieve rapid deployment of RTS?

Context and challenges

There are multiple RTS support incentives targeting investment costs in India apart from net and gross metering, with different approaches towards commercial and industrial (C&I) and residential consumers.

C&I consumers are eligible for exemptions on electricity duties and grid charges and can claim accelerated depreciation of PV assets. In addition, loans for RTS installations are available at low interest rates for companies under the Priority Sector Lending scheme by the Reserve Bank of India.

In the case of residential customers, the main support scheme is the capital subsidy aimed to decrease the upfront cost of RTS investment for 4 GW capacity. Such CFA is disbursed under the Grid Connected Rooftop Solar Programme – Phase II.¹

To claim CFA, the systems must be built by installers empaneled by DISCOMs through competitive bidding. Empanelment procedures allow choosing installers who offer the lowest price for system installation and its maintenance for five years and fulfil the minimum technical specifications laid down in the bid and periodically specified by MNRE. Also, only domestically produced modules and cells can be used for availing the CFA. Furthermore, to resolve the issue of unfeasibly low rates, MNRE has recently amended this scheme, wherein completion of 10% of

¹ CFA provides up to 40% of the benchmark RTS investment costs for capacity up to 3 kW, and 20% for capacity between 3 kW and 10 kW for individual households. For group housing societies and residential welfare associations, CFA is limited to 20% for RTS investments and for supply of power to common facilities a maximum up to 500 kW capacity. In addition, many states, such as Madhya Pradesh, Gujarat and Bihar, introduced additional subsidies funded from state resources to further increase the attractiveness of RTS investment.

the capacity allocated to the bidder has been made mandatory. The aim is to reduce the risk of aggressive bidding and underperformance.

DISCOMs were made the main implementation agencies for disbursement of subsidies under the current programme. They are responsible for choosing eligible installers from competitive tenders, and passing the subsidy to them. DISCOMs also provide active support to the interested customers in the entire process, from evaluation of premises to commissioning. In addition, DISCOMs are responsible for organising awareness campaigns and creating dedicated online platforms for consumers interested in RTS.

IEA and CEEW analyses show that by utilising the net metering scheme and subsidies, RTS owners can achieve a return of their investment in three to five years in many states, which should drive a dynamic growth of RTS capacity. However, the implementation of existing policies remains a challenge, leading to much slower RTS adoption than the expected rate. The main challenges are as follows:

Inefficiencies associated with the vendor empanelment process under subsidy schemes – The current cost-driven empanelment process forces companies to offer the cheapest equipment and service, which may create a threat to the quality of installation, possibly discouraging consumers interested in RTS. Moreover, the requirement to use only domestic modules and cells with currently limited manufacturing capacity might also lead to delays in projects execution.

Solution: Removing procedural inefficiencies associated with subsidy schemes (*details of each solution highlighted under the challenges are presented in the subsequent sections*).

Too much responsibility on DISCOMs with limited rewards – DISCOMs were made the main implementation agency for disbursement of subsidies under the CFA scheme. DISCOMs are responsible for selecting vendors, making contacts with customers, and fulfilling all procedures regarding installation and system inspection. The administrative burden associated with such responsibilities as well as the necessity to possess a high level of expertise in RTS technology is often too much for financially strained DISCOMs, leading to delays in deployment of RTS. In addition, the rewards offered to DISCOMs for effectively executing RTS obligations, such as the central performance-based financial incentive, are not considered highly attractive, especially when the loss of revenue due to higher RTS penetration is considered.

Solutions: Reducing responsibilities of DISCOMs and increasing rewards; facilitation of open-access power procurement.

Highly complicated assessment of overall RTS benefits – While calculating the possible benefits and returns from RTS investment, the owner has to take into account multiple factors associated with financing costs, net metering revenues, maintenance of installed projects, and subsidy or tax exemptions. Each of these factors is connected with some degree of risk, which makes investment decisions difficult, especially for residential users or smaller companies.

Solution: Simplification of the investment process and support rules for small RTS.

Improving the implementation mechanisms of current incentives can lead to significant growth of RTS capacity as observed in other countries with a similar level of support as India were introduced. Further simplification of the support rules or introducing other proven incentives can provide an additional boost to RTS market.

