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Scaling up Rooftop Solar Power in India: The Potential of Municipal Solar Bonds

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Abstract

India has made great progress in reaching its ambitious goal to scale up renewable energy capacity to 175 GW in 2022. Solar power plays a central part in achieving this goal and installations of utility scale power have seen a dramatic increase in the last few years. Rooftop solar, however, is lagging and more needs to be done to achieve its 40 GW capacity target by 2022. To meet the remaining rooftop target, this study estimates that the total capital requirement could be as high as USD 31.8 billion in addition to current subsidies and USD 39 billion excluding subsidies. The study suggests that municipalities can play a larger role in the acceleration of rooftop solar in India and proposes the use of municipal bonds to support the scale up of rooftop solar in India and details how such bonds could be designed and implemented. The study also applies proposed bond model to two Indian cities- Surat and New Delhi (NDMC) and illustrates how municipal bonds can significantly reduce the costs for rooftop solar and make it competitive and benefit different type of consumers in these cities.

Keywords: Municipal Finance, Municipal Bond, Rooftop Solar, Climate investment, energy finance, energy infrastructure, renewable energy

JEL classification: Q42, Q48, R51

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Executive Summary

India has set an ambitious renewable energy target of 175 GW by 2022, including 100GW of solar power. Of that, the government aims for 60 GW to be utility-scale solar, and the rest to be rooftop solar. Though India has made significant progress on the 60 GW utility-scale solar target, getting to the 40 GW rooftop solar target will be a significant undertaking. As of December 2016, installed capacity of rooftop solar was only ~1.25 GW, which means that ~6 GW would need to be installed every year to reach the 40 GW target by 2022. Filling this gap between the current installment and the 40 GW goal will require an estimated USD 39 billion (INR 3 trillion).

This paper—produced in collaboration between Indian Council for Research on International Economic Relations (ICRIER), Climate Policy Initiative (CPI) and Stockholm Environment Institute (SEI), and funded by the Swedish Energy Agency as part of its support for the New Climate Economy project—proposes the use of municipal bonds to support the scale-up of rooftop solar in India, and details how such bonds could be designed and implemented.

The adoption of rooftop solar is primarily driven by expected savings in electricity costs, the need for an alternative source of electricity, and the desire to mitigate climate change risk. However, three key barriers hinder the growth of this technology in India: high upfront capital expenditure, perceived performance risk, and limited access to debt capital. The first two issues can be addressed through a third-party financing model.

However, the third-party financing model has had limited success due to inadequate availability of debt capital for project developers. This lack of availability is driven by various factors, including: limited avenues of raising debt capital, already stressed commercial banks in India, concerns on the credit quality of the developer, limited long-term capital opportunities for Indian financial institutions with regard to rooftop solar, and small ticket size of investments leading to high transaction costs.

Municipal financing, via issuance of municipal bonds, has the potential to increase debt availability for rooftop solar project developers and lower rooftop solar costs up to 12%.

In the proposed model, which we are calling "solar municipal bond model" (SMB), a municipal entity would play the role of a finance aggregator for renewable energy project developers. Funds available through a municipal bond would be disbursed to project developers via a Public Private Partnership (PPP) approach, similar to the Design-Build-Finance and Operate (DBFO)[1] model with the financing activity taken care by municipal corporation or corporate municipal entity (CME). By aggregating projects, this model would allow a project developer to access the debt capital markets otherwise difficult to access.

[1] In this PPP approach, the private party assumes the entire responsibility for the design, construction, finance, and operate the project for the period of concession.

Municipalities have several market advantages in their potential role as finance aggregators for rooftop solar:

- **Institutional goals and mandates:** Municipalities have target-based responsibilities to increase renewable energy deployment under the Solar City Program, so they have a built-in incentive to increase rooftop solar.

- **Access to debt capital markets:** Compared to rooftop solar developers, municipalities are in a better position to access the debt capital market due to their larger balance sheets.

- **Superior credit profiles:** More than half of the rated municipalities – 94 in total - are investment grade (i.e. BBB- or above); whereas almost all rooftop developers are below investment grade. The better credit profile of municipalities compared with project developers can help in raising debt capital at lower costs.

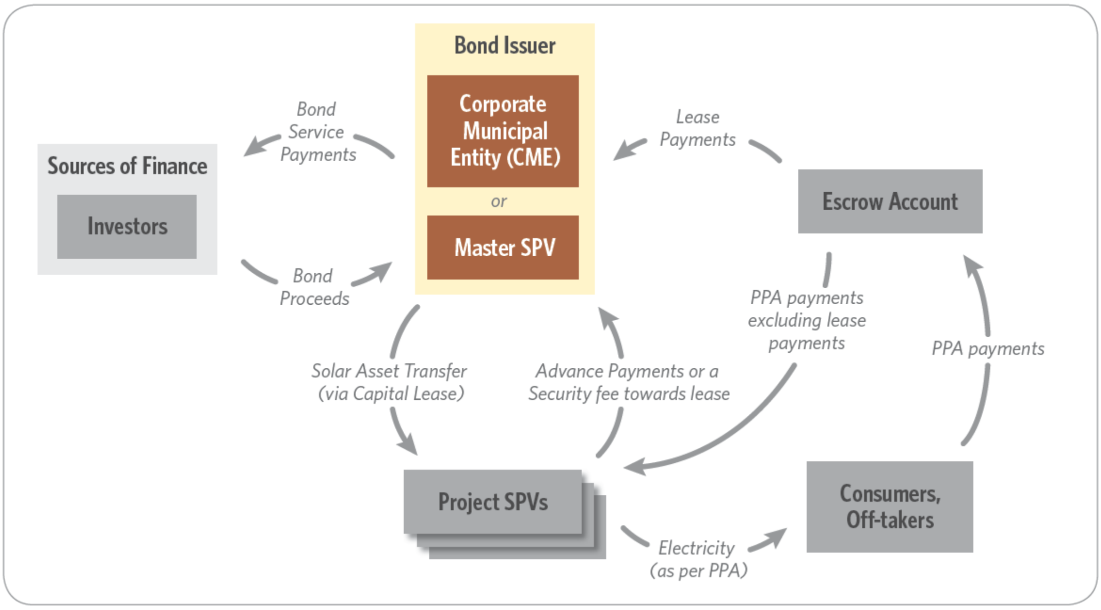
- **Access to public guarantees:** Compared to private project developers, municipalities (as public entities) have relatively better access to public guarantees that are typically required to achieve the risk-reduction necessary to attract institutional investment.

- **Diverse revenue sources:** Municipalities have multiple sources of revenues (e.g. property taxes), which can provide additional security to investors.

- **Good consumer engagement:** Given municipalities' relatively good proximity with the consumers, the government can quickly facilitate rooftop solar project aggregation.

Innovative transaction structures would be required to facilitate the role of municipalities as finance aggregators. A particularly attractive structure (Figure ES-1) is where a municipality-owned master special purpose vehicle (SPV) or a corporate municipal entity (CME) would raise the bonds and disburse the proceeds of these bonds to SPVs owned by project developers via capital lease arrangements. In our paper, we also provide a detailed roadmap for municipalities to deploy the proposed model.

Figure ES-1: Transaction Structure to raise Municipal Bond for Rooftop Solar Financing



The SMB model shows considerable promise based on its application to Surat and New Delhi[2]. For Surat and New Delhi, rooftop solar potential is 727 MW with a capital requirement of INR 38.5 billion and 110 MW with a capital requirement of INR 6 billion respectively. By reducing the cost of rooftop solar by up to 12%, a municipal bond would not only make rooftop solar competitive with existing tariffs, but also provide the much needed additional debt capital.

Apart from reduction in the cost of financing, a solar municipal bond also has the potential to mobilize the significant untapped investment into the rooftop solar sector, for example, from domestic institutional investors, which, according to a previous CPI study has an untapped investment potential of USD 56 billion in debt for renewable energy. Issuing municipal bond for solar will also help in building municipalities' capacity to access the debt capital markets, and utilize an innovative transaction structure for other projects.

Despite its promise, implementation barriers remain, which are described below in the order of how critical they are:

- **There is no statutory mandate for municipal corporations to promote electricity generation:** The municipal functions listed under the 12th Schedule of the 74th Constitutional Amendment do not include power generation. Though Municipal Corporations would play limited roles as financiers in the proposed model, this may prove to be the most significant barrier.

[2] We examined these cities because they are not only on the list of the solar cities program of MNRE, but also perform well across key metrics such as local governance, service delivery, revenue generation, and renewable energy projects. For this study we focus on the non-residential sector

- **Solar municipal bonds would need to achieve high credit ratings:** India's debt capital market is relatively shallow, as it fails to attract enough investors if the credit rating of the bond is below AA or A+. Hence, high credit ratings of the municipal bonds would be critical to the success of the model.

- **Municipalities are required to provide minimum equity contribution of 20% of the project cost:** According to Section 12 (5) of SEBI's Regulations[3], municipalities would need to provide 20% of project costs as equity. Since most municipalities are struggling to meet the investment demand for basic infrastructure services, this regulation will be hard to meet.
- **Absence of supporting regulations will hinder municipal corporations to act as a financial company:** In the proposed transaction structure, proceeds of the bond would be disbursed to projects via capital lease arrangements. Since capital leases are mostly executed by financial entities, in the absence of any specific regulation, municipalities might be reluctant to act as the finance aggregators.
- **Reluctance of Municipal Corporation to issue bonds:** Successful issuance of municipal bond warrants transparency and due diligence in project management and accounting practices of municipal corporations. Many municipal corporations have serious shortcomings on these fronts and have to revamp their current practices before bond issuances.
- **High transaction cost:** One potential downside of the proposed model is that transaction costs could be higher than either self-ownership or third party financing models, mainly due to the novelty of the approach.

This paper, therefore, recommends several focused interventions to address these barriers. Table ES-2 focuses on solutions/recommendations for the most critical barriers, as well as their potential impact and feasibility. Impact is the ability of the proposed recommendation to address the challenge, and feasibility is the likelihood of implementation for the recommendation.

The proposed SMB model, though radical and futuristic, could be crucial if India wants to achieve its rooftop solar target by 2022. If we are able to successfully address the barriers highlighted in the above table, it will not only help rooftop solar to scale up its growth, but also help municipal corporations to use the similar structure for other priority infrastructure projects.

Next steps include further analysis in future work, particularly on an appropriate incentive mechanism to involve municipal corporations to act as financiers for private projects, which this study does not cover.

[3] Securities and Exchange Board of India (Issue and Listing of Debt Securities by Municipalities) Regulations, 2015

Table ES-2: Summary of Barriers and Potential Solutions to improve the feasibility of the proposed model

BARRIERS	SOLUTIONS/RECOMMENDATIONS	KEY PARTICIPANT	IMPACT	FEASIBILITY
There is no statutory mandate for municipal corporations to promote electricity generation.	Introduce amendments in state and national legislation to allow municipal corporations to facilitate electricity generation projects.	Legislative bodies at State and Central level	High	Low
Solar municipal bonds would need to achieve high credit ratings	Use instruments such as Partial Credit Guarantees (PCG) or first-loss funds to enhance the credit rating of the bond.	Institutes such as USAID, IREDA etc. can provide PCG while MNRE can capitalize first-loss fund using National Clean Energy Fund (NCEF)	High	Medium
	Through proper due diligence, select consumers (off-takers) so that only the credit-worthy consumers are eligible to install solar rooftop projects.	Municipal Corporation with the help of credit rating agencies.	High	Medium
	To address off-taker risk, use property-assessed clean energy (PACE).	Municipal Corporations	Medium	Low
Municipalities are required to provide minimum equity contribution of 20% of the project cost	Introduce regulatory changes to waive off this requirement. However, the proposed transaction structure attempts to overcome this barrier by proposing the capital lease mechanism, where project developers will make an upfront advance payment. This should help in compensating for the equity capital contribution.	SEBI	Medium	Low
Absence of supporting regulations will hinder municipal corporations to act as a financial company	Introduce amendments in regulations to allow municipal corporations to act as financiers for clean energy generation projects. Both for its own consumption and for the use of private consumers.	SEBI and Ministry of Finance	Medium	Low
Reluctance of Municipal Corporation to issue bonds	Build its capacity to overcome this structural issue with the help of relevant entities.	Ministry of Finance, USAID, World Bank	High	Medium
High transaction cost	Pool the solar rooftop projects across the municipal corporations (cities). This would increase the bond issuance size and hence may bring down the transaction cost.	MNRE, Ministry of Finance	Low	Medium

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1. Introduction

In the past two years, India has made significant strides in moving towards its ambitious renewable energy target of 175 GW of installed capacity by 2022. This includes 60 GW from wind power, 100 GW from solar power, 10 GW from biomass power and 5 GW from small hydropower

