GERMI

SHAKTI
SUSTAINABLE ENERGY
FOUNDATION

Demand Aggregation of rooftop solar systems in India

Strategies to accelerate the distributed clean energy transition in India

White Paper

www.germi.org

Authors

Akhilesh Magal

Head Renewable Advisory

Karan Patel
Mitt Siddhpura
Prathit Dave
Surbhi Bhansali

Research fellows

Table of Contents

List of Abbreviations

CFA	Central Financial Assistance
DA	Demand Aggregation
DisCom	Distribution Companies
EPC	Engineering Procurement and Construction
EMI	Equated Monthly Installments
GERMI	Gujarat Energy Research and Management Institute
GIZ	Gesellschaft für Internationale Zusammenarbeit
GUVNL	Gujarat Urja Vikas Nigam Limited
GW	Gigawatt
IDO	International Development Organization
kW	kilowatt
MNRE	Ministry of New and Renewable Energy
MW	Megawatt
NCEF	National Clean Energy Fund
NGO	Non-Government Organization
NREL	National Renewable Energy Laboratory
RPO	Renewable Purchase Obligation
RTPV	Rooftop Photovoltaic
SDC	Swiss Agency for Development and Cooperation
VNM	Virtual Net Metering
USAID	United States Agency for International Development

Background

The Ministry of New and Renewable Energy (MNRE), Government of India has set an ambitious target of 100 GW solar photovoltaics by 2022. The 100 GW target is further divided into 60 GW of utility scale solar installations and 40 GW of distributed rooftop photovoltaic (RTPV) installations. The utility solar segment in India has seen a relatively rapid growth with a capacity addition totalling to 32 GW (as of Mar 31, 2020). On the contrary the rooftop segment has seen the addition of just 2.5 GW in the same span of time. Figure 1 below depicts the growth of the solar market in rooftop segments.

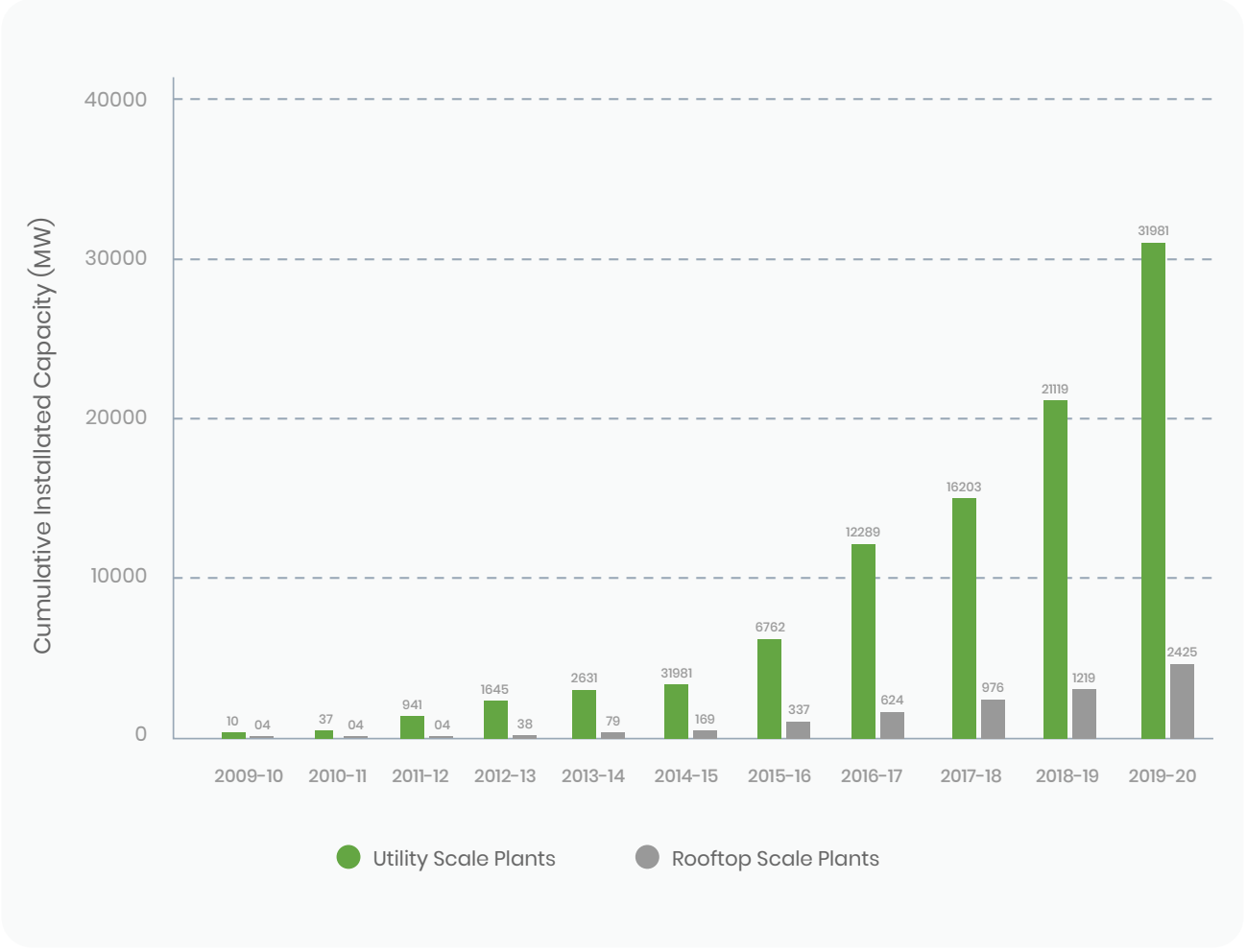


Figure 1: Growth of the Indian Rooftop Solar Market

Source: MNRE

In order to promote RTPV systems among residential consumers, MNRE has traditionally relied on an upfront capital subsidy disbursed through the National Clean Energy Fund (NCEF). In Phase-1 of the rooftop program, the ministry provided an upfront capital subsidy in the form of central financial assistance (CFA) to the residential, commercial and industrial sector of up to 30% of the benchmark cost or the actual system cost, whichever is lower. Under Phase-II of the rooftop programme, the subsidy for the residential sector has been restructured to 40% of the cost for systems of capacity upto 3 kW and 20% of the capital cost for systems of capacity greater than 3 kW and upto 10 kW. Thus, the practice of subsidizing small systems has been reemphasized under Phase 2. This aggressive subsidization has played an important role in increasing the installations of RTPV systems across the country.

Despite this, the target of 40 GW is almost certainly likely to be missed. The reasons behind the slow uptake of rooftop solar segments are affordability (high upfront costs), lack of standardized products, lack of awareness among consumers and issues of financing. To boost up the installations of RTPV systems among the residential, commercial and industrial segments, all these challenges need to be addressed. Several solutions have been proposed to overcome these barriers. One such lesser discussed and emphasized method is demand aggregation. This report examines the role that demand aggregation can play in accelerating India's progress towards the 40 GW RTPV goal and outlines a specific case study where Gujarat Energy Research and Management Institute (GERMI) has catalyzed the aggregation of a small number of consumers in Gandhinagar, Gujarat.

