Identification of Rooftop Solar PV Business Models with High Replication Potential in India

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Executive Summary

The main aim of this study is to identify the most promising business case driven installations of rooftop solar PV that hold the best potential to be replicated across India. The study investigates twelve case studies across six states of India — Gujarat and Maharashtra in the west; Delhi in the north; Odisha in the east; Tamil Nadu in the south and Jammu and Kashmir as a special hill state.

Eight sub sectors are investigated as a part of this study. They are: Residential, Large Commercial Retail, Warehousing, Religious, Educational, Manufacturing-Textiles, Healthcare and Government. Each of these sectors is evaluated along five parameters: tariffs, support & facilitation, roof availability, visibility and ease of adoption.

The results show that the sectors that hold the highest replication potential are **Education, Cold Storages, Large Commercial Retail** and **Manufacturing-Textile**. Replication potential is assessed using a combination of publically available data sets and roof area measurements using satellite imagery. The results from the potential assessment reveal that the education sector has the highest potential among the four categories in the six selected states. Total potential for all private and government schools and colleges is **12,508 MW** - out of which the maximum potential is from both private and public schools (**~9,500 MW**). Of this, it is recommended to selectively target colleges and universities (2,932 MW) due to increased awareness of RTPV in these institutes. In terms of the target state, the analysis shows that the state of Maharashtra holds the highest potential for the universities with a total potential of nearly 1,200 MW. The educational sector also pays among the highest tariffs in the country, since educational institutes fall under the commercial tariff category. Retail tariffs for the commercial category in all states studied are higher than the levelized cost of electricity from RTPV systems in both CAPEX model and RESCO models. In particular, universities would form prime targets for a targeted deployment of rooftop solar PV, firstly, owing to the presence of larger rooftop sizes. Secondly, power consumption for most universities are likely to be far higher than schools (greater than 10,000 units per month) and mostly occur during daylight hours, thereby matching the generation profile of RTPV systems. Thirdly, universities are likely to have greater awareness about the benefits of solar RTPV systems. Additionally, all the studied states have net metering regulations that enables these institutions to export excess energy during vacations.

The second sub-sector that holds most promise is the manufacturing sector - spinning mills, with a total potential of over **500 MW**. The state of Tamil Nadu has a significant cluster of spinning mills and holds the greatest potential of close to 400

MW of potential RTPV capacity. Textile mills pay industrial tariffs which are often greater than INR 7.00/kWh in most states (inclusive of all duties and taxes), which makes RTPV systems a financially attractive investment. Textile industries tend to have constant electrical loads and therefore are ideal segments for deploying rooftop solar PV systems. Due to the high consumption, nearly all the energy generated by the RTPV system in absorbed within the building premises itself and there is a low probability that any energy from the RTPV system shall flow back into the grid. The analysis shows that an average textile mill that invests in a RTPV system shall make a project IRR of 15% on their investment. In the event that investment is not possible, the option of RESCO model (third party owned) will also lead to a direct benefit of greater than INR 1 million per month depending on the consumption. This makes industrial spinning mills a prime target for the deployment of RTPV in the country.

The third recommended sub-sector is **Cold Storages**, with an estimated potential of over 71 MW in the six states assessed. The state that holds the greatest potential is Gujarat (30 MW+). Cold storages typically run throughout the day in order to preserve the goods stored inside them, thereby providing a near constant electrical load curve. Cold storages also have high consumption (> 10,000 units a month) thereby making RTPV investment a beneficial decision. The financial analysis for a 500 kW system shows an average project IRR greater than 15% making it an attractive financial investment.

The fourth and final recommended sector is large commercial retail spaces such as malls and shopping complexes. The estimated potential for this sector is a modest **56 MW**. However, malls attract high number of visitors and thereby creating high visibility which could serve as a secondary multiplier effect if marketed adequately. The state of Maharashtra hosts some of the largest malls in the country, has among the highest power tariffs in the country for commercial sector and has the highest potential for RTPV systems (**24 MW**). Since malls pay some of the highest tariff among any consumer categories in India, they have attractive financial benefits with project IRRs often exceeding 15%.

The report concludes that RTPV systems are already cost competitive with grid tariffs for most commercial categories in the six selected states in India. The sectors can be targeted through a three step approach: 1) Improve awareness 2) Demand aggregation and 3) Hand-holding companies to assist in price negotiation and quality monitoring.

In terms of business models, both CAPEX and RESCO models are financially viable and can be deployed based on the consumer's ability to invest in the system. It is recommended to deploy CAPEX models only in those instances where there is a direct interest in the system from the consumer. In those cases where the building owner and the energy consumer are different, RESCO based models can be deployed in order to ensure the system in well maintained.

Abbreviations

AD	Accelerated Depreciation
CAPEX	Capital Expenditure Model
CFA	Central Financial Assistance
CUF	Capacity Utilization Factor
DBT	Direct Bank Transfer
DisCom	Distribution Company
EPC	Engineering, Procurement and Construction
GBI	Generation Based Incentive
GIZ	Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatt
IRR	Internal Rate of Return
LCOE	Levelized Cost of Electricity
LOI	Letter of Intent
MNRE	Ministry of New and Renewable Energy
MW	Megawatt
NCEF	National Clean Energy Fund
NPV	Net Present Value
NSM	National Solar Mission
NVVN	NTPC Vidyut Vyapar Nigam Limited
O&M	Operation and Maintenance
OPEX	Operational Expenditure Model (RESCO)
PPA	Power Purchase Agreement
PPP	Public Private Partnership

PV	Photovoltaic
RESCO	Renewable Energy Service Company
RTPV	Rooftop Solar PV
SECI	Solar Energy Corporation of India Limited
SERC	State Electricity Regulatory Commission
SMC	Surat Municipal Corporation
STPL	Sharadha Terry Products Ltd
TPDDL	Tata Power Delhi Distribution Limited

Introduction

India's solar market has grown exponentially since 2009-2010. The growth began with the announcement of the Gujarat Solar Policy 2009 and the National Solar Mission (NSM). Since then, nearly all states across India have announced state specific policies to promote both centralized and decentralized solar generation.

Figure 1 below indicates the development of the rooftop solar PV market in India. The total rooftop solar capacity as of 2017-18 stands at 1,064 MW which represents approximately 5% of the total solar capacity in India. This is in contrast to most international markets such as Germany, US and Japan, where the market is skewed far more towards rooftop installations as opposed to utility installations.

Despite the low contribution of rooftop solar PV systems to the market share, there has been a recent spurt in the growth of rooftop PV (henceforth 'RTPV') systems in India. As the graph indicates, the market more than doubled between the years 2016-17 and 2017-18. The main reasons for this strong growth are 1) Rapid decline of solar system costs 2) Increasing power tariffs especially for the commercial and industrial consumer segments 3) growing awareness of rooftop among consumers and 4) Increased participation in the market from several small, medium and large EPC companies.

This leads to the inference that the market could be on the verge of an exponential growth, provided certain bottlenecks in the sector can be eased.

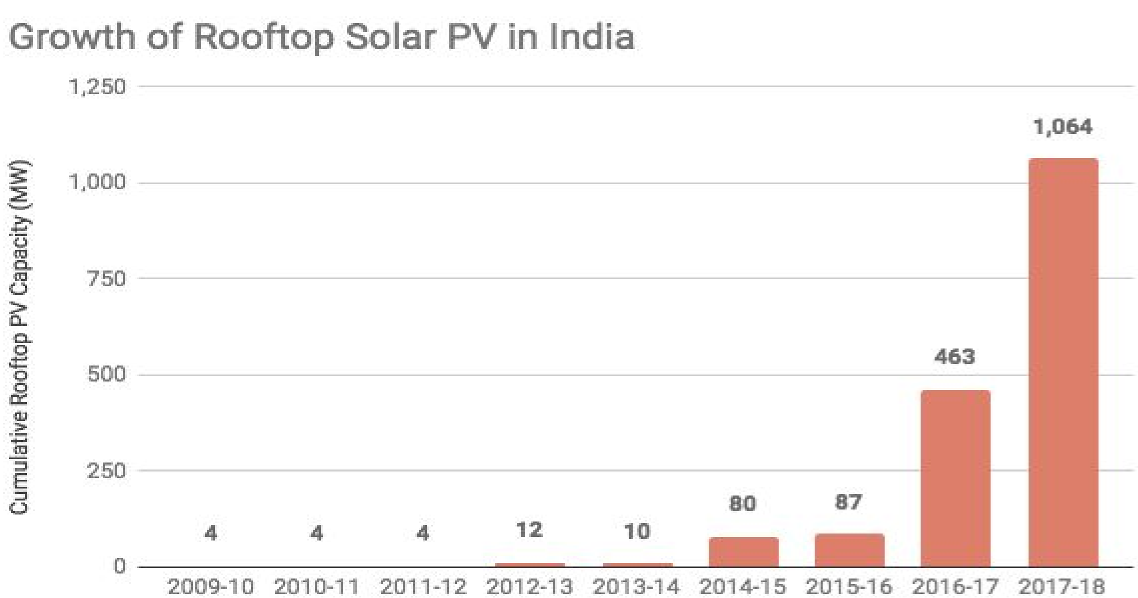

Figure 1: Development of the rooftop solar PV market in India

Some of the main bottlenecks in the sectors are:

1. **Lack of awareness of the benefits of rooftop solar PV in the market**
   Several roof owners still see solar technology as "two lights, a fan and a charger". While this attitude has rapidly changed over the last few years, this view still remains in a large section of the smaller cities in India. While the awareness on the benefits of rooftop solar PV have indeed improved for industrial and commercial consumers, there still remains a large segment that are unaware of the procedural aspects and the financial benefits that rooftop solar PV systems can bring to them.

2. **Process for net-metering**
   There is great variation in the net metering process of many states, with each state having its own set of peculiar requirements and interpretation of the SERC net metering orders. Even within states that have several DisComs, the approval processes and interpretation of billing and credit procedures vary.

3. **Conflict of interest with the DisCom**
   Rooftop solar PV systems are usually installed by those consumers that have the highest tariffs i.e. commercial, industrial and large residential consumers. These consumers also cross subsidize power tariffs i.e. these consumers bear the cost of supply of often free power to the farm sector. As these consumers reduce their consumption from the DisCom, the DisComs are put in a disadvantageous financial position. As a result of this, most DisComs are hesitant to approve rooftop solar PV systems.

4. **Quality Issues**
   Unlike centralized solar plants, RTPV plants are usually not governed by strict power purchase agreements with utilities or other nodal companies (SECI/NVVN). Rooftop solar PV systems in India are mainly installed to reduce electricity consumption. Because of this, there is a lack of focus on "How much the plant generates" and rather the focus is "how many kW is installed". This lack of focus on performance has resulted in the fact that many installation companies have compromised on quality. Quality compromises have brought about a poor name to the sector and indeed to the technology itself. The lack of quality is a severe bottleneck to the successful development of the RTPV sector in India.

The Importance of Quality Led Growth

As India’s rooftop solar market is poised for a strong growth, there is a particular and genuine concern of quality of the installed systems. Among the sites that are visited, many sites have maintenance issues such as poor earthing, corrosion of mounting structures and poorly cleaned PV modules. Most importantly, Government sites are poorly maintained, except when the RTPV system is owned and operated by a third party (RESCO). This shortcoming can be addressed by moving away from a one-time capital subsidy to a generation based on-going incentive. This ensures that the systems are well maintained over their lifetime.

Despite these specific constraints, as indicated in figure 1, the rooftop solar market has accelerated in recent years mainly on account of the financial viability for consumers. Figure 2 below shows the average power tariffs (inclusive of all taxes) plotted for each of the major states in India. Also indicated are average power prices from solar PV systems of various capacities across both capex and opex ownership models.

