COALITION FOR URBAN TRANSITIONS
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Affordable and clean energy for all: Lessons on rooftop solar from Delhi, India

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Use of all suitable roofs in cities for solar power and heat will be important in meeting the Paris Climate Agreement goals. It will also be key to achieving the 2030 Sustainable Development Goal 7, target 1 - 'universal access to affordable, reliable and modern energy services'. Achieving this is now becoming a key challenge for national governments, particularly those with growing urban populations and energy demand.

This paper analyses lessons from India, where electricity consumption is set to triple by 2040. It finds that clear national leadership supporting municipal authorities to incorporate innovative business models that help low-income households to access renewable energy is critical. If new approaches used in New Delhi were adopted nationwide, they would deliver 8 gigawatts of additional solar capacity by 2022, reduce energy bills for 2.6 million households, create 100,000–150,000 jobs and reduce carbon dioxide emissions by 10 megatonnes a year—the equivalent of closing four coal-fired power stations.

This policy brief is one of a series on frontrunning climate actions in cities around the world. The objective of this series is to strengthen the evidence on the economic and social implications of low-carbon, climate-resilient urban development. The series focuses on providing robust data on actual or ex post outcomes of climate action, ranging from better public health to job creation to greater equity. Each case study explores some of the preconditions for the successful design and delivery of urban climate action and provides national policy recommendations that could enhance their effectiveness and benefits.

Photo credit: Visty Banaji

About this policy brief

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Highlights

- Universal access to affordable, reliable and modern energy services is the first target of the 2030 Sustainable Development Goal (SDG) 7; increasing the share of renewable energy is the second target. Access to modern energy can improve household health by reducing indoor air pollution and the incidence of burns and by increasing household incomes by enabling the use of appliances and work and study beyond nightfall. **A sufficient supply of affordable, low-carbon electricity is critical to ending poverty and supporting economic development in cities.**

- Global energy demand is set to expand by 30 per cent by 2040.[1] Renewable sources of energy now meet 40 per cent of new demand, thanks to the falling costs of clean energy technologies. **Since 2010 costs have fallen 70 per cent for new solar PV**, 40 per cent for batteries and 25 per cent for wind.[2]

- India is a global leader in improving electricity provision: **half a billion Indians have gained access since 2000, almost doubling the country's electrification rate.** However, coal has fuelled about 75 per cent of the new electricity access,[3] with substantial implications for air quality and greenhouse gas emissions.

- The Government of India has introduced the Jawaharlal Nehru National Solar Mission, which sets a target of 100 gigawatts (GW) capacity of solar power by 2022, including a target of 40GW through rooftop solar panels.[4] **Rates of solar take-up have been much higher in the commercial and industrial sectors than in the residential sector.** Inability to pay and lack of credit mean that most urban households are not able to participate in the solar transition. Distribution companies also stand to lose revenue through the transition.

- In New Delhi, **innovative policies and business models are helping make the economics of small-scale rooftop solar more attractive.** The Government of the New Delhi Capital Region has established generation-based incentives for solar power that pay owners of solar panels Rs. 2 (about US$0.03) for every kilowatt hour of electricity they export to the grid. This tariff is complemented with group and virtual metering policies that create more options to mobilise third-party investment. New Delhi also offers capital subsidies for solar panels and has mandated that government buildings need to source their renewable energy from the region.

- **Distribution companies in New Delhi are now experimenting with multiple new business models to reach low-income households,** including utility-led community solar, on-bill financing and partnerships with third-party investors.[5] One project, a single-point delivery system for 200 low-income households, adds 9.7 megawatts (MW) of generation capacity, saves households Rs. 4,500 (US$66) a year in energy bills, offsets 12 metric tons of carbon dioxide (tCO_2-e) emissions equivalent annually and created 240 jobs.

- If these approaches enabled rates of residential rooftop solar installation to match those in the commercial and industrial sector, **8GW of additional capacity could be installed across India by 2022.** The increase would reduce energy bills for 2.6 million households, create 100,000—150,000 jobs and reduce carbon dioxide emissions by 10 megatonnes (Mt)—the equivalent of closing four coal-fired power stations. Supporting decentralised renewable technologies to scale could therefore make a major contribution to healthier, inclusive and sustainable development in India's fast-growing cities.