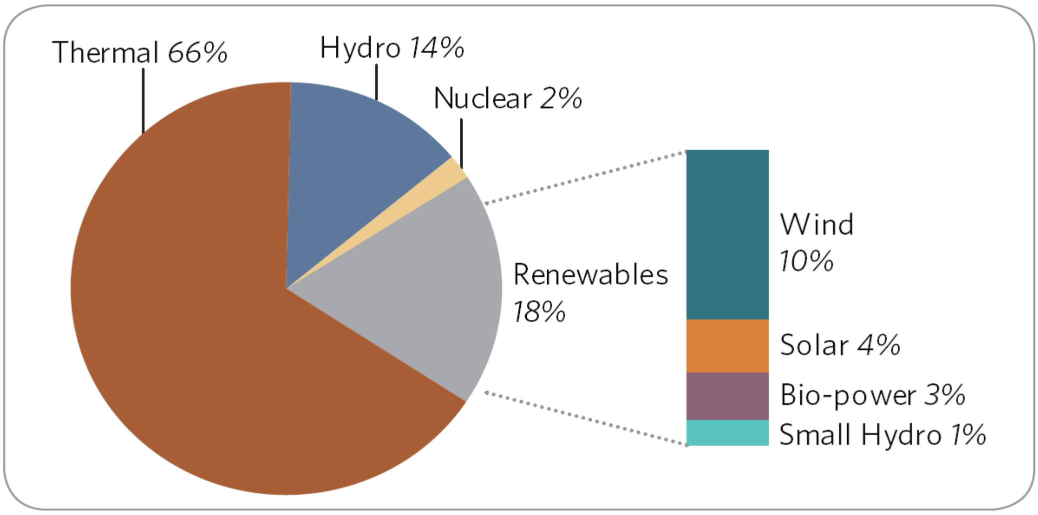
Currently solar power, wind power, biomass power, and small hydropower together contribute to about 60 GW or 18% to India's total power capacity (Figure 1) with solar alone accounting for 24% of the total renewable electricity mix. However, in order to meet India's renewable energy goals, wind power installations will need to double from their current capacity, while the solar power capacity has to scale by more than seven times in the next five years. If India succeeds in achieving these targets, an increase in coal power capacity will not be required post 2022 (CEA 2016).

From 2013-2016, installed rooftop solar capacity has grown from 117 MW to 1,250 MW (BTI 2017),which means that the Indian rooftop solar capacity has increased tenfold in just three years. The accelerating growth in rooftop solar systems is driven by the fact that the technology is already price competitive in many Indian states and sectors (CPI 2016). Recognizing the potential of solar technologies, the National Solar Mission of India has earmarked 40 GW of its 100 GW by 2022 solar power target for rooftop solar.

Despite significant progress in rooftop solar installations, reaching India's target of 40 GW by 2022 will be challenging.

Despite India's considerable progress in bringing down the cost of rooftop solar installations, the deployment rate is still insufficient to achieve the national target of 40 GW by 2022. Given the current rate of annual capacity additions, it is estimated that only ~13 GW of rooftop solar will be installed by 2022 (BTI 2017), a figure far short of the target.

Figure 1: Power capacity in India by generating technology (as of 2017/11/30, % share)



Source CEA 2016

Immediate action by the government, industrial stakeholders, utilities, and other stakeholders is therefore necessary to overcome regulatory and financial challenges that hinder further deployment. This includes introducing innovative financial interventions. In this report, we discuss one such intervention: Municipal corporations as financial aggregators for rooftop solar.

The report is structured as follows: First, in Section 2, we look at investment needs to reach rooftop solar targets, drivers and barriers of rooftop solar in India. In Section 3, we look at rooftop solar financing in the context of broader sustainable urban and infrastructure financing measures in India. Section 4 explains the proposed solar municipal bond model as well as expected benefits and limitations of this model. Section 5 then applies this model to two regions—Surat and New Delhi—in theoretical examples. Section 6 concludes by discussing potential challenges to the implementing of solar municipal bonds and what can be done to address them.

2. Investment needs, drivers and barriers of rooftop solar in India

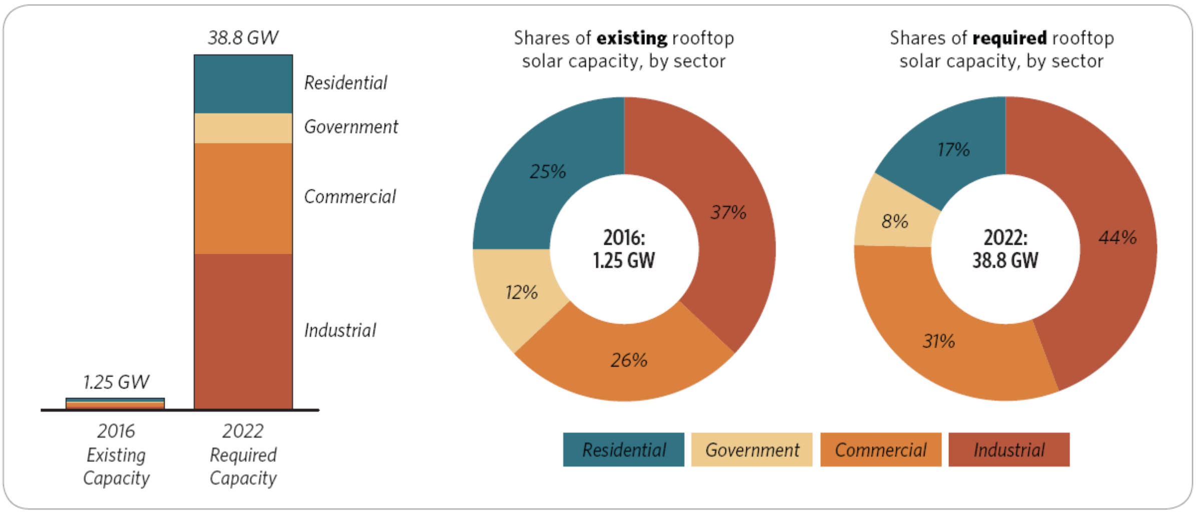
This section looks at why we need to consider new models of financing as well as partnerships to be successful in scaling up the solar technology present in the Indian market.

> *In the next five years, the rooftop solar sector needs to increase 32 times from its present capacity to reach the government's target of 40GW by 2022*

In order to reach the national target of 40 GW, rooftop solar capacity needs to increase 32-fold in the coming five years. Of the total installed rooftop solar capacity of 1.25 GW (until Dec. 2016), the industrial sector has deployed the largest share, followed by the commercial sector and then the residential sector (Figure 2). Most of the remaining target is also expected to come from the industrial sector (44%). To meet this target, the sector has to increase its capacity by close to 37 times. The commercial sector also has to expand its contribution by about 37 times to host its expected capacity of 12.06 GW. Though the expected share of residential and public (government) buildings in the national target are comparatively less, they also have to expand their contribution by close to 21 times to meet the national targets.

The sectoral growth estimates are calculated based on the assumption that governmental and residential buildings will contribute approximately 10 GW to rooftop solar by 2022 (NITI Aayog 2015).

Figure 2 (center): Shares of rooftop solar capacity by sector in India in 2016 and Figure 3 (right): Expected shares of rooftop solar capacity by sector in India to achieve 2022 target (38.75 GW)



Source: BTI 2017, Niti Aayog 2015, Authors Calculations

2.1 Investment needs to achieve the national rooftop solar target

Given the considerable gap between currently installed and expected capacity by 2022, there is large need for investments in rooftop solar capacity. Estimates of investment needed to scale up rooftop solar are subject to costs for solar panels, capital, labor and operations, and levels of national and state-specific subsidies and taxes.

To meet the outstanding 38.75 GW rooftop solar target by 2022, a total of INR 2.07 trillion (USD 31.8 billion) is required, in addition to current subsides and INR 2.52 trillion (USD 39 billion) excluding subsidies.

Table 1 shows the estimated investment needs of the rooftop sector for the outstanding 38.75 GW of solar power necessary to achieve the 2022 target. Based on our interviews with municipal government officials in New Delhi and Surat, and the benchmark prices of rooftop solar, the estimated price for residential buildings is INR 70,000 per kW and INR 65,000 per kW for governmental, commercial and industrial buildings. In the calculations, we have also considered the current levels of subsidies available for rooftop solar systems across different types of states. Furthermore, we have also calculated a 35% tax on the accelerated depreciation at the rate of 40%. In Appendix 1, we have given the cost calculations in detail.

Table 1: Capital investments needed for outstanding 38.75 GW of rooftop solar in India by 2022

Capital investments		Units
Residential + Government (with capital subsidy)	43,857.0	INR Cr.
Industry + Commercial (accelerated depreciation)	163,308.0	INR Cr.
Total Cost in INR	207,165.0	INR Cr.
Total Cost in USD*	31,871.5	USD Million

Based on MNRE 2017 a, 2017 b, 2014 and authors calculation

* Assuming INR 65 = USD 1

2.2 Drivers for rooftop solar adoption in India

There are many factors driving the adoption of rooftop solar in India[4]. These include cost savings, energy access, "green" benefits, and government mandates. We discuss each of these in turn.

Rooftop solar offers significant and increasing costs savings.

Cost savings are the key driver of rooftop solar in India:

- In many Indian states and market segments, the levelized cost of electricity (LCOE)[5] of rooftop solar is already lower than the existing average grid rates of tariffs paid.
- Rooftop solar is approximately 17% and 27% cheaper than the average industrial and commercial tariff respectively (Figure 4), without considering net-metering policies.
- Rooftop solar is also already achieving grid parity in the residential sector in states such as Uttar Pradesh, Maharashtra, and Rajasthan (CPI 2016).
- In the governmental sector, rooftop solar has become competitive in Delhi, Uttar Pradesh, Karnataka, Haryana and Andhra Pradesh.
- In other states, the gap between rooftop solar and conventional sources of electricity is fast decreasing.

Details about LCOE calculations are provided in Appendix 2.

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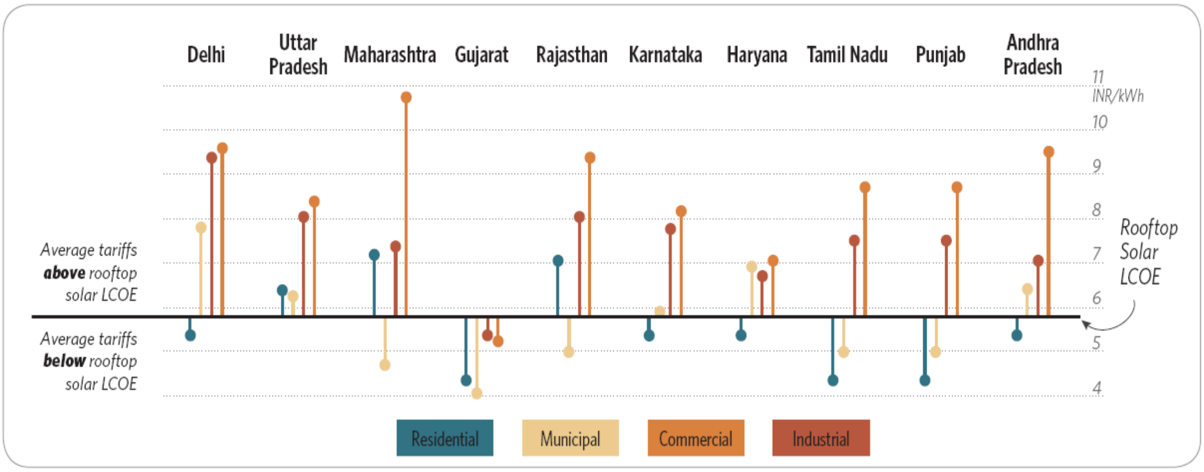
4 A more detailed description of the drivers and barriers to rooftop solar can be found in (CPI 2016)

5 The levelized cost of electricity or LCOE is the average cost of electricity that helps to break even in terms of the return expected by the developer. It represents the minimum unit revenue required to meet all the cost including the return on equity, given the project's financial parameters. Please see Appendix 2 for how the LCOE was calculated using a typical project cash flow model

Figure 4: Average electricity tariffs for different states and market segments and rooftop solar LCOE



Note: Only the generation costs (i.e. LCOE) has been considered as many states have exempted renewable energy form paying others charges such as wheeling charges and cross-subsidy charges. Also, we have not incorporated the impact of any subsidy such as accelerated depreciation in the LCOE calculations

Rooftop solar can help increase access to energy

The second key driver for rooftop solar is energy access. Access to affordable power is a major issue for Indian households in both urban and rural areas. Though the power deficit is falling rapidly across the nation, access remains an issue with 304 million people in the country still lacking access to electricity (NITI Aayog 2017). The lack of access and unreliable supply often leads to reliance on alternatives like diesel generators, which are subject to high price volatility, in addition to numerous harmful health and climate effects.