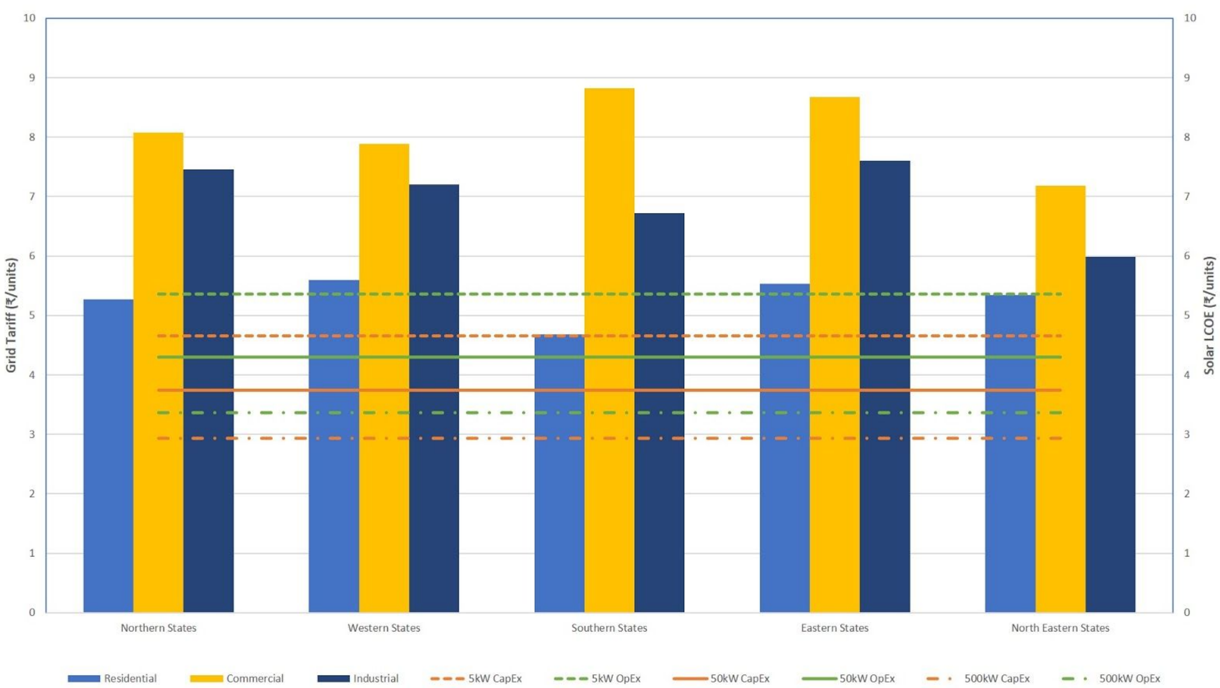

Figure 2: Overview of tariffs and RTPV LCOE

The figure indicates that electricity price from RTPV systems are already cost competitive with power tariffs across most regions in India. For a detailed state-wise power tariff graph, kindly refer to Annexure 1. Financial viability of RTPV systems will be the leading driver of the market in the coming years. A long term concern is the support of the distribution companies (DisComs) to RTPV given the fact that these systems take away revenue from their valuable customer base.

Approach to Study

In order to identify the business driven rooftop solar photovoltaic (RTPV) cases and recommend the upscaling strategy to GIZ, the following approach has been adopted:

1. Selection of Target States and Case Studies

The first step in the study is to identify the target states across India. The main consideration for the selection of the target states is the group of states allocated to GIZ by the Ministry of New and Renewable Energy (MNRE). Further, a wide geographical distribution across India is considered in order to maximize the diversity in terms of radiation as well as support and facilitation. At least one state is considered from North, South, East and West. In addition, a special hill state is also considered.

Based on these criteria, a total of six target states are considered:

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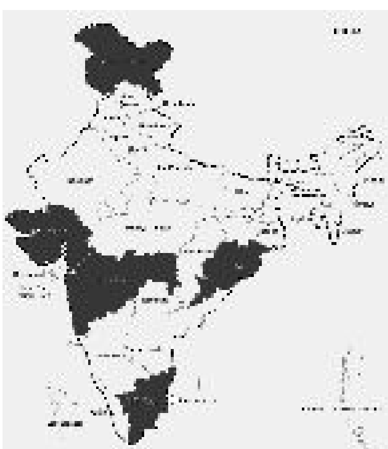
<tr><td rowspan="6"></td><td>North India</td><td>New Delhi</td></tr>
<tr><td rowspan="2">West India</td><td>Gujarat</td></tr>
<tr><td>Maharashtra</td></tr>
<tr><td>South India</td><td>Tamil Nadu</td></tr>
<tr><td>East India</td><td>Odisha</td></tr>
<tr><td>Hill States</td><td>Jammu and Kashmir</td></tr>
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Table 1: List of selected states across India

The case studies in each state were identified and classified according to base sectors and sub-sectors.

Five Base Sectors are identified based on the power tariff applicable to them:

1. Commercial
2. Industrial
3. Mixed (indicates several buildings across different categories)

4. Railway
5. Residential

The base sectors are further classified into several categories on the basis of building use like large commercial retail, small & medium commercial retail, railways, transport, healthcare, etc. A total of 46 case studies across 15 sub-sectors were initially identified. For the full list of categories studies please see Annexure 2.

Subsequently, twelve most suitable case studies are shortlisted. Emphasis is given to uniqueness of technical parameters or the business model.

The twelve selected case studies are listed below:

#	Case Study Name	Base Sector	Sub Sector	State
1	Gandhinagar 5 MW program	Mixed	Mixed	Gujarat
2	Civil Hospital, Ahmedabad	Commercial	Government Building	Gujarat
3	Guru Cold Storage, Ahmedabad	Commercial	Warehouse	Gujarat
4	Raj Bhavan (Governors House)	Commercial	Government Building	Jammu and Kashmir
5	Viviana Mall, 91 KW in Mumbai	Commercial	Large Commercial Retail	Maharashtra
6	Shree Ayyappa temple 54 KW, Thane	Commercial	Religious	Maharashtra
7	65 kWp Raheja Eternity, Kandivli	Residential	Residential	Maharashtra
8	Utkal University (200 kW)	Commercial	Education	Odisha
9	100 kWp Shiv Bhole society, sector 7 Dwarka	Residential	Residential	Delhi
10	Tata Power DDL 212 kW Solar Carport on Unity One mall	Commercial	Large Commercial Retail	Delhi

11	Sharadha Terry Products Ltd (STPL), Coimbatore	Industrial	Manufacturing	Tamil Nadu
12	Surat Municipal Corporation, Science Centre	Mixed	Mixed	Gujarat

Table 2: List of case studies finalized

The last step involved contacting the EPC company / site owner / developer for getting the technical and financial details as well as the permission for visiting the sites.

2. Gathering Technical, Financial and Business Model Related Data

Having finalized the list of case studies, necessary site details are compiled in order to evaluate each case study. Personal interviews with project stakeholders were conducted.

A detailed questionnaire was prepared in advanced (Annexure 3) that would aid data collection. The questionnaire consists of the following data points:

- General information
  - Start and end dates of the project
  - Roof and system ownership
  - Consumer category of building
- Technical information
  - Location (For Global Horizontal Irradiance)
  - Roof type and Installation Area
  - EPC company details
  - System information
  - General consumption behaviour
  - Grid connectivity information
- Financial information
  - CapEx or OpEx model
  - Investment, equity, debt and subsidy details
  - Working investment (O&M cost per kW, inverter replacement cost & Insurance premiums)
  - Tax depreciation details
  - PPA offered, PPA period (In case of OpEx business model)
- Policy information
  - Policy/Norms followed

    - Subsidy scheme details
- Drivers and other factors
    - Prime motive for installing solar pv rooftop
    - Any problems faced during registration and during or after installations
    - Engineers and owners suggestions and comments

3. Technical and Financial Viability Analysis

Once the technical and the financial data was collated, each model was evaluated for technical completeness and financial viability. These results are converted into a designed case studies that may be presented to potential adopters of RTPV. The main focus of the case studies is to serve as a marketing document that could be handed out to potential adopters of rooftop solar.

An excel based cash-flow model is developed to evaluate the profitability of each project. The primary aim of the model is to display both the project and the equity internal rate of return (IRR) along with the payback period. The model is also capable of handling both the CAPEX or the OPEX ownership model. Some of the inputs for the model are listed below. Refer to the financial model (delivered separately along with this report) for further details.

- CAPEX Model
    - Inputs are project financings (initial investment, subsidies, loans etc.), operational cost (insurance premiums, O&M charges etc.) and power tariff data.
    - Result indicates the levelized cost of generation and the payback period with a graphical representation of the cumulative savings to consumer for the entire life of the system.

- OPEX/RESCO Model
    - Input data for the opex model are the tariff rates applicable for consumer and the PPA details signed between the two parties i.e developer and the consumer.
    - Output shows the net present value (NPV) of the savings to the consumer as well as the total year on year savings for the period of next 25 years in a graphical format.
- Common technical inputs for both CapEx and OpEx model
    - Irradiance specific data based on the geographical
    - location of sites.
    - System capacity installed
    - Annual energy production by the solar system

- Capacity Utilization Factor (CUF)
- Plant life of each systems
- Year-on-year degradation of module power output
- Inverter lifetime
- Price escalations in O&M

4. Definition of Criteria to Select and Rank Sub-Sectors

Having analysed each case study according to technical and financial parameters, the next step in the study is to identify those sub-sectors that have a high replication potential. In order to identify and evaluate these case studies, evaluation criteria have been designed. The following parameters have been considered while designing the criteria:

1. Tariff
2. Support and Facilitation
3. Roof Availability
4. Visibility
5. Ease of Adoption

Each of these parameters are assigned a numeric value ranging from 1 to 5 depending on the sub-sector. A detailed description of this ranking methodology is given in the section 'Selection of Target Sub-sectors'.

5. Determining of Replication Potential

Having defined criteria for evaluation of various sub-sectors in order to select them under the study, the next step is to determine the replication potential of these case studies in MW terms. This capacity represents the maximum potential that can be installed for these sub-sectors for the specific states that have been identified in the step 1 of the approach.

The approach adopted to estimate the replication potential involves estimating the total no. of consumers under a particular category using publically available lists. For instance, in order to determine the total RTPV potential for malls in Gujarat, one could look at a mall association list that enumerates all the malls in Gujarat and then estimate the total rooftop area of each mall and then arrive at a total installable RTPV potential.
Secondly, a measurement was made to estimate the shadow free RTPV feasible area for each building. This method uses publicly available satellite imagery such as Google Earth to perform the measurements. Having known the RTPV potential for one mall,

an extrapolation could be performed to obtain the total RTPV potential for all the malls in a given state, based on a sampling average.

6. Next steps

In order to further to upscale RTPV installations in the identified promising sectors, the report aims to provide recommendations for the sectors to support and assist in the uptake. The report also provides a detailed sector specific action plan GIZ to adopt for upscaling the RTPV installations.

Key Findings | Case Studies

Site 1: 5 MW program, Gandhinagar, Gujarat

The Gandhinagar 5 MW program is an example of a public private partnership (PPP) model in the rooftop segment that offers three specific benefits:

1. It provides for a guaranteed power offtake through agreements with the DisCom.
2. It allows gross-metering, which delinks consumption of the resident of the building premise and the generation of solar power. This makes the model ideal for those buildings where there are multiple service level connections in the same premise. Net metering for such consumers would be impossible.
3. The scheme also aggregates demand through the identification of rooftops, especially in the Government sector.

The program was initially built on high feed-in tariffs and a minor viability gap funding, which reflected the actual costs of solar equipment in 2011-12. The model can easily be replicated today with significantly reduced tariffs.

Therefore, this PPP model can be adopted in states, cities and more so in local communities. This is a quick way of achieving scale and de risking many elements for investors and/or EPC companies.

Site 2: Civil Hospital, Ahmedabad, Gujarat

The 1.2 MW rooftop solar installation on Civil Hospital, Ahmedabad, Gujarat is an example of a completely Government driven and subsidized installation. The system was financed completely through a grant of the Climate Change Department of Gujarat along with the Central Government grant for rooftop solar systems disbursed through MNRE. The hospital did not have to contribute anything to the capital investment.

This model is an ideal financing model for Government buildings and a fast way to ensure upscale. However the operation and maintenance of such installations must be ensured through strong O&M contracts.

One way to ensure maintenance would have been to lease out the rooftop to a potential developer who could in turn sign a gross metering agreement with the local power distribution company (similar to the Gandhinagar 5 MW model). Therefore, any model that does not involve an equity buy-in from the concerned building owner is recommended to go through a third-party owned gross metering model.

Site 3: Guru Cold Storage, Ahmedabad, Gujarat

Cold storages make the perfect business case for rooftop solar installations for several reasons:

1. These buildings fall under the commercial tariff category and therefore it makes a direct financial benefit in terms of reduced energy costs.
2. Cold storages require their refrigeration systems to be on throughout the day. This provides a near-constant load profile which makes it ideal for rooftop solar systems. If sized properly, the cold storage could consume 100% of all the energy generated by the rooftop solar plant, thereby avoiding any export to the utility's grid.
3. The panels create a shadow on the roof and prevent thermal gain from the sun. This further reduces the cooling load in the building, thereby improving efficiencies and reducing energy bills.

It is recommended that cold storages be taken up as a dedicated segment for the promotion of rooftop solar systems in India. There can be both CAPEX and RESCO models offered to such consumers. Demand can be aggregated by working closely with cold storage associations across the country.

Site 4: Raj Bhavan, Jammu, Jammu & Kashmir

The 83 kW installation at Jammu, J&K is a good example of Government driven rooftop installations. The merits of this type of models is the rapid aggregation of demand. The risk with Government installation tends to occur when the ownership of the system is given to the occupant of the building. Despite operation and maintenance contracts and generation guarantees, there is risk of non-performance of the system over time due to lack of buy-in into the project.

This is where, a third-party owned gross-fed model is ideal for Government buildings are must be considered for a rapid scale up in future.