Solutions

Removing procedural inefficiencies associated with subsidy schemes

Enabling a wider range of installers to access a subsidy-driven residential PV market would lead to an increase in the supply of services and more competition, thereby increasing quality and efficiency. The subsidy amount should remain capped at benchmark level to promote cost-efficiency of RTS projects and control the total subsidy cost. At the same time, wealthy customers should have the option to choose higher-quality, more expensive products; receive the subsidy; and pay the difference. Such flexibility is common in other countries, where subsidies are offered, e.g. in the European Union and the United States. The flexibility increases confidence among customers, allowing installers to create their own offers, which results in driving more investment.

India is aiming to stimulate the growth of PV manufacturing capabilities. However, allowing utilisation of imported equipment in subsidy schemes up to the defined and limited extent could lead to the acceleration of rooftop PV deployment and

strengthen domestic manufacturing processes in the long term. Wider equipment availability would increase the confidence of consumers, and increased competition could lead to a decrease in costs and supply-chain improvements, and encourage Indian manufacturers to improve the quality of their products.

Reducing responsibilities of DISCOMs and increasing rewards

Decentralisation of responsibilities for RTS deployment is required to decrease pressure on DISCOMs, which are often in a challenging financial situation and lack the necessary resources to fulfil their tasks efficiently. Transferring responsibilities that are not directly connected with core DISCOM business to other public agencies and the private sector could decrease delays in installation procedures. Despite strict official timelines, delays can reach up to six months in many Indian states, which discourages consumers.

In many developed RTS markets, distribution companies are responsible for technical issues only, such as providing meters and testing if the installation meets all technical standards or not. Installers are usually responsible for the promotion of their products through public awareness campaigns, and consumers are free to choose products. Responsible government agencies or their authorised contractors transfer the subsidy to the consumer through direct electronic deposit. Such division of responsibilities allows more efficient process, through which each party can act in its own interest and utilise in-house competencies.

Current regulations provide DISCOMs with subsidies and performance-based incentives, aimed to increase their administrative capacity and execute RTS responsibilities. However, the observed reluctance of many DISCOMs in promoting RTS in their service areas and delays in administrative processes prove that the offered incentives are too small. To encourage the DISCOMs, offered incentives should be adjusted or other mechanisms should be introduced, such as an RPO sub-target for RTS. Calculations of the overall support level should take into consideration the actual loss of DISCOM revenue due to deployment of RTS and the costs of necessary investments in upgrading the infrastructure, analytical capabilities and digitalisation.

Simplification of investment process and support rules for small RTS

Apart from the achieved savings, simple supportive rules and investment processes are the most important aspects in making RTS investment decisions

by residential and small commercial consumers. A multitude of national and state incentives; gross or net metering schemes; and investment processes requiring engagement with DISCOM, bank and installer are often confusing for consumers. Introducing rules that allow customers to achieve a favourable investment return while minimising the requisite efforts should be promoted to achieve acceleration of RTS growth. For example, in developed RTS markets of Europe and the United States, installers usually serve as single contact points. They provide finances, install RTS plants, deal with distribution company, claim subsidies and intermediate in receiving generation-based incentives.

To kick-start the small-scale RTS market, simplification of support rules can also be considered. It could take the form of a simple and attractive feed-in tariff dedicated to all installations below a certain system capacity threshold and up to the total RTS installed capacity on the state level. Such a tariff should encompass all other incentives and subsidies, and allow to achieve a payback period for the RTS investment in approximately five years. Apart from simplifying rules for consumers, providing a stable and long-term revenue stream could also unlock commercial lending, especially if public agencies could serve as a guarantor in case DISCOMs fail to provide timely payments. As an example, a simple and attractive feed-in tariff plan has been successfully used in Germany to initiate the rapid growth of the RTS market, helping the country to become one of the leaders in deployed RTS capacity today.

Facilitation of open-access power procurement

In case of larger C&I consumers, liberalisation of power procurement options can be an important driver of RTS capacity growth. Allowing commercial consumers to directly purchase renewable electricity from RTS owners and the utilise power grid of the DISCOM could spur the PPA market and result in faster growth of RTS capacity. Surplus electricity produced in RTS systems could be sold directly to other consumers, propelling the competitive market and alleviating the administrative burden connected with disbursement of public support. In such a scenario, state regulatory agencies should set adequate and fair levies for the utilisation of grid, allowing for maintenance costs to be covered, although it should not be excessively high to prevent open-access agreements. Such rules should remain stable for providing long-term confidence to both generators and consumers. The proposed solution should be considered in the long term as it requires a comprehensive approach for the entire electricity market to balance the interests of all stakeholders and ensure efficiency of the new system.