Generating electricity that is clean and affordable

THE GLOBAL CHALLENGE

The transition away from fossil fuels towards renewable energy is critical to preventing dangerous climate change, particularly as demand for energy, specifically electricity, in developing countries is growing rapidly. Without significant increases in energy efficiency, global energy demand in 2040 will be almost twice what it was in 2000.[6] Although the share of renewables in the global energy mix is increasing, emission reductions in high-income economies are largely offset by rising emissions from low- and middle-income and developing countries. If implemented effectively, clean energy alternatives to fossil fuels can simultaneously avoid these emission increases and provide development benefits for poorer countries and their citizens. However, although the cost of solar photovoltaic (PV) technology has plummeted, large swathes of the global population are unable to afford the up-front costs of installation.[7]

Renewable energy, particularly small-scale solar PV systems, can increase access to electricity, lower energy bills, reduce air pollution, and improve health and livelihoods.[8] It can provide better lighting for working or studying in the evenings, allow small businesses to operate for longer hours or from home and reduce the time and physical effort required for domestic work.

Greater uptake of renewables can also have wide benefits for the national and local economy. The installation of rooftop solar panels is labour-intensive, generating many good-quality jobs.[9] A shift away from fossil fuel power can improve air quality and reduce economic exposure to volatile fossil fuel markets. New value chains can build local knowledge and skills, fostering innovation and supporting industrial and commercial competitiveness. Commercial, industrial and public sector organisations, as well as residential communities, can become "prosumers"—producing and consuming much of their own energy rather than relying wholly on grid electricity, thereby reducing their operating costs and allowing them to mobilise new sources of energy investment.[10]

Energy companies can also benefit from new revenue streams, unlocking new investment in generation capacity and drawing on a range of smaller producers in a flexible way to match demand flows. The installation of new meters for connecting solar PV systems to the grid improves transparency, enhancing revenue collection and supporting load management. It may also open up new business models and tariff structures through smart-metering technologies.

Realising these benefits and achieving greater penetration of renewables in the energy mix will require improvements in efficiency. Upgrading grid networks to handle additional capacity from solar energy and manage two-way power flows (through new meters and software) would enable the power sector to better cope with rising demand for electricity.

City- and state-level governments stand to benefit from flexible and locally generated sources of energy and lower costs of electricity to public institutions that install solar PV systems. Clean and affordable energy is also a precondition for wider human and economic development. It can therefore help governments achieve myriad political and policy objectives, such as shifting away from reliance on fossil fuels and government subsidies in the power sector. The growth of renewables in particular should prove attractive to decision-makers in light of the sector's capacity to generate jobs, foster local supply chains and attract commercial finance. These benefits are particularly important in developing cities where unemployment is high, the electricity supply is unreliable or expensive and there is a limited pipeline of bankable projects to unlock investment.[11]

THE CHALLENGE IN INDIA

By 2040 electricity consumption in India is set to triple from today's rates. Coal's share of the energy mix is expected to fall from 75 per cent to 55 per cent, but higher demand will increase greenhouse gas emissions.[12]

India has set ambitious renewable energy targets. Key barriers—such as integration with the grid and infrastructure challenges—need to be overcome for certain technologies (such as rooftop solar) to become economically viable.[13] If new policies are not implemented and the power sector continues to grow to meet the 2040 level of demand, premature deaths from air pollution are projected to reach almost 2 million cases a year.[14]

At least 24 per cent of India's urban population live in informal settlements, where incomes are typically lower and air pollution greater than average.[15] Many people living in formal housing also have incomes that are too low or volatile to access the infrastructure, technology or finance needed to invest in small-scale renewable energy. Nine out of 10 urban residents in India earn less than US$10 a day.[16] Much of the urban population is therefore effectively excluded from the solar transition. Preventing dangerous climate change and realising the multiple development benefits of expanding rooftop solar will depend on finding ways for these households to join the solar revolution.