Site 5: Viviana Mall, Thane, Maharashtra

Viviana Mall in Mumbai hosts a megawatt scale rooftop solar installation, making it one of the largest rooftops for malls in the country. Rooftop solar PV systems for malls are an obvious and direct way to reduce energy costs. Both CAPEX and OPEX models might be explored depending on whether the mall would like to make an investment in the system. Additionally, accelerated depreciation benefit of 40% of the asset value can be taken by the owner. One of the constraints in malls is the availability of unobstructed roof space. Further, any space in a mall could be monetized, roof restaurants and even parking are in vogue. Therefore, it is recommended the the solar installation be made at an elevated profile, which allows the mall owner to monetize the roof space. Another challenge could be that there are multiple service connections in malls, thereby making it difficult to attribute the energy to a single or even multiple consumers within the building. Some state policies like Delhi do offer group net-metering but these are yet to be fully operationalized. However, the energy generated from the rooftop solar plant might be used for common loads such as lights, air conditioners and elevators within and outside the building.

It is recommended that GIZ target the malls and other retail sub-sectors as a part of their strategy since there is a direct monetary benefit to the consumers.

Site 6: Ayyappa Temple, Mumbai, Maharashtra

Ayyappa Temple in Mumbai Maharashtra is a unique example of a rooftop solar PV system installed on premises of a religious institution. Religious institutions in most states in India pay tariffs nearly equal to commercial tariffs, making it an economically feasible business driven approach. Religious temples are usually incorporated as trusts and most of the better known temples, churches etc. tend to be well funded in India, making the CAPEX model ideal for such premises.

There is also a potential 'herd effect' from similar religious institutions taking up rooftop solar technology, given India's strong cultural and religious fabric. There is also the subtle positioning of the sun being associated with the Hindu God *Surya* that can be leveraged while promoting this technology. One concern is the lack of flat rooftop space owing to the fact that religious buildings have oddly shaped roofs (domes / spires / towers).

Site 7: Raheja Eternity Apartments, Mumbai, Maharashtra

Raheja Eternity Apartments is an example of a group of environmentally and socially conscious members whose objective is to decrease the environmental footprint of their society, at the same time accruing savings on power bills. Residential societies in certain states, especially Maharashtra pay power tariffs in excess of INR 10.00/kWh which makes solar rooftop system a direct financial benefit. One concern for residential societies could be the fact that roof space is a shared right i.e. it belongs to all members of the society. Therefore, without a working group net metering policy in place, it would be impossible to attribute and apportion the

energy among individual energy meters of each home. Therefore, any rooftop solar system can only cater to common electrical loads such as common lighting, pumps, lifts, etc.

Rooftop Surveys of major cities of Delhi, Mumbai, Chennai and Hyderabad suggest that the majority rooftops in cities are residential buildings. Therefore, these types of buildings hold the greatest potential for deploying solar rooftop systems. However, the necessary government support and facilitation is required to ensure that these systems will benefit each individual consumer and not just the society's common electrical loads.

Site 8: Utkal University, Bhubaneswar, Odisha

The Utkal University rooftop installation is a prime example of how roof space can be utilized for solar PV installation when the building owner is unable to make an investment in the project. Universities are also ideal locations for rooftop solar PV installations on account of adequate roof space that is available. These types of customers are idea for third-party RESCO gross metered model.

It is recommended that GIZ target universities across India through a 'Green University Campaign'. This can be spearheaded in coordination the University Grants Commission (UGC), the nodal body that manages all universities in India in association with MNRE in coordination with GiZ.

Site 9: Shiv Bhole Society, New Delhi

The Shiv Bhole Residential Society in New Delhi is a unique example of a RESCO model on a residential housing society. This model is possible mainly on account of a generation based incentive (GBI) of INR 2.00/kWh for three years being provided by the State Government of Delhi. While the GBI certainly makes the business case for the residential consumer attractive, the model is still viable without GBI. The project developer offers a tariff of INR 4.66/kWh from the 100kW (developer avails 30% capital subsidy from MNRE). These economics makes the entire business case extremely attractive for the consumers.

This is one of the few community residential solar projects on a RESCO modes in India and could be potentially replicated in other housing societies across India. The challenge though would be to get the model work without subsidies.

Site 10: Solar Carpark, Unity Mall, New Delhi

The rooftop solar car park is a building integrated solar PV (panels act as a roof structure) incorporated on to the topmost floor of Unity Mall in New Delhi is an excellent example of how valuable real estate can be still retained and in fact add considerable value through the addition of a RTPV system.

Unity Mall has a 212 kW system installed on a CAPEX basis without any subsidies. The building hosts an elevated structure on which rooftop solar PV modules are installed. The entire energy is consumed on site and the mall makes a per unit saving of around INR 6.

Malls and similar commercial establishments are prime examples of RTPV business cases that can be built without any subsidy on account of high energy tariffs. Most real estate developers of commercial spaces also have adequate upfront capital to invest in such structures, thereby making CAPEX based investments ideal; however RESCO models also would be viable. One constraint for malls is the limited roof space which can only cater to a fraction of the total energy requirement for the building.

Site 11: Sharadha Textiles, Coimbatore, Tamil Nadu

Sharadha Textiles is a part of the conglomerate KG Group of textiles. This 4.85 MW is a large rooftop solar installation across two sites near Coimbatore in Tamil Nadu.

Textile industries usually operate on three shifts of 8 hours, especially when capacity of the factor is being operated at 100%. This makes the textile industry an ideal target for the deployment of RTPV installations. One concern could be the lunch breaks of 30-45 minutes take during noon time, when the solar generation is at its peak. Another concern is a Tamil Nadu specific concern where net metering and banking benefits are not extended to industries. While this is a Tamil Nadu specific concern, it could underline the attitude that power utilities will take towards such high consumption industries in future.

Despite these specific concerns, RTPV installations are ideal for textile industries especially due to the ever increasing costs from power procurement from DisComs. Already the levelized cost of electricity from a RTPV plant is lower than industrial tariffs in almost all states across India.

Site 12: Sites from Surat Municipal Corporation (SMC), Surat, Gujarat

This case is a study of multiple sites under a common program of the Surat Municipal Corporation (SMC). The model is similar to the Gandhinagar 5 MW rooftop program. In Surat, the SMC has taken an active role in promoting RTPV installations as a part of their effort to make Surat into a smart city, where green energy procurement is an integral part. There RTPV installation is on the science center (100 kW).

This case study highlights the role that key stakeholders such as the SMC can play when they take an active role in promoting RTPV installations. SMC has used its sites and available incentives to push forward RTPV installations in the city. Despite the fact that this case study is not a business driven case, there are two key learnings from this study:

1. There is a significant scale effect when Government entities champion RTPV
2. There is a potential savings for even Government owned buildings.

However, the significant risk is the lack of ownership in Government offices and public buildings. It is therefore recommended, that third party owned systems are deployed in the event Government buildings need to be explored.

Selection of Target Sub-Sectors

Each of the twelve case studies are attributed to two classification heads - **Base Sectors** and **Sub-Sectors.** The **Base Sector** classification is on the lines of the consumer category of DisComs i.e. Commercial, Industrial, Residential, etc. The power tariff classification is adopted as the first layer of classification as it is the most important driver to determine viability of business cases. Since there can be several sectors within commercial, a further classification of Sub-Sectors is adopted based on type of building use. The sub-sectors identified for the selected case studies are Large Commercial Retail, Education, Manufacturing- Textile, Residential, Cold Storage, Religious, Healthcare and Government Offices. The second step of classification shall assist in identifying the specific sector / consumer groups to be targeted for upscaling activities.

Base Sector	Sub-Sector
Commercial	Large Commercial Retail
Commercial	Education
Industrial	Manufacturing Textile
Residential	Residential
Commercial	Cold Storage
Commercial	Religious
Commercial	Healthcare
Commercial	Government Offices

Table 3: Overview of classification strategy of selected case studies

Selection and Rating of Sub-Sectors

After classifying the sub sectors, they are further evaluated and ranked to access the best sub-sectors in the selected states on which GIZ could facilitate the upscale of RTPV installation in coordination with the MNRE. The five criteria defined for the evaluation of subsectors:

1	Tariffs	**Determines how high the existing grid tariff**

		is, which in turn determines the viability of the business case. The tariff category also captures the amount of consumption in that tariff category.
2	Support & Facilitation	**Determines how supportive is the Government and DisCom** for that particular sub-sector. For instance, incentives may exist for residential customers but not for commercial consumers.
3	Roof Availability	**Determines whether or not adequate roof space is available** for the installation of a RTPV system. For instance, educational buildings are likely to have large roof spaces as opposed to malls or temples (awkward roof shapes).
4	Visibility	**Determines how visible the RTPV installation is for a given sub-sector.** For instance, places that have a high footfall from consumers are more likely to have an impact on adoption.
5	Ease of Adoption	**Determines how prone the consumer group is to adopt RTPV.** For instance mall owners would find RTPV systems far more affordable compared to homeowners. Secondly, awareness among commercial users is likely to be far higher than government officers.

Table 4: Selection criterias and their concepts

Based on the above five criteria, each of the subsectors are evaluated based on a rating index from one to five. The results of the evaluation is tabulated in table below.

Overall Rating Concept									
Sub Sector	Tariffs		Support & Facilitation		Roof Availability	Visibility	Ease of adoption		Total Score
	Tariff Category	Consumption	DisCom Facilitation	Government Support			Affordability	Awareness	
Large Commercial Retail	5	5	1	1	2	5	5	5	3.6
Education	5	3	3	5	3	4	3	5	3.8
Manufacturing Textiles	3	5	3	3	4	3	4	4	3.6
Residential	1	1	5	5	1	4	1	2	2.5
Cold Storage	5	5	3	3	5	2	4	3	3.7
Religious	5	1	3	5	1	5	5	1	3.2
Healthcare	5	5	3	1	3	2	4	2	3.0
Government Offices	5	3	5	5	2	1	1	1	2.6

Table 5: Overall rating concept for selected sub sectors

Rating	Legend	
	Tariff Category	Consumption
1	Tariff <= Rs. 5 /kWh	Consumption <=10,000 kWh/month
3	Rs. 5 /kWh < Tariff <= Rs. 7 /kWh	10000 <Consumption <=50,000 kWh/month
5	Tariff <= Rs. 7 /kWh	Consumption > 50,000 kWh/month

Table 6: Legend for Tariff Rating Criteria

Rating	Legend
	Percentage Available Area
1	0-20%
2	20-40%
3	40-60%
4	60-80%

Table 7: Legend for Roof Availability criteria

Rating	Legend	
	DisCom Facilitation	Government Support
1	Poor | DisCom views migration of these sub sectors as a high threat to their business	Poor | Subsidy and tax benefits provided to these sub sectors are the lowest
3	Medium | DisCom views migration of these sub sectors as low a threat to their business	Medium | Subsidy and tax benefits provided to these sub sectors are moderate
5	Excellent | DisCom doesn't view migration of these sub sectors as a threat to their business	Excellent | Subsidy and tax benefits provided to these sub sectors are highest

Table 8: Legend for Support & Facilitation criteria

Rating	Legend
1	Poor | These sub sectors have the lowest footfall of people to whom RTVP system can be advertised
2	Low | These sub sectors have low to moderate footfall of people to whom RTVP system can be advertised
3	Medium | These sub sectors have moderate footfall of people to whom RTVP system can be advertised
4	High | These sub sectors have moderate to high footfall of people to whom RTVP system can be advertised
5	Excellent | These sub sectors have the highest footfall of people to whom RTVP system can be advertised

Table 9: Legend for Visibility criteria

Rating	Legend
1	Poor | These sub sectors have the lowest spending power
2	Low | These sub sectors have low to moderate spending power
3	Medium | These sub sectors have moderate spending power
4	High | These sub sectors have moderate to high spending power
5	Excellent | These sub sectors have the highest spending power

Table 10: Legend for Affordability criteria

1. Tariffs

The grid tariff is the most important factor in deciding the business case viability. Today, solar rooftop systems have already breached grid-parity in many states in India. The figure shows grid tariffs for three consumer categories (residential in blue, commercial in yellow and industrial in dark blue) across the target six states in India. The horizontal lines depicted in the graph indicate the solar levelized cost of electricity based on both capex and opex models for three different system sizes (5, 50 and 500 kW). These numbers have been derived from the financial model developed specifically for this project.