What is Demand Aggregation?

Demand aggregation (DA) is the process of bringing together several potential RTPV consumers who are preferably geographically co-located or form natural category clusters (religious societies, industrial organization members, etc.). The aggregated demand is often presented as a single project to an installer or an investor providing the installers the benefit of economies of scale.

DA is not just a means of taking advantage of price reduction due to volumes, but also to increase consumer ownership, ensure consumers have a say in the quality of the systems and finally bring about a cooperative effort in educating the consumer about the technology and its maintenance.

There are four principal actors in aggregating demand among RTPV consumers: the group of consumers, the vendor/installer (or the Engineering Procurement and Construction (EPC) company), the aggregating agency and the local government.

The group of consumers are either united geographically or as categories of consumers such as industrial associations (example: cold storage association) or religious affiliations (example: members of a sect or a spiritual organization). The vendor is typically, though not necessarily, a registered (or empanelled) EPC

company under the state or national subsidy scheme who is contracted to execute the project and work with the local government for the necessary approvals. The aggregator can typically be a not-for-profit agency (in our case GERMI), or can be a specific business set up as an aggregator (example: AHA solar app, Fourth Partner Energy, etc.).

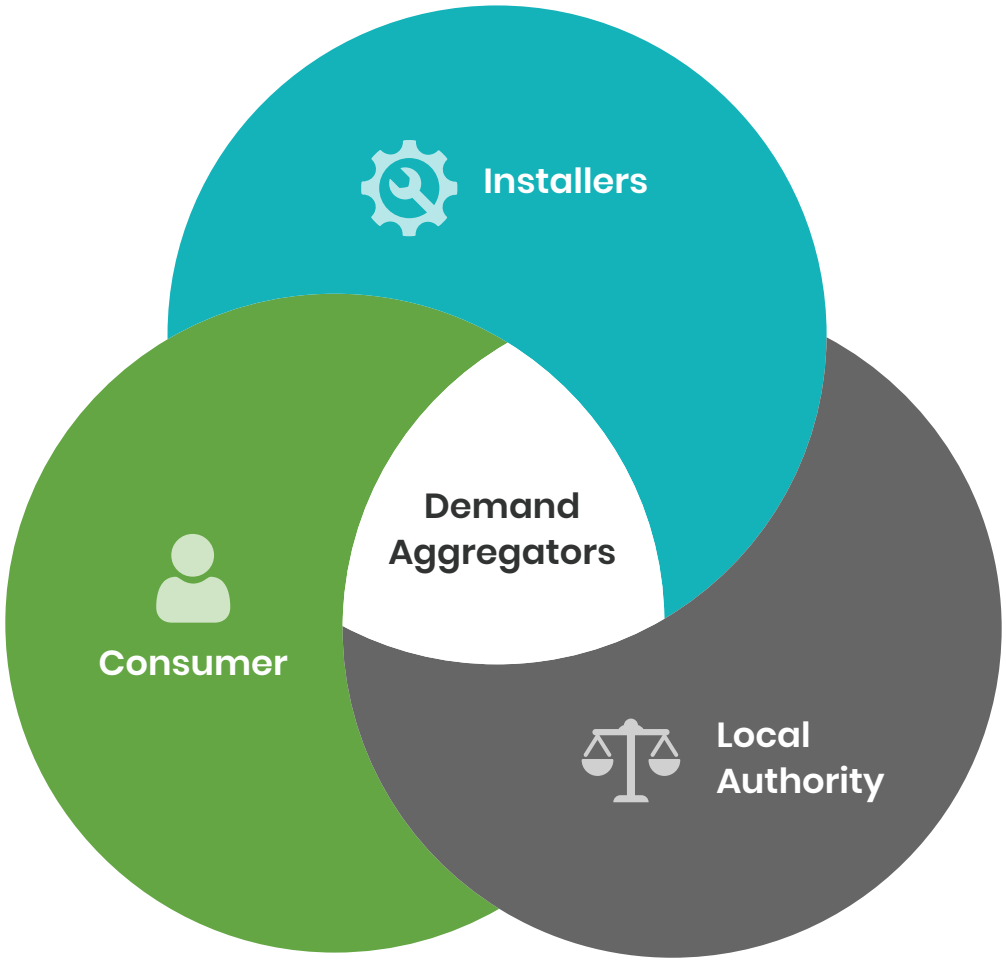


Figure 2: Stakeholders in demand aggregation

Why is Demand Aggregation Important?

DA in particular can significantly accelerate India's deployment of RTPV systems. These systems, unlike large scale solar PV projects, are distributed across a wide number of roofs, each with its own topology and unique characteristics. The fragmented nature of the market makes mass adoption a challenge, especially when consumers are not fully acquainted with the technology. RTPV systems are unlike other electrical or electronic consumer goods such as mobile phones and televisions that actively engage consumers. We can think of RTPV systems more as your water tank (how do you engage and excite consumers to adopt it?). While financial benefits accruing from reduced electricity costs is certainly an attractive proposition, one needs to go beyond economic reasons to start building consumer awareness. Reaching several consumers in one go can significantly reduce the time spent in acquiring consumers by any EPC company. A study done by the National Renewable Energy Laboratory (NREL) in America estimated customer acquisition costs to be as high as 13%. The numbers are quite similar in India with research indicating that it ranges between 10-12% which is a significant part of the overall system costs, despite lower labour costs. Many EPCs do not follow strict accounting practices that accurately bifurcate input costs, which suggests that this number could be higher for smaller EPC companies.

Key benefits of Demand Aggregation

1. Accelerates customer education

For consumers, DA can help accelerate the process of getting acquainted with the technology and navigating through its myriad choices. Today there are umpteen number of options - do you go in for poly or monocrystalline modules? Do you go in for string inverters or micro inverters or DC optimizers? What kind of mounting structure would be best suited for your roof? Since RTPV systems are not off-the-shelf products, understanding these choices and making educated comparisons can be challenging and even overwhelming. Working with a demand aggregator helps a large group of customers get acquainted with the technology. Secondly, DA helps consumers fully appreciate risk versus the benefit that RTPV systems can offer over their lifetime. Third, understanding maintenance and troubleshooting issues can significantly improve customer satisfaction and reduce the downtime of systems.

From an installer's perspective, getting many customers aware at the same time, significantly reduces efforts and costs. This is especially useful for small EPC companies that have limited (or no) sales and marketing staff.

2. Accelerates adoption rates

From a policy maker and an implementation agency's perspective, demand aggregation can significantly accelerate the progress towards the solar goals of the state or the region. Due to the proximity of consumers, it is expected that the project execution period will be shorter for all the participating consumers. This is because installers can benefit from mass procurement of inverters,

modules and mounting structures. This also reduces their cost on logistics and manpower.

3. Could (potentially) improve quality

When DA is done by an actor who understands solar PV technology, they could potentially act as a watch-dog and can provide non-partisan oversight into the quality of the system being installed. This is possible only if the DA agency is a non-EPC player with a larger interest in the sector as opposed to an EPC company. The DA agency can work with the EPC to ensure that no corners are cut. Such a non-partisan actor can significantly support the implementation agency, given that most of these agencies are short staffed.