Renewable energy and in particular rooftop solar can greatly contribute to improve this situation. Additionally, rooftop solar offers a more price-stable and less harmful alternative to conventional electricity.

Solar power has the social image of being “green”

The third key driver for the adoption of rooftop solar is desire on behalf of consumers to have an image of being environmental friendly and modern. Consumers who are driven by this factor are even willing to pay higher prices than grid power or make capital investments. This applies mostly to the industrial, commercial and public sectors.

The government has requirements to install solar power

The fourth key driver behind rooftop solar in India is governmental as well as state-wise Renewable Purchase Obligations (RPO). These requirements only apply to commercial and industrial segments. By 2022, the government prescribed solar-specific RPO is set to increase to 3% (MNRE 2017 c).

2.3 Barriers to rooftop solar in India

Despite falling prices and strong drivers of rooftop solar deployment, barriers remain. Measures to accelerate the adoption of rooftop solar also need to address these known barriers, which include high upfront costs, limited access to debt, perceived risks, policy challenges, and energy storage costs. We discuss each in turn.

High upfront costs for installation

The most significant barrier to rooftop solar in India is high upfront costs for installation. The size of a typical rooftop solar installation in the commercial and industrial segments is around 150-200 kW, and would cost between INR 9.7 - 13 million per installation assuming the current price of INR 65,000 per kW Commercial and industrial consumers are often reluctant to invest such a high amount upfront, especially for a non-core business activity.

Limited access to debt finance

The second most significant barrier to rooftop solar adoption is limited access to debt finance. Due to perceived high risks and suspicion about performance for this relatively new sector, banks are reluctant to lend to solar rooftop projects. Borrowing costs can therefore be as high as 12% or more. Due to the smaller size of the projects in the rooftop solar sector, developers do not approach banks for loans because of the proportionately higher transaction cost per unit of project cost. Furthermore, the market for third-party debt capital from bond issuance is still marginal in India, as outlined in greater detail in Section 3 and 4. As a result of these factors, most of the rooftop solar projects in India are being financed with equity capital with minimal debt during development stages (BNEF 2016). As the cost of equity capital is usually more expensive than debt, the overall project cost then becomes more expensive.

Consumer perception of risks and performance

Another important barrier to rooftop solar has been the perception of risks and performance among consumers. Rooftop solar power is still a relatively new technology in India and, therefore, there is a perception that it may not perform as expected over its lifetime. Additionally, there are trust issues as several entrepreneurs in the rooftop solar market are comparatively new with little track record.

Challenges in the implementation of net-metering policies

Another key barrier to rooftop solar adoption is the poor implementation of net-metering policies across the states. Although, 27 states and union territories have issued net metering policies or regulations since the issue of the model net metering regulations in 2013, only a few states have begun the actual implementation of the policy. The slow or patchy progress in the net-metering policy can be attributed primarily to issues like inadequate policy frameworks, passive opposition from DISCOMs; and insufficient training at the local utility level.

High price of energy storage

The current high price of energy storage is also a barrier to rooftop solar. As solar power can only be generated during the day time, it warrants energy storage to ensure continued usage at night time or when solar radiation is low. Currently, the cost of a rooftop solar system with battery storage could be between INR 90,000 and 135,000 per kW depending on voltage (MNRE 2017 b). The issue of consumer-owned, behind the meter energy storage, however, may be less pressing if effective net-metering policies are in place that are complemented by front-of the meter, and grid-based storage[6].

3. Financing of sustainable urban development in India

Rooftop solar is part of a large portfolio of measures to promote sustainable urban development in India. Experiences of municipal governments to finance this development offer important insights into how rooftop solar can be scaled up to achieve the national target of 40 GW by 2022. In this section, we discuss about the rooftop solar in the context of sustainable urban development in India and role of municipal corporation in terms of financing the urban infrastructure.

3.1 Role of rooftop solar in sustainable urban development

There are multiple benefits for municipalities that take an active role in promoting rooftop solar in their constituencies. Several cities are taking part in the national government`s Solar City Program and have drawn up master plans to install rooftop solar in their respective jurisdiction. Besides being a clean form of energy, it can also contribute to efforts to improve access to energy, provision of reliable and cheaper electricity supply, reduction of air pollution etc. Given that rooftop solar is a decentralized form of electricity generation, local governments are also in a much better position to understand the risks and find solutions together with local customers and developers. However, we first need to understand the current situation of municipal corporations as far as funding overall larger sustainable infrastructure development projects is concerned.

3.2 Current sources of public financing for sustainable urban development

Municipalities in India are largely financed by state and central funds. The funding channels in India are segmented across three levels: primarily central funds, state funds, and city level revenues. The central government usually allocates grants or central funds for local governments. Similarly, states will give grants to cities depending on local programs and needs. States also share part of their revenue with cities as recommended by state finance commissions. The city level revenue comes from tax and non-tax sources. Other than these sources, cities may also apply for loans, and grants from national, and international development institutions to finance their projects.

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[6] Financial and technological barriers to energy storage may also be overcome by new business models based on virtual power stations, currently evolving in the US, Germany and Australia, that aggregate multiple rooftop solar and decentralized battery storage systems

The funding gap for urban infrastructure in India

Though funding from the higher levels to municipal government has increased in recent years, there is a burgeoning gap between demand and supply of funds. Traditionally, capital expenditures were met through intergovernmental transfers, grants, and scheme funds. Today, however, with increased demands on urban service delivery and infrastructure, these sources may not be enough.

For example, the High Powered Expert Committee (HPEC), appointed by Ministry of Urban Development in its report on Indian Urban Infrastructure and Services estimated that funding required for urban infrastructure over 20-year period from 2012 to 2031 will be Rs 39.2 lakh crore at 2009-10 prices (USD 830 billion) (HPEC 2011). The committee also highlighted there would be an accompanying increase in the cost of upkeep of old and new assets. As per the projections this would be to the tune of INR 19.9 lakh crore (USD 420 billion) over the same period (HPEC 2011). The Economic Survey of India 2016-17 points out that much of this should come from local resources (GoI, 2017). As municipal contribution to India's GDP is critically low at 0.54 percent of the GDP (Mathur et.al 2011), there is an immediate need to step up revenue mobilization and explore new sources of funding at city level.

3.3 Past experiences with municipal bonds to finance urban development

Many countries have been successful in using municipal bonds to fill funding gaps for city projects. India has experimented with municipal bonds since 1999 to raise additional sources of funding for projects, but with limited success. The municipal bond market in India has raised only about INR 13 billion in the last 20 years (World Bank 2011). Out of the bonds issued, most of the funds were used for water supply, water sanitation, and roads. The tenors of the bonds issued have typically been between five to fifteen years, with fixed interest rates. There has been few pooled finance bonds where small municipalities collectively issued bonds under a state-owned entity created precisely for this purpose. It is clear that overall, significant challenges remain in making municipal bonds successful, especially since the financial health of the majority of urban governments is not robust enough to furnish debt.

A new push for India's municipal bond market

The government of India has recently put new framework in place under the Fourteenth Finance Commission to incentivize municipalities to issue bonds to finance urban infrastructure. Most recently, through the Smart Cities Mission, the central government has encouraged cities to delve into the municipal bond market again. The biggest turnaround in this respect came in 2017 when the municipal corporation of Pune successfully issued a municipal bond. This was the first municipal bond in last fourteen years, and experts expect it to be followed by similar issues from other municipal corporations. The first tranche of the Pune bond, rated AA+ raised Rs.200 crore and would finance a water supply metering project in the city. The bond offered a 7.59% rate of interest was well received by the market, being oversubscribed six times.

These recent developments in the municipal bond market can be leveraged for the rooftop solar sector as well. In the next section, we discuss how these municipal bonds can also be used to fund rooftop solar projects in India.

4. Using municipal bonds to finance rooftop solar developers

As the previous section has shown, there is both an opportunity and challenges of using municipal corporation for the acceleration of rooftop solar. Therefore, if municipalities are to play a role in the necessary acceleration of rooftop solar in India, they will need to look for new sources of finance and business models to spur the required development. This will also require building partnerships with local solar developers and other stakeholders in the domestic and even international financial markets.

The feasible route for municipalities would be to collaborate with rooftop solar developers deploying projects using third party financing model.

There are two business models to deploy rooftop solar in India.

- The first one is the CAPEX model in which the consumer fully owns finances and consumes the energy generated by the PV system. Consumers in the CAPEX model are fully responsible for all capital expenditures, and bear all risks of operations, management, and maintenance. The CAPEX model accounts for approximately 84% of currently existing rooftop solar systems in India and is mainly driven by commercial and industrial operators (BTI 2017).

- The second model, is the OPEX model or the third party financing model in which a renewable energy service company (RESCO) provides all the necessary capital and is responsible for installing, operating, and maintaining the rooftop solar system in exchange for a fixed-tariff Power Purchasing Agreement (PPA) with a customer, or multiple customers. This model is also referred as third-party financing model.

As CAPEX model is a self-funding model for the rooftop solar projects as far as the end consumer is concerned, it does not require much financing support from external entities. On the other hand, the third party financing model requires significant debt investment from the capital market. Hence, the municipal corporation can collaborate with the rooftop solar developers to facilitate the access of the debt capital from the capital markets under the OPEX model route.

The OPEX model has been proposed as one of the promising solutions to address several barriers to scaling rooftop solar discussed in section 2.3. According to a previous study (CPI 2016), the third party financing model is expected to dominate the rooftop solar market, given its benefits for consumers of no upfront and installation, operation and management services being carried out by local developers. Globally, the third-party financing model has been a significant driver of growth in the rooftop solar sector. However, the third party financing model has not picked up in India at the rates expected due to the lack of availability of debt capital at competitive cost, which affects the ability for companies advancing this business model to scale.

Thus, to achieve further scale for the OPEX model for rooftop solar in India, alternative methods of financing should be considered.

4.1 Overview of Solar Municipal Bond model – Rooftop Solar Projects under OPEX route financed through Municipal Bonds

In this study, we propose an alternate approach where municipal corporations can play the role of finance aggregators for rooftop solar projects deployed under the Opex route. The proposed model called **Solar Municipal Bond (SMB) model** advocates a bottom-up approach to facilitate financing for rooftop solar projects and complements the existing government efforts to achieve the 40 GW national targets. The SMB model suggests using municipal financing for rooftop solar projects. It is based on a public-private-partnership (PPP) investment approach for rooftop solar projects at city level where municipalities would issue bonds and then transfer the proceeds to private solar rooftop developers through special purpose vehicles (SPVs).

This model differs slightly from a conventional design-build-finance-operate (DBFO) model. In a typical DBFO investment model, all activities from design to operation are taken care by a private developer. In the proposed model, however, we are recommending that municipalities should raise debt capital to finance rooftop solar development. The transaction structure is similar to the Morris County model successfully used in the USA for financing the rooftop solar but limited to the public places only. The proposed SMB model advocates its implementation beyond public buildings.

4.2 Rationale for municipal bonds for rooftop solar projects

Before discussing the transaction structure of the solar municipal bond model in more detail, we first discuss the rationale of using municipal bonds as financing mechanism for the rooftop solar:

Municipalities have already been assigned certain renewable energy targets under Solar City Program

Municipalities have target-based responsibilities to increase renewable energy deployment under the Solar City Program[7], so they have a built-in incentive to increase rooftop solar in their jurisdiction. However, the targets set under the program are quite moderate and municipal corporations can be given additional responsibilities to increase these targets as per their true potential.

[7] Solar City program, developed by MNRE in 2015, aims at minimum 10% reduction in projected demand of conventional energy at the end of five years at city level, through a combination of enhancing supply from renewable energy sources in the city and energy efficiency measures. It is designed to support/ encourage Urban Local Bodies to prepare a roadmap to guide their cities in becoming ‘renewable energy cities’ or ‘solar cities

Municipalities are in a better position to raise capital by issuing bonds than private developers

The main advantage for the proposed public-debt based financing for rooftop solar under the OPEX model is that compared to private developers, municipal governments are in a better position to raise capital by issuing bonds. The key reason behind this is that Municipal Corporations have relatively larger balance sheets as compared to that of a rooftop solar developer, which provides the feasible financial strength and capital base to raise bonds from the capital markets.

Municipalities have good credit ratings and benefit from state guarantees

One important reason why municipalities are in a better position to raise debt-based finance than project developers is their credit ratings relative to that of rooftop solar project developers. More than half of the rated municipalities—94 in total—are investment grade (i.e. BBB- or above); whereas almost all rooftop developers are below investment grade. A high credit worthiness is essential for successful listing of a bond as it not only helps in reducing the cost of debt servicing but also attracts long-term institutional investors.