The policy context: Rooftop solar targets and subsidies in India

In a business as usual scenario, electricity consumption in India is projected to increase by almost 3,000 terawatt hours (TWh) in the decade between 2012 and 2022, with a significant portion of the increase coming from buildings.[17] In order to address the current, and potentially increasing, national energy deficit, the Government of India is aiming to bring 100GW of solar energy online by 2022, 40GW of which should come from rooftop solar panels. More than half of this rooftop potential is in the residential sector.[18]

Rooftop solar is well-suited to cities, where high premiums on undeveloped land make it difficult to justify building large ground-mounted solar farms.[19] Residential rooftops are more numerous than larger commercial options, but they are often used for other purposes, such as drying clothes and growing food and as additional social space. Larger commercial, industrial and public buildings may have vacant rooftops and could install solar PV systems without significant opportunity costs.

Installing solar panels on so many distributed and diverse spaces is challenging, but evidence suggests that technical factors do not constrain deployment.[20] Surveys of stakeholders reveal concerns over economic, social and political issues, such as problems with siting panels without obstruction, access to finance, and transaction costs associated with long supply chains and complicated investment models.[21] The persistence of subsidies for fossil fuels, lack of consumer awareness about emerging renewable energy technologies and the need for training and skills throughout the supply chain also hold down demand.[22]

The energy policy context at the national, state and municipal levels in India has become increasingly complex, reflecting the country's federal structure and political history.[23] Political priorities, preferred policy instruments and governance arrangements differ widely across states. States and utilities vary in their willingness and capacity to extend infrastructure into informal settlements, for example, which affects whether households that invest in solar PV will have the option of connecting to the grid.[24] There are also technical and geographical variations associated with energy infrastructure and rural-urban demographics, such as local grids' ability to accommodate additional capacity from new solar installations. Given these differences, national and state policies need to be flexible, sensitive and clearly grounded in a commitment to expanding access to clean, affordable energy to maximise the potential benefits of a solar energy transition.

THE NATIONAL CONTEXT

India's federal structure produces complex multilevel governance arrangements in the power sector. The central government is responsible for setting energy targets, strategies and policy frameworks, but states and territories determine how to implement these broad agendas in their own jurisdictions. Decentralisation notwithstanding, the national political economy of energy remains important.

Subsidies for the power sector decreased from US$35.8 billion in 2014 to US$20.4 billion in 2016, but about 90 per cent of them still go to fossil fuels.[25] The central government also owns the national power grid infrastructure, sets the price of tariffs for some electricity companies and manages interstate issues such as power trading.

The central government has two flagship programmes to expand solar photovoltaics: the Jawaharlal Nehru National Solar Mission and the Sustainable Rooftop Implementation for Solar Transfiguration of India (SRISTI), which is still under consultation. The Jawaharlal Nehru National Solar Mission sets a target of 100GW capacity of solar power by 2022, including 40GW through rooftop solar panels.[26]

As of March 2018, the uptake of large-scale ground-mounted solar farms in rural or peri-urban areas (23.7GW) was 10 times the uptake of urban rooftops (2.4GW).[27] Projections for rooftop solar suggest that the commercial and industrial sectors will vastly outpace the residential and public sectors, largely because of more favourable economies of scale. Achieving national targets and realising the multiple wider benefits of decentralised energy will depend on a significant increase in the deployment of decentralised solar in urban residential areas.

Numerous existing policies incentivise uptake, including a 30 per cent subsidy on the capital costs of installing solar on residential and public buildings (provided by the Ministry for New and Renewable Energy) and various tax exemptions (provided by the Ministry of Finance). Even with these incentives, however, investing in solar power remains unviable for the large parts of the population that have low incomes and no access to capital.

