ROOFTOP REVOLUTION:

Unleashing Chennai's & Hyderabad's Rooftop Potential


The solar thermal plant set up by Trans Solar Technologies, in collaboration with Holy Family Hospital, New Delhi.
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Solar Power: Photovoltaic Installation on University Roof.
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ABBREVIATIONS

AD	Accelerated Depreciation
APPC	Average Pooled Purchase Cost
CEIG	Chief Electrical Inspector to Government
CMDA	Chennai Metropolitan Development Authority
DisCom	Distribution Company
DT	Distribution Transformer
EHT	Extra High Tension Line
ESRI	Environmental Systems Research Institute
FID	Field Identity Number
FiT	Feed-in Tariff
GBI	Generation Based Incentive
GCC	Greater Chennai Corporation
GHG	Greenhouse Gas
GHMC	Greater Hyderabad Municipal Corporation
GIS	Geographical Information System
GW	Giga Watts
HT	High Tension Line
kW	Kilowatt
kWh	Kilowatt hour
MNRE	Ministry of New and Renewable Energy
MW	Mega Watts
NCPRE	National Centre for Photovoltaic Research and Education
NGA	National Geospatial-Intelligence Agency
PID	Plot Identity Number
PV	Photovoltaic
RESCO	Renewable Energy Service Company
RTPV	Rooftop Solar Photovoltaic
SRS	Stratified Random Sampling
SERC	State Electricity Regulatory Commission
TNEB	Tamil Nadu Electricity Board
TNERC	Tamil Nadu Electricity Regulatory Commission
TSERC	Telangana State Electricity Regulatory Commission
UNDP	United Nations Development Program
USGS	United States Geological Survey

PREFACE


Solar Powered Night School in India.
© Marcus Franken / Greenpeace

In the run up to the Paris climate talks in 2015, India announced a goal of having 100 GW installed solar capacity by 2022, of which 40 GW would come from rooftop solar/distributed sources. No other country at a similar position on the development ladder has such ambitious clean energy targets, and this has allowed India to justifiably lay claim to a leadership position in tackling the global climate challenge.

India remains energy-deficit, with hundreds of millions having no or inadequate access to electricity. At a time when pollutants from fossil fuels have created an air quality crisis across virtually every Indian city, the ability to generate electricity without contributing to the air pollution problem is invaluable. Solar (and wind) energy is vital to meet India's goal of ensuring electricity access to all households, without also worsening the country's air quality through fossil fuel combustion. On the climate front, if humanity is to successfully keep global temperature rise as close to 1.5°C as possible, India will have to do its part to reduce the carbon intensity of its growth, even as it works to improve the quality of life of its poor. At a time when climate change influenced weather events have exacted a devastating toll in India and across the world, the win-win benefits to constraining the growth in India's carbon emissions is clear.

Since the 100 GW solar target has been announced, utility-scale solar in India has progressed well, with costs falling and installations growing fast.

However, progress in the rooftop/distributed segment has been slow, with less than 1861[1] MW installed as of September 2017. While growth rates are high, this is from a virtually non-existent base, and at the current trajectory, India will fall far short of the 40 GW target by 2022. This is despite significant policy incentives at the national level (30% capital subsidy) and at regional levels in terms of net metering/feed in tariffs.

Achieving the rooftop solar goal is in many ways more vital than the utility-scale goal, as distributed solar offers grid resilience, avoids AT&C losses and broadens the community of direct solar beneficiaries, all critical to building the energy system of the future. Greenpeace believes that much more needs to be done to educate consumers of the benefits of going solar, to smoothen bureaucratic wrinkles standing in the way of faster solar adoption and harness the power that states and distribution companies wield in support of India's ambitious solar goals.

Towards this end, Greenpeace India is launching a multi-city programme to spread awareness among residents and small business owners of the advantages of going solar. This report's analysis of the rooftop solar potential of Hyderabad and Chennai, conducted by GERMI, is a part of this effort. We hope the results, and the methods explained in the report, help spur a faster, deeper uptake of solar rooftops by citizens across India.