Municipal Corporations have relatively easier access to public guarantees

Being government-backed entities, municipal corporations can leverage upon the strength of the state or central government to secure guarantees on bonds. This helps in raising the credit rating of the bonds. For private project developers, it is quite difficult to access such guarantees from the government institutions.

Municipalities' internal revenue offers security for investors

In addition to the project revenues which are used to service the bond payments, municipal corporations have various other streams of revenues such as property taxes, service taxes etc. which can provide security for investors in case project revenues are not sufficient to service the bond payments. Private solar developers rarely have revenues other than that from solar energy generation.

Aggregation and economies of scale make municipal bonds more feasible

One of the key issues that a private rooftop solar developer faces in raising the debt capital is the small size of the projects, which increase transaction costs. Given municipalities' relatively good proximity with the consumers, the municipal corporation can quickly facilitate rooftop solar project aggregation. If rooftop solar developers would like to access the debt capital through municipal bonds, multiple developers would have to aggregate their projects at city level which would ensure the aggregation of the projects and make the issuance of the bond more feasible. This process will also help to reduce the transaction costs of raising the debt capital.

Incentives for municipal corporations to professionalize financial operations

Municipal bond issuance can expedite governance reforms. A municipal bond issue would mean not only a plethora of challenges but also offer the local body a number of opportunities. Most importantly, a successful bond issue warrants financial discipline and accountability of the issuer. Past experiences have proved that efficiency of project management systems, procedures to reduce time delays and cost overruns, and a healthy revenue system are essential for constant engagement with capital markets. A rooftop solar project in this respect could be a less risky project than alternative projects to be funded through bonds as the revenue streams of a rooftop solar project are largely assured due to PPAs and would prepare municipalities for larger issues in the future.

4.3 Transaction structure of the proposed municipal bond model

The proposed solar municipal bond model for rooftop solar combines public debt-based finance with an existing OPEX model. Under this mechanism, a public entity would issue a bond at low cost- long tenor and transfers the bond proceed to a private developer. This model is quite similar to bond-PPA model called Morris County Model, named after Morris County in New Jersey, U.S., which developed the model to finance solar power installations on public facilities in 2011 (NREL 2011).

However, in the proposed bond model for India, we are going one step further from the U.S. based Morris county model. In Morris County model, the municipal corporations raise bonds to facilitate the financing of only those solar projects, which are installed for municipal corporation consumption. In the proposed model, the fund raised through a municipal bond would be used to finance as many rooftop solar projects as possible including residential, commercial, and industrial customers.

The model combines many of the benefits of self-ownership and third-party ownership from the perspective of local government as consumer. Like self-ownership, the model allows local government to leverage low-cost public debt. Like a third-party financing model, the proposed model enables the developer to benefit through savings passed on from tax incentives i.e. the accelerated depreciation benefit. In addition, the local government and the other consumers receive fixed electricity costs for a long-term contract and has no operating and maintenance responsibilities for the solar equipment.

Figure 5 shows the transaction structure of the municipal solar bond model that is based on public-debt and OPEX model of project deployment. A public entity, in this case a special purpose vehicle (SPV) which is 100% owned by a municipality, issues a revenue bond[8] which would be ring fenced with the project cash flows. We refer to this SPV as Master SPV or the corporate municipal entity (CME)[9]. The bond can be raised by the municipal

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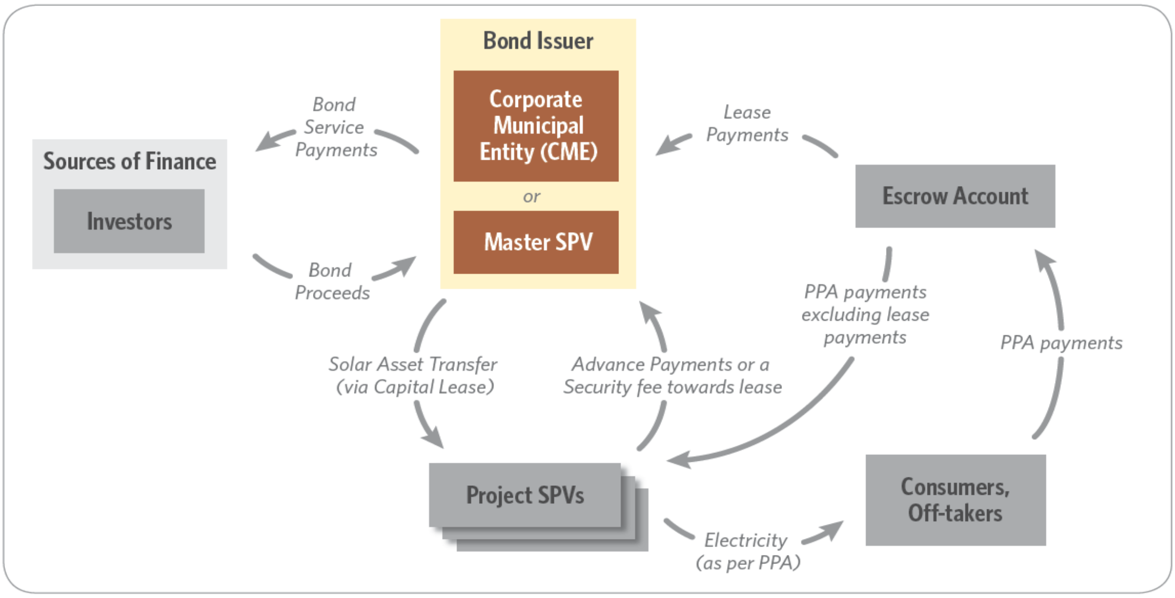
8 Revenue bonds are the municipal bond that finance revenue-generating projects and may be secured by a specified source of revenue in certain cases

9 Corporate municipal entity means a company as defined under Companies Act, 2013, which is a subsidiary of a municipality and which is set up to raise funds for a specific municipality or group of municipalities

corporation directly as well. The main reason of raising the bond via SPV is to de-link the financial risk of the project from the municipal corporations' financial books. However, we have assumed that the CME or the municipal corporation, whoever is raising the municipal bond, meets the required eligibility criteria laid by SEBI (SEBI 2015). The CME then issues a request for proposal (RFP) seeking solar developer(s) to build, operate and own solar rooftop projects or a portfolio of projects on municipal buildings and other consumer segments.

Figure 5: Transaction Structure of Solar Municipal Bond Model



The CME floats the bond to finance/refinance the development cost of solar PV projects. The CME then enters into a capital lease agreement[10] with the project SPVs owned by project developers. The project SPVs then sign a PPA with consumers to sell the electricity from PV systems.

4.4 Limitations of the Solar Municipal Bond structure

Size of municipal bonds

As per the SEBI's guidelines, a bond should have a minimum issuance size of INR 1 billion if the issuance is via public placement route. Municipal Corporations can also go for a private placement route to raise the bond as there are no such restrictions[11]. However, if we want to optimize the transaction cost, the issuer should ideally raise at least INR 1 billion for private placement and INR 1.5 billion for public placement. Debt-based capital of this size would

[10] The capital lease arrangement transfers the ownership of the project to the solar developers for federal tax (40% AD benefits available for Solar PV projects) purposes as public entities i.e. master SPV in this case would not be eligible to get these tax benefits

[11] Business Standard (2014). SEBI issues new norms for public issuance of debt securities. http://www.business-tandard.com/article/mar-kets/sebi-issues-newnorms-for-public-issuance-of-debt-securities-114061701088_1.html

allow municipalities and solar rooftop developers to build rooftop solar systems of large-scale, and achieve low capital costs by pooling in individual small-scale projects.

The model is more suitable for non-residential consumers

The credit rating of the bond is one of the key criteria to ensure its successful subscription. In addition to the credit rating of the SPV, which depends partially on the rating of the respective municipality, the off-taker risk would be of utmost important. In the case of rooftop solar installed under the Opex route, enforcement of PPA contracts is a major concern for the project developers. This enforcement becomes relatively difficult when the off-taker is a residential consumer. On the other hand, off-taker risks of municipal, commercial, and industrial consumers are relatively lower. Also, most of the existing rooftop solar projects under OPEX models in India involve commercial and industrial customers (BTI 2017). Hence, for initial success of the SMB model, we recommend disbursing the capital from the bond proceeds for the projects in the non-residential consumer class. Hence, the solar municipal bond model will remain most suitable for non-residential customers because of low off-taker risk until a solution is found to reduce residential off-taker risk.

Short-term solutions for initial project stability are needed prior to refinancing projects through the municipal bond

It should be noted that the origination of initial debt would be through a conventional bank as bonds are not suitable when portfolios of projects have not reached to a certain scale, as is the current case in India for rooftop solar. Once the projects get stabilized and start generating regular revenues, the initial debt would be refinanced through the municipal bond. It is assumed that a bank would agree to originate the short-term loan because of: a) the larger size of the projects achieved through aggregation of all the projects at the municipal corporation level; b) the assurance from the municipal corporation that the initial short-term loan would be paid or refinanced through a municipal bond within a year or two.

Another way to reach the required stability in project portfolios before the municipal bonds can be raised would be to create a warehouse line of credit. This warehouse would take care of the required aggregation of the creditworthy rooftop solar projects and also provide the initial line of credit over a period not exceeding 24 months. Once the required aggregation and the stability in terms of project cash flows is achieved, the refinancing of the warehouse line of credit would be done by issuing asset backed municipal bonds. The refinancing should reduce the loan costs and free up capital from the warehouse line of credit to finance additional projects (CPI 2016c).

4.5 Expected benefits of the solar municipal bond

Municipal financing, via issuance of municipal bonds, has the potential to increase debt availability for rooftop solar project developers and lower rooftop solar costs by up to 12%.

In this section, we discuss the benefits of the of the solar municipal bond model.

Lower cost-longer tenor of debt reduces the levelized cost of electricity of rooftop solar

The solar municipal bond structure is expected to offer better debt terms than commercial alternatives, which are passed on to electricity consumers. In this model, the project developers make capital lease payments that fully cover the bond service payments. These lease payments would be lower than the payments on commercial loan that a solar developer would otherwise have borrowed. The lower cost is expected due to the better credit rating of the municipalities, over-collateralization of the bond, and certain upfront payment towards the capital lease. The tenor of the lease is also expected to be longer compared to that of the commercial loan due to more flexibility available in a capital lease mechanism. Hence, the cost savings due to low-cost, long-term lease capital would enable the project developer to offer an attractive PPA price to its consumers.

Table 2 shows the expected impact of cost of financing using municipal bonds on the cost of rooftop solar power[12]. As there are little empirical data about the yield curves of municipal bonds in India, it is difficult to estimate the probable costs of municipal solar bonds. Thus, we use the cost of debt of the recent green bonds raised by Indian entities as a proxy to estimate the benefits of the proposed municipal bond.

A tax-free bond for a tenor of 12 years can reduce the solar power cost by 8.38%, and, if tenor can be increased to 15 years, the reduction would be more than 11.5%. This means that rooftop solar power would become cost competitive for residential consumers in the states of Delhi, Karnataka, Haryana, Punjab, and Haryana if these states opt for the municipal bond approach (see Figure 4). The recent municipal bond (taxable) issued by Pune Municipal Corporation has a coupon rate of 7.59% (Bloomberg 2017). If a similar coupon rate is assumed for municipal rooftop solar bonds, then the reduction in the cost of solar power can be even greater than 11%.

Even if the bonds are issued as taxable instruments, the relatively better credit rating of the municipal corporations is expected to make their borrowings cheaper than that of the solar developer. For example, recently, Pune Municipal Corporation (PMC) raised a bond at a coupon rate of 7.51% (Bloomberg Quint 2017) and New Delhi Municipal Corporation (NDMC) announced its plan to raise a bond via non-convertible debenture (NCD) route and is expecting similar coupon rates (Livemint 2017). Both these municipal corporations are being rated AA+ by credit rating agencies and hence have a competitive cost of debt.

[12] See Appendix 2 for how the LCOE was calculated

Table 2: Estimated impact of expected low cost and long-term municipal bond on indicative cost of solar power

	Debt Term (Cost of Debt, Tenor)	Solar Rooftop LCOE (INR/kWh)	% Reduction in Solar LCOE
Commercial Loan (Base Case)	(11.5%, 12 Yrs)	5.79	
Municipal Bond with cost similar to recent green bonds	(9.33%, 12 Yrs)	5.48	5.38%
Tax Free Municipal Bond [a]	(8.00%, 12 Yrs)	5.28	8.78%
Municipal Bond with longer tenor	(11.50%,15 Yrs)	5.69	1.66%
Tax Free Municipal Bond with longer tenor	(8.00%, 15 Yrs)	5.12	11.52%

a We have taken the case of Tax-free municipal bond to show one of the best scenario as far as the reduction in cost of financing is concerned. However, funds raised through tax free bonds can only be deployed for capital investments in urban infrastructure such as water supply, sewage or sanitation, drainage, solid waste management, roads, bridges and urban transport. Hence, power generation projects may not be eligible to raise capital via tax-free municipal bonds under current regulations.