The SRISTI scheme was proposed by the Ministry for New and Renewable Energy in 2017. It designates distribution companies as responsible for the rollout of grid-connected rooftop solar and pays them for the new rooftop solar-to-grid connections they facilitate.[28] Although this incentive may increase the number of systems installed, it does not guarantee good maintenance and effective operations thereafter. Other responsibilities for distribution companies and other governance actors concerning monitoring and evaluation have been proposed. The final details of the SRISTI scheme are being worked out—subject to lobbying by many interested parties.

THE STATE AND CITY CONTEXT

Regulatory bodies in India's states and territories set electricity price tariffs and manage the licenses of distribution companies, which generally take the form of state-run electricity boards or privately owned enterprises. Distribution companies are subject to an inconsistent mix of regulations and policies from central and state governments, which are often politicised.

A pertinent example is the way electricity tariffs for low-income households are cross-subsidised through higher tariffs on commercial, industrial and high-consuming households. This system, which is politically contentious to reform,[29] has locked distribution companies into a vicious cycle in which consumers subject to higher tariffs tend to switch to solar as a cheaper alternative, reducing the number of consumers available to bear the costs of cross-subsidisation and pushing the price of grid electricity up further.

Within the context of the national Solar Mission targets, states have substantial autonomy over how they finance and develop their own projects. They often use generation-based incentives, remunerating solar panel owners for energy they supply to the central grid. Capital subsidies and tax exemptions are vital for improving the economic viability of rooftop solar energy, particularly among the urban poor, who usually lack the capital needed for upfront investment. Most states in India provide a mixture of these incentives. Some states also use mandates, requiring that distribution companies source a certain percentage of their supply from renewable sources and that certain public buildings and new developments install rooftop solar PV systems.

Despite these incentives, uptake remains low. Several persistent barriers are to blame for the limited deployment of rooftop solar by Indian households. They include lack of awareness, public misperceptions about the risk and costs of solar power, ineffective implementation of financial incentives and long payback periods.[30] Some of these constraints

can be partly attributed to the fact that local distribution companies stand to lose revenue when their customers switch to solar and yet are expected to facilitate its roll-out. Enabling national policy frameworks and scalable business models are needed to help bridge these competing interests.

Methodology

Fifteen stakeholders in the rooftop solar sector were interviewed regarding how deployment could be scaled up and co-benefits realised. They included a sustainability expert and representatives of the private sector (including firms of various sizes); the national, state, and city governments; civil society organizations and NGOs; and a national trade association. A detailed policy analysis was undertaken to map the multilevel governance context and identify key stakeholders involved in implementing the Delhi Solar Policy of 2016.

The case study: Flexible policies and business models in New Delhi

New Delhi, a city of about 18 million people in 2016, has the fastest-growing population in India and one of the of the highest population densities in the world, estimated at 11,297 people per square kilometre. The region in which it is located (the National Capital Region) is 97.5 per cent urbanised.

The city's average per capita income is nearly three times the national average, but 10 per cent of the population still lives in poverty[31] (according to the official definition, which is likely an underestimate).[32]

Residential electricity tariffs are heavily subsidised in Delhi. More than 80 per cent of the population receives a 50 per cent subsidy on its bills.[33] Perhaps unsurprisingly, electricity consumption in the capital has grown by 42 per cent over the last decade, with average household consumption now matching that of Germany (three times the average for the rest of India).[34]

Delhi's air pollution problem is notorious, with almost 15,000 premature deaths in 2016 linked to illnesses caused by inhaling particulate matter.[35] This problem disproportionately affects the poorest, who live near polluted sites, such as industrial zones and highways, and spend more time walking, cycling or working outside.[36]

Switching local industry and the power sector away from coal and solid fuels towards renewables is a top priority for the municipal government. Meeting the city's growing electricity demand with power generated from cleaner sources would reduce air pollution. With 300 days of sunshine a year on average and 31 square kilometres of rooftop space, Delhi potentially has 2.5GW of rooftop solar, 49 per cent of it located in the residential sector[37] (although air pollution and fog can mean that the actual levels of solar radiation can be much lower).