Question 5: How can residential and SME consumers be effectively encouraged to invest in RTS?

Context and challenges

The design of remuneration rules, subsidies and other incentives, and availability of financing options determine the economic attractiveness of RTS investment. However, from a consumer's perspective, awareness of the available support and real-life obstacles in policy implementation are often considered the key factors in making investment decisions.

There are several main non-policy challenges that discourage RTS investment, especially among residential and SME consumers, as listed below.

Low consumer awareness about RTS benefits – The economic attractiveness of RTS systems has greatly improved in many Indian states in recent years, allowing for rapid investment return and significant savings throughout the project lifetime. However, consumers still consider RTS an expensive power source, and have low awareness of vendor availability, support schemes and application processing steps.

Solution: Putting more effort into education campaigns; creating information centres about products and developers (*details of each solution highlighted under the challenges are presented in the subsequent section*).

Lack of compelling information about RTS benefits – Efforts have been made by public agencies at the state and national levels to present information about RTS benefits. However, advertising campaigns have limited effect as they mostly rely on online platforms and smartphone applications, which are often not considered trustworthy among consumers.

Solution: Putting more effort into education campaigns.

Too-complicated investment process – The need to contact multiple stakeholders, including banks, DISCOMs and installers, connected with long approvals processes, and the lack of capable officials to provide information and guidance, are highly discouraging for consumers interested in RTS.

Solution: Simplification and streamlining of administrative procedures.

Delays in the investment process – The insufficient administrative capacity of DISCOMs, limited choice of vendors, requirement to use only domestically manufactured PV modules and cells in subsidised residential projects, difficulties in obtaining financing, and delays in subsidy disbursement often translate to a prolonged investment process. Despite strict official timelines, it can often take up to six months from expression of interest to connection of an RTS system.

Solution: Simplification and streamlining of administrative procedures.

Significant focus on the lowest cost at the expense of quality – Current rules regarding subsidies for residential consumers put a lot of pressure on developers to offer the cheapest service and equipment. Although there are requirements regarding minimum technical standards, it is difficult to maintain quality standards of installations; for example, RTS should be able to operate for up to 20 years, much higher than the obligatory 5-year warranty.

Solution: Strengthening quality control and allowing higher-quality equipment in subsidy schemes.

Lack of proper rooftop space availability – Solar PV is a relatively new technology. Many rooftops, especially in residential and commercial buildings, do not have the necessary structural strength or space to install PV systems. Legal ownership is also an obstacle to RTS installation, especially in multifamily and rented buildings.

Solution: Including RTS in building codes, city planning and rooftop ownership regulations

Lack of skilled RTS workforce – The RTS sector is very labour-intensive; it requires much more labour compared with other renewable power technologies.

Therefore, RTS has immense potential to create quality jobs for a trained workforce for installation and maintenance of the systems. [According to CEEW research](#), the addition of 1 MW of RTS capacity creates as much as 24.7 job-years, compared with 3.4 job-years for utility solar PV and 1.3 job-years for onshore wind. However, due to such large demand for labour, it is often challenging for developers to find qualified workers, and organising hands-on training is often too expensive for them.

Solution: Supporting knowledge sharing between developers and workforce training.

Finding solutions to the above-mentioned challenges for policy implementation could boost RTS adoption without the necessity of introducing significant changes in regulations.

Solutions

Putting more efforts into education campaigns

[CEEW analyses](#) have shown that word of mouth is the most trusted source of information on RTS for residential consumers (who make approximately 26% of the respondents), followed by advertisements by solar vendors (22%), television (19%) and DISCOMs (16%). Given this, targeted campaigns and neighbourhood programmes might be the most effective ways to engage residential communities. Public institutions and agencies should also co-operate more with private-sector communication companies in advertising the benefits of RTS by organising workshops and demonstrations featuring real-life examples of successful investments. Opening channels focused on active question-answer sessions and two-way discussions on concerns of consumers instead of one-way communication would additionally improve the effectiveness of education campaigns.

DISCOMs have a ready consumer-facing interface, and are well suited to spread the awareness of RTS among their customers. However, DISCOMs currently have limited motivation to engage in awareness-raising campaigns, as growth of RTS decreases their revenues. This situation might change if DISCOMs start to engage more in the RTS value chain and pursue innovative business models. These will bring benefits to DISCOM from more RTS users.