Issuance of municipal bonds enhance the capacity of local governments to access capital markets

Given that rooftop solar projects have become commercially feasible in India, raising municipal bonds for such projects is attractive for municipal governments interested in accessing capital markets for a broader range of projects, as well as for prospective investors in these bonds. This model will be a good proof-of-concept for municipalities to build their capacity for future bond and capital market-financed projects.

Mobilization of a varied class of investors into the rooftop solar sector

Domestic investors including institutional investors, non-banking finance companies (NBFC) and development finance institutions is an important class of investors for rooftop solar in India. CPI (2016c) shows that these investors have a total debt investment potential of USD 56 billion to be channeled to renewable energy in India.

Solar power generation projects provide a relatively stable stream of revenues for longer duration via PPAs. This will attract investors, especially institutional investors who prefer longer, stable and predictable returns on their investments. Hence, a significant amount of untapped investment can be unlocked for rooftop solar through the municipal bond route.

Municipal bonds issued in the past have been able to attract large domestic institutional investors (DIIs), such as provident funds, insurance companies, mutual funds, and commercial banks, irrespective of the projects for which the bonds were raised. Hence, investments from these DIIs can be mobilized into the rooftop solar segment via municipal bonds.

As they will be issued for clean energy projects, municipal bonds for rooftop solar will be green bonds that can attract additional classes of investors such as the dedicated green bond funds, private and public investors and multilateral organizations. India is already among the top ten largest green bond issuers in the world, with the majority of proceeds (76%) allocated to renewable energy projects (CBI 2017 a). Hence, the proposed bond should be labeled as 'green' municipal bond to tap these additional classes of investors.

5. Indian case studies on business as usual compared with municipal bonds

In this section, we set baselines in order to apply the municipal bond model to the cities of Surat and New Delhi to better understand its implications, challenges, and benefits over a business as usual scenario. We first describe the governance context, renewable energy ambitions, and financial health of each city (Section 5.1). We then describe the three renewable energy target scenarios (Section 5.2) before applying the CAPEX (business as usual) model (Section 5.3). In Section 5.4 we describe our assumptions for the municipal bond model, before applying it to each case (Section 5.5) to determine whether the municipal bond model materially helps meet city-level renewable energy targets.

Municipal bonds can bring down the cost of rooftop solar power in both New Delhi and Surat by 11.5% compared to the base case, with even more significant benefits in Delhi.

5.1 Case studies: Surat & New Delhi

These cities were chosen as case studies because they are both part of the national Solar City Program, have set themselves rooftop solar targets, and have no prior experience in bond issuance. The description of the two cities' financial status is based on an analysis of their budgets in the past years.It should be noted that 'New Delhi' in the study refers to the area under New Delhi Municipal Council (NDMC).

Million-plus cities need to have much bigger rooftop solar targets to meet their respective state targets by 2022.Given existing energy consumption patterns, sectors like industry and commercial businesses can be bundled to raise solar bonds at the city level.

Surat, Gujrat

Surat is one of the fastest growing cities in India and has demonstrated commitment for adoption of renewable energy and energy conservation in its city activities. Leading by example, Surat Municipal Corporation (SMC) currently meets more than 25% of its energy consumption through renewable energy. Surat is also one of the first municipalities in India to run its sewage treatment plant with biogas. Furthermore, the city has a long history of proactive city administration, extensive stakeholder arrangements, and a proven track-record of successful completion of ambitious projects. For instance, the climate-change governance model in the city has brought together public, private, and civil society actors to contribute to the city's climate-change adaptation strategy.

Like most Indian cities, Surat is largely dependent on grants, contributions, and subsidies. Tax revenues, however, have increased in the recent past due to recent reforms in property tax collection and improvements in tax collection efficiency. The share of capital expenditure in the total expenditure has also increased from 33% in 2004-05 to 54% in 2014-15. This, however, has led to capital deficits and the need to step up fund-raising for future capital investments.

New Delhi

Placed centrally in the National Capital Region (NCR) of India, New Delhi Municipal Council (NDMC) is an urban local body formed to govern what is often referred to as Lutyen's Delhi. Unlike other municipal governments, the New Delhi Municipal Council (NDMC) does not have a representative self-government. Instead, a council of government appointees and nominees govern it. The municipality is also the licensee of electricity distribution in its jurisdiction, a unique case for an Indian local body.

As the capital of India, New Delhi has been actively promoting renewable energy and energy efficiency projects, especially solar though national programs like the Solar City Program and the Smart City Mission. To carry out any ambitious national level plan, NDMC demonstrates good fiscal strength with a surplus position; it meets its expenditure with its own revenue and has been debt free. The internal revenue constituting 95% of the total receipts makes it very self-reliant. Unlike most other Indian local bodies, income from non-tax sources like electricity and water distribution is the most important source of revenue for New Delhi. Delhi could leverage its strong financial position to access new sources of capital to finance sustainable urban development.

5.2 Assessment of different rooftop solar scenarios and targets

In this section, we consider three scenarios, and, based on these scenarios, we have established the rooftop solar capacity targets for Surat and New Delhi. These scenarios are defined below.

Scenario I: Rooftop solar targets according to the Solar City Program

The first scenario reflects the rooftop solar target stated in the solar master plans that the two cities developed as members of the Solar City Program. These plans also outline how different sectors share the solar rooftop target. Notably, the Solar City Program plans for both Surat and New Delhi rely heavily on the residential sector for achieving their rooftop solar targets. Since we have calculated the sectoral and aggregate targets by subtracting the installed solar rooftop capacity, both the targets match what the city has reported to the Solar City Program.

Scenario II and III: City level rooftop solar targets devolved from the national target of 40 GW by 2020

We have developed two scenarios devolving from the national target of 40 GW of rooftop solar by 2022. For this national target, the Ministry for New and Renewable Energy (MNRE) provides state level targets. According to MNRE, the target for the states of Gujarat and Delhi are 3.2 GW and 1.1 GW respectively (MNRE 2015). In order to calculate the local investment needs for rooftop solar, we need to further devolve state targets to the city level targets. In this study, we use principle component analysis to apportion the state targets to million-plus cities located in the state of Gujarat and districts in Delhi (see Appendix 3). The indicators that were used to assess cities and develop rooftop solar target scenarios are detailed in Appendix 3. These indicators are grouped into economic, technical and market acceptance, which we assume, would have a positive impact on the uptake of rooftop solar systems.

Once the city level targets are derived, this target is then further allocated to various sectors. For Scenario II, sectoral shares come from the Solar Cities Program plans while for Scenario III, the sectoral shares come from their respective existing energy consumption.

Rooftop Solar scenarios and potential targets for Surat

Table 3 shows rooftop solar scenarios for Surat across different market segments. In Scenario I, Surat shows a technical potential of up to 418 MW of rooftop solar by 2022, of which 6 MW has already been installed atop municipal buildings[13]; this means that the current target of installed rooftop solar capacity for Surat is 412 MW (Table 3).

Now, in Scenario II and III with devolved statewide targets, Surat would set a target to install roughly 75% more capacity than what the city has pledged in their Solar City Program plan (Scenario I).

Table 3: Rooftop solar target in Surat for three different scenarios

Sector	Scenario I	Scenario II	Scenario III
	Rooftop solar target in MW		
Residential	179.0	313.7	122.2
Commercial	50.0	88.0	79.4
Industrial	160.0	280.7	516.3
Public [a]	23.0	44.5	9.0
Total	412.0	726.9	726.9

a Includes buildings for governmental, education, health, social, recreational and religious services

13 According to interviews with officials in Surat conducted in November 2016

Solar rooftop scenarios and potential targets for New Delhi

Table 4 shows rooftop solar scenarios for New Delhi across different market segments. In its Solar City Program plan, New Delhi has stated a target of up to 7.2 MW of rooftop solar capacity (Scenario I), of which 2.1 MW has been installed atop governmental buildings, thus already meeting the rooftop solar target of 1.5 MW set under public sector. Hence, the outstanding solar rooftop target according to New Delhi's plan is 5.7 MW.

When devolving the state target of 1.1 GW, New Delhi would need to increase its rooftop solar target by more than 15 times (Scenario II and III). It should be noted that to achieve its renewable energy targets, Surat and New Delhi can also purchase renewable energy certificates (RECs) to compensate for the lack of rooftop solar capacity. New Delhi has been purchasing RECs in the past to meet its renewable energy obligations. Officials from both cities interviewed for this study, however, stated that they don't wish to be dependent solely on RECs to meet their obligations since the supply and price of RECs are variable.

Table 4: Rooftop solar target in New Delhi for three different scenarios

Sector	Scenario I	Scenario II	Scenario III
	Rooftop solar target in MW		
Residential	4.5	70.0	18.2
Commercial	1.2	18.8	89.5
Public	-	20.9	2.0
Total	5.7	109.7	109.7

5.3 Assessment of CAPEX costs for different rooftop solar scenarios and cities

> *To realize the full potential of rooftop solar capacities in India's cities, huge amounts of capital Investment will be needed. For example, the total investment required could be as high as INR 38,479 million in in Surat and INR 5,985 million in Delhi*

In this section, we calculate the capital needs for different rooftop solar scenarios and market segments in Surat and New Delhi. This analysis allows us to compare the cost for CAPEX / business-as-usual model to the proposed municipal bond-OPEX model.

As mentioned previously, in the CAPEX model for rooftop solar, consumers bear the entire upfront capital costs of the rooftop solar system. We have based our calculations on the current benchmark costs of rooftop solar set by the government (MNRE 2017 a), set at INR 70,000 for up to 10 kW, INR 65,000 for 10 - 100 kW, and INR 60,000 for 100 - 500 kW.

Importantly, our cost estimates are also based on the assumption that individual rooftop solar systems will in general not exceed 10 kWp and those of institutional, commercial and industrial customers will on average not exceed 100 kWp. In addition, our calculations also consider the different types of national and state-specific subsidies for rooftop solar consumers including the 30% capital subsidy from the Indian Government (see section 2.1). As part of the Solar City Program, Surat and New Delhi are also eligible for additional support in the form of grants[14].

CAPEX costs for different scenarios and market segments in Surat

Table 5 shows the estimated CAPEX costs for rooftop solar in Surat for the three different scenarios and sectors. Based on current prices for rooftop solar and subsidies, our calculations for Surat suggest that the total cost to achieve 412 MW through rooftop solar by 2022 (Scenario I) will be around INR 19,767 million. However, on the basis of the national target of 40 GW allocation among million-plus cities in Gujarat, Surat needs to take the burden of meeting the target of 727 MW (Scenario II and Scenario III), which would result in total costs of INR 34,873 million and INR 38,479 million respectively. The table below as well as the following subsections present more detailed costs estimates per sector and scenario. It is important to note that the proposed hybrid solar bond model in this report is most suitable (at least in the initial stage) for Surat's commercial and industrial sectors. If the municipal corporation is successful in aggregating these two sectors they can achieve 210 MW, 368 MW, and 595 MW capacity for the three scenarios respectively. Based on these figures if the city wants to raise a bond, its size will be in the range of INR 11,730 to 33,290 million. Thus, our analysis suggests that raising a bond based on Scenario III is more realistic given the size of other municipal bonds raised in the recent past.

Table 5: Estimated capex costs for rooftop solar in Surat for different scenarios and sectors

Sector	Scenario I	Scenario II	Scenario III
	Net cost of rooftop solar in INR Million		
Residential	6,981	12,235	4,764
Commercial	2,795	4,917	4,441
Industrial	8,944	15,693	28,858
Public [a]	1,047	2,028	416
Total	19,767	34,873	38,479

a Includes buildings for governmental, education, health, social, recreational and religious services

14 Under the Central Financial Assistance (CFA), up to INR 25 million will be provided to each pilot solar city for any renewable energy project or device installation. This is a conditional fund and is only provided if the same amount can be made available by the city administration or by the state. Additionally, up to INR 95 million will be provided through CFA to the solar city again with the condition that same amount must be arranged by the city administration/ district/state on their own or other sources including PPP. Besides these hard grants, the central government is willing to commit up to INR 4 lakh for seminars/ workshops trainings, awareness campaigns and a city can conduct up to 50 such events and maximum amount for these activities is restricted to INR 10 million.

Residential sector

In Scenario I and Scenario II, we expect the residential sector to make up the largest share of the rooftop solar capacity in Surat by 2022. Residential buildings make up approximately 81% of the total built space. Table 6 shows the CAPEX costs for rooftop solar installations on residential buildings in Surat for the three different scenarios. These costs include the 30% capital subsidy that residential rooftop solar owners can accrue from the central government, in addition to the INR 10,000 per kW subsidy from the Gujarat state government (GoG 2015 2016).