4. Reduced costs

DA can harness the powers of economies of scale to significantly lower costs. Cost savings accrue from reduced equipment prices due to bulk procurement and reduced customer acquisition costs. For instance, from the latest tender by Gujarat Urja Vikas Nigam Limited (GUVNL), the benchmark price of a 1-1.5 kWp system is INR 46,827 whereas the price for a 10 kW is INR 43,005, indicating the role economies of scale in reducing costs.

Implementation Pathways

Having seen that DA can be an effective strategy to help accelerate the adoption of RTPV systems in India, the following section lays out strategies that can be espoused by policy makers.

Policy based approaches

The Ministry of New and Renewable Energy (MNRE) has already allocated RTPV targets to each state. However, each state is yet to form district level solar deployment plans. Forming district level plans and steering committees that can monitor progress on a quarterly basis can help the states create demand as well as ensure that the demand distribution is uniform across the state. State nodal agencies can roll-out district wise or even city wise tenders based on some demand estimation methodologies (like the ones mentioned in the annexure of this report).

Second, states can support community solar policies and regulations such as virtual net metering (VNM) that aid demand aggregation. VNM is critical especially for densely built up urban areas where roof space is scarce but energy demand is high, such as high rise buildings. Besides, most new construction, especially residential buildings are high rise apartments. These factors predicate the need for policies that can help consumers set up a common solar plant (usually ground based) and share their consumption at different points in the city (known as solar sharing programs). Such policies will aid consumers to come together and aggregate themselves.

Third, facilitate a new type of business model that would enable power aggregators at the distribution network. Power aggregators are privately owned companies that are essentially power traders. These companies can aggregate

consumer demand and procure power from various sources (distribution licensee, exchange, bilateral contracts, etc.). These aggregators should also have a Renewable Purchase Obligation (RPO) applicable in which incentives can be given to maximize RTPV potential. The aggregators could also favorably be disposed of to RTPV to reduce transmission and distribution costs. However, enabling such business models requires a change in the electricity act (proposed in 2020) and would require carriage and content separation in order to set the legal basis for such models. This would prevent any conflict of interest with the discom.

> **An Idea: A national ranking system for 'best performing solar municipality and gram panchayat' can be instituted. In this ranking system, a special 'Solar Award' can be accorded to the best performing local government body. This can promote a sense of healthy competition.**

Community Based Approaches

International Development Organizations (IDOs) like the United States Agency for International Development (USAID), Gesellschaft für Internationale Zusammenarbeit (GIZ), Swiss Agency for Development and Cooperation (SDC) and others can play a crucial role in aggregating demand. The MNRE has already allocated groups of states to each of these major development agencies working in the field of solar PV in India. Working with MNRE and state nodal agencies, these organizations can form a network within each state composed of local activists, educational institutes, research institutes and NGOs. This network can serve as a support structure to help spread awareness on RTPV and bring consumers on board.

At the heads of this network can be the local institute or an NGO or a community

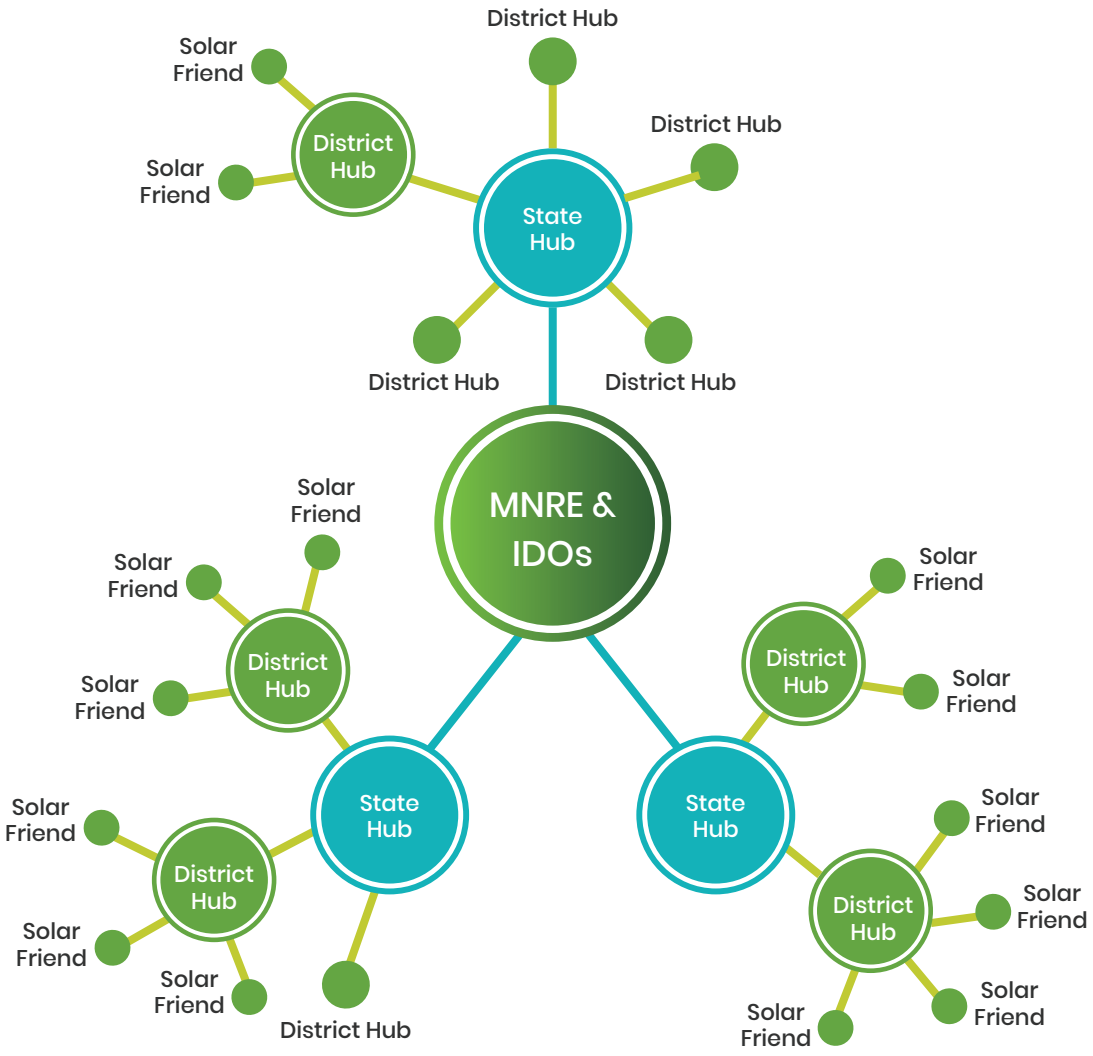


Figure 3: Schematics of the knowledge network

group, which is typically not-for-profit. This agency is known as the 'hub' and acts as the knowledge repository. Ideally each district should have its own 'hub', with possibly more for each district. Connected on the network and to the hub lie individuals termed as 'Solar Bandhus'. These are highly trained individuals who serve as community leaders and work in educating consumers and aggregating demand. These Solar Bandhus act on behalf of the consumers and help make educated choices on the right EPC partner and ensure the best deal for the consumer(s). Various strategies can be structured to keep this model self sustaining. A small 'connection fee' can be charged which helps sustain these 'Solar Bandhus'. Therefore, this network not just acts as a pathway to aggregate demand, but also creates employment opportunities for the youth.