DELHI SOLAR POLICY 2016

In 2016 Delhi set annual targets towards a goal of adding 2GW of solar capacity by 2022.[38] Several policies support progress towards these targets. Some, such as capital subsidies, are aimed at incentivising middle- to higher-income households to install solar panels on their roofs. Others—such as mandates that require that government buildings and state-owned distribution companies source their renewable energy from within the region—are intended to benefit public institutions and the local economy.

Cutting across all of them, and helping improve the economic case for third-party investors, is the generation-based incentive and flexible metering arrangements of the 2016 Delhi Solar Policy.[39] This policy introduced an incentive of Rs. 2 (about US$0.03) per kilowatt hour (kWh) of solar energy exported to the grid for residential households, helping reduce their overall electricity bill through two-way metering.

Generation-based incentives are paid either through gross or net metering, both of which set an upper limit on the amount paid out. In gross metering, all the energy generated is fed into the grid; in net metering, some proportion of the energy generated is consumed by the owner before the excess is injected into the grid. There are pros and cons to each; the way the metering process itself is managed is arguably more important.

The introduction of group and virtual net metering in Delhi enables a level of flexibility that helps overcome barriers to deployment. Group metering allows the owners of more than one rooftop, such as a local government that runs a school and a hospital, to install solar panels on the sunnier and larger of them but to share the economic benefits between the institutions (i.e., through deductions on their electricity bills). Virtual metering allows owners of rooftops to share in the economic benefits of solar PV systems paid for by third-party investors, through direct consumption of the energy produced or reductions on their bills. In this case, the investors receive interest payments and can also receive deductions on their electricity bills, if the connection is manged by the same distribution company. This option is particularly well-suited to low-income urban communities or peri-urban land owners who lack the capital to invest in solar panels but would benefit most from lower electricity prices.

EXPLORING NEW BUSINESS MODELS FOR DISTRIBUTION COMPANIES

An enabling policy environment, such as the one in Delhi, provides opportunities for distribution companies to mitigate some of the potential revenue losses they have been experiencing and to play a more proactive role in the solar transition. The Solar Rooftop Policy Coalition—a coalition of energy experts, think tanks and green investment consultants—argues that group and virtual metering are building blocks for developing new business models and attracting more investment to the sector.[40]

Two of the three distribution companies in New Delhi –BSES Yamuna and BSES Radjhani– are run as joint ventures between Reliance Infrastructure PLC and the Government of Delhi. BSES Yamuna operates in the east of the city, where it serves largely low-consumption residential customers (85 per cent of its residential customers consume less than 400kWh/month, which means that they pay one of the lowest (and least profitable) tariffs. For this distribution company, and others with similar customer profiles, three viable models would strengthen their position in the sector and help make rooftop solar accessible to their low-income customers:[41]

- **Utility-led community solar**. Solar panels are installed on the rooftops of multioccupancy buildings or large buildings in the public and private sectors. The community or third-party investors may pay the upfront costs. Power and/or generation-based incentives are shared among the community, based on their initial contributions and energy consumption. This model helps households overcome their lack of access to upfront capital or a rooftop space or their aversion to risk.
- **On-bill financing**. Solar panels are installed on the rooftops of an individual household. Third-party investors pay the upfront cost. Power- and/or generation-based incentives go to households, which repay the capital cost through their monthly energy bills (the utility recovers the energy savings until it recoups its investment). This model helps individual households overcome their lack of access to upfront capital.
- **Solar partner**. Solar panels are installed on multiple rooftops, after distribution companies aggregate and tender the space to third-party investors. Third-party investors pay the upfront cost, which they recover from the sale of energy to residential customers at a custom tariff. The distribution company captures the generation-based incentives

Underlying each model is the use of flexible metering arrangements and the recognition that distribution companies are uniquely placed to support the solar transition. The two models that rely on third-party financing put the distribution companies in an intermediary role, allowing them to manage the risk aversion of financiers and lack of capital of low-income households by offering quality assurances and redress procedures for customers and investors. This mechanism has huge potential to expand the deployment of decentralised renewables in lower-income urban areas.