[1] *http://bit.ly/2DgReWX Bridge to India*

EXECUTIVE SUMMARY

This report is an outcome of a study that aims to compute the rooftop solar PV potential of the cities of Hyderabad and Chennai, India. The report is broadly divided into four sections. Section one is an introductory section that examines the current status of RTPV deployment in both cities. It also looks at the policy framework and the regulatory background in both states of Telangana (of which Hyderabad city is the capital) and Tamil Nadu (Chennai city). A key observation in both states is that the deployment of rooftop solar PV is lackluster despite existing policies and regulations that support rooftop solar. If deployment rates do not significantly increase, it is unlikely that that India's rooftop solar PV (RTPV) deployment target of 40 GW by 2022 will be met. Hyderabad and Chennai, by virtue of being Tier 1 cities, are representative of locations in India from where most demand for RTPV solar is likely to arise.

A much more fundamental question to be asked is whether India's cities can host the 40 GW target; or quite simply, "Are there adequate roofs on which 40GW of RTPV systems can be installed?". The second section develops a methodology to estimate the rooftop PV potential of Hyderabad and Chennai. Although the methodology relies on satellite imagery and land use maps that are unique to the cities, it can easily be replicated across other cities with a few minor modifications. The methodology uses freely available tools such as Google Earth, Google Maps, Wikimapia, etc. that are open source and accessible to all with an internet connection and a computer. This would aid other groups to quickly replicate this study for their own cities.

The third section reports the results of the assessment for both cities.

Key results:

Hyderabad: The total rooftop solar potential of the city is 1.73 GW.

- Buildings in Osmania University (Annexure IV) collectively have a potential of over 5,100 kW.
- The Begumpet and Rajiv Gandhi International Airports can house PV arrays with over 700 kW capacity.
- The city's railway stations have a solar PV potential of about 3,187 kW.
- All bus depots in Hyderabad can together host nearly 3000 kW of solar.
- All metro stations can host 679 kW.

Chennai: The total rooftop solar potential of the city is 1.38 GW.

- Railway station roofs can hold 3,582 kW
- Metro station roofs can hold 1,696 kW.
- Bus Depot roofs can host approximately 938 kW of solar PV.
- The Chennai International Airport can host approximately 889 kW of rooftop solar.

The results are reported (see Annexures) across each zone (or circle) of each city and across different consumer categories such as commercial, industrial, multipurpose use, public and semi public, residential, transportation and military buildings (only in the case of Hyderabad). The aim of classifying results by zones is to help local municipalities estimate their potential and engage with citizens to accelerate the rooftop PV revolution. The category wise classification would help potential developers and EPC[2] companies target their clients quickly. For the same reason, the largest contributors to the rooftop PV potential in the transportation sector (bus depots, railways, metro stations, airport) are listed out in the annexure. We hope that this level of granularity of results will aid policy makers, the industry and advocacy groups target the relevant audience and accelerate the deployment of RTPV in India.

Is India's 40GW solar rooftop goal feasible?

Finally, in the last section we look at what these numbers mean in the larger context of India's 40 GW solar rooftop goal. We compare these numbers with other rooftop potential studies carried out for the cities of Delhi, Mumbai and Patna. We also try to draw inferences based on urban patterns . Example:, "how much rooftop PV can a city hold?". Based on a thumb rule estimate of megawatt potential of RTPV per square kilometer, we estimate the potential of all tier 1 and 2 cities of India. We gauge that all of India's tier 1 and 2 cities can host over 62 GW of RTPV. Since it would be foolhardy to assume that the entire potential is realizable in the near term owing to a host of factors such as affordability, awareness and technical feasibility, we look at current adoption rates (i.e. number of roofs that have RTPV systems). We have sampled three neighborhoods in Germany and one in San Francisco to understand how many rooftops in a given neighborhood have RTPV systems installed. Our rudimentary analysis shows that this ranges from 5-24% of all roofs that have solar PV potential. It may be assumed that India's RTPV adoption rate in the near term would be far below that of such affluent neighbourhoods. Assuming an average adoption rate of 10% over the next 5 years, we are looking at a total installed solar PV capacity of about 6 GW by 2022 or so in Tier 1 and Tier 2 cities. A significant portion of the 40 GW by 2022 distributed solar target would therefore need to come from smaller towns, rural and semi-rural locations, grid connected solar pumps and other distributed solar applications, which might necessitate other incentivising schemes.