Table 6: Estimated capex costs for rooftop solar residential buildings in Surat

Cost for residential sector				
	Scenario I	Scenario II	Scenario III	Unit
Total solar installation	179	313.72	122.15	MW
Cost of 1 kW	70,000.0	70,000.0	70,000.0	INR
Total cost	12,530	21,961	8,550	INR Million
Central subsidy @ 30%	3,759	6,588	2,565	INR Million
State subsidy (capacity < 1 kW)	1,790	3,137	1,221	INR Million
Total subsidy	5,549	9,725	3,787	INR Million
Net cost for rooftop solar	6,981	12,235	4,764	INR Million

Public sector

Like residential consumers, public buildings such as municipal offices, religious structures, school and hospitals also enjoy subsidies from the central government. Compared to residential buildings, however, public buildings have the advantage of having large and continuous rooftop areas. Based on the benchmark price set by the government, the cost to install 1 kW of rooftop solar capacity is INR 65,000 on which the applicant gets 30% subsidy from the national government. As Table 7 shows, estimated CAPEX costs expectedly differ between the different scenarios. When we compare Scenario I and II with Scenario III, it is clear that the costs for rooftop solar on public buildings will be higher if we set this market segment to install more capacity.

Table 7: Estimated capex costs for rooftop solar on public buildings in Surat

Costs for public buildings				
	Scenario I	Scenario II	Scenario III	Unit
Total solar installation	23,000.0	44,577.0	9,138.2	kW
Cost of 1 kW	65,000.0	65,000.0	65,000.0	INR
Total cost	1,495	2,898	594	INR Million
Central subsidy @ 30%	449	869	178	INR Million
Net cost for rooftop solar	1,047	2,028	416	INR Million

Commercial sector

Commercial customers currently pay INR 4.50 per kW in addition to monthly fixed costs (TPL 2016). However, we expect the cost for conventional energy to increase by 3-4% annually (TERI 2016). In order to encourage commercial consumers to move to rooftop solar, the government of India has a program under which they are eligible to claim tax rebates on accelerated depreciation of 40% for rooftop solar systems. Despite these subsidies, our calculations indicate (Table 8) that rooftop solar remains well above grid power tariffs, at least in the short-term under a CAPEX model. Table 8 shows by how much CAPEX costs for rooftop solar on commercial buildings in Surat differ across scenarios.

Table 8: Estimated capex costs for rooftop solar on commercial buildings in Surat

Costs for commercial buildings				
	Scenario I	Scenario II	Scenario III	Unit
Total solar installation	50,000.0	87,960.0	79,449.2	kW
Cost of 1 kW	65,000.0	65,000.0	65,000.0	INR
Total cost	3,250	5,717	5,164	INR Million
Accelerated depreciation @ 40%	1,300	2,287	2,065	INR Million
Corporate tax @ 35%				
Tax saved through depreciation	455	800	723	INR Million
Net cost of rooftop solar plant	2,795	4,917	4,441	INR Million

Industrial sector

Surat is mainly known for its textile and diamond industries. Within the municipality limits, almost 10% of the area is under industrial use whereas in the larger development (Surat Urban Development Area- SUDA) area, more than 20% of the area is under industries. Most of the textile units also depend on power generated from diesel, which costs around INR 16-18 per KW (TERI 2016). Industrial consumers pay the same amount of INR 4.90 tariff per KW, plus some additional charges, but also benefit from the government's tax rebates on accelerated depreciation of 40% for rooftop solar systems. This can provide significant saving to industrial consumers, as they pay only 35% tax on the depreciated value of the plant and machinery. Table 9 shows how the CAPEX costs for rooftop solar on industrial buildings in Surat differs between the different solar rooftop scenarios.

Table 9: Estimated capex costs of rooftop solar on industrial buildings in Surat

Costs for industrial buildings				
	Scenario I	Scenario II	Scenario III	Units
Total solar installation	160.00	280.74	516.26	MW
Cost of 1 kW	65,000.0	65,000.0	65,000.0	INR
Total cost	10,400	18,248	33,557	INR Million
Accelerated depreciation @ 40%	416	7,299	13,423	INR Million
Corporate tax @ 35%				
Tax saved through depreciation	1,456	2,555	4,698	INR Million
Net cost of rooftop solar plant	8,944	15,693	28,858	INR Million

CAPEX costs for different scenarios and market segments in New Delhi

Table 10 shows the estimated CAPEX costs for rooftop solar in New Delhi for the three different scenarios described in section 5.2 and their associated market segments. Based on the current prices for rooftop solar, national and state subsidies, we estimate that the total cost to achieve the current target of 7.2 MW through rooftop solar by 2022 (Scenario I) will be around INR 342 million. However, on the basis of the national target of 40 GW allocation among million-plus cities in the state of Delhi, New Delhi will have to take the burden of meeting the target of 109.8 MW (Scenario II and Scenario III)) which would result in total costs of INR 5,431 and INR 5,985 million respectively. Table 10 as well as the following subsections presents more detailed CAPEX costs estimates per sector and scenario. Note that due to its miniscule size and share in energy consumption, the industrial sector is not considered in New Delhi. Similar to Surat, if we draw a realistic bond model for New Delhi, its residential and commercial sectors under Scenarios II and III provide the best opportunities. If we combine the capacities of these sectors, we can achieve a total of 89 MW and 107 MW. Based on these figures, we can raise a bond with a size range of INR 447.8 to 589.3 million.

Table 10: Estimated capex costs for rooftop solar in New Delhi for different scenarios and sectors

Sector	Scenario I	Scenario II	Scenario III
Net cost of rooftop solar in INR Million			
Residential	219	3,430	893
Commercial	67	1,048	5,000
Public [a]	-	953	92
Total	286	5,431	5,985

a Includes buildings for governmental, education, health, social, recreational and religious services

Residential sector

The residential sector of New Delhi consumes 16% of the city's total electricity consumption. According to the government's benchmark costs, rooftop solar will cost an estimate of INR

70,000 per kW. Homeowners who install rooftop solar are eligible for a 30% capital subsidy from the central government along with a state level subsidy of INR 2 per kWh. The latter subsidy is specific to Delhi state, which comes under the Generation Based Incentive (GBI) (GNCTD 2016). GBI is applicable only for residential customers with a minimum generation eligibility criteria of 1,100 kWh per year (capping at 1,500 kWh), and the subsidy is given on gross solar energy generated. This scheme started on January 1, 2016 and will run for three years, until the end of 2018.

Table 11 shows the costs for rooftop solar on residential buildings in New Delhi for the three different scenarios. The estimated costs to comply with New Delhi's Solar City Program Plan (Scenario I) would be INR 219million. The costs for the residential sector would increase by more than 15 times if the statewide target would be devolved based on New Delhi's Solar City Program (Scenario II). If the target would be devolved based on the actual electricity consumption (Scenario III), the required investment would increase by more than 4 times over Scenario I.

Table 11: Estimated capex costs for rooftop solar on residential buildings in New Delhi

Costs for residential buildings				
	Scenario I	Scenario II	Scenario III	Units
Total solar installation	4.47	70.00	18.23	MW
Cost of 1 kW	70,000.0	70,000.0	70,000.0	INR
Total cost	313	4,901	1,276	INR Million
Central subsidy @ 30%	94	1470	383	INR Million
State subsidy (INR 2 per kWh)	00.01	00.14	00.04	INR Million
Total subsidy	94	1470	383	INR Million
Net cost for rooftop solar	219	3430	893	INR Million

Public sector

In New Delhi, a considerable percentage of land is under government jurisdiction, which includes government buildings, historic, religious, and community purpose buildings, public parks, and markets. Under the Solar Master Plan (Scenario I), New Delhi has set a target of 1.5MW for this sector. The latest data shows that the city has already achieved this target. Here, the CAPEX costs will be between INR 953 million and 92 million for Scenario II and III respectively (Table 12); assuming rooftop solar systems on public buildings can benefit from the same capital subsidy and capacity benchmark.

Table 12: Estimated capex costs for rooftop solar on public buildings in New Delhi

Costs for public buildings				
	Scenario I	Scenario II	Scenario III	Units
Total solar installation	-	20.95	2.01	MW
Cost of 1 kW	-	65,000.0	65,000.0	INR
Total cost	-	1,362	131	INR Million
Central subsidy @ 30%	-	409	39	INR Million
Net cost of rooftop solar plant	-	953	92	INR Million

Commercial buildings

Commercial buildings are one of the dominant features of New Delhi. Given the nature and purpose of the buildings (service sector firms, corporate offices, and shops), this sector consumes the largest amount of electricity, at almost 80 percent of the total energy in the city. However, given their small rooftop footprint, there is a limited opportunity to install rooftop solar systems in this sector. As Table 13 shows, the capital cost to install the solar rooftop capacity outlined in New Delhi's Solar City Program Plan (Scenario I) is INR 67 million. If we consider the current energy consumption (Scenario III), the CAPEX costs for the other Scenarios (I and II) are considerably higher.

Table 13: Estimated capex costs for rooftop solar on commercial buildings in New Delhi

Costs for commercial buildings				
	Scenario I	Scenario II	Scenario III	Unit
Total solar installation	1.20	18.74	89.46	MW
Cost of 1 kW	65,000.0	65,000.0	65,000.0	INR
Total cost	78	1218	5,815	INR Million
Accelerated depreciation @ 40%	31	488	2,326	INR Million
Corporate tax @ 35%				
Tax saved through depreciation	11	17	814	INR Million
Net cost of rooftop solar plant	67	1,048	500	INR Million

5.4 Estimated impact of municipal bonds on indicative costs for rooftop solar in Surat and New Delhi

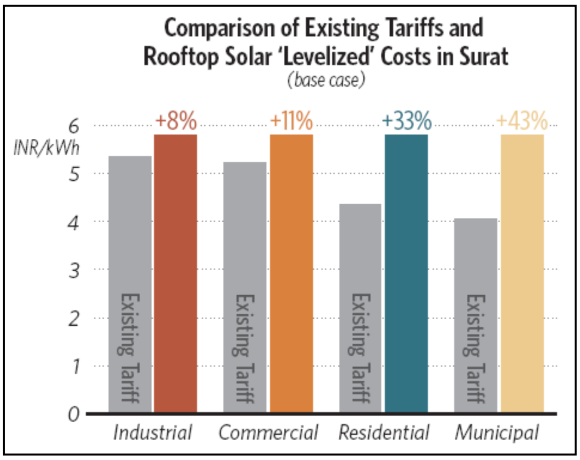
In this section, we estimate the potential savings from municipal bonds for rooftop solar projects in Surat and New Delhi. The calculations below show that municipal bonds lower the cost of rooftop solar power. This is primarily because municipalities can raise debt-based capital at much lower rates than private developers.

Figure 6 and 7 compare existing tariffs for different market segments in Surat and New Delhi with levelized cost of electricity (LCOE) of INR 5.79 per kW/h of rooftop solar without municipal bonds (base case) and LCOE of INR 5.12 per kWh with municipal bonds. The cost difference between these two LCOEs is due to the difference in the cost of debt capital and the difference in the debt tenor. We base this on the assumption that municipalities can raise debt-based capital at a lower rate than commercial rooftop solar developers can and also the debt raised through bond market would be relatively longer than the tradition commercial loan raised from banks. We base our first LCOE on a repayment period of 12 years and a fixed interest rate of 11.5%. The second LCOE, which is backed by a municipal bond, has a repayment period of 15 years and a fixed interest rate of 8% (close to recent PMC's municipal bond).

Municipal bonds can make rooftop solar power less expensive than current commercial and industrial tariffs in Surat. As figure 6 shows, the municipal bonds can bring the LCOE of rooftop solar below the existing tariffs for commercial and industrial customers in Surat. Municipal bonds would also reduce the costs of rooftop solar power for residential and municipal (public) consumers in Surat. However, the existing electricity tariffs for the two sectors are much lower.

Similarly, municipal bonds can bring down the cost of rooftop solar power in New Delhi where it is already cheaper than existing tariffs across the consumer categories. As shown in Figure 7, using municipal bonds to finance rooftop solar projects will further the case of rooftop solar in New Delhi.