Tools: Solar Maps

State nodal agencies in partnership with academic institutions and research organizations should build a solar map for every district. Solar maps essentially estimate the total theoretical potential of any region based on the available roofscape. These maps should be published on a web portal similar to Google's Project Sunroof project where consumers can register their interest. Once the number of interested consumers crosses a certain threshold for a particular community, a tender can be floated for those consumers.

Prints of these maps should be advertised on boards in every district and community and circulated in social media. Such solar maps should mention effective savings in monetary terms as well as effective reduction in CO2 emissions. Grass root level organizations can use these maps to bring awareness about solar and DA by advertising them in communities and societies.

Image Source: Google sunroof project

Such maps should also highlight community solar policies with VNM options for people living in high rise apartments. Solar maps can be a motivating factor for bringing people on board.

> **NOTE: For estimating district level targets and buildingsolar maps as discussed above, organizations and governments can refer to a study that GERMI and Greenpeace had performed. The report "Rooftop Revolution: Unleashing Chennai & Hyderabad Rooftop Potential" of this study is available at - https://bit.ly/2x4m9HW**

Utility-based, on-bill financing model

This is a DA strategy for those consumers (lower-middle class, middle class) who want to install a RTPV system but cannot afford to pay the full upfront cost. This model will include multilateral contracts between utilities, money lenders and end consumers. Money lenders such as banks, Non-Banking Financial Companies (NBFCs) or private investors would lend directly to the consumer.The consumer will use this money to install the RTPV site at his premises. Loan repayment will be done by the consumer continuing to pay for the electricity via monthly or bi-monthly bills. The savings from the RTPV system would go into paying his loan as an EMI, essentially like an classic ESCO model. The lenders securitize the loan repayment through a contract with the utility for a secured cash flow. Utilities may charge a facilitation/service charge and will pass on the EMI amounts to the money lender. After the full loan repayment, the ownership will be passed on to the consumers and the electricity bills would reduce significantly thereafter.

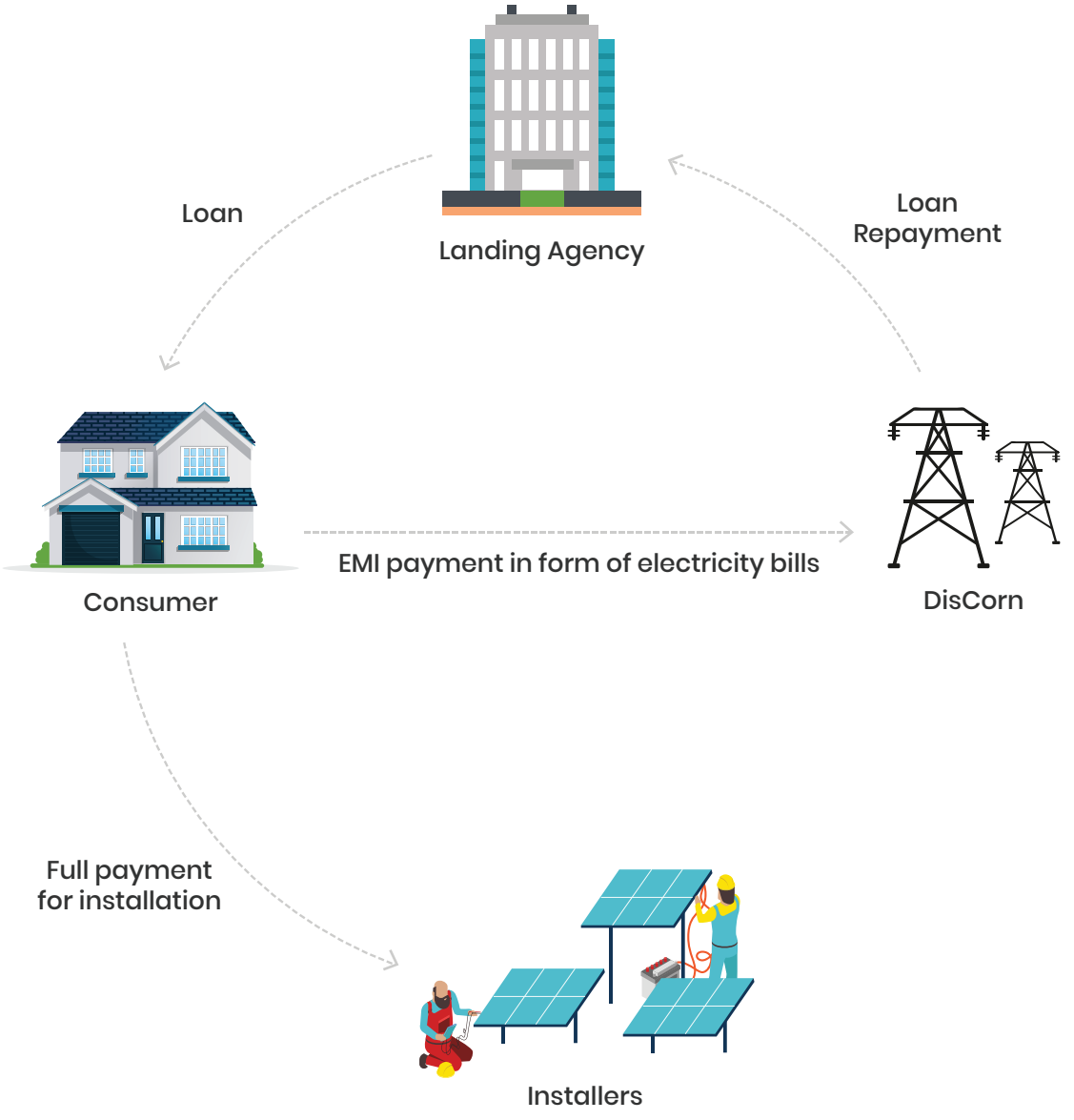


Figure 4: Mechanism of utility based, on-bill financing model

Credits: CEEW | scaling rooftop solar plant | scaling rooftop solar

A community interaction

Gujarat Energy Research and Management Institute (GERMI) organized an DA seminar on the 7th of December 2019 to educate and work with people living in high rise apartments about SURYA – Gujarat (Surya Urja Rooftop Yojna) Policy. The motive behind the seminar was to explain how the high-rise dwellers can opt for solar to meet the power requirement of their common loads and avail the benefit of the government subsidy. Several consumers requested active support from GERMI to make technology choices and select a trusted vendor. Seeing the enthusiastic response from participants, it was clear that GERMI can act as a facilitator between the EPC and the consumer.