[2] *Engineering Procurement and Construction*

Solar Energy Trainees at Work in Lebanon.
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INTRODUCTION

Importance of Rooftop Solar PV (RTPV)

The solar PV market in countries such as Germany has been driven primarily by rooftop solar PV (RTPV) systems. India's solar energy development pathway has been quite the opposite, with the country's emphasis mainly on utility scale solar such as large MW scale solar plants and even bigger solar parks. The rooftop solar PV segment in India has somewhat struggled over the years despite adequate incentives from the Government.

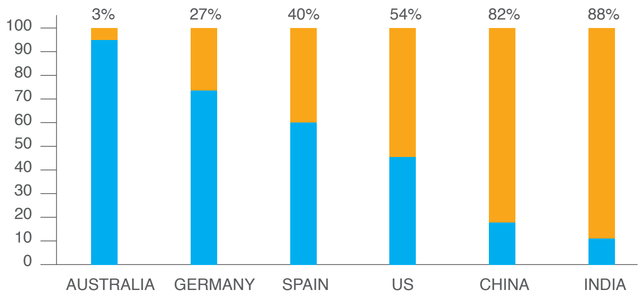

Figure 1.1: Share of utility scale solar v/s rooftop solar (BRIDGE TO INDIA)

The Ministry of New and Renewable Energy (MNRE) provides 30% of the capital cost of the RTPV systems as an upfront subsidy to the residential and educational sector. In addition some states like Gujarat provide an additional subsidy of INR 10,000 per kW (restricted to INR 20,000), while some other states like Karnataka provide attractive Feed-in Tariffs (FiT). Commercial and Industrial establishments can avail accelerated depreciation (AD) of 40% in the first year after commissioning the RTPV system. Additionally, Industrial and Commercial customers in most states are already paying higher electricity tariffs, providing a good financial incentive to meet at least a portion of their energy needs through RTPV. Despite these drivers, the uptake of RTPV in India has been rather slow (see figure below).

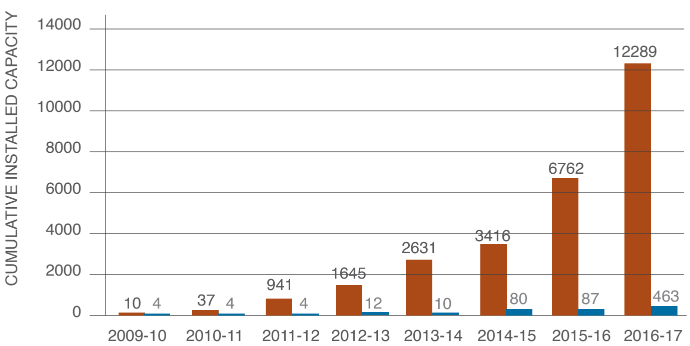

Figure 1.2: Cumulative capacity growth of the solar PV market in India (MNRE annual report)

There are broadly three reasons for the slow uptake of RTPV systems in India.

- **Capital Cost Constraints:** Despite the adequate subsidies being accorded to the residential segment, the capital cost of RTPV systems remain quite high. The cost ranges from about INR 55,000 per kW to about 70,000 per kW based on the quality of components used. For a average household of a connected load of about 3kW, this translates to INR 165,000 to INR 210,000 for the entire system. This is still beyond the reach of most families.

- **Conflict of Interest:** Every RTPV system must be permitted by the local Distribution Company (DisCom). However, installing a RTPV system will also ensure that the discoms revenue especially from some of its most bankable customers (industrial and commercial) is reduced. This represents a conflict of interest. Most DisComs delay the process, or in some cases even unofficially reject applications despite net metering regulations. In other instances, the policy provisions also limit the size of RTPV systems in order to limit the revenue loss for DisComs.