An example of a consumer-oriented initiative is the CEEW campaign in the form of workshops, social networking and open discussion sessions implemented between November 2020 and January 2021 in the Safdarjung Enclave and Karkardooma areas of Delhi. The aim was to raise the awareness of RTS among residents through active participation from vendors and DISCOMs, and drive RTS demand in Delhi. In effect, 117 interested consumers were registered in both the areas, totalling the capacity of approximately 145 kW.

Simplification and streamlining of administrative procedures

Simplification of administrative procedures and reducing the number of factors necessary to analyse investment-making decisions are required to encourage RTS investment by small consumers. The number of interactions from consumers, paperwork and duration of the entire process of RTS implementation should be reduced to a minimum.

Standardisation and simplification of procedures would also decrease the administrative burden on DISCOMs. Solutions might include simplified forms, fast-tracked applications, rapid approvals for less complex systems and outsourcing the RTS administrative process to a qualified third party. More focus on administrative efficiency could reduce costs of the application process and requisite timescale, leading to a decrease in delays in processing. DISCOMs should be encouraged to introduce more efficient procedures through technical assistance from public agencies, incentives for achieving faster RTS capacity growth and imposing penalties for non-compliance with the set maximum duration of the entire RTS connection process.

The MNRE has already issued a standard operating procedure with tentative timelines for installation of RTS projects by DISCOMs. The MNRE also provides help to DISCOMs in developing online portals specific to RTS under various technical assistance programmes, which is a positive example of actions aimed at streamlining RTS administrative procedures.

Supporting knowledge sharing between developers and workforce training

Public agencies should support workforce training to stimulate competition and quality of RTS supply. Individual companies often find it difficult to invest in training, which leaves them with a limited number of qualified workers, thereby hindering their development potential. The organisation of public training

programmes could significantly help the developers and allow faster sector growth. For instance, the MNRE is implementing the Surya-Mitra education programme, which has so far allowed more than 47 000 workers to receive technical training on RTS installation.

Public agencies should also engage in sharing of knowledge among installers, and support an increase of service standards. Because of the disaggregated nature of the RTS market, many small companies may lack access to best industrial practices, which limits the quality of their service. Organising public-sector-funded trainings and workshops in co-operation with the private sector would lead to more compliance with technical standards and further improve workforce skills, resulting in more confidence among consumers in the long term.

Strengthening quality control and allowing higher-quality equipment in subsidy schemes

Subsidy rules should not force installers and consumers to use the cheapest equipment, which is often in compliance with the lowest allowed technical standard. From consumers' perspective, the ability to choose from a wide range of products, make informed decisions on installing higher-quality RTS systems and receiving subsidies would significantly increase their confidence, especially among wealthy consumers. The expected operational life of a solar PV system is approximately 20 years, while the standard warranty is only 5 years. Therefore, consumers should be able to analyse the risks and decide if they want to install a more reliable system, even if it is more expensive.

Creating information centres about the local RTS market

Consumers should be aware of the specific details regarding the RTS market in their local area to be able to make confident and informed decisions on investments. Public agencies, in co-operation with DISCOMs, should engage in creating comprehensive online databases and information centres. It would provide easily accessible information on certified and empanelled vendors and installers; offered RTS products; hosting capacity of local distribution grids; number of RTS projects in the local area; details of available remuneration schemes, subsidies or other incentives; and guidelines regarding the administrative processes. Easy access to relevant data and information would increase awareness among consumers, vendors, installers and developers. It would increase the confidence of consumers and facilitate the expansion of RTS business in the most suitable areas. Widespread knowledge on the benefits of

RTS and available options could also increase the public pressure on DISCOMs to facilitate new connections.

Indian example: Gujarat demand aggregation model

To accelerate rooftop adoption, Gujarat carried out a statewide demand for an aggregation programme under the Saurya Gujarat Scheme. The state allocated funds of INR 9 120 million towards residential subsidies designed on the lines of the MNRE Phase II subsidy scheme. Consumers could avail themselves of the state subsidy or the MNRE subsidy. The state used various marketing channels such as newspaper advertisements, a dedicated hotline number and multiple online portals to register interest to engage with consumers. The state empanelled more than 450 vendors to carry out the implementation work. The programme witnessed an overwhelming response, and more than 118 000 applications were received on the government portal.