Keeping this in mind, GERMI took an initiative to aggregate demand for solar consumers. The primary goal behind this action was to ensure that participating consumers are better educated, receive better quality

installations and potentially reduce the price due to aggregation. By the end of registration period for SURYA- Gujarat Scheme 2020-21, GERMI had aggregated demand of four individual home owners and a group housing society of 80 members (46 kW). The total installation capacity had reached 31kW. During our interaction with these consumers it was clear that organizations like GERMI can provide non-partisan oversight into the quality of the system being installed, linking customers and installers.

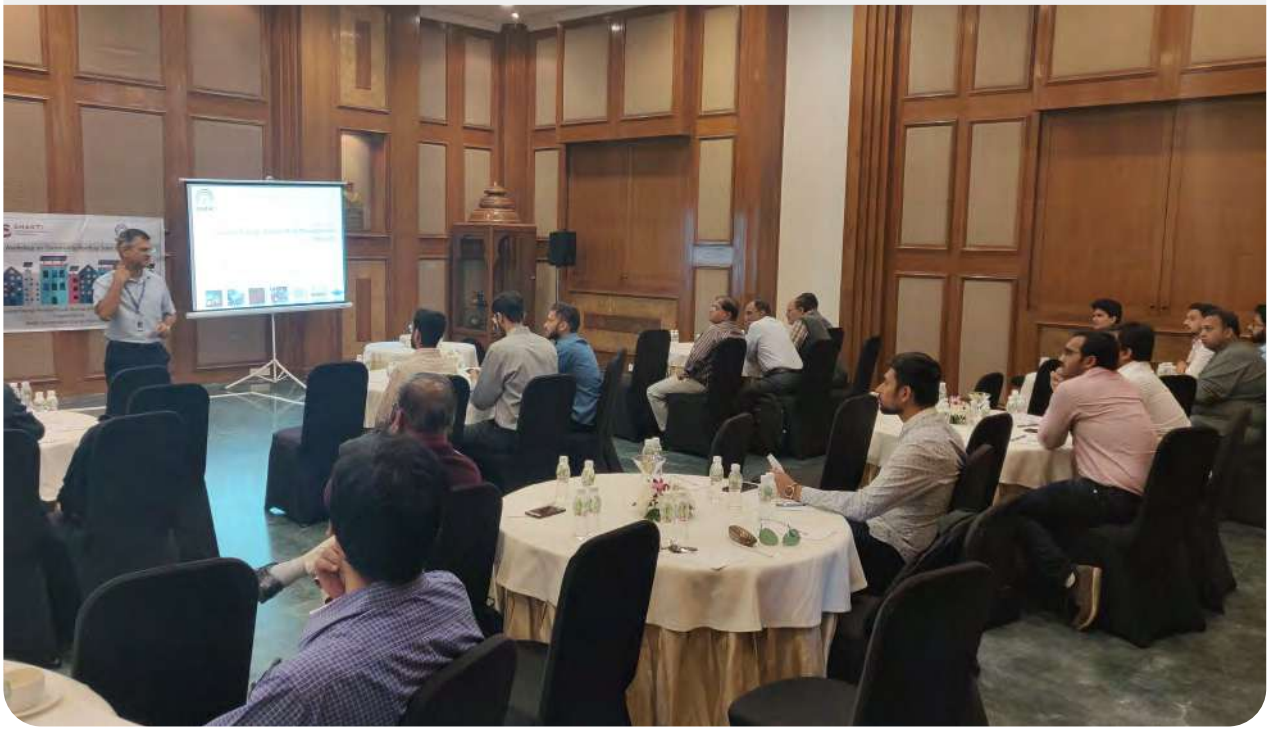


Image source: DA seminar organized by GERMI about solar RTPV system

Recommendations

Based on the above sections, GERMI makes the following recommendations to implement DA strategies to accelerate the uptake of RTPV in India.

- The MNRE and state nodal agencies should come up with district wise RTPV potential and implementation plans for each state. These plans can be aided by solar maps and other online tools to aggregate consumers.

- International aid organizations with MNRE and state nodal agencies could help in forming a RTPV knowledge network that is composed of local activists, educational institutes, research institutes and NGOs. The network can consist of 'Solar Bandhus' that can support consumers in their locality to make relevant choices in selecting vendors and technology and ensure that the system operates over its lifetime. This network can act as the backbone of the demand aggregation movement at community level.

- Education institutes and research organizations in these networks should build solar maps for their cities and make the information publicly available on a website. Solar maps can act as a great tool for community solar movement.

- DisComs could introduce a utility based solar model in their distribution area. DisComs already having a huge consumer base can be the most efficient consumer aggregator, especially given that discoms have to meet their renewable purchase obligations (RPO).

Annexure 1 : Creating Solar Maps | A Case Study of Gandhinagar

Why Solar Maps?

As a part of this study GERMI realized that the creation of solar maps indicating the total RTPV potential for any geographical area is vital. Establishing the top-line demand helps policy makers plan for city specific tenders and assist them in calibrating the state's RTPV goals. Second, it helps EPC players significantly to establish clusters where they can market their products and services. As a part of this study, GERMI decided to map out the RTPV potential for the city of Gandhinagar. The methodology can be scaled up to other cities and similar DA exercises can be carried out.