- **Customer Effort Barrier:** RTPV systems are unlike off-the-shelf power electronic equipment such as air conditioners and washing machines. They are highly customizable and site specific. This prevents equipment dealers and installers from quoting a single price per kW, which often leads to confusion among customers. Additionally, popular online retail portals do not sell ready to use rooftop solar systems, which makes a high entry barrier.

Despite these challenges, RTPV provides specific benefits to customers, discoms and the country as a whole apart from the known benefit of reducing greenhouse gas (GHG) emissions.

- **Benefit to DisCom:** Reduction in distribution and transmission losses.

  RTPV systems are located closer to the load than centralized power plants. This greatly reduces the transmission and distribution losses incurred along the grid. These losses are typically borne by the utility. Secondly, RTPV systems also help boost tail-end voltages which are prone to lag due to the length of some distribution feeders.

- **Benefit to the Customer:** Diversification of supply (energy security) and savings on power bills

  RTPV systems help customers (especially industrial and commercial customers) reduce their power bills. It also helps hedge against any future price rises. Rooftop systems when coupled with storage and/or generators also give a certain degree of security over the energy supply. This is especially true in areas that face significant power cuts.

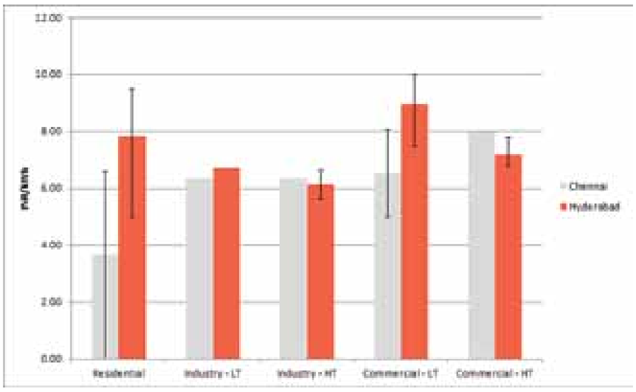

Figure 1.3: Summary of grid prices in Chennai and Hyderabad [3] [tariff orders]

- **Benefit to the Nation:** Job creation is far more significant compared to utility scale solar PV. Owning to the distributed nature of RTPV, it ensures that no single corporation or installer can corner the market. This leads to a much more distributed job generation profile across the country. Several studies have shown that the number of jobs created per MW from RTPV is 2.22 times higher than that of utility scale PV[4].

Need of the Report

Given the benefits of RTPV systems to India and the challenges being faced in deploying these systems across the country, it is important for the State and Central Governments to set time based targets. While MNRE has assigned targets to various states, there doesn't appear to be a traction and a seriousness in implementing these targets. It is equally unclear if these targets can actually be installed on the rooftops. Therefore the first exercise that needs to be carried out is a survey of the major cities of each state to ascertain whether the 40 GW rooftop solar target actually has adequate rooftops. This puts the target in context and provides a ceiling limit against which states, cities and even municipalities can plan RTPV deployments.

This report focuses on determining the rooftop solar potential of the cities of Hyderabad and Chennai. We hope that this would give policymakers precise scientific inputs that would enable realistic target setting. Further, the methodology developed in this report would help other groups assess the rooftop potential of other cities across India, which ultimately would help arrive at the rooftop potential of those cities. The report also provides a rough yard stick to assess the RTPV potential of all Tier 1 and Tier 2 cities in India.

Current RTPV Status of Hyderabad

Policy Support

The Government of Telangana announced its solar policy in 2015. Consumers are free to choose either net or gross meter for sale of power to the DISCOMs under this policy. This is an important policy clause, since it enables the adoption of third party investment (known as RESCO models).

The tariff applicable for units generated under gross metering at 11 KV and below would be average cost of service of the DISCOM as determined by Telangana State Electricity Regulatory Commission (TSERC). The tariff applicable for units under net metering would be Average Pooled Power Purchase Cost (APPC). Projects under both gross and net metering would be subject to monthly billing and settlement. However, no special FiT has been accorded to RTPV systems.