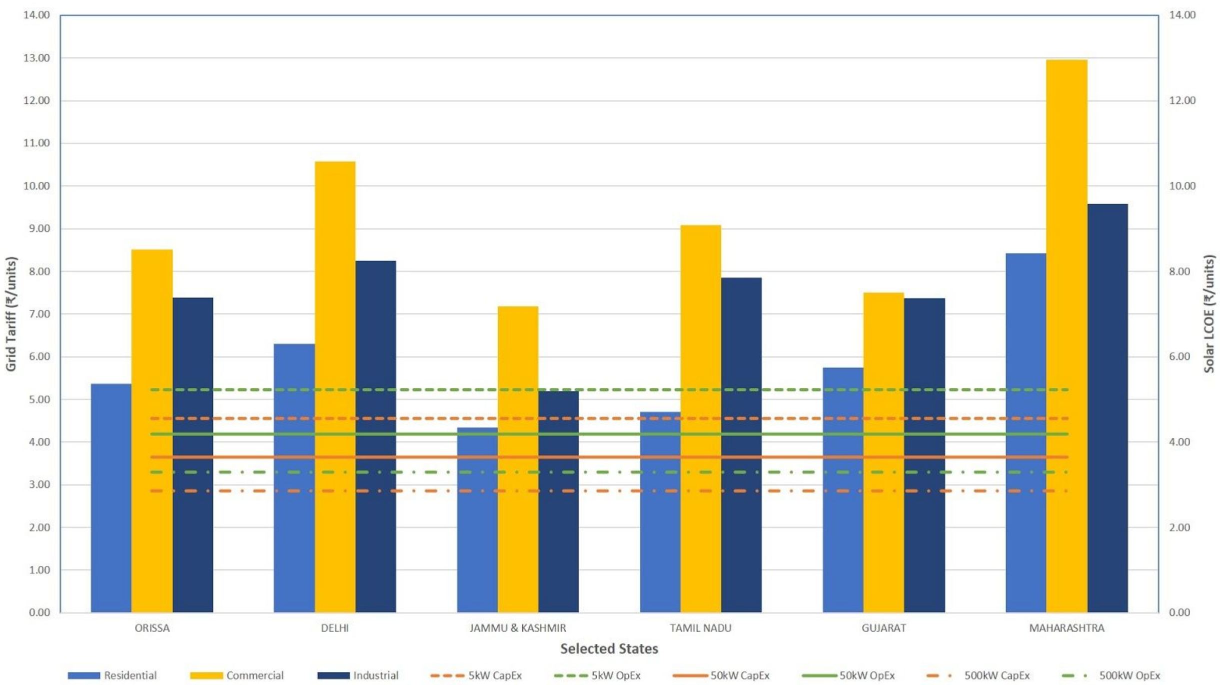


Figure 3: Overview of tariffs and solar LCOE in the six selected states for this study

The idea behind this criterion is that, if grid electricity prices for a sub-sectors in a state is considerably higher than the levelized cost of electricity from solar power generation, this target sub-sectors and state shall be the suitable target for business development in solar market. This will motivate these consumers to augment a portion of their electricity (if not all) from RTPV systems. However, high tariffs alone would not justify the shift to RTPV. There is also a need for a significant consumption.

In general, higher the consumption, greater the incentive for the consumer to shift to RTPV. Therefore the tariff category is subdivided into two sub criteria:

1. Tariffs
2. Consumption

A rating concept of 1 to 5 has been adopted throughout for each criterion. However, since there are only three distinct possibilities under tariff i.e. residential, commercial and industrial a rating of 1, 3, 5 are retained (2 and 4 are dropped). Therefore those consumers who fall under the highest tariff category (i.e. commercial) take the rating value of 5, industrial consumer adopt 3 and residential consumers adopt 1.

A similar index is adopted for the consumption sub category. A rating of 1 indicates low consumption, 3 - medium consumption and 5 high consumption. For instance Large Commercial Retail category takes a value of 5 whereas a residential premise takes on a value of 1.

2. Support & Facilitation

This criterion determines the degree to which a particular sub sector is supported in terms of government policies and incentives and two, the support that is anticipated from the local distribution company.

Several incentives and subsidies are slowly being withdrawn from the commercial and industrial segment due to the fact that these segments are already cost competitive with grid tariffs. However, subsidies continue to be extended to residential home owners and some educational institutes. As a result of which, the residential or religious sub sector is given a high rating of 5 (excellent), whereas the commercial retail sub sector is given a rating of 1 (poor).

The second sub-criterion is support from the local distribution company. This is an important criteria because of the DisComs are responsible for according the net metering approvals. Most DisComs are increasingly becoming wary of the fact that high value customers such as commercial and industrial are reducing their consumption from the grid. This rating captures the attitude and therefore the support of DisComs now and going into the future to various sub sectors. Government offices and Residential sub sector is given the highest rating of 5 (excellent support) whereas large commercial retail is ranked 1 (poor). Other sub sectors such as cold storages, religious and healthcare are rated 3 (medium) mainly because all these sub sectors are attributed to base sector of Commercial Tariffs, however they do not have a truly commercial image as perhaps a mall has.

3. Roof Availability

The availability of shadow free rooftop space is one of the greatest challenges in urban landscapes in most major cities in India. Therefore, while buildings may fall under the commercial tariff rates and have high consumption, they may not have adequate roof area to install a RTPV system of a considerable size that can have a significant impact on energy bills. Therefore, roof availability is considered as a separate criterion for evaluation of sub-sectors. A rating of 5 (Excellent) is given to Cold Storages, since these buildings are essentially warehouses that have adequate rooftop area. The next largest segment in terms of rooftop area is manufacturing - textiles since most spinning mills have a large area footprint due to the industry being a process industry. Manufacturing is therefore accorded a rating of 4 (High). Both healthcare and education are ascribed a rating of 3 (average or medium). Government buildings are given a rating of 2 (low) on account of somewhat limited space. And residential buildings are given the least rating of 1 (poor) due to severe space restrictions especially in apartments. Religious buildings are also given a rating of 1 (poor) due to irregular roof structures (domes, pyramids or spires) that may cast shadows on nearby roof areas.

4. Visibility

Visibility helps answer a key question, "how visible and therefore marketable is the solar installation'. For any new technology, seeing is believing and therefore the impact of publicly seen or communicated Installations. The rationale followed in ranking sub sectors along visibility is to understand which of these buildings see most people (footfalls). It is for this reason that large commercial retail buildings and religious buildings are attributed the highest rank of 5 (excellent). Educational institutes and residential buildings are ranked 4 (high). Cold storages tend to be located in remote or run-down areas of the city and don't often see potential RTPV customers visiting and are therefore rated 2 (Low). Finally, government buildings are rated the lowest rating of 1 (poor) since these buildings do not communicate to customers. An important factor here is that RTPV systems are usually installed on a roof which is usually not seen by the people visiting or using that building. Therefore, strong communication in the form of boards (ex: 'You are entering a Green Building') is necessitated.

5. Ease of Adoption

Ease of adoption is a criterion that evaluates how easy is it for a potential client to adopt a RTPV system. This criterion is further subdivided into two subcategories of Affordability and Awareness. Affordability ranks a sub sector on the ability to afford a system on CAPEX mode. In case the company chooses to opt for OPEX mode, then the strength of the balance sheet would determine its negotiating position on the

PPA. Therefore financial strength is a crucial factor in determining affordability. Therefore large commercial retail takes the highest rating of 5 (excellent). Manufacturing and Cold Storages take on values of 4 each (High) due the ability to invest in RTPV systems, followed by educational (3). The least ranking is attributed to residential and government offices since there are genuine concerns on ability to invest in these systems.

Considering above five selection and rating criteria, following is the average rating chart for all nine sub-sectors represented in a graphical format.

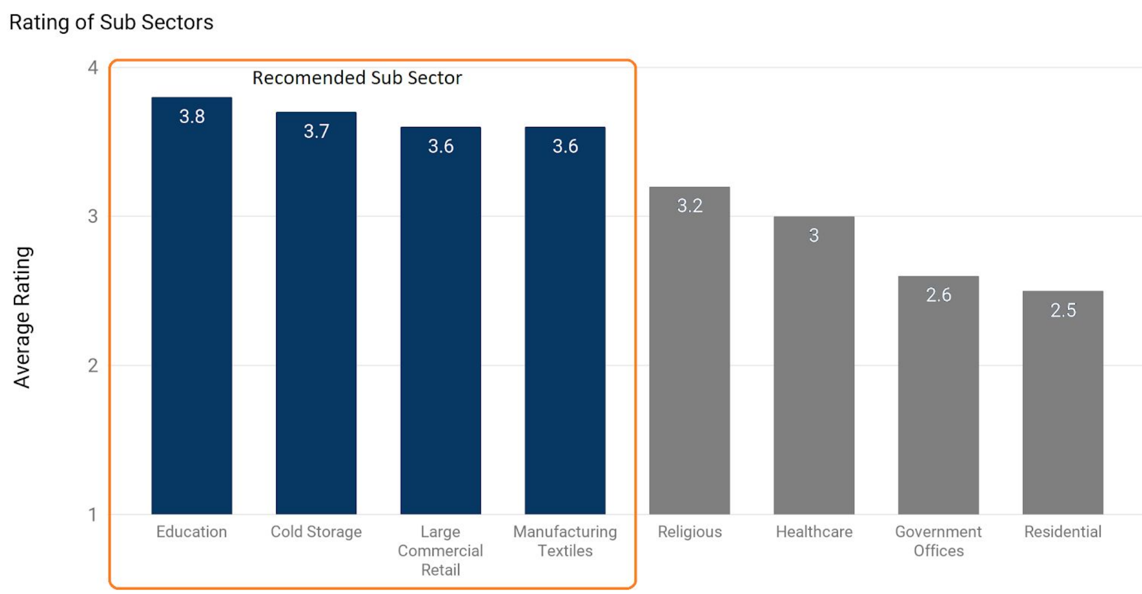


Figure 4: Average ratings of sub-sectors based on the defined criteria

The graph is sorted in a descending order of the ranking, with the suggested sectors for engagement highlighted as blue bars in orange box and the remaining highlighted as gray bars. Education, Cold Storage, Large Commercial Retail and Manufacturing Textile may be considered as a part of GIZ strategy.

B. Replicability Assessment:

Having identified, ranked and selected the sub sector, the next step was to assess a top-line potential in terms of MW for each sub sector. The MW potential for each sub sector has been assessed using satellite tools such as Google Earth and publically available lists for numbers in each sub-sectors. The detailed methodology followed for different sub-sectors is outlined in annexure 4. The outcomes of this methodology are reported below:

Education

Results Summary	Potential (MW)
Potential for all Universities and Colleges	**2,932**
Potential for all Private Schools	**4,739**
Potential for all Government Schools	**4,759**

Table 11: Estimated cumulative RTPV potential of various sections under Education sub sector across the six selected states

From the estimated RTPV potential for the education sub sector, around 24.6 % solar potential comes from universities and colleges in selected six states. Schools also contribute significantly to this potential, however are far greater in number and difficult to aggregate.

Cold Storage, Large commercial retail, Manufacturing-textile

Results Summary	Potential (MW)
Cold Storage	**71**
Large Commercial Retail	**58**
Manufacturing - Textiles	**505**

Table 12: Summary of potential for cold storage, large commercial retail and manufacturing - textiles across the selected six states

The results indicate that the educational sector far outstrips the potential compared to all other sectors given the sheer size of number of institutions (schools, colleges and universities) across the six selected states. For a detailed break-up of the potential, please refer to annexures 5 to 8.

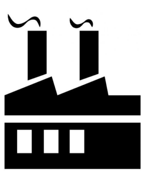
Recommendations and Action Plan

Based on the detailed site visits, analysis of the data and an overall understanding of the RTPV sector in India, the following recommendations are made.

Recommended Thrust Areas for GIZ

One of the key facilitation roles that can be played by any agency is the role of demand aggregation. And the key outcome of this study is to identify sectors that are most likely to adopt RTPV systems. Based on the outcomes of this study, the following sub sectors are recommended for a directed, sustained and targeted thrust from GIZ. The numbers in megawatt indicate the replication potential for each sector across the six selected states in India.

Sector	Potential across selected states	SWOT Analysis
Educational Institutions *Colleges and Universities only*	**2,932 MW**	Strengths: • Large roof space, fairly spread out • Low threshold of entry due to high awareness Weakness • Holidays will lead to excess generation • Investment cost barrier Opportunities • Highest potential across all selected sub sectors • 'Green Campus' campaign • High visibility Threats • Security concerns due to children

 **Cold Storages** *Cold storage facilities for agricultural commodities*	**71 MW**	Strengths: ● Constant base load ● Reduce thermal gain Weakness ● Financial strength not so strong (agriculture sector) ● Remote locations, dusty Opportunities ● Good financial benefits ● Easy to target due to working associations Threats ● Crop failures lead to latency of cold storages
 **Large Commercial Retail** *Large shopping centers and malls*	**58 MW**	Strengths: ● Daytime load curve ● High tariffs Weakness ● Roof space restrictions ● Billing complexities due to several owners in same premises Opportunities ● Accessible and easy to target Threats ● Shadowing from future developments
 **Manufacturing - Textile** *Industrial units involved in spinning*	**505 MW**	Strengths: ● Tariffs moderately high ● Constant load curve Weakness ● Investment constraints ● Poor roof structure Opportunities

		● Sector has already some excellent projects ● Active industry association Threats ● Industry highly sensitive to cheap imports

Table 13: Recommended target sub sectors

The analysis shows that the educational sector has a significant potential that far outstrips the potential for the other three recommended segments: Cold Storages, Large Commercial Retail and Manufacturing - Textiles.