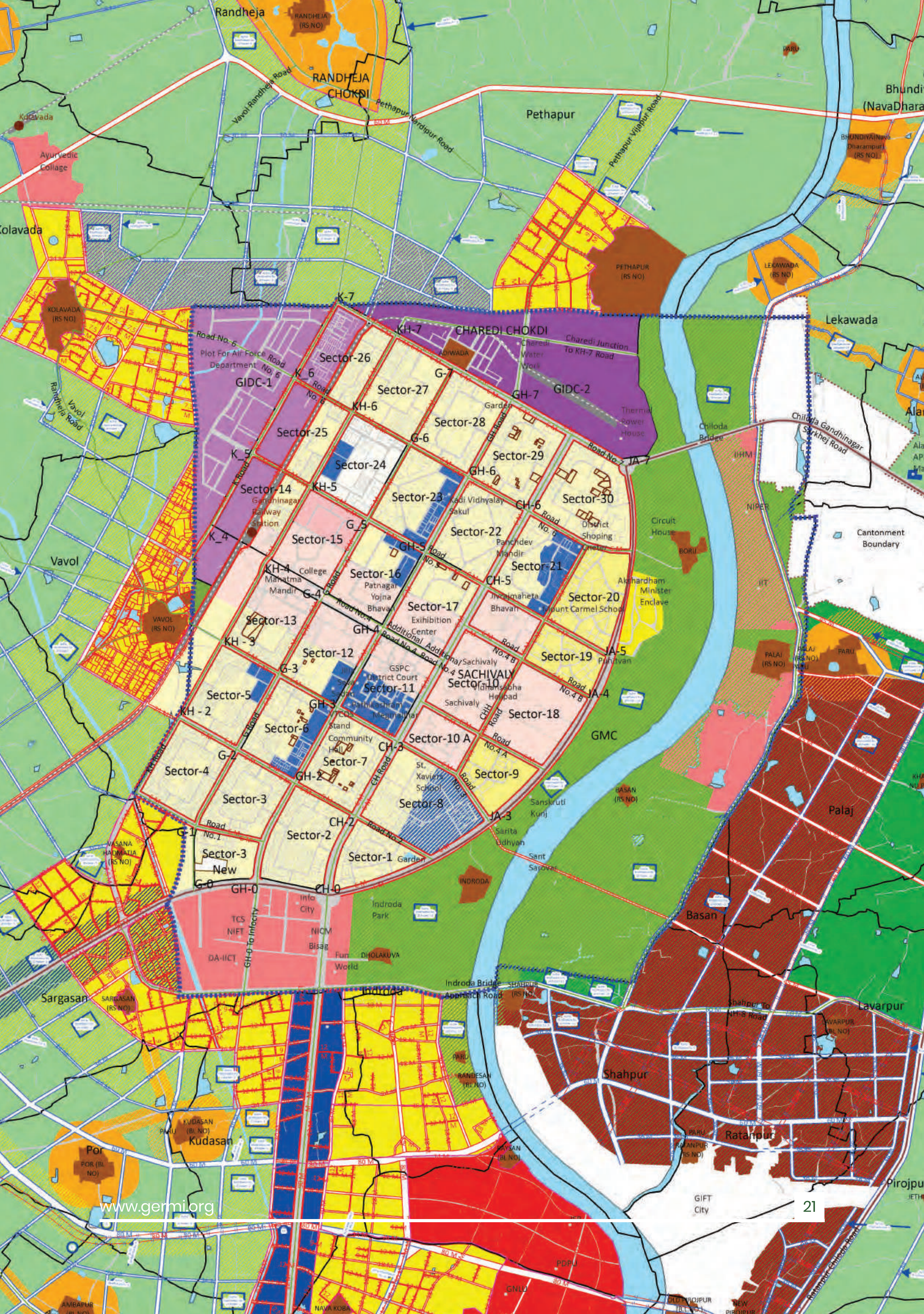
Description of the study

GERMI has created a solar potential map of the entire city of Gandhinagar using open source satellite tools such Google Earth. The study area selected for Gandhinagar rooftop assessment is the jurisdiction of Gandhinagar Municipal Corporation (GMC) boundary along with emerging southern areas. Gandhinagar city covers the area of 177 sq km with the coordinates of 23.237560, 72.647781.

Gandhinagar is a well planned city which is divided into 30 sectors. Due to this, it was easy to identify the category of the building from the land use map of the city. Based on this, buildings were classified into five different categories. Categories and their respective potentials are mentioned below:

MW	Special Cases Locations
2.6	Gujarat Knowledge Society
2.7	Vidhan-Sabha
1.1	Railway Station
0.6	Sports Authority of India
7.8	Vibrant Gujarat exhibition Hall
0.2	Akshardham
0.4	Gymkhana

Total estimated potential of RTPV in Gandhinagar: 288 MW


Randheja
RANDHEJA CHOKDI
Vavol Randheja Road
Pethapur Nardipur Road
Pethapur
Pethapur Vijapur Road
Bhundi (NavaDhara
Kolavada
Ayurvedic Collage
PETHAPUR (RS NO)
LEKAWADA (RS NO)
KOLAVADA (RS NO)
Lekawada
K-7
KH-7
CHAREDI CHOKDI
Charedi Junction To KH-7 Road
Road No. 6
Plot For Air Force Department
GIDC-1
GIDC-2
Sector-26
Sector-27
Sector-28
Sector-25
Sector-24
Sector-29
Sector-30
Sector-23
Sector-22
Sector-21
Sector-20
Sector-14
Sector-15
Sector-16
Sector-17
Sector-19
Sector-13
Sector-12
Sector-11
Sector-10
Sector-18
Sector-5
Sector-6
Sector-7
Sector-10 A
Sector-9
Sector-4
Sector-3
Sector-8
Sector-2
Sector-1
Sector-3 New
G-7
GH-7
G-6
GH-6
CH-6
G_5
GH-5
CH-5
G-4
GH-4
G-3
GH-3
CH-3
G-2
GH-2
CH-2
G-1
G-0
GH-0
CH-0
K_6
KH-6
K_5
KH-5
K_4
KH-4
KH-3
KH-2
JA-7
JA-5
JA-4
JA-3
Thermal Power House
Chiloda Bridge
Chiloda Gandhinagar Sarkhej Road
IIHM
NIPER
IIT
Cantonment Boundary
Circuit House
Akshardham Minister Enclave
GMC
SACHIVALY
Vavol
VAVOL (RS NO)
Vavol Randheja Road
Gandhinagar Railway Station
Mahatma Mandir
PALAJ (RS NO)
Palaj
BASAN (RS NO)
Basan
Sanskruti Kunj
Sarita Udhyan
Sant Sarovar
INDRODA
Indroda Park
DHOLAKUVA
Fun World
Info City
TCS
NIFT
NICM
Bisag
DA-IICT
GH-0 To Infocity
VASANA HADMATIA (RS NO)
Sargasan
SARGASAN (RS NO)
Indroda
Indroda Bridge Approach Road
SHAHPUR (RS NO)
Shahpur
Shahpur To NH-8 Road
Lavarpur
Ratanpur
GIFT City
Pirojpur
RANDESAN (BL NO)
Kudasan
KUDASAN (BL NO)
Por
POR (BL NO)
PDPU
GNLU
AMBAPUR
NAVA KOBA
OLD PIROJPUR (BL NO)
NEW PIROJPUR
Ratanpur Chiloda Road