Regulatory Background

TSERC released its draft net metering regulations in 2016. The highlights of the regulation are:

- The capacity limits for rooftop based net metering range from 1kW to 1 MW
- RTPV systems of capacity greater than 75kW require special approval from the Central Electricity Inspectorate General (CEIG)
- Grid penetration limit is capped at 30% of distribution transformer capacity; which means that only 30% of all power at a transformer can come from net metered solar PV systems
- No grid connection voltages are mentioned in the regulation, which implies that the regulations mentioned in the state grid supply code shall prevail

On-ground Implementation

The implementation of net metering in Telangana is reported to be far smoother than Tamil Nadu. Both DisComs i.e. Telangana Southern Power Distribution Company Limited and Telangana Northern Power Distribution Company Limited are actively accepting and processing applications for net metering.

Current Status

The state of Telangana has a total installed rooftop solar PV capacity of 54 MW[5] by September 2017. The estimated installed RTPV capacity in Hyderabad is 34 MW (Bridge to India).

Current RTPV Status of Chennai

Policy Support

The Tamil Nadu Solar Policy was announced in 2012 and promotes the deployment of both utility scale and rooftop scale PV systems in the state. The state initially provided a Generation Based Incentive (GBI) for domestic consumers for a limited period of time until 2014, which has since then been rescinded. The policy also introduced net metering for commercial and residential establishments while conspicuously leaving out Industrial buildings - most likely to protect the interests of DisCom.

The connectivity voltages are given below[6]:

Solar PV System Size	Connection Voltage
< 10kWp	240 V
10kWp to <15 kWp	240/415V
15 kWp to < 100kWp	415 V
> 100 kWp	11kV

Table 1.1: Solar PV system connection voltages in Tamil Nadu

[3] Respective tariff orders from Telangana and Tamil Nadu
[4] CEEW-NRDC, "Filling the skill gap in india's clean energy market", february 2016. http://bit.ly/2yK7lss
[5] *http://bit.ly/2DgReWX The numbers includes both MNRE subsidized systems and unsubsidized systems.*
[6] *Tamil nadu solar energy policy 2012, Government of Tamil Nadu, http://bit.ly/1cvKbVv*

Regulatory Background

The Tamil Nadu Electricity Regulatory Commission (TNERC) officially released the order on “LT Connectivity and net metering in regard to Tamil Nadu Solar Energy Policy 2012” in 2013[7]. The highlights of the order are:

- Net metering is applicable to residential, commercial and government buildings only. Industrial consumers have been conspicuously left out.
- Electricity generated from RTPV system and injected into the licensee’s grid shall be capped at 90% of the electricity consumption by the eligible consumer at the end of a settlement period. That is, no more than 90% of a consumers requirement can be met by RTPV systems.
- In the event that export of energy is greater than the import of energy, this shall be carried forward to the next billing cycle. The maximum carry forward is for a period of one year. Any excess energy at the end of the year shall be treated as void.
- Grid penetration limit is capped at 30% of distribution transformer capacity

The regulation also differs from the policy in terms of connection voltage for a particular system size (see table below). Such contradictions become bottlenecks and increases ambiguity for homeowners and investors.

Solar PV System Size	Connection Voltage
< 4 kW	240 V single phase OR 415 V three phase
>4 kW and <= 112 kW	415 V three phase
> 112 kW	At HT or EHT level

Table 1.2: Solar PV system connection voltages as per TNERC regulation

On-ground Implementation

The on-ground implementation of net metering in Tamil Nadu is sketchy. The Tamil Nadu Electricity Board (TNEB) recently filed a petition in TNERC of significantly overhauling the net metering regulation. The proposed amendments would adversely harm the market. It appears that TNEB is concerned of losing most of its high paying consumers.

Current Status

Tamil Nadu is a leader in the rooftop solar PV capacity with a total installed capacity of 163 MW[8]. The estimated installed RTPV capacity in Chennai is 38 MW (Bridge to India).