Including RTS in building codes, city planning and rooftop ownership regulations

Building codes should be adjusted to incorporate rooftop design standards necessary for PV installation. Currently, it is mostly impossible to utilise rooftops because the buildings were designed without foreseeing such installations. For example, the rooftops have either insufficient structural strength or unsuitable shape, or are already utilised for air conditioning or recreation. Future standards should ensure that new buildings are suitable for RTS installations, even if investments are to be made after building construction. Policy makers and regulators should also create a legal framework allowing residents of multi-apartment buildings or local communities to invest in RTS on their shared rooftop space.

The MNRE has already asked various state governments to issue the necessary notifications for the installation of RTS projects in buildings above certain floor area or connected electrical load, which is a good example of promoting RTS through construction regulations. Some states such as Haryana, Chandigarh, Chhattisgarh and Uttar Pradesh have issued such mandatory notifications, while others such as Delhi and Jharkhand have also included mandatory installation of RTS for eligible buildings in their RTS policies.

City planning procedures should also be adjusted to allow maximum utilisation of RTS on rooftops of new buildings, with analysis including not only rooftop construction but also shading from other buildings and natural obstacles. Plans should also include building-integrated photovoltaics, which are a rapidly developing technology and have an enormous potential for deployment in the near future. Ideally, city planning standards should comprehensively include infrastructure for various DERs, including RTS, EVs and energy storage to maximise the synergies and benefits of integrating these technologies.

An example of promoting RTS through comprehensive city planning is a recent request from the MNRE for each state to choose one important city or a renowned tourist destination and turn it into a “Solar City”. In such Solar Cities, all applicable houses should be equipped with RTS, and all electricity needs are to be fulfilled through solar or other renewable energy sources. Additionally, renewables should be the main source of energy for transportation, with a majority of vehicles being electric and powered by charging stations with 100% renewable energy supply.

International example: Solar mandate in California (United States)

In 2020, the new law came into force in California, demanding all newly constructed residential buildings to be equipped with a PV system. The system capacity should be large enough to provide the complete annual electricity demand estimated for individual buildings. The regulation allows decreasing the mandatory RTS system size if battery storage and energy efficiency measures are used. Consumers can participate in a net metering scheme, allowing them to achieve significant savings on electricity bills, offsetting higher building construction costs.

Question 6: How can a holistic policy approach for all DERs be adopted to maximise the value of rooftop PV, in combination with EVs and storage?

Context and challenges

DERs such as rooftop PV, battery storage and EVs are forecast to significantly grow in India in the coming decades. These resources not only provide direct benefits to individual consumers but also have the potential to provide system flexibility services at the local level and to the overall power system when aggregated.

RTS, especially if combined with battery storage, can contribute to balancing demand, decongesting the distribution network, complying with RPO, and reducing transmission and distribution losses. They can offer fast and accurate responses to system operators, and modularity enables a wide range of installation sizes and potential locations for deployment. Such systems can be deployed in grid areas where flexibility is the most required, enabling instant reaction and increasing system redundancy, and leading to savings in electricity grid development. PV and battery costs are declining fast. Therefore, increasing the attractiveness of distributed systems can potentially make them the cheapest flexible energy resources.

EVs still show a negligible share in the Indian mobility market, but the Indian government has a target of 15% of vehicle sales to be electric by 2022. A beneficial incentive programme has been introduced, called Faster Adoption and Manufacturing of Hybrid and Electric Vehicles, which provides subsidies to cities across India worth around 20-30% of the cost of the purchase of EVs. India also has a support programme for local EV manufacturers. Several states such as Karnataka, Telangana, Delhi, Andhra Pradesh and Maharashtra have followed national policy and set state-level targets for the deployment of EVs, including electric buses.

EVs can also act as an energy resource, the same as a grid-connected battery. Benefits of this resource to the power system depend on the type of charging method and the time at which they are charged or discharged. Encouraging favourable consumer behaviour is a key to realise that potential.

The following requirements need to be fulfilled to realise the full potential of DERs:

Adoption of new approaches towards retail tariff design, power system operation, the wholesale electricity market and energy policy – In the future, power systems with millions of RTS systems, grid-connected batteries and EVs, and the current paradigm of centralised electricity system with one-directional power flow from large generators to consumers, will no longer be valid. Regulations and market design need to be adjusted to enable this transition, encourage effective resource utilisation and ensure security of electricity supply. Enabling successful integration of distributed resources will allow building the cheaper, cleaner more effective and more secure power system of the future.