Action Plan for GIZ

The action plan for GIZ is divided into three parts, first, increasing awareness on RTPV systems and the benefits, second, aggregating demand in the recommended sectors and third, act as a facilitation agency to aid contractual agreements.

The following table outlines the action plan that could be adopted by GiZ:

1	**Awareness of RTPV benefits**: The first step is to contact the recommended companies in each sub-sector and educate clients on the financial attractiveness of RTPV for their establishments. This will involve marketing, financial calculations and basic technical details on the system. Based on the recommendations provided in the previous section, specific consumer groups should be targeted through workshops, campaigns and seminars.
2	**Aggregating demand:** In order to improve the negotiation potential of consumers, it is necessary to aggregate demand. Greater the MW, greater the possibility for negotiating price reductions. Demand could be aggregated by getting consumers to sign an MoU or a commitment to the campaign (ex: green campaign). Once demand has been aggregated, the project should be presented as a portfolio to EPC companies.
3	**Hand holding:** This involves assisting identified companies from project conceptualization until commissioning of the system. This involves the following steps: a. Selection of the EPC vendor for installations through an open and fair procurement process b. Vetting the contracts - EPC contract in case of CAPEX models and a Power Purchase Agreement (PPA) in case of OPEX/RESCO model c. Monitoring to ensure the quality of components and workmanship

Sectoral Recommendations and Action Plan

Action Plan | Education

- The education sector is comprised of two separate categories that would require distinct treatment: 1) schools 2) colleges and universities
- A 'Green Campus' initiative can be started where faculty as well as students can be identified from each university college. These faculty and students can be

called as 'Green Ambassadors'. This initiative will increase the involvement and increase ownership of the targeted college/university.

- The list of colleges and universities under the apex body University Grants Commission (UGC) is provided in Annexure. Representatives from each of these universities can be invited to a conference in Delhi/ regional centre. The agenda of the conference could specifically be to highlight the benefits of RTPV systems for the education sector.
- A list of interested institutions can be compiled and a preliminary technical assessment can be made by the nominated green ambassadors. A separate training can be organized for these ambassadors on site evaluation and assessment. The result of the technical assessment could be the indicative RTPV potential for their university or college.
- The demand can be aggregated and a common tender can be issued, which will result in significant cost reductions. The tender could be both for CAPEX or OPEX based systems based on the universities requirements.
- The MNRE and the respective state nodal agency can also be involved in the initiative in order to smoothen and facilitate the approval process. Any incentives for the educational sector may also be channeled through the green campus initiative[1].

Action Plan | Cold Storage & Others

- Cold storages can be approached through the various state cold storage associations (see annexure 6 for complete list of cold storages).
- Similarly Mall Owners Association and Textile associations can be approached for other sub-sectors (Annexure 5)
- An initial conference / workshop can be held to elicit the participation from interested members. The result of the workshop could be a Letter of Intent (LOI) stating the interest of the cold storage owner to participate or adopt RTPV through this initiative.
- Once the LOI has been issued, an initial scoping and technical feasibility study can be performed to assess RTPV potential. The result of this process will be to aggregate demand
- A preliminary study on the financial capabilities or the preferences of the cold storage companies can also be done to evaluate their business model preference (CAPEX / RESCO)
- A common tender could be issued to invite quotes from EPC companies. This process can be managed transparently to reduce price while ensuring quality
- GIZ along with a third party consultant can monitor installations to ensure quality.

[1] MNRE Solar / Green Cities Program. https://mnre.gov.in/solar-cities

- A similar approach can be adopted for the other recommended sub-sectors (textile and large commercial retail)

Detailed Action Plan

The three step action plan is elaborated in the table below:

Step 1: Awareness				
#	**Action**	**Stakeholder**	**Indicator of success**	**Estimated Timeline**
1	Contact companies that have been identified in each sub-sector to invite them to a half-day workshop /seminar	Members of sub-sectors / associations (refer to Annexure)	Confirmed participation of company/ institution	15 days
2	Arrange one day seminar / workshop on 'Benefits of RTPV systems'. The main agenda of the seminar could be: 1. Overview of solar energy systems 2. Financial benefit of RTPV systems 3. Business Models 4. Approvals, procedures, etc. 5. O&M of systems In addition to improving awareness of financial benefits, one of the main goals of this workshop is get companies/institutions to evince interest in adopting RTPV systems. It is recommended to enter into a non-binding LOI/MOU to get some form of commitment. It is recommended to organize one workshop for the particular targeted sector in each of the six selected states. An official from MNRE may be invited to participate in the event	GIZ and members identified above	Attendance and successful learning outcomes for stakeholders Signing of LOI/MOU with interested stakeholders	1 day

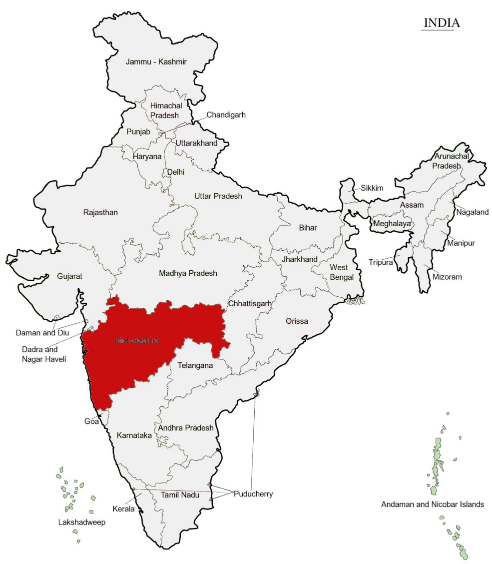
Step 2: Aggregating Demand				
3	Engaging with companies/ institutions that have signed LOI/MOU. This could also be in the form of a campaign mode (Example: Green Campus or Voluntary Renewable Energy Commitments)	Stakeholders from the workshop	No specific indicator as this is an ongoing process	On-going process
4	Estimate technical solar RTPV potential from each of the shortlisted companies so as to arrive at a total figure for that state and sub-sector (demand aggregation). The technical estimation can be outsourced to a third party consultant.	GIZ in coordination with a consultant and identified stakeholder	Total MW potential across each state and sub-sector	2 -3 months
Step 3: Handholding				
5	**Option 1:** Identifying contractors and price through a bid process to arrive at the lowest prices, while setting appropriate quality protocols and requirements. This will require GIZ to provide assistance in contracts, vetting the business model etc. **Option 2:** Alternatively, in the event GIZ does not want to coordinate a bid process, GIZ can facilitate a platform to connect EPC companies to potential clients. However, in this case, ensuring quality of the systems can be challenging	GIZ, consultant and EPC contractors	**Option 1:** Launch of bid / price quotes **Option 2**: Connecting EPC contractors with potential clients	3-6 months
6	Monitor project progress and help eliminate any barriers (technical / legal or financial) that might arise during the project. GIZ might also contract a consultant to provide these services.	GIZ, Stakeholder and consultant	**Commissioning of RTPV system**	2-4 months depending on system size and other

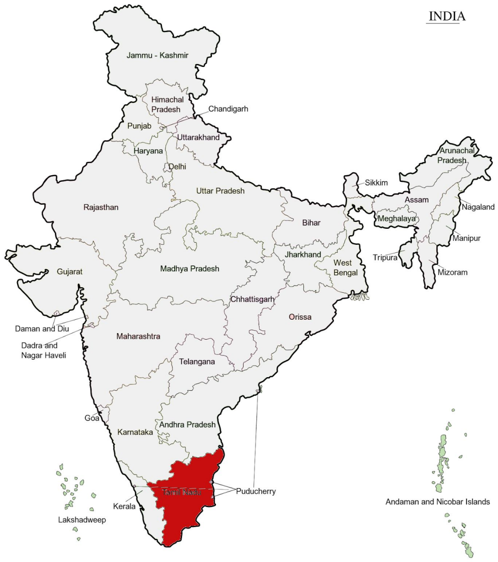
				complexiti es

State Wise Recommendations

Based on the potential assessment of each of the four recommended sub sectors, it is clear that different states have different potential for different sub sectors (see annexure for a state-wise breakup of potential across different sub-sectors).

For example, the textile sector is dominant in Tamil Nadu and nearly absent in Jammu Kashmir. The education sector is very strong in Maharashtra but has a muted potential in Delhi. Therefore the following statewise recommendations are made.

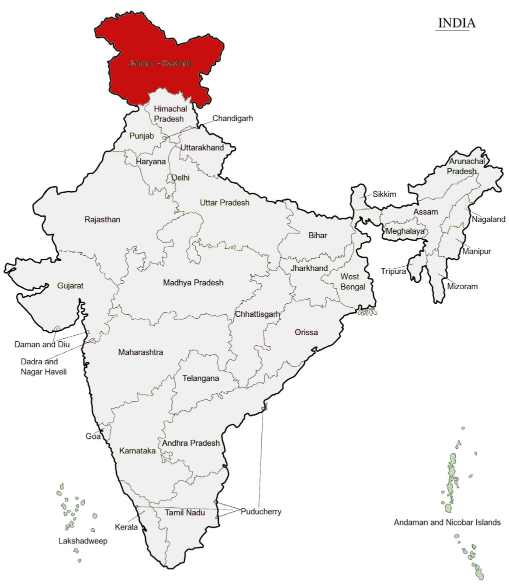
State	Recommended Sectors with Potential
Maharashtra 	**Potential:** Education: 4,847 MW Manufacturing - Textile: 97 MW Large Commercial Retail: 24 MW Cold Storage: 14 MW **Recommended Sub Sectors:** 1. Education 2. Large Commercial Retail
Tamil Nadu	**Potential:** Education: 2,927 MW Manufacturing - Textile: 384 MW Cold Storage: 9 MW Large Commercial Retail: 7 MW



Recommended Sub Sectors:

1. Education
2. Manufacturing - Textile

Jammu and Kashmir



Potential:

Education: 859 MW

Large Commercial Retail: 3 MW

Cold Storage: 1.6 MW

Manufacturing - Textile: 0.5 MW

Recommended Sub Sectors:

1. Education

Gujarat

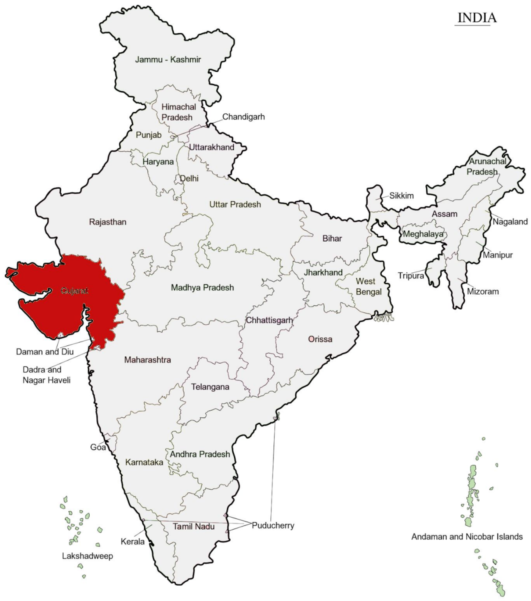
Potential:

Education: 1,368 MW

Cold Storage: 32 MW

Large Commercial Retail: 11 MW

Manufacturing - Textile: 15 MW



Recommended Sub Sectors:

1. Education
2. Cold Storage

Delhi

Potential:

Education: 323 MW

Large Commercial Retail: 9 MW

Cold Storage: 4.7 MW

Manufacturing - Textile: 0.4 MW

Recommended Sub Sectors:

1. Education
2. Large Commercial Retail

Odisha

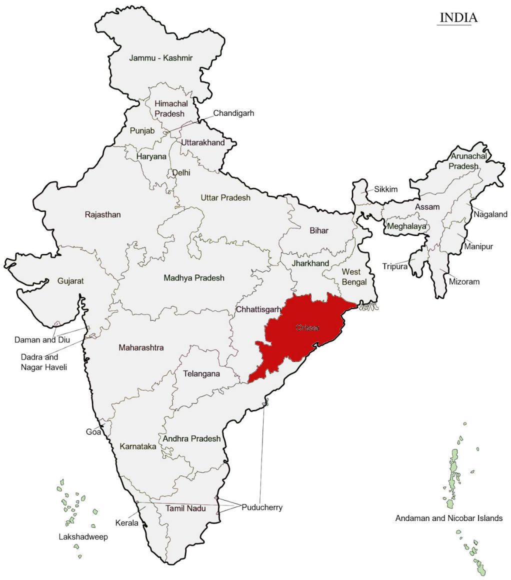
Potential:

Education: 2,183 MW

Cold Storage: 10 MW

Manufacturing - Textile: 7 MW

Large Commercial Retail: 2 MW



Recommended Sub Sectors:

1. Education
2. Cold Storage

Table 14: State wise Recommended Sectors with Potential

Each of the selected six states have been ranked as per the potential for the various sub-sectors selected in this report.