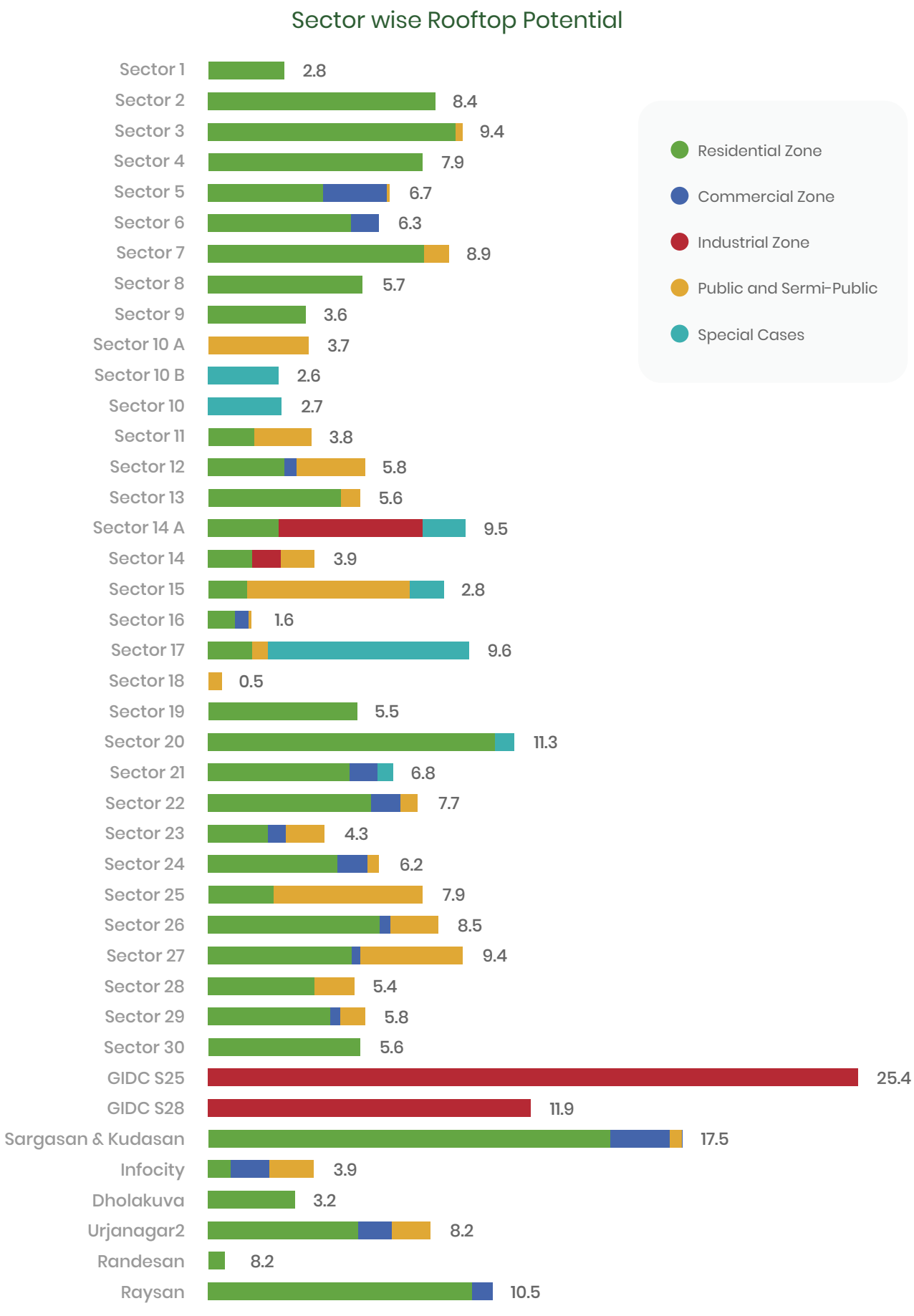


Figure 5: Sector wise RTPV potential for Gandhinagar city in MW

Buildings that have a large shadow free roof and a very high visibility are classified in special cases as these are the low hanging fruits which should be targeted first. GERMI now plans to present these findings to concerned government departments to ensure that these low hanging fruits are solarized as soon as possible.

GIS mapping methodology and categorization

To map the potential of the city of Gandhinagar, the publically available land use map from GUDA (Gandhinagar Urban Development Authority) was used. The classification of land by GUDA is closely allied to the categories of electricity consumers as suggested by Gujarat Electricity Regulatory Commissions(GERC). There are five broad categories, namely:

- Residential zone
- Commercial zone
- Public and semi-public zone
- Industrial zone
- Special cases (iconic buildings with large roofs)

The software used to map the potential was Google Earth Pro which is a freely available GIS based tool open source platform. The RTPV potential in terms of installed capacity is calculated with an assumption that the area required for installing 1 kWp of the photovoltaic system is 10 sq.m. This assumption considers modules with efficiency of 15% and adding to that, another 50% area for inner spacing.

Methodology

To map the city of Gandhinagar, the methodology that GERMI has developed in earlier such city estimation attempts was used. The earlier report "Rooftop

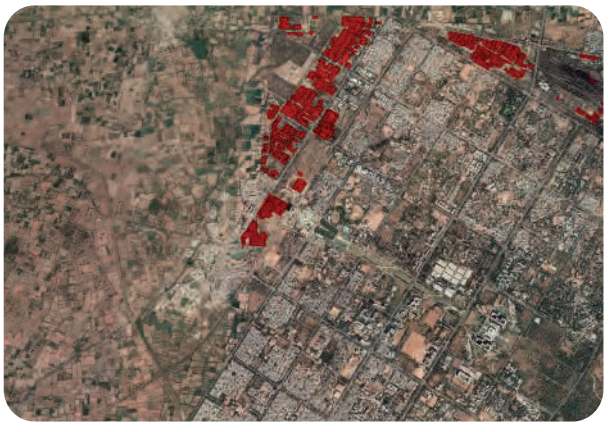
Revolution: Unleashing Chennai & Hyderabad Rooftop Potential" by GERMI and Greenpeace is available at https://bit.ly/2x4m9HW. The following section outlines the methodology adopted.

Stage 1: Land categorization and plot measurement area

This step includes overlaying the land-use map on the image of Gandhinagar which is followed by demarcation and measurement of plots according to the land use category.

Residential Area

Commercial Area



Industrial Area

Public and Semi-public Area

Stage 2: Sampling of selected plots

The samples are randomly selected, taking 10% of total marked plots and measurement of solar feasible area is done for the randomly selected samples. The ratio of solar feasible to the total plot area is computed. Calculate the average sampling solar feasible ratio of the considered area.

Stage 3: Extrapolation of data for remaining plots

Extrapolate the average solar feasible area for the respective categories and compute for the total area considered. Subsequently, add the RTPV potential of the special cases to the present category wise potential determined.