AGGREGATING CAPACITY THROUGH SINGLE-POINT DELIVERY SYSTEMS

BSES Radjhani is the largest distribution company in New Delhi, with 2.3 million customers. It operates in the south and west of the city. As of March 2018, it had 22MW of metered solar connections in operation. As in the rest of India, the residential sector represented the smallest proportion of its customers (15 per cent).

In an effort to boost residential uptake, BSES Radjhani has embarked on a plan to aggregate solar capacity among its customers to attract investment. In 2018 it demonstrated the viability of the utility-led community solar model by installing single-point delivery systems to groups of community-owned buildings. This system allows solar PV systems to be installed on multiple rooftops and then connected to the grid through a single metering point. Because power flows in both directions are aggregated, consumption costs and production benefits can be shared among all of the households living in each building. In several instances, such as the Shiv Bhole housing society, third-party investors and the distribution company funded these installations; the lower monthly electricity costs were immediately available to the community.

The involvement of distribution companies and community-level intermediaries provided assurances to both customers and investors. For households, the involvement of these intermediaries helped ease the complicated application processes and contracting of solar panel vendors. For investors, the housing society was able to provide a bank guarantee equivalent to three to six months of solar generation, helping it overcome its lack of creditworthiness. Once the installation costs are paid off in full, ownership will be transferred to the households. The solar panels will provide a valuable asset, reducing household energy bills and generating income by exporting power to the grid. This single-point delivery system is being rolled out to 200 customers in just one area of New Delhi, equivalent to 9.7MW of rooftop solar capacity, avoiding 12tCO_2-e a year and creating 240 jobs (see Box 1).

Box 1

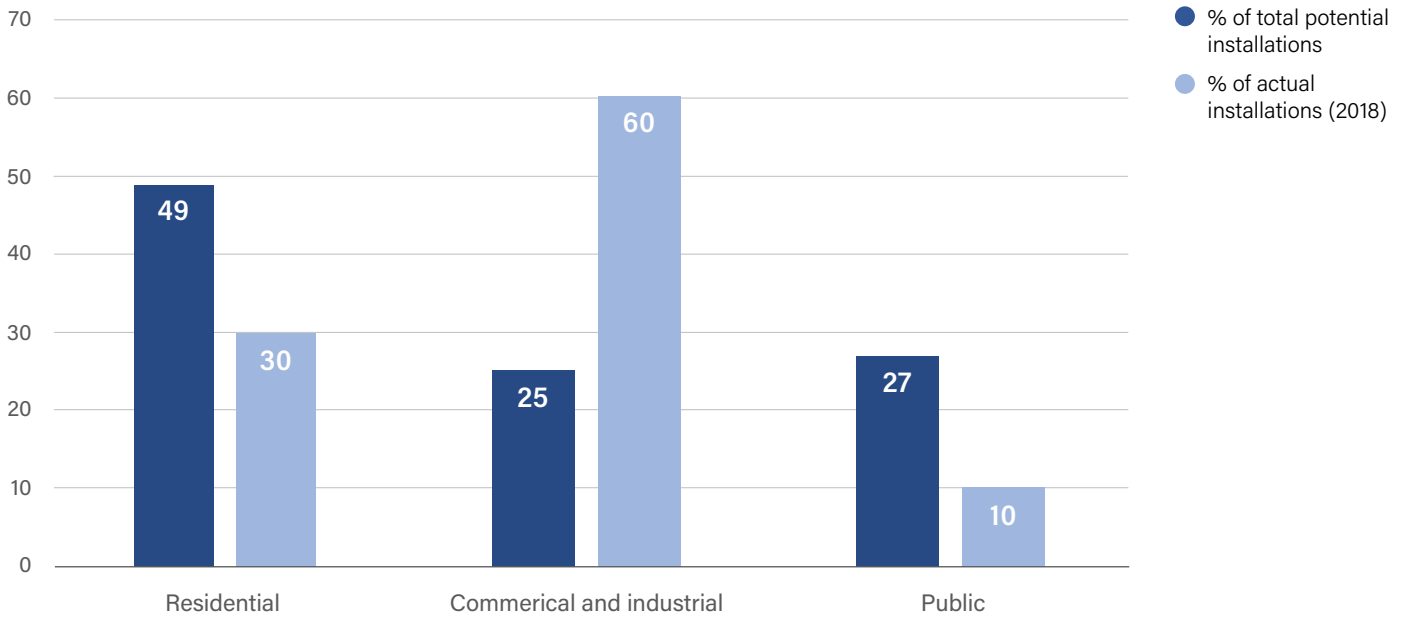
BSES Radjhani's Solar City Initiative at a glance