Sub-sectors and States	Education	Manufacturing Textile	Large Commercial Retail	Cold Storage
Delhi	6	6	3	5
Gujarat	4	3	2	1
Maharashtra	1	2	1	2
Tamil Nadu	2	1	4	4
Odisha	3	4	6	3
Jammu and Kashmir	5	5	5	6

Table 15: Ranking of States for Selected Sub-sectors

Business Model based Recommendations (CAPEX / RESCO)

As indicated through the replicability assessment, education institutions would contribute to a significant potential across all six target states. Out of the overall 12,508 MW, a significant portion of this comes from Government schools (4,759 MW) nearly 40%. However, based on our visits to Government owned buildings it was discovered that the lack of ownership is one of the biggest concerns for the long-term sustainability and maintenance of the RTPV systems. The lack of incentives and ownership from Government owned buildings means that although a kW of capacity may be installed, the system remains offline or underperforms very often. In order to circumvent the problem, it is recommended that all Government owned buildings be approached through a RESCO/OPEX model. In this model, the ownership will lie with the developer and the owner would only be responsible for leasing or renting the roof. This would address any maintenance related issues. There are other

CAPEX or RESCO?
Our site visits show that CAPEX installations must be encouraged where there is a direct ownership and an incentive in the proper function of the RTPV systems. This means that most industries, commercial complexes, residences can opt for CAPEX modes. In the event where the upfront investment is a constraint, then RESCO may also be explored.

However, for those buildings especially Government buildings where there is a lack of ownership and no incentive for the proper running of the system, the RESCO (OPEX) model is recommend. The RESCO model would ensure that the third party investor or developer operates and maintains the systems in order to generate the designed energy and reap the corresponding financial benefits from the systems.

The table below summarizes the application of CAPEX and RESCO models over specific criteria.

#	CAPEX	RESCO
Financial Capability	The CAPEX model is best suited for those consumers that have the ability to spend upfront on the RTPV system	The RESCO model is best for those consumers who cannot afford or do not intend to spend on the RTPV system
Recommended sector types	Those buildings where the occupant has a stake or an interest in the project Example: **Own residential, commercial, industrial buildings,**	Those buildings where the occupant does not have a stake or interest in the project Example: **Government Buildings**, buildings that are leased out to a tenant and some educational institutions where there is no single ownership
Recommended Metering Scheme	Net Metering or Gross Metering depending on the consumers preference	Gross Metering only since the investor's revenues cannot be a function of the consumption of the building
Availability of Accelerated Depreciation Benefit	AD benefit can be availed since the asset is owned on the books	AD benefit cannot be claimed by the consumer
Policy Restrictions	CAPEX models are allowed in all states	Some states have placed restrictions for RESCO models for specific categories such as industrial or commercial Example: Gujarat

Table 16: Overview of CAPEX and RESCO Models

Reforming India's Power Tariffs

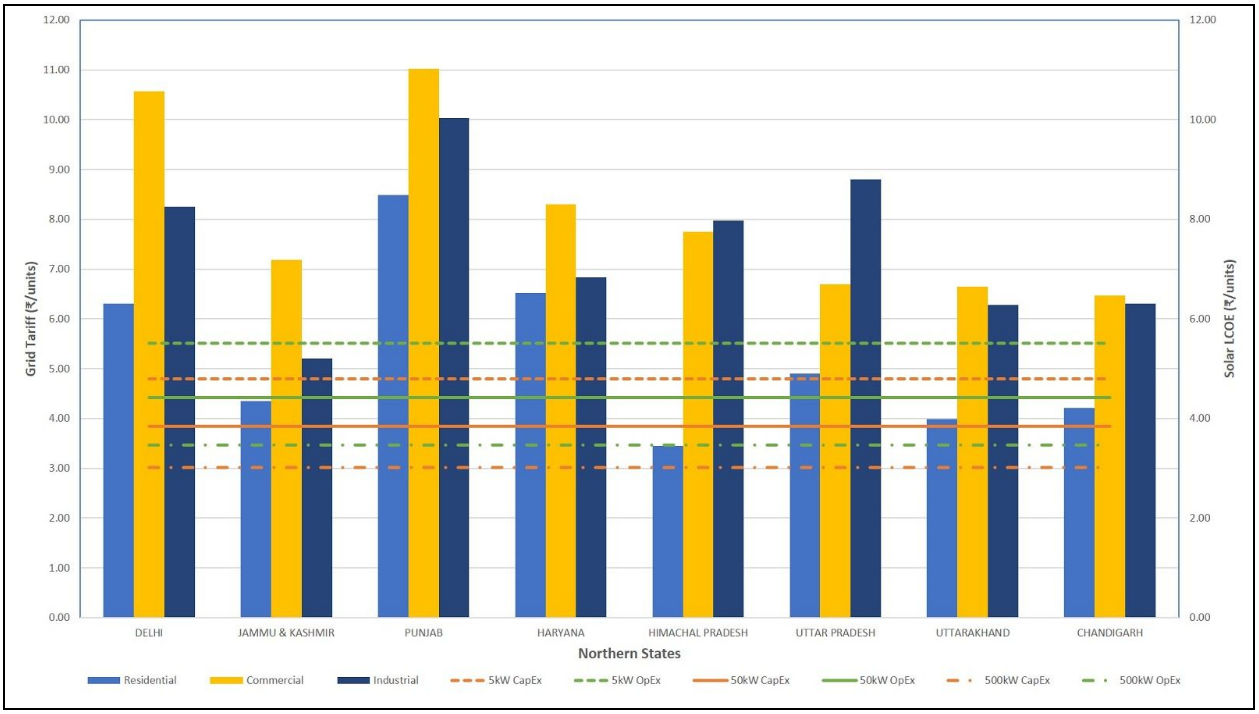
RTPV systems are usually adopted by consumers that pay the highest retail tariff in India (commercial, industrial and high consumption residential). While this augurs well for consumers, it reduces the revenue for India's already financially strained power utilities (DisComs). As more and more consumers leave the grid, the utility would be forced to increase prices for the remaining consumers, which would in turn incentivize many more consumers to adopt RTPV systems. This is known as the utility death spiral. While this isn't unique to India, the situation might be exacerbated owing to cross subsidies. India's power tariffs are cross-subsidized i.e. commercial and industrial consumers pay far higher tariffs to subsidize the nearly free power given to the agricultural segment. Therefore as the number of consumers leaving the grid increase, the tariff increase can only be passed on to the remaining high paying consumers and not all consumers. This results in the death spiral being rather acute and could happen quite quickly.

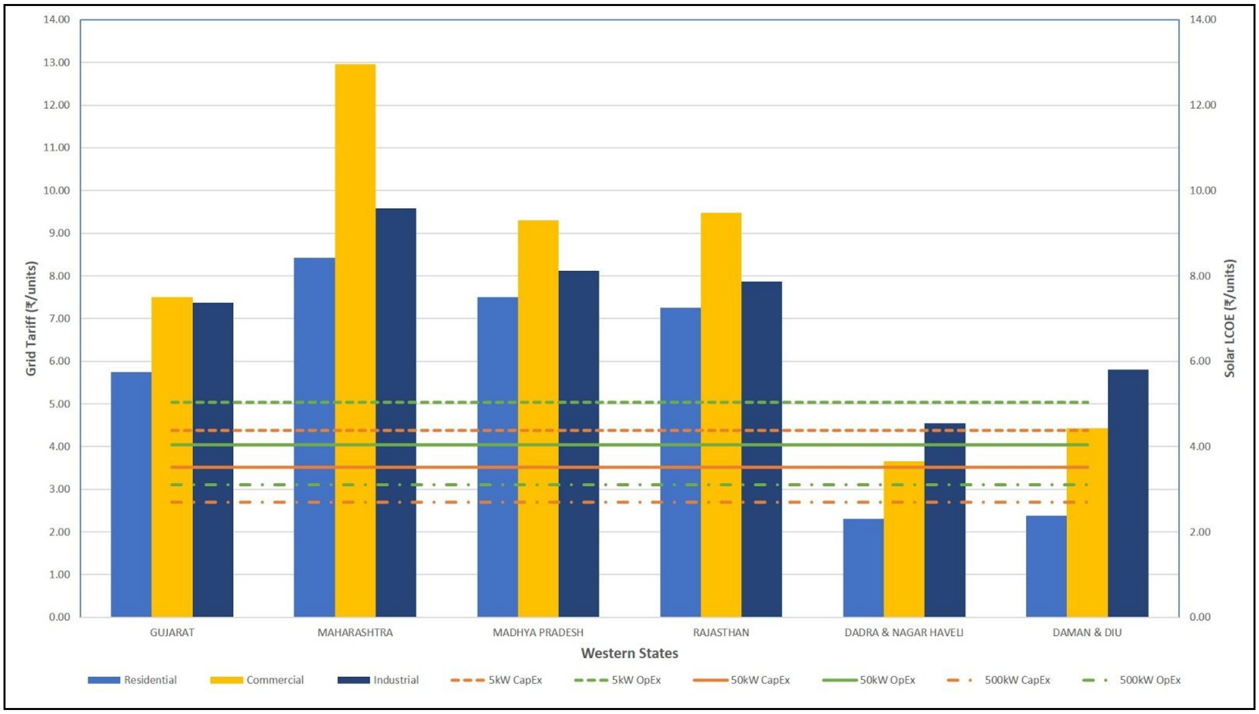
If one has to take a long-term sustainable view on the RTPV sector in India, what is desperately needed in tariff reforms in the power sector. This is a significant challenge owing to the political nature of such measures. However, one significant step that can be taken is to ensure that any subsidies for the farm segment be borne by the State or Central Government and not by other consumers. This would decrease tariffs for other consumers and prevent a death spiral situation for the utility.

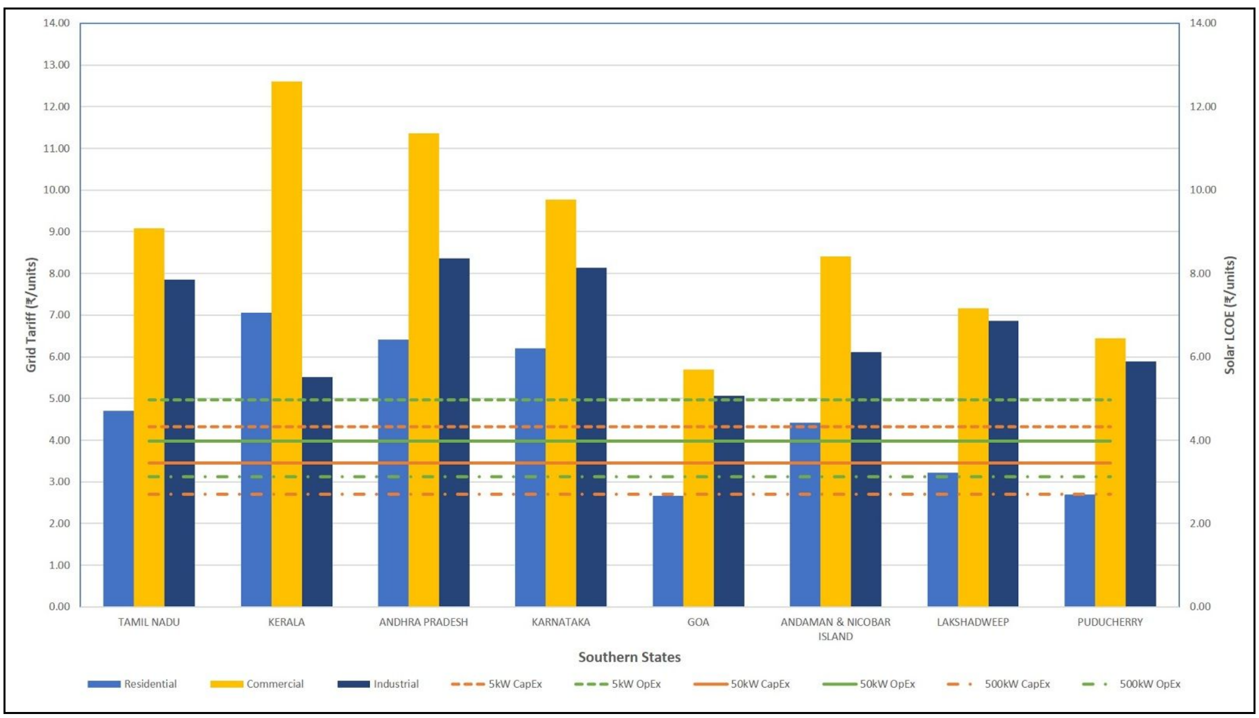
Despite this, many observers see the increase in RTPV as an inevitable happening. Utilities are faced with a choice of either opposing the technological change or by adopting it. In fact, utilities are best positioned to profit from RTPV systems by reaching out to their existing consumer base to promote such systems. Utilities already have access to billing systems and consumer databases. Additionally, they already understand the grid network on which these tail end distributed generation systems will come online. They also have the electrical engineering capabilities to carry out such installations. These models known as utility owned business models could be the most important change required in order to keep the RTPV sector sustainable in the long run.
Utility driven business models can be CAPEX or OPEX based systems based on the preference of consumers. In both cases financing support can be provided and recovered through the existing monthly invoices for the power bills. Ultimately, India's RTPV goals cannot be achieved without the active participation of India's utilities.