Figure 6: Comparison of existing electricity tariffs with rooftop solar LCOE with and without municipal bonds for Surat



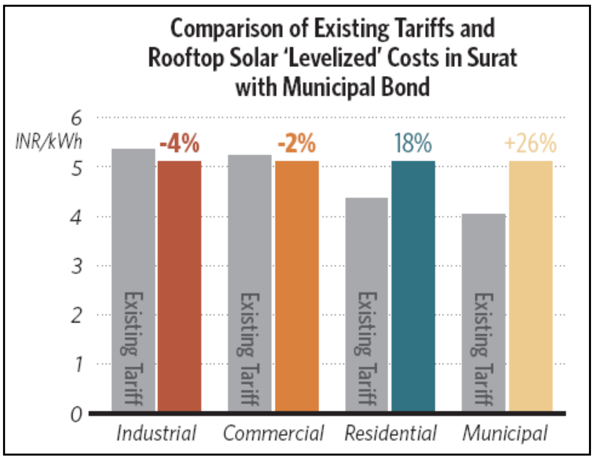
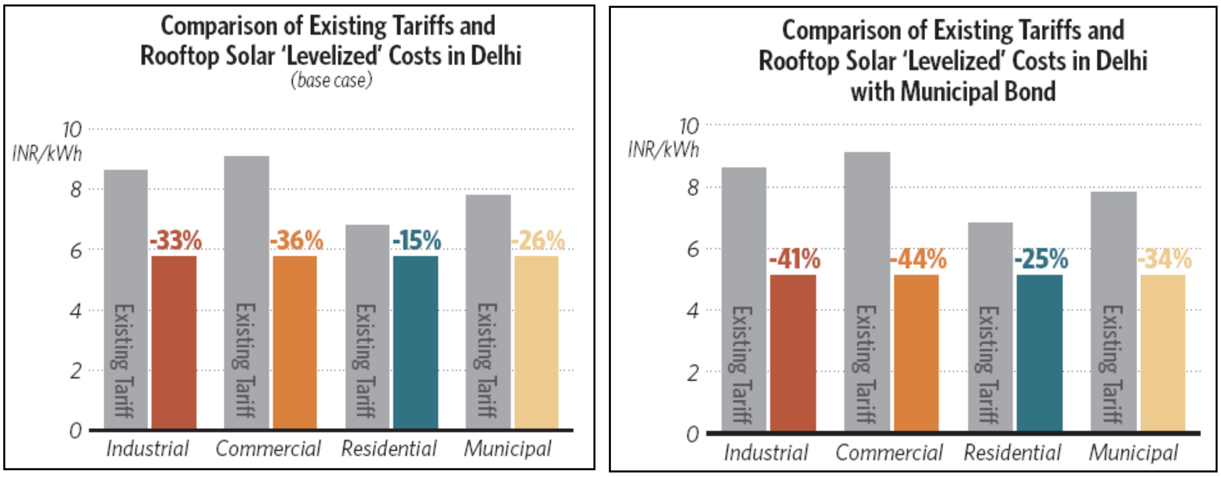


Figure 7: Comparison of existing electricity tariffs with rooftop solar LCOE with and without municipal bonds for New Delhi



Our results clearly indicate that municipal bonds can help lower the LCOE of rooftop solar in both case studies: Surat and New Delhi. For both cities, costs of solar power can go down by 11.5% compared to the base case. In Delhi, the benefits are even more significant, as the existing tariff levels are much higher than in Surat for all consumer categories. Here LCOE of rooftop solar even without lower borrowing costs from municipal bond are already below existing tariffs across all market segments, and municipal bonds can make the technology even more attractive to residential, governmental, commercial and industrial consumers.

Overall, these results suggest that municipal bonds can be an important alternative step in promoting the OPEX model of rooftop solar in India across different market segments and cities.

6. Moving forward with the municipal bond OPEX model for rooftop solar in India

This study has proposed municipal bond financing to help urban governments and private developers jointly raise capital and deploy rooftop solar systems at a scale needed to achieve India's ambitious goal of 40 GW installed capacity by 2022. In this final section, we suggest measures to address challenges in using municipal bonds to support the OPEX model for rooftop solar deployment, and lay out a roadmap for local governments and national authorities to scale up municipal bonds using the OPEX model.

6.1 Recommendations to address challenges of Municipal Solar Bonds

For the proposed municipal bond OPEX model to be successful in India, policymakers, municipal corporations, regulators, and other stakeholders will need to address the key challenges of municipal bonds discussed earlier. Despite its promise, implementation barriers remain, and are described below in the order of their criticality:

- **There is no statutory mandate for municipal corporations to promote electricity generation:** The municipal functions listed under the 12th Schedule of the 74th

Constitutional Amendment do not include power generation. Though Municipal Corporations would play limited roles as financiers in the proposed model, this may prove to be the most significant barrier.

- **Solar municipal bonds would need to achieve high credit ratings:** India's debt capital market is relatively shallow, with credit ratings below AA. Hence, high credit ratings of the municipal bonds would be critical to the success of the model.

- **Municipalities are required to provide minimum equity contribution of 20% of the project cost:** According to Section 12 (5) of SEBI's Regulations[15], municipalities would need to provide 20% of project costs as equity. Since most municipalities are struggling to meet the investment demand for basic infrastructure services, this regulation will be hard to meet.

- **Absence of supporting regulations will hinder municipal corporations to act as a financial company:** In the proposed transaction structure, proceeds of the bond would be disbursed to projects via capital lease arrangements. Since capital leases are mostly executed by financial entities, in the absence of any specific regulation, municipalities might be reluctant to act as the finance aggregators.

- **Reluctance of Municipal Corporation to issue bonds:** Raising municipal bonds requires market based due-diligence of the financial books. This due diligence is difficult as most of the municipal corporations in India still do not follow transparent accounting practices.

- **High transaction cost:** One potential downside of the proposed model is that transaction costs could be higher than either self-ownership or third party financing models, mainly due to the novelty of the approach.

In Table 14, we focus on the top solutions/recommendations for the most critical barriers, as well as their potential impact and feasibility. We define "impact" as the ability of the proposed recommendation to address the challenge, and "feasibility" as the likelihood of implementation for the proposed recommendation.

The proposed model, though radical and futuristic, is crucial if India wants to achieve its rooftop solar target by 2022. If we are able to successfully address the barriers highlighted in the above table, it will not only help rooftop solar to scale up its growth, but also help municipal corporations to use the proposed model for other priority infrastructure projects.

Next steps include further analysis in future work, particularly on an appropriate incentive mechanism to involve municipal corporations to act as financiers for private projects, which this study does not cover.

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15 Securities and Exchange Board of India (Issue and Listing of Debt Securities by Municipalities) Regulations, 2015

Table 14: Potential Solutions to improve the feasibility of the proposed model

BARRIERS	SOLUTIONS/RECOMMENDATIONS	KEY PARTICIPANT	IMPACT	FEASIBILITY
There is no statutory mandate for municipal corporations to promote electricity generation.	Introduce amendments in state and national legislation to allow municipal corporations to facilitate electricity generation projects.	Legislative bodies at State and Central level	High	Low
Solar municipal bonds would need to achieve high credit ratings	Use instruments such as Partial Credit Guarantees (PCG)[a] or first-loss funds to enhance the credit rating of the bond.	Institutes such as USAID[b], IREDA[c] etc. can provide PCG while MNRE can capitalize first-loss fund using National Clean Energy Fund (NCEF)	High	Medium
	Select consumers (off-takers) through proper due diligence, so that only the credit-worthy consumers are eligible to install solar rooftop projects.	Municipal Corporation with the help of credit rating agencies.	High	Medium
	To address off-taker risk, use property-assessed clean energy (PACE).	Municipal Corporations	Medium	Low
Municipalities are required to provide minimum equity contribution of 20% of the project cost	Introduce regulatory changes to waive off this requirement. However, the proposed transaction structure attempts to overcome this barrier by proposing the capital lease mechanism, where project developers will make an upfront advance payment. This should help in compensating for the equity capital contribution.	SEBI	Medium	Low
Absence of supporting regulations will hinder municipal corporations to act as a financial company	Introduce amendments in regulations to allow municipal corporations to act as financiers for clean energy generation projects. Both for its own consumption and for the use of private consumers.	SEBI and Ministry of Finance	Medium	Low
Reluctance of Municipal Corporation to issue bonds	Build its capacity to overcome this structural issue with the help of relevant entities.	Ministry of Finance, USAID, World Bank	High	Medium
High transaction cost	Pool the solar rooftop projects across the municipal corporations (cities). This would increase the bond issuance size and hence may bring down the transaction cost.	MNRE, Ministry of Finance	Low	Medium

a We also estimated an indicative size of PCG, which can enhance the credit rating of a municipal bond for rooftop solar project as shown in Appendix 4.

b United State Agency for International Development (USAID) is the lead U.S. Government agency that works to end extreme global poverty and enable resilient, democratic societies to realize their potential.

c Indian Renewable Energy Development Agency Limited (IREDA) is a Government of India backed non-banking financing company (NBFC) under the administrative control of Ministry of New and Renewable Energy (MNRE).

6.2 Roadmap for local governments and national authorities

In the final section of this report, we propose a roadmap for local governments and national authorities to use municipal bonds to scale up rooftop solar capacity and to fund OPEX projects. Some of the below mentioned steps would be performed in parallel rather than sequentially.

Step 1: Project Development Plan

To start the processes of using municipal bonds to finance the rooftop solar developers under the OPEX model, municipalities would be required to develop detailed project plans. Municipal Corporations can take the help of Solar Energy Corporation of India (SECI) Limited, which is implementing a large-scale grid connected rooftop solar project and is already in Phase 4 (SECI 2017). We describe the key sub-steps below:

1. Assess of the potential solar rooftop capacity. Primary target markets would be municipal, governmental, commercial, and industrial consumers as most of the savings in electricity cost would be in these consumer categories.

2. Engage with project developers and consumers to understand their requirements.

3. Select developers who can participate in this program based on pre-defined selection criteria.

4. Estimate the capital investment requirement based on the solar rooftop potential assessment.

5. Depending on the case, develop an investment plan for the project components including phasing as well as financing approved by the local authority or the agency.

6. Mobilize the capital structure of the projects with proposed funds.

7. Require project developers to submit project feasibility reports to Municipal Corporations, which can then be used by the corporations to obtain a 'Viability Certificate' from the public financial institution[16].

8. Select the viable projects that would be eligible to get funding through municipal bond.

9. Require project developers to sign a standardized PPA with consumers. A standardized PPA would provide more comfort to the bond investors.

The key entities involved in these steps include municipal administrations, project management companies (PMC) or a Solar Cell Unit if the municipality is part of the Solar City Program, legal advisors (for capital lease agreement formulation and drafting standardized PPAs), project developers to create project SPVs, and consumers.

Step 2: Creating a Master SPV

In the next step, municipalities should incorporate corporate municipal entity (CME) or the master SPV, which would document its assets, liabilities and equity on its own balance sheet rather than on the municipalities' balance sheet. This arrangement would help municipalities

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16 As per the regulations on Issue and Listing of Debt Securities by Municipalities Regulations by the SEBI, the public issue of debt securities can take place only when the issuer can show evidence of the project being financially viable. According to Section 7 (6). of the regulations, "The issuer shall, before filing of draft offer documents with the Board, obtain a "Viability Certificate" or Detailed Project Appraisal Report (DPR) from a scheduled commercial bank or public financial institution, stating that the project is financially viable, based on the estimates/assumptions available at the time"

with their management of assets and liabilities, lower risks, achieve higher credit ratings, lower funding costs, improve financial flexibility, and lower capital requirements. The key responsibility of the CME would issue the municipal bond and enter into the capital lease obligations with the project SPVs owned by private project developers.

Creation of CME would follow guidelines similar to those proposed by the government for the Smart City Program. The only difference would be that it may not have any nominee from the central government and focus would be on solar power generation projects only. The majority of shares in the SPV would be controlled by the municipal government, while some of the shares would be controlled by the state government. The key functions and responsibilities of the Master SPV would be similar to a SPV under the Smart Cities Mission.

The key entities involved in this step include municipal governments, state governments finance commission, and project SPVs.

Step 3: Credit rating assessment of the bond issuance

Some institutional investors, such as pension funds are not allowed to purchase non-rated securities. Credit rating agencies would determine the credit rating of municipal bonds. This rating will differ from municipalities' credit rating, as the proposed bond would be issued by an SPV as a part of structure transaction. The steps for credit rating assessment are as follows:

1. Preliminary analysis on financial health of projects would be done by the credit rating agencies.

2. An exploratory meeting would be conducted during which information is given about the criteria for assigning a rating and requirements to obtain a final rating.

3. Rating agencies would then develop the credit assessment. The analysis of contracts stipulated by the Master SPV helps in the credit assessment, and by reviewing the term sheets, financial models, expected revenues, cashflow models, liabilities, and risks of CME and project SPVs. Independent advisors would also be required to assist the municipalities in this process.

4. After successful completion of the above steps, the credit rating agencies publish the final credit rating.

The key entities involved with this step include the master SPV, project developers, and credit rating agencies.