Photo voltaic panel installed at Elounda Sands Hotel, Crete.
© Greenpeace / Steve Morgan

[7] *TNERC. Order no. 3 dated 13.11.2013. http://bit.ly/2sWYS3t*
[8] *The numbers includes both MNRE subsidized systems and unsubsidized systems.*

METHODOLOGY IN ASSESSING RTPV POTENTIAL

This chapter describes the methodology and techniques followed in the rooftop photovoltaic (RTPV) capacity estimation for the cities of Hyderabad and Chennai. An emphasis is laid on using open source, freely available and user populated maps and Geographical Information System (GIS) software. In particular, the tools used for this study are Google Earth[9], ArcGIS[10], Wikimapia[11] and MyMap[12].

Land use maps determined by the local municipal corporations of both cities were used to classify areas of each cities into eight land use categories: residential, commercial, industrial, multipurpose, transportation, public and semi public, military and unconstructed or unfeasible lands. The land use classification data is generally not available in open source maps and therefore detailed land use maps from both Hyderabad and Chennai Municipal Corporations were used.

Greater Hyderabad

Description of Study Area

The study area selected for Hyderabad is the area under the jurisdiction of Greater Hyderabad Municipal Corporation (GHMC). The GHMC area is comprised of a total area of 625 square kilometers. The approximate geographical location of the area is in between the coordinates of 17°32' N - 17°17'N latitude and 78°19'E - 78°36'E longitude.

The area under GHMC is divided into five principal municipal zones - North, South, East, West and Central. Each of the above zones is further divided into administrative circles. There are a total of 18 circles in Hyderabad, which are further subdivided into a 150 wards. A ward represents the smallest unit of geographical abstraction for land use purposes. The figure below shows the area under GHMC, which is further classified into zones, circles and wards.

Figure 2.1: (A) Zones (B) Wards of the area under Greater Hyderabad Municipal Corporation

Figure 2.2: Circle divisions of the area under Greater Hyderabad Municipal Corporation[13]

Figure 2.3 : Layered map of GHMC jurisdiction, Osmania University and the area of available land use map (in blue color)

GIS Mapping methodology and Categorization

Identifying land use categorization is the first step in determining the RTPV potential of any city. Land use categorization is necessary in order to report potential across different consumer segments. There are eight primary land use classification that are used in this report. Residential, commercial, industrial, public and semi use, transportation, multipurpose use, military land and unconstructed space. The classification is closely allied to the categories of electricity consumers as suggested by State Electricity Regulatory Commissions (SERC). Knowing potential across specific consumer segments would aid policy makers and the industry to direct their efforts to those dedicated segments where the potential is sizable and where the uptake of RTPV systems are likely to be quickest.

In case of Hyderabad, there were no publicly available official GIS land use maps that could be used. However, there was a single land use map prepared by the Environmental Systems Research Institute (ESRI) and uploaded on the ArcGIS platform. This land use map is developed under the partnership of ESRI, MapmyIndia, United States Geological Survey (USGS) and The National Geospatial-Intelligence Agency (NGA) (see figure 2.4). The limitation of this map was that it did not cover the entire 18 circles of Greater Hyderabad and was only limited to seven inner circles of Hyderabad Municipal Corporation.

[9] *Google Earth, https://www.google.com/earth/*
[10] *ArcGIS, http://arcg.is/29DXfTY*
[11] *WikiMapia, http://bit.ly/2zQSKNa*
[12] *Google My Maps, http://bit.ly/2ePaTBI*
[13] *Greater Hyderabad Municipal Corporation, http://bit.ly/2gWpPDT*

Greenpeace is a global organisation that uses non-violent direct action to tackle the most crucial threats to our planet's biodiversity and environment. Greenpeace is a non-profit organisation, present in 40 countries across Europe, The Americas, Asia and the Pacific.

It speaks for 2.8 million supporters worldwide, and inspires many millions more to take action every day. To maintain its independence, Greenpeace does not accept donations from governments or corporations but relies on contributions from individual supporters and foundation grants.

Greenpeace has been campaigning against environmental degradation since 1971 when a small boat of volunteers and journalists sailed into Amchitka, an area north of Alaska, where the US Government was conducting underground nuclear tests.This tradition of 'bearing witness' in a non-violent manner continues today, and ships are an important part of all its campaign work.

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