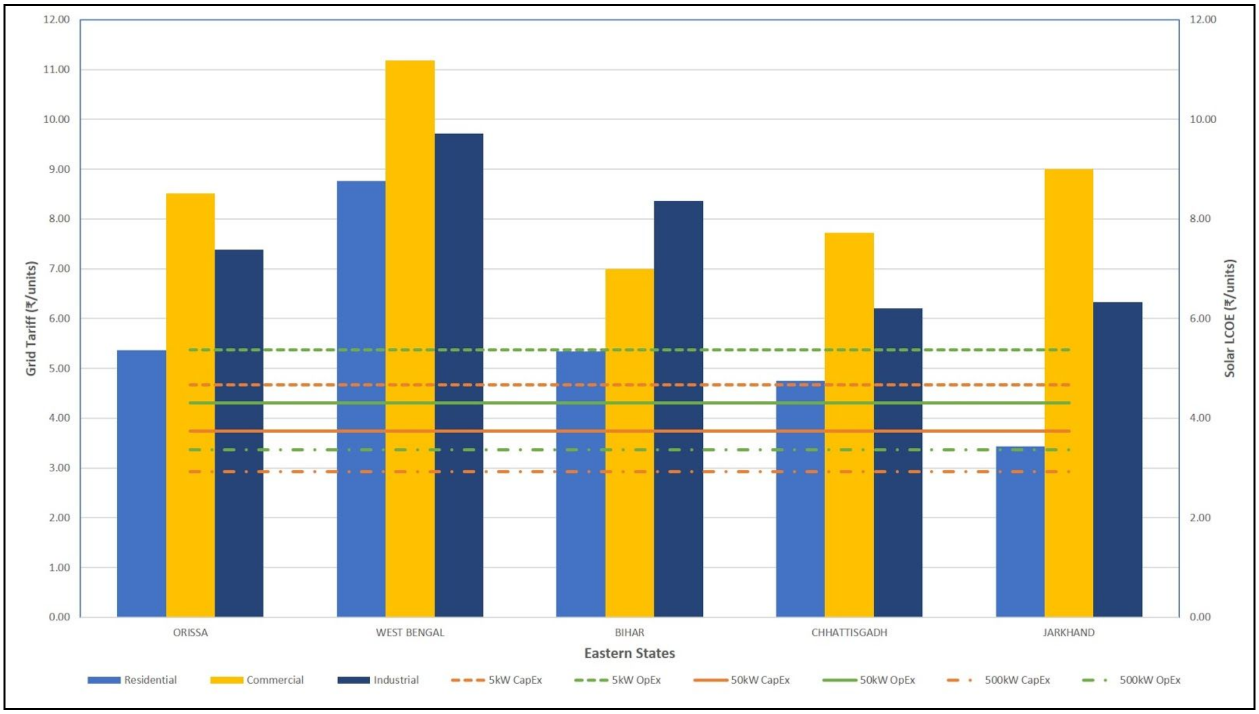
Annexures

Annexure 1: Tariffs Versus LCOE Comparison Across All States in India




Grid Tariff (₹/units)
Solar LCOE (₹/units)
GUJARAT
MAHARASHTRA
MADHYA PRADESH
RAJASTHAN
DADRA & NAGAR HAVELI
DAMAN & DIU
Western States
Residential
Commercial
Industrial
5kW CapEx
5kW OpEx
50kW CapEx
50kW OpEx
500kW CapEx
500kW OpEx


Grid Tariff (₹/units)
Solar LCOE (₹/units)
TAMIL NADU
KERALA
ANDHRA PRADESH
KARNATAKA
GOA
ANDAMAN & NICOBAR ISLAND
LAKSHADWEEP
PUDUCHERRY
Southern States
Residential
Commercial
Industrial
5kW CapEx
5kW OpEx
50kW CapEx
50kW OpEx
500kW CapEx
500kW OpEx


12.00
11.00
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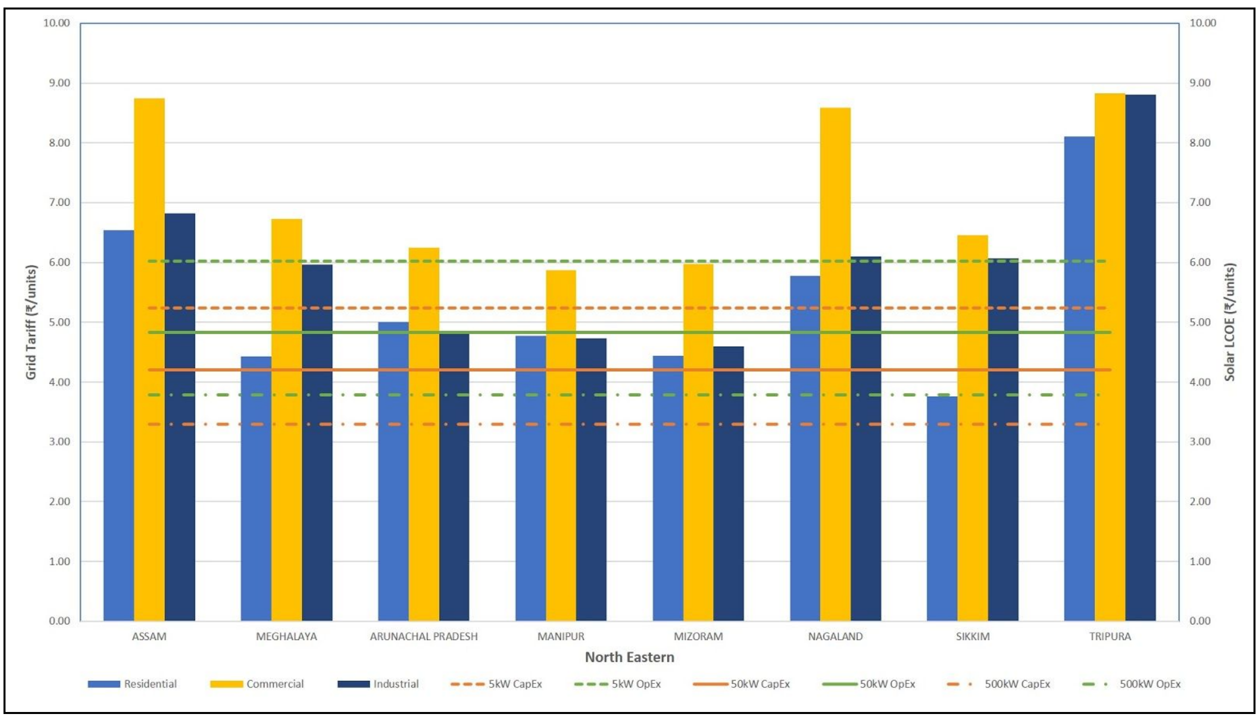
Grid Tariff (₹/units)
Solar LCOE (₹/units)
ORISSA
WEST BENGAL
BIHAR
CHHATTISGADH
JARKHAND
Eastern States
Residential
Commercial
Industrial
5kW CapEx
5kW OpEx
50kW CapEx
50kW OpEx
500kW CapEx
500kW OpEx


10.00
9.00
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Grid Tariff (₹/units)
Solar LCOE (₹/units)
ASSAM
MEGHALAYA
ARUNACHAL PRADESH
MANIPUR
MIZORAM
NAGALAND
SIKKIM
TRIPURA
North Eastern
Residential
Commercial
Industrial
5kW CapEx
5kW OpEx
50kW CapEx
50kW OpEx
500kW CapEx
500kW OpEx

Annexure 2: List of Case Studies Considered

#	Base Sector	Sub Sector	State	Site Name
1	Commercial	Large Commercial Retail	Maharashtra	200 kW, Royal Heritage Mall, Pune, Maharashtra
2	Commercial	Small & Medium Commercial Retail	Punjab	New Fruit and Vegetable Market in Mohali, 2 MW
3	Commercial	Large Commercial Retail	Maharashtra	Viviana Mall, 91 KW in Mumbai
4	Commercial	Education	Gujarat	M.S.University 964 KW
5	Commercial	Education	Chandigarh	1 MW Solar power plant at Punjab Engineering College (PEC), Chandigarh
6	Commercial	Religious	Maharashtra	Shree Ayyappa temple 54 KW, Thane
7	Commercial	Healthcare	Haryana	500 kWp Medanta Medicity Hospital – Gurgaon - Parking for 300 Cars
8	Commercial	Healthcare	Delhi	300 kWp Holy Family Hospital, Delhi
9	Commercial	Warehouse	Gujarat	Guru Cold Storage, Ahmedabad
10	Commercial	Religious	Punjab	Dera Baba Jaimal Singh Premises, 11.5+7.5 MW
11	Commercial	Large Commercial Retail	Delhi	212 kW Solar Carport on Unity One mall
12	Commercial	Transport	New Delhi	500 KW Rooftop Solar Installations in Delhi Metro Stations
13	Commercial	Transport	Kerala	Cochin International Airport
14	Commercial	Transport	Gujarat	BRTS bus stops Surat
15	Commercial	Transport	Delhi	6.3 MWp Delhi Metro Rail

				Corporation
16	Commercial	Transport	Gujarat	Ahmedabad airport
17	Commercial	Transport	Delhi	Delhi Airport Terminal 2: 2.5 MW rooftop plant.
18	Commercial	Government Building	Delhi	80 KW Solar Photovoltaic Plant at Parliament House Annexe,
19	Commercial	Government Building	Chandigarh	Model Central Burail Jail, Sector-45, Chandigarh
20	Commercial	Government Building	New Delhi	President's Estate 508 KW
21	Commercial	Government Building	Gujarat	1 MWp Ahmedabad Civil
22	Commercial	Government Building	Delhi	1MW rooftop solar plant at the Thyagaraj Stadium
23	Commercial	Government Building	Jammu and Kashmir	Raj bhavan (Governors House)
24	Commercial	Government Building	Jharkhand	Government owned buildings
25	Commercial	Education	Jharkhand	CMPDI Head office developed by GERMI
26	Commercial	Government Building	New Delhi	Yamuna Sports Complex 400 KW
27	Commercial	Government Building	Karnataka	M. Chinnaswamy Stadium 400 KW
28	Commercial	Education	Odisha	Utkal University (200 kW)
29	Commercial	Education	Uttarakhand	IIT Roorkee 1.8 MW
30	Industrial	Manufacturing	Delhi	Rooftop Solar Project at Yamaha Manufacturing Unit by Amplus Solar,
31	Industrial	Manufacturing	Rajasthan	Sutlej Textiles and Industries Ltd. (STIL), Bhawanimandi
32	Industrial	Manufacturing	Tamil Nadu	Murugan Textiles 2 MW
33	Industrial	Manufacturing	Gujarat	RTPV installation on an industrial rooftop.