Step 4: Credit enhancement measures

Credit enhancement measures would be required to reduce repayment risk and to raise the issuance rating to the required investment grade so that institutional investors are able to invest in such debt issuances. Some of the popular measures to do credit enhancement are specific revenue pledges or ring fencing cash flows to support the bond service payments to the bondholders in addition to the project cash flows; securing credit guarantees from national or multinational development finance agencies.

The key entities involved in this step include credit rating agencies, development finance agencies, and state and/or central government.

Step 5: Identifying an underwriter for the bond issuance

The final step before offering the bond on the market is to find an underwriter of the bond. In most cases, this would be an investment bank. This step would also finalize the transaction structure, bond pricing, placement location (domestic or foreign), and draft offer documents.

The key entities involved in this step include underwriters such as Investment banks, municipalities, project SPVs and state, and/or governmental if either provides credit guarantees.

Step 6: Identify the cornerstone investor

The final step is to identify a cornerstone investor (a key private or institutional investor) who would subscribe the significant portion of the issued bond. Securing a cornerstone investor such as multilateral banks can add legitimacy and credibility to a municipal bond. While it helps in reducing the credit risk, it also increases investor’s confidence in the bond, the municipality’s capacity to manage the project and the OPEX model of rooftop solar.

The key entity involved in this step is the underwriter**.**

Step 7: Other Steps

1. Identify a loan originator who is ready to provide a short-term loan in the initial phases of the project. This loan would be then refinanced through the capital raised by municipal bond. A warehouse line of credit would also be required to hold the projects in their initial stages.

2. Create an escrow account. This account would be required to hold the PPA payments and disburse the lease payments to the main SPV and the remaining to the project developers.

3. The escrow account may also be used to hold the capital for credit enhancement measures.

4. Acquire certification from the Climate Bond Initiative or World Bank. This would be helpful in attracting a certain class of investors, which are either mandated to invest in climate change or those investors which strategize their investments with regards to climate change/sustainable development.

5. Purchase and transfer project assets from the master SPV to project SPVs via capital lease agreement.

6.3 *Conclusion*

While India has been a frontrunner with respect to ambitious targets for rooftop solar, the probability of India achieving these targets by 2020 remains low, especially because of the policy hurdles and the current deployment rates.

Our study reveals that even if cities meets the city-level Solar City Program targets, these set goals are too modest to add up to what the specific states require in order for India to achieve the over-arching goal of 40 GW by 2020. In our case study cities of Surat and New Delhi, required investment to reach the national target could go as high as INR 38.5 billion and INR 6 billion, respectively at cost-effective terms. Hence, there is an urgent need for innovative interventions to promote and finance rooftop solar deployment.

This study shows that access to cheaper finance via municipal bonds would go a long way in promoting renewable energy deployment. In particular, municipal bonds employed for the OPEX business model can take advantage of lower debt costs, which lowers the levelized cost of rooftop solar and makes rooftop solar power cost competitive in many states of India across market segments. Under the assumption that the observed fall in prices in the solar sector continues, we expect the rooftop solar power financed by municipal bonds and managed by private developers to achieve grid-parity in the residential, public, commercial and industrial sector across India in the coming years.

However, to fully exploit the potential of the solar municipal bond model and address its challenges, municipalities, governments, finance institutions, and other stakeholders need to take several measures. These measures should include initiatives to promote municipalities' engagement in electricity generation, improve implementation of net-metering policies, ease regulatory difficulties for municipalities to issue bonds and build financial partnerships with local rooftop solar developers, and enhance municipal credit ratings. These steps would require a higher level of policy coordination between local and national authorities and financial institutions, with greater financial transparency at the municipal government level.

If these steps are taken, solar municipal bond model can significantly contribute to India's goal of 40 GW rooftop solar by 2022. In addition, municipal bond issuance would offer municipal governments an opportunity to build capacity in project management and gain experience in raising capital from the capital markets. Given the steady and assured stream of revenues expected from the rooftop solar projects, this engagement with markets would open up doors for future engagements to finance other essential urban services as well (such as water, sanitation, etc.), which may require even greater debts. Therefore, this model provides a 'soft landing' option for municipal governments seeking large future funding sources. Furthermore, successful partnerships between municipalities, state and national governments, and private developers also create significant economic and social benefits for sustainable urban development. Next steps include further analysis in future work, particularly on an appropriate incentive mechanism to involve municipal corporations to act as financiers for private projects, which this study does not cover.

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Appendix 1: Cost estimates for rooftop solar in India by 2022

Appendix Table 1.1: Cost for Residential Sector

Cost for residential sector		Units
Total solar installation target	6,445,074	kW
Special States	444,710	kW
Rest of India	6,000,364	kW
Cost of 1 kW	70,000	INR
Total cost for special states	3,113	INR Cr
Total cost for special states after 70% subsidy	934	INR Cr
Total cost for rest of India	42,003	INR Cr
Total cost for rest of India after 30% subsidy	29,402	INR Cr
Net rooftop solar cost	30,336	INR Cr

Appendix Table 1.2: Cost for Public Sector

Cost for public sector		Units
Total solar installation target	3,093,536	kW
Special States	213,454	kW
Rest of India	2,880,082	kW
Cost of 1 kW	65,000	INR
Total cost for special states	1,387	INR
Total cost for special states after 70% subsidy	416	INR
Total cost for rest of India	18,721	INR
Total cost for rest of India after 30% subsidy	13,104	INR
Net rooftop solar cost	13,521	INR Cr

Appendix Table 1.3: Cost for Industrial Sector

Cost for industrial sector		Units
Total solar installation target	17,157,876	kW
Cost of 1 kW	65,000	INR
Total cost	1,115,261,941,365	INR
Total cost	111,526	INR Cr
Accelerated depreciation @ 40%	44,610	INR Cr
Corporate tax	@ 35%	
Tax saved through depreciation	15,613	INR Cr
Net cost of rooftop solar plant	95,912	INR Cr

Appendix Table 1.4: Cost for Commercial Sector

Cost for commercial sector		Units
Total solar installation target	12,056,513	kW
Cost of 1 kW	65,000	INR
Total cost	783,673,408,635	INR
Total cost	78,367	INR Cr
Accelerated depreciation @ 40%	31,346	INR Cr
Corporate tax	@ 35%	
Tax saved through depreciation	10,971	INR Cr
Net cost of rooftop solar plant	67,396	INR Cr

Appendix 2: Assumption for rooftop solar LCOE model

Calculation of Levelized Cost of Electricity: The levelized cost of electricity (LCOE) is the average cost of electricity that helps to break even, in terms of the return expected by the developer. It represents the minimum unit revenue required to meet all the cost including the return on equity, given the project's financial parameters. Following table (Appendix Table 2.1) highlights the key input parameters used in a typical project cash flow model to arrive at the levelized cost of electricity (LCOE) of rooftop solar project.

Drivers of LCOE: Several factors such as return on equity (ROE), interest rate, capital expenditure (CAPEX), debt-tenor and capacity utilization factor (CUF) influence the LCOE. Using project level cash flow model, we assessed that the LCOE is highly sensitive to capex and CUF while other factors moderately impact the LCOE. CAPEX, ROE, interest rate has the direct proportionate impact on the LCOE while the CUF and the tenor of debt inversely impact the LCOE.

Appendix Table 2.1: Assumptions for rooftop solar LCOE model

Assumptions for rooftop solar LCOE model	
Power Generation	
Capacity Utilization Factor (P50 PLF)	19%
Useful Life	25 years
Capital Cost	
Average Capital Cost (INR million/MW)	60[a]
Operating Expense	
O & M Expenses(1st Year) (INR million/MW)	0.5
Escalation in O & M Expenses	4.0%
Financial Assumptions	
Debt to Equity Ratio	70%
Minimum Debt Service Coverage Ratio (DSCR)	1.2
Repayment Period	12 years
Interest Rate (Fixed)	11.50%
Expected Return on Equity (Post tax)	14%
Tax Incentive	
Tax Exemption u/s 80 IA (up to first 10 Years)	100%
Minimum Alternative Tax	23.55%

a The capital cost of INR 60 million/MW has been taken under the assumption that the rooftop solar projects would be of more than 100 kW.

Appendix 3: Principle component analysis to devolve national and state- wise rooftop solar targets

We use the principal component analysis (PCA) to examine and quantify the key factors for renewable energy deployment and use those to derive targets at a city level. Principal component analysis (PCA) is a statistical technique used for data reduction. The leading eigenvectors from the Eigen decomposition of the correlation or covariance matrix of the variables describe a series of uncorrelated linear combinations of the variables that contain most of the variance (STATA, 2014). In addition to data reduction, the eigenvectors from a PCA are often inspected to learn more about the underlying structure of the data and generating weights. We used Kaiser Criterion[17] to derive the weights; we calculated the sum of squared loadings for components one to three. We then standardized the specific indicator values for each of the cities, according to the maximum-minimum formula. A list of factors used in the PCA, Appendix Table 3.1 details the rationale for their selection. We have grouped these factors into three types of categories: economic, technical and market acceptance. We took cities with more than one lakh inhabitants in the state of Gujarat and districts with more than one million inhabitants in Delhi for sample assessment. As the urban areas contribute the most to electricity consumption and have higher affluence levels to absorb the comparatively high costs of renewable technologies, most of the rooftop solar would be met by urban areas. Supportive urban governance systems would help with greater diffusion as well.

Appendix Table 3.1: Factors determining RE deployment

	Variables	Rationale	Data Source
I. Economic Factors			
1.	Number of electricity consumers	Potential market for RE	Central Electricity Authority Electricity Authority, Census 2011
2.	Per capita electricity consumed	-do-	NSSO Consumption expenditure survey for Urban Districts (alternatively electricity sold in a district /electricity consumers- from state websites)
3.	Electricity Cost (grid)	Willingness to pay	NSSO Consumption expenditure survey, Discom Reports
II. Technical Factors			
5.	City Population	Constraint on allocation	Census 2011
6.	DISCOMfinances	Ability of DISCOMs to absorb RE	Power Finance Corporation's document on DISCOM finances
III. Market Acceptance Factors			
7.	Number of households using internet	Population receptive to new technologies	NSSO Consumption expenditure
8.	Governance systems	City Budgets/ Property tax coverage	City documents
9.	-do-	Service Coverage	Census 2011
10.	Affluence	Affluent households to absorb initial high costs (Households with TV, Computer/Laptop, Tele- phone/mobile phone and Scooter/ Car)	Census 2011

17 selecting components that have eigen values greater than 1

Our results show that built up space, population size, affluence levels and internet usage i.e. receptiveness to new technologies have been given the highest weights. Appendix Table 3.2 presents the specific figures for index weights. These index weights have been used to calculate each city's performance and to devolve the renewable energy targets.

Appendix Table 3.2: Indicator weights according to the PCA analysis

S. No.	Variables	Index Weights	
		Surat	**NDMC**
1	Electricity consumption price	12%	14%
2	Per capita elec. consumption	10%	13%
3	Built up urban area	13%	12%
4	Number of households	13%	12%
5	Proportion of affluent households	12%	14%
6	Internet using households	13%	13%
7	City tax collection	10%	-
8	Households with treated water in taps	9%	13%
9	Discom revenues	8%	9%

Economic	• Affluent households • Electricity Consumption • Electricity prices
Technical	• Built up area • Number of households • DISCOM financials
Acceptance	• Reliability of current governance systems • Acceptance towards new technology (e.g.internet)

Appendix 4: Credit Enhancement Requirements for Solar Municipal Bond

For the illustration purpose, we have also estimated the expected size of the PCG using the cash flows of a typical solar rooftop project. Note that these numbers are just an estimate and actual size may differ based on the actual project cash flow. In this illustration, we have used the India Rating's methodology to arrive at the size of the PCG. The PCG requirement, to enhance the credit rating of any debt instrument depends on several factors. These factors usually include the standalone rating of the bond issuer, rating of the guarantor, nature of cash flows of the issuer, and nature of guaranteed debt. To arrive at the indicative size of PCG required and in order to lift the credit rating to a certain target level i.e. AA in this case, we used debt service coverage ratio (DSCR) as the control output variable. An indicative rating of a typical infrastructure project with a minimum DSCR of 1.20 is BBB and to lift the rating to AA, the DSCR must improve to 1.7. It is important to mention here that to get a minimum DSCR of 1.2 without any credit guarantee, we have assumed a LCOE of INR 6.8/kWh for the sample project cash flow. Based on these parameters, we estimated that the minimum size of the PCG required to lift the credit rating from BBB to AA would be ~31% of the total debt principal. As per the usual practice and past experiences, we have observed that PCG underwriters have provided up to 50% of the total debt as PCG. Hence, if we increase the PCG size to 50%, then we can expect even lower LCOEs.

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