Solutions: Introducing tariffs expressing the real costs of electricity supply in a specific time and place; opening the power market for demand-side management (DSM); enabling distributed resources to provide ancillary services to the power system; modernising transmission and distribution grids design and operation; opening power markets to consumers *(details of each solution highlighted under the challenge are presented in the subsequent section)*.

Solutions

Introducing tariffs expressing the real costs of electricity supply in a specific time and place

Designing retail tariffs plays a major role in stimulating the favourable behaviour of electricity consumers and owners of distributed power systems. Clear price signals are necessary to encourage users, e.g. to decrease consumption and inject electricity from their battery during peak hours of electricity demand and charge EVs during low system load at night.

Connecting retail prices to real costs of electricity supply stimulates efficient use of distributed system resources. In simpler cases, such a solution can take the form of time-of-day tariffs, with a single higher electricity price during all peak hours and a lower price during off-peak hours. For example, the tariff system in France allows cheaper electricity consumption at night, encouraging heating of electric

boilers when system demand is low. Time-of-day tariffs are also used in India's industrial sector, and are even mandatory in certain states for energy-intensive industry. However, introducing them to a wider range of consumers, especially owners of DERs, would be necessary to utilise the full potential of DERs.

In advanced cases, tariffs can be fully dynamic, with pricing depending on the actual system situation. In order to further increase the efficiency of the pricing system, tariffs can stimulate the optimal spatial allocation of resources and demand centres. In nodal power systems used in United States power markets such as PJM Interconnection and Electric Reliability Council of Texas (ERCOT), the price of electricity and remuneration for generation depends not only on interim generation costs but also on the place of energy injection to the grid. In such arrangements, tariffs express the exact costs stemming from transmission losses and grid congestion. Such systems assign a premium to increase the generation of resources located close to the most demanding areas, and provide an additional boost to the distributed systems. The VGRS framework from CEEW is a step in this direction, and can be utilised to set dynamic electricity prices.

International example: Value-based PV remuneration model in New York (United States)

New York State is in the process of switching from a traditional net metering scheme to a value-based system. New York's focus is to connect the revenue of RTS with the actual value that it brings to the system, considering savings in energy production, capacity investment, environmental benefits, grid development and maintenance and their variability in time and space. After extensive consultations with all stakeholders, a new and more complex system was created, aiming to promote the development of distributed installations, including PV, storage and demand-side response, in the manner that is most beneficial to the entire power system. The new system provides incentives for efficient power generation and consumption, while also ensuring simple rules for residential and small commercial consumers.

Opening the power market for DSM

DSM solutions are based on the flexibility of power demand enabled by remote control, storage capabilities and price signals. Controlled and rewarded decreases in electricity demand can be treated at par with the increase in power generation, and are often a cheaper solution than utilisation of expensive peak generators.

Aggregated RTS systems, coupled with batteries and EVs, have technical capabilities to act as an enormous DSM resource, thereby significantly increasing the flexibility of the power system, shifting the demand to off-peak hours, and decreasing system-wide costs of power supply. CEEW analysis on urban microgrids (integrated RTS, storage and grid system) suggests that optimum use of solar and battery in DSM can provide an additional benefit of INR 1.08 per unit of solar electricity. To utilise this potential, regulation should enable DSM resources to participate in power markets and compete with generators.

Enabling distributed resources to provide ancillary services to power system

Battery storage coupled with RTS systems have the technical capability to offer multiple sources of value for the power system. This includes providing energy, ancillary services, and addressing congestion at the distribution and transmission levels. Distributed systems can contribute to meeting reserve requirements and help to manage frequency variations.

To utilise these benefits, regulations and system operation framework need to allow distributed resources to participate in the ancillary services market. In some power systems, such as the PJM Interconnection in the United States, specialised companies can aggregate the distributed resources into virtual power plants, and services to the power system operator through remote control of small devices. Such services can be cheaper than the services offered from conventional power plants, enabling the reduction of system costs of power supply and providing the owners of distributed resources with an additional stream of revenue.