34	Industrial	Manufacturing	UP	Pata Petrochemicals complex (GAIL), 5.76 MW
35	Industrial	Manufacturing	Tamil Nadu	Sharadha Terry Products Ltd (STPL), Coimbatore
36	Industrial	Manufacturing	Maharashtra	40 kWp M/s Ashapura Engineering Pvt Ltd, Waluj industrial area in Aurangabad
37	Industrial	Manufacturing	Karnataka	100 kWp Somu Group, bangalore
38	Industrial	Manufacturing	Gujarat	3.9 MW across Gujarat | ONGC for Captive Consumption
39	Mixed	Mixed	Tamil Nadu	Mahalaxmi Associates 14.4 kwp
40	Mixed	Mixed	Gujarat	5 MW RTPV Program in Gandhinagar
41	Mixed	Mixed	Gujarat	Surat Municipal Corporation, Science Centre & Katargram waterworks
42	Railway	Railway	Assam	Guwahati-India's first solar power railway station 700 KW
43	Railway	Railway	Delhi	First solar-powered DEMU (diesel electrical multiple unit) train
44	Railway	Railway	Jammu and Kashmir	Katra railway station 1 MW solar project
45	Residential	Residential	Maharashtra	65 kWp Raheja Eternity, Kandivali
46	Residential	Residential	Delhi	100 kWp Shiv Bhole society, sector 7 Dwarka

Annexure 3: Rooftop Solar Photovoltaic Power Plants Site Visit Form

GERMI

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Rooftop Solar Photovoltaic Power Plants Site Visit Form

SURVEY DETAILS

[A] General information

Name of the Customer/ Organization : ____________________

Site name : ____________________

Location : ____________________

Start of development : ____/____/________

Date of commissioning : ____/____/________

Roof ownership : ____________________

System ownership : ____________________

Type of building :
- ☐ Commercial
- ☐ Residential
- ☐ Industrial
- ☐ Government / Public
- ☐ Transportation

Operation and Maintenance Activities : ____________________

[B] Technical Information

System Information

Solar PV System Capacity ________ KW

Available Area : ________ m2

Total Installation Area : ________ m2

Technology used :
- ☐ Mono Crystalline
- ☐ Poly Crystalline
- ☐ Thin film
- ☐ Other ____________

EPC Company : ____________________

PV Module Model : ____________________

PV Module Capacity : ____________________

No of Modules : ____________________

Inverter Model : ____________________

Inverter Capacity : ____________________

No of Inverters : ____________________

Operational Days in a week : ________ Day

Auxiliary consumption ________ kWh

Average Monthly Units Consumed from Grid : ________ kWh

Roof Construction :
- ☐ RCC
- ☐ Wooden
- ☐ Metal Sheds

		☐	Other	________ Specify
Is there lighting protection and other electrical/fire safety systems available	:	☐	YES	
		☐	NO	________

Grid Connectivity Information

Metering	:	________	
Contracted demand from DISCOM	:	________	kVA
Grid availability	:	________	%
Power Cuts (Avg. Daily)	:	________	hrs
Grid Tariff	:	________	INR/kWh

[C] Financial Information

CapEx or OpEx	:	☐	CapEx
		☐	OpEx

CapEx

Total investment costs (CapEx)	:	________	INR
Subsidy (if given)	:	________	[% of CAPEX] or INR
EPC (equipment, engineering and construction) cost per kW)	:	________	INR/kW
Project development (permits, licenses, travel, misc) costs	:	________	INR
Inverter replacement costs	:	________	INR
O&M cost per kW	:	________	INR/y/kW
Insurance (% of depreciated CapEx)	:	________	%

Tax Depreciation

Depreciation benefit availed?		☐	YES
		☐	NO
Tax depreciation rate considered	:	________	%
Maximum allowed depreciation of CAPEX	:	________	%

OpEx

PPA offered	:	________	INR/kWh
PPA Escalation (if any)		________	%/y
PPA Period	:	________	Years

[D] Policy Information

Drivers (Social/Government)	:	________
Scheme/Policy/Norms followed (Net Metering / Gross Metering)	:	________

Subsidy (if given)

Details on statutory /other clearances obtained :

How would you rate the application and registration process (1 to 5)

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

Any specific comments and/or improvements

[E] Drivers and other factors

What was the prime motive for the installation :

Any problems faced (during / after installation)

[F] Other Information

Attached? : ☐ YES ☐ NO Attachment No.

Site survey map : ☐

Floor Plan : ☐

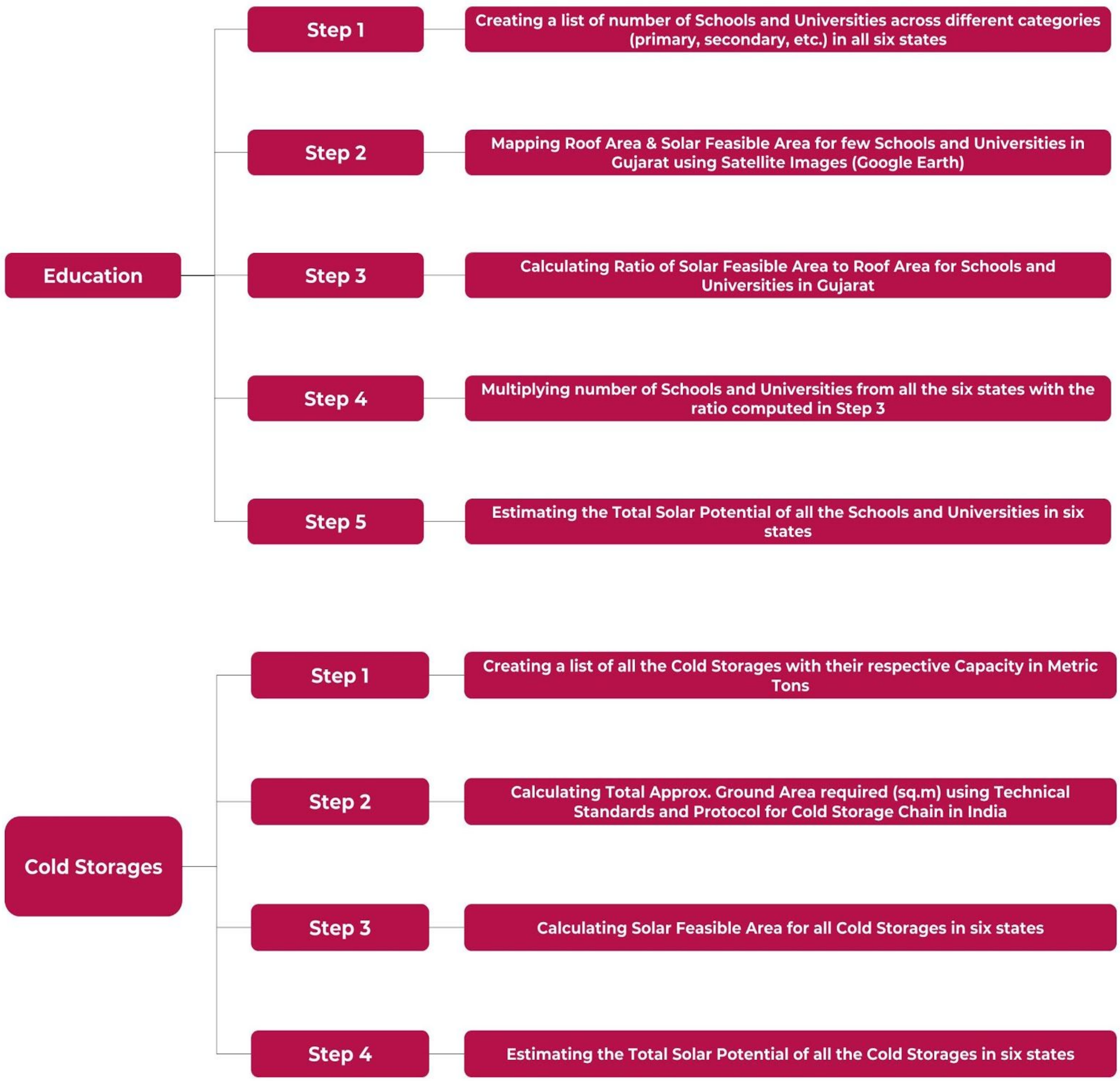
Roof Plan : ☐

Electricity Bills (Winter and Summer) : ☐

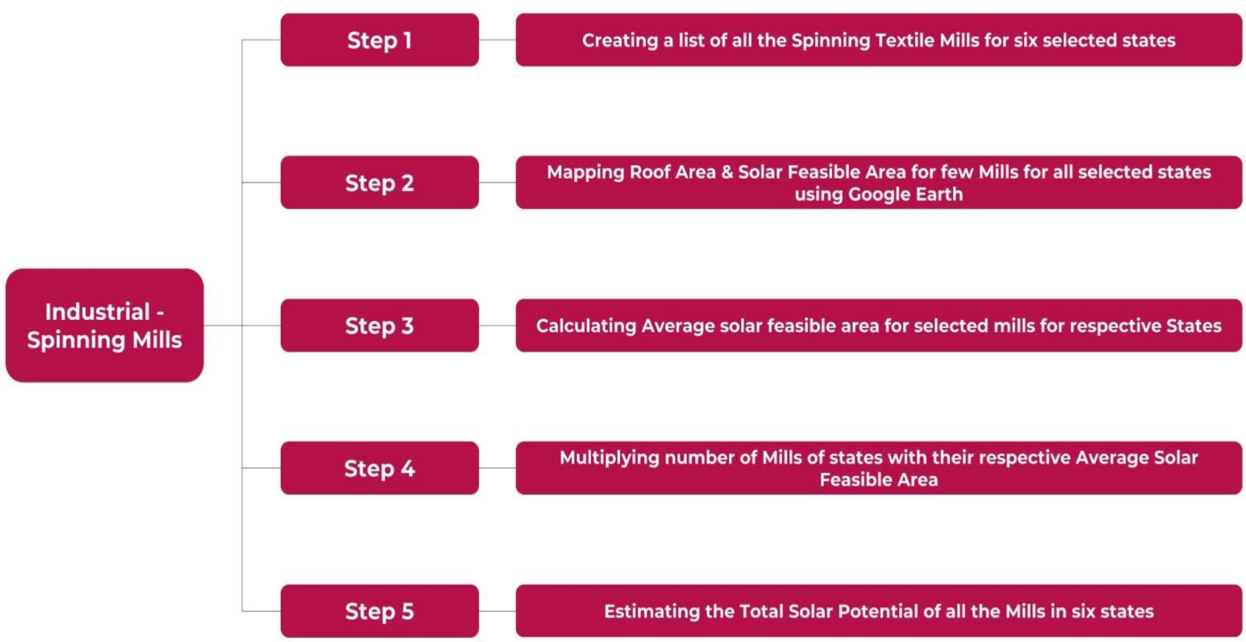
Photograph : ☐

Comments from Engineers

Annexure 4: Detailed Methodology For Potential Assessment




Large Commercial Retail
Step 1
Creating a list of all the Malls in Tier 1 & 2 cities in six selected states
Step 2
Mapping Roof Area & Solar Feasible Area for all the Malls only in Gujarat using Google Earth
Step 3
Calculating Ratio of solar feasible area to roof area for all malls in Gujarat
Step 4
Multiplying number of Malls from other states with that average feasible area
Step 5
Estimating the Total Solar Potential of all the Malls in six states


Industrial - Spinning Mills
Step 1
Creating a list of all the Spinning Textile Mills for six selected states
Step 2
Mapping Roof Area & Solar Feasible Area for few Mills for all selected states using Google Earth
Step 3
Calculating Average solar feasible area for selected mills for respective States
Step 4
Multiplying number of Mills of states with their respective Average Solar Feasible Area
Step 5
Estimating the Total Solar Potential of all the Mills in six states

Annexure 5: Calculation of Total Solar Potential of Malls

Sr. No.	State	Total No. of Malls in Tier 1 Cities	Total No. of Malls in Tier 2 Cities	Total Solar Feasible Area	Solar Potential (MW)
1	Gujarat	23	35	110,015	11
2	Maharashtra	76	41	236,982	24
3	Jammu & Kashmir	0	16	27,122	3
4	Odisha	0	14	23,732	2
5	Tamil Nadu	20	13	66,111	7
6	Delhi	42	0	92,555	9
				Grand Total	**56**

For the list of all the malls across six states please refer to the sheet provided here.

Annexure 6: Calculation of Total Solar Potential of Cold Storages

Sr. No.	State	No. of Cold Storage	Capacity (MT)	Total Approx. Ground Area required (sq.m)	Solar Feasible Area (sq.m)	Solar Potential (MW)
1	Gujarat	342	855,144	719,262	323,668	**32.37**
2	Maharashtra	388	360,064	302,850	136,282	**13.63**
3	Jammu & Kashmir	20	41,049	34,526	15,537	**1.55**
4	Odisha	104	274,175	230,609	103,774	**10.38**
5	Tamil Nadu	136	227,229	191,122	86,005	**8.60**
6	Delhi	91	123,293	103,702	46,666	**4.67**
					Grand Total	**71**

For the list of all the Cold Storages across six states please refer to the sheet provided here.

Annexure 7: Calculation of Total Solar Potential of Schools and Universities

Results Summary	Potential (MW)
Potential for all Universities and Colleges	**2,932**
Potential for all Private Schools	**4,739**
Potential for all Government Schools	**4,759**

Calculation:

Sr. No.	States	Total Schools	Total University & College	Solar Potential | Schools (MW)	Solar Potential | Universities (MW)	Total Solar Potential | Schools & Universities (MW)
1	Gujarat	44,545	2000	887	481	1,368
2	Maharashtra	104,971	5000	3,644	1,204	4,847
3	Delhi	5,727	150	287	36	323
4	Jammu & Kashmir	28,714	380	768	91	859
5	Odisha	68,977	1150	1,906	277	2,183
6	Tamil Nadu	57,992	3,500	2,085	843	2,927
Grand Total		310,926	12,180	9,575	2,932	**12,508**

For the list of Schools and Universities across six states please refer to the sheet provided here.

Annexure 8: Calculation of Total Solar Potential of Spinning Mills

Sr. No.	State	Number of Spinning Mills	Solar Potential (MW)
1	Gujarat	50	15
2	Maharashtra	162	97
3	Tamil Nadu	931	384
4	Odisha	15	7
5	Jammu & Kashmir	2	0.5
6	Delhi	3	0.4
	Grand Total	**1,163**	**505**

For the list of Spinning Mills across six states please refer to the sheet provided here.