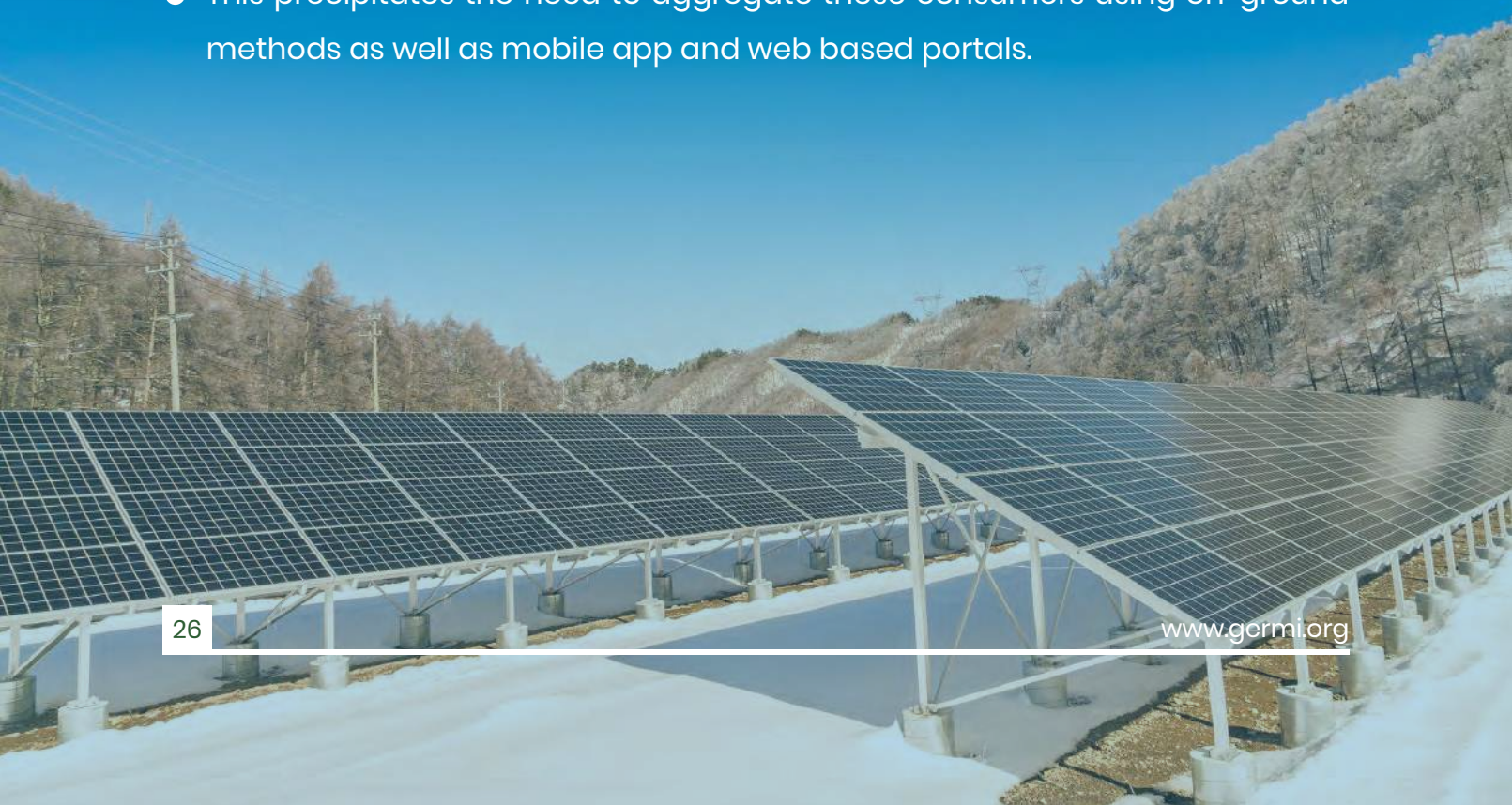
Stage 4: Calculation and Results

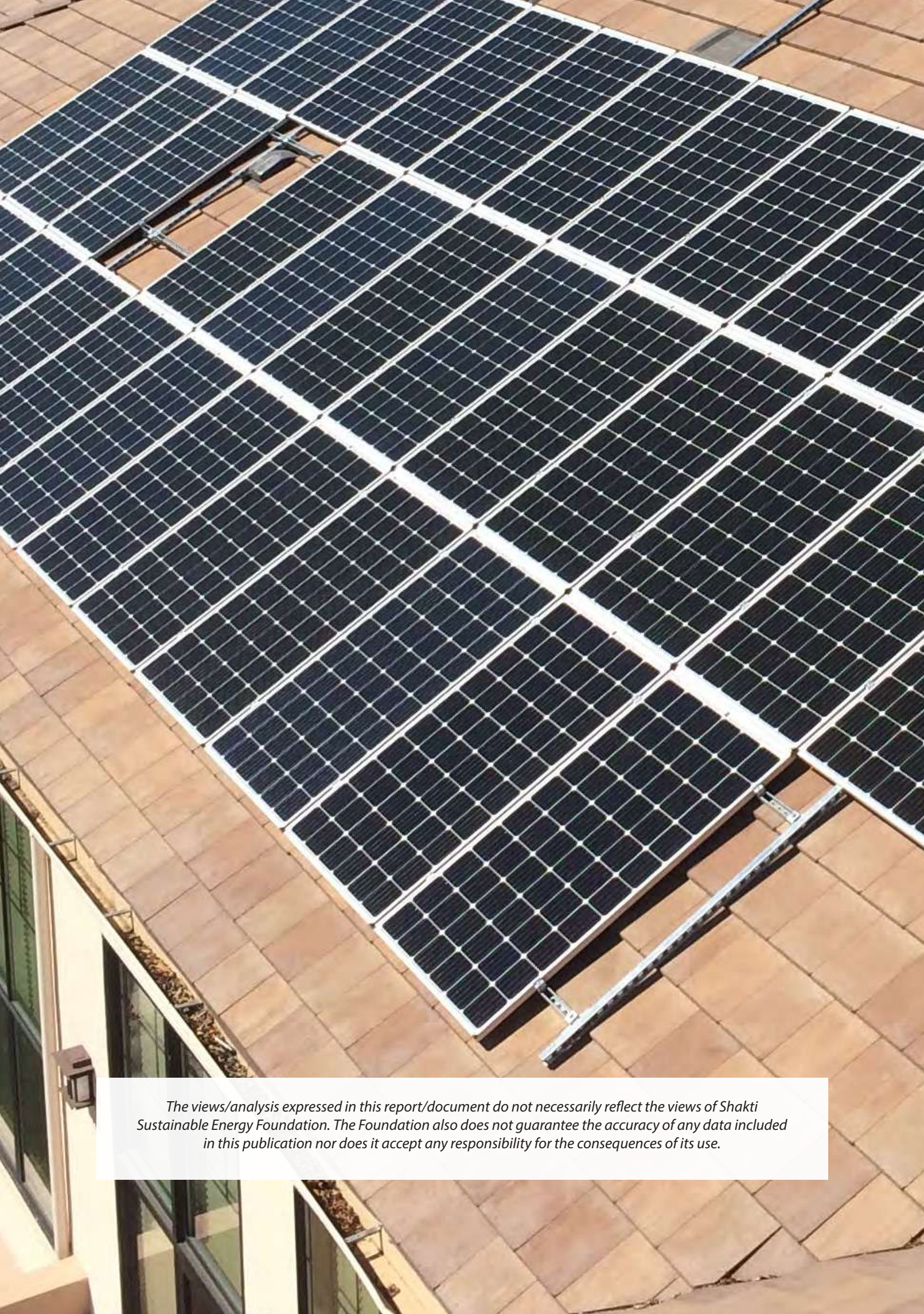
Calculate the potential sector-wise and category-wise and thus analyze the results.

Results and Conclusion

The results of the mapping exercise for the city of Gandhinagar tells us the following:

- Solar Maps can be a quick way of estimating the top-line demand for any city or a region.
- These maps can help create demand clusters which can then be auctioned in a transparent bidding process conducted by the local authority or the nodal agency for solar PV.
- In the specific case of Gandhinagar, the total RTPV potential is estimated to be 283 MW with the majority coming from residential clusters.
- Other similar studies show that the residential sector is indeed the largest in terms of MW capacity across Indian cities.
- However, given the distributed demand across the city, reaching these consumers can come at a significant cost to EPCs and other agencies.
- This precipitates the need to aggregate these consumers using on-ground methods as well as mobile app and web based portals.





GERMI

Gujarat Energy Research & Management Institute

1st Floor, Energy Building, Pandit Deendayal Petroleum University,
Raisan Village, Gandhinagar - 382 007.

Phone:+91 79 23275361 | Fax : +91 79 23275380 | Email: information@germi.org