Modernising transmission and distribution grids design and operation

To prepare power systems for the revolution of DERs and ensure secure system operation, it is essential to expand and accelerate the modernisation of the existing grids. System operators need to prepare transmission and distribution systems as well as their control centres for massive deployment of new smart resources. Operators will need to install millions of smart meters, digitalise operations, and vastly expand analytical and modelling capabilities. This modernisation process will take many years, but grid owners and policy makers should be prepared for it.

Opening power markets to consumers

Owners of PV systems, and battery storage or EVs, in principle can act as independent, dispatchable generators. One of the solutions to achieve high efficiency of utilisation of such resources is to allow them to participate in electricity markets, following demand and supply rules. This way, generators would have incentive to generate electricity when it is required the most, just like today's conventional power plants.

This solution is being explored in many power markets, especially in Europe and the United States. These regions are creating self-sustainable mini-grids and allowing local trading of electricity. Through this, the members of local communities are allowed to directly sell electricity to their neighbours and utilise surplus generation for local consumption. Such a solution could lead to significant savings in maintenance and development of the distribution system and increased supply security.

International example: Liberalised RTS market in Australia

Australia has one of the highest RTS penetrations in the world, with over 25% of households having PV installations, and with up to 40% in the states of South Australia and Queensland. In the beginning of the Australian RTS market, RTS owners were guaranteed generous feed-in tariffs and the surplus generation was simply injected to the grid. Currently, electricity retailers purchase surplus electricity from RTS systems based on open market conditions. Each RTS owner can choose from multiple electricity purchase offers and optimise electricity sales, in some cases with utilisation of battery storage and demand control.

Conclusions

Achieving significant acceleration of RTS deployment in India will require finding the answers to six key policy and regulatory questions that were identified during the workshop titled “Unlocking the economic potential of rooftop solar in India” and through additional analysis by the IEA and CEEW.

Fortunately, a wide range of possible answers could be derived from good international and Indian examples, consultations with various Indian RTS stakeholders, and analytical works by the IEA and CEEW. Considering the short time left for India to achieve its 2022 renewable targets, the majority of proposed solutions do not require structural changes in the central or state regulatory frameworks and could result in faster RTS growth in the next one to two years.

To achieve this, the actions taken by policy makers and RTS market participants in the short to medium term should focus on **enhancing economic incentives for DISCOMs to support RTS deployment**. Reluctance of DISCOMs in supporting RTS development is often the main reason for the slow uptake of RTS, especially in residential and commercial segments. Encouraging innovative DISCOM-led RTS business models, expanding DISCOMs’ RTS benefits assessment capabilities, improving central incentives to DISCOMs and optimising RTS remuneration schemes should allow DISCOMs to gain and ensure support from RTS adoption.

At the same time, to **improve access to financing for consumers interested in RTS investment**, relevant institutions should encourage RTS demand aggregation; standardise and simplify RTS loan application processes in public, private and multilateral banks; and increase their involvement in providing affordable loans and guarantees. Easy access to affordable financing should greatly increase the ability of residential and commercial consumers to invest in RTS.

Moreover, the current rules of **RTS remuneration schemes should be carefully reconsidered to provide more balance in sharing of RTS costs and benefits** among all power system users and DISCOMs. Optimising remuneration rules to ensure RTS attractiveness to consumers, while providing fair remuneration for DISCOMs and minimising RTS impact on grid stability, are not easy tasks. It should be undertaken very carefully, with consideration of the interests of all stakeholders. However, solutions such as net billing could provide the requisite flexibility to achieve a much-needed balance among various stakeholders.

In parallel, more effort is required in **streamlining the RTS investment process and disbursement of subsidies**, as well as **promoting RTS among residential and SME consumers**. From a consumer's perspective, investing in RTS should be as simple as possible, with a minimal number of required actions and short processes. Furthermore, well-informed consumers should be much more eager to invest in RTS. Vendors or installers with high market visibility should be able to expand their businesses more confidently in a cost-effective manner.

Introducing proposed solutions should allow India to build a thriving RTS market and considerably accelerate its capacity growth in the medium term. However, **policy makers should already plan the next phase of the power system driven by the rise of DERs** in the long term. The popularisation of RTS, distributed energy storage and EVs will cause drastic changes in the operation of power systems. The preparation of policy and regulatory framework for such a shift will allow reaping the full benefits of RTS and promote the building of the sustainable, efficient, reliable and secure Indian power system of the future.

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Questions or comments?

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