- Number of community groups involved: 200
- Annual rooftop solar potential: 9.7MW
- Annual CO_2 offset: 12 tCO2-e
- Number of jobs created: 240
- Tariff reduction: From Rs. 5 (US$0.069) to Rs. 2.66 (US$0.037) per KWh
- Annual savings: Rs. 4,500 (US$66) for each of 60 households
- Other benefits: Eliminates upfront costs for households by attracting third-party investment

Scaling up the benefits

Although half of the potential rooftop space in New Delhi is residential, only a third of installations are taking place in this sector (see Figure 1). Installations in the public sector are also very low, but there are many opportunities for accelerating deployment there—through mandates and group metering between buildings that have the same local authority owner, for example.

Figure 1
Potential and actual rooftop solar installations in New Delhi, by sector, 2018



Source: Data from Bridge to India. 2017. India Solar Rooftop Map.

The combination of subsidies, group metering policies and single-point metering systems available in the Delhi Capital Region means that distribution companies have a clear economic case for taking an active, even leading, role in the solar transition. If distribution companies can leverage their position as trusted intermediaries between residential consumers and various public and private sector investors and developers, the economic potential of rooftop solar becomes much more substantial: Large portions of the 2GW potential of rooftop solar capacity in Delhi can be aggregated to achieve new economies of scale and attract investment.

If flexible policy arrangements, improved financing and new business are able to make residential rooftop solar energy as viable as its commercial and industrial counterparts, other cities could replicate these successes, driving country-wide uptake. Based on a relatively conservative estimate of an additional 8GW of rooftop solar capacity by 2022, this uptake would reduce electricity costs for more than 2.6 million households and reduce annual carbon dioxide emissions by 10MtCO_2-e—the equivalent of closing four coal-fired power plants. Rooftop solar would also create jobs, as it is considerably more labour intensive than other forms of renewable energy. With average job creation of about 24 job-years per MW in India, this uptake would create almost 150,000 new jobs.[42]

At this scale, the wider benefits of increasing the percentage of solar in the national energy mix would begin to materialise. Reduction in air pollution associated with proximate coal-fired plants and heavy industry would drastically improve the quality of life for urban dwellers— something the government is keen to achieve, given the significant costs to life and the economy. More broadly, solar uptake by lower-income groups could help drive economic development. Without carefully designed progressive policy frameworks, solar uptake will remain concentrated in upper- and middle-income demographics, exacerbating India's already stark levels of inequality.[43]

Policy recommendations

Six main policy recommendations emerge from this case study.

1. **Provide accessible and reliable information about the solar sector to households, communities and investors**

   The national government can stimulate demand for solar panels by raising awareness about solar power, including awareness of potential financial returns; available incentives; and wider economic, social and environmental benefits. Awareness raising should involve a combination of general public education and specific information targeted to distribution companies, commercial banks, housing societies and other key stakeholders. Application and installation procedures should be simplified, in order to encourage investment and reduce transaction costs. Measuring performance after installation would build confidence in the sector and inform capacity projections. Improving training, monitoring and accreditation in the sector would help stabilise the supply chain and ensure that sustainable jobs are created.

2. **Provide opportunities for skills training and job growth in the solar sector**

   Installing and maintaining solar PV systems can generate jobs and economic growth. Government support for apprenticeships, training schemes, accreditation and provision of a directory of qualified technicians would help build the skills needed to work in the solar industry and increase the number of jobs created locally. Distribution companies have an interest in supporting training efforts, as they will require more solar technicians.

3. **Require public sector institutions to install solar on their rooftops**

   Issuing nationwide mandates that require public sector buildings to install rooftop solar wherever certain conditions (such as cost-efficiency and rooftop size) are met would help grow local markets for solar power. Public institutions have an opportunity to benefit from virtual net metering and third-party investments.

4. **Upgrade the national grid to better accommodate new and intermittent solar capacity**

   Upgrading transformers to cope with additional capacity and removing restrictions on the load that solar arrays are allowed to add to the grid is vital for encouraging investment. Increasing the efficiency of power flows and improving the software used to manage these flows would raise the return on investment for distribution companies and solar array owners alike as energy is generated and transferred more effectively.

5. **Incentivise distribution companies, as well as end users and investors, through solar policies**

   At both the national and state level, India has put sophisticated, if imperfect, policies in place to drive the solar transition. They could be improved by monitoring to ensure that beneficiaries get the most out of their investments and that subsidising solar installations does not yield low value for money. There remains a policy gap in terms of supporting and engaging distribution companies. They can play a catalytic role by facilitating customer and supplier aggregation, providing financial guarantees and brokerage and offering a range of energy services associated with management of the solar-grid system. Implementing the new SRISTI scheme for incentivising distribution companies' participation in the solar sector as soon as possible is critical.

6. **Address inefficiencies in the implementation of capital subsidies, tax breaks and generation-based incentives**

   The transfer of financial support, such as the Central Financial Assistance and generation-based incentives, is too slow, discouraging households and the supply chain from getting involved and causing capital flow issues, especially for the poorest households. Improving the governance of these mechanisms would increase the confidence of investors and installers; building their pipeline would also encourage households to invest. Some tax exemptions for households adopting solar are delivered through income tax, making them inapplicable to most low-income households, which pay little or no taxes. Reforming this mechanism is critical to incentivising these households to invest in solar power.

Conclusions

Rooftop solar can help meet India's growing electricity demands. It can reduce fossil fuel use (and the air pollution and greenhouse gases associated with it) and provide economic benefits such as jobs and energy savings. The economic opportunities are particularly significant in urban areas, where there is scope for aggregation and connection to the grid. The national government plays an important role in setting the renewables and solar agenda, providing economic incentives and enabling state governments and the private sector to pursue innovative approaches to policy implementation.

India's urban population is growing rapidly—and most urban residents have limited means. Without enabling policies and new business models, there is a risk that clean, affordable electricity will remain out of reach for many low-income households.

This case study demonstrates how low-carbon investments have the potential to tackle multiple urban challenges—if appropriate policy frameworks are in place. Delhi's flexible incentives combined with the single-point metering system are making rooftop solar more affordable and accessible. These business models and technical solutions could be replicated by towns and cities across India, if the central and state government put in place the policy prerequisites. Doing so is essential if India is to achieve its own renewable energy targets and the SDG targets of affordable and clean energy and sustainable cities and communities.

ENDNOTES

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ABOUT THE COALITION FOR URBAN TRANSITIONS

The Coalition for Urban Transitions – launched in 2016 at the Climate Leaders' Summit in New York – is a major new international initiative to support decision makers to unlock the power of cities for enhanced national economic, social, and environmental performance, including reducing the risk of climate change. The Coalition provides an independent, evidence based approach for thinking about 'well managed' urban transitions to ensure that the growth of urban areas, and the accompanying process of economic, social, and environmental transformation, maximises benefits for people and the planet.

The initiative is jointly managed by the **C40 Cities Climate Leadership Group (C40)** and **World Resources Institute (WRI) Ross Center for Sustainable Cities**. Members include over 20 major institutions spanning five continents, including research institutions, city networks, international organizations, infrastructure providers, and strategic advisory companies. The initiative will be overseen by a Global Urban Leadership Group to steer and champion the work.

Follow the Coalition's work at www.coalitionforurbantransitions.org on LinkedIn, on Twitter @NCEcities and Facebook @coalitionforurbantransitions.

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