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GOVERNMENT OF INDIA  
MINISTRY OF NEW  
AND RENEWABLE ENERGY

A close-up, angled view of a solar panel array, showing the grid lines and individual cells in shades of blue and white.

ACCELERATING  
**SOLAR ROOFTOP**  
IN INDIA

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# ABOUT THE USAID PACE-D TECHNICAL ASSISTANCE PROGRAM

The Partnership to Advance Clean Energy - Deployment Technical Assistance (PACE-D TA) Program was launched in July 2012, as a part of the bilateral initiative under the U.S.-India Energy Dialogue. The six-year program was led by the U.S. Agency for International Development (USAID) and the U.S. Department of State; and implemented in partnership with India's Ministry of Power and the Ministry of New and Renewable Energy (MNRE).

The PACE-D TA Program focused on assisting the Government of India (GOI) in the deployment of energy efficiency (EE), renewable energy (RE) and cleaner fossil technologies. This was done by strengthening policy and regulatory institutions, enhancing institutional and human capacity, implementing pilot projects and increasing access to finance. The Program's activities were aligned to support the GOI's core energy priorities such as 100 GW of solar by 2022 and Power for All.

## OVERVIEW

With nearly 300 days of sunshine every year, India has a huge opportunity to harness solar power to spur low carbon growth and leapfrog to a greener economy. While the GOI and the state governments have taken several initiatives to scale up solar technologies, the market requires a strong ecosystem to unlock its vast potential. This is especially true for solar rooftop due to its dispersed nature of investment, ownership and generation. While some states have begun to blaze the solar rooftop trail and have taken significant steps in promoting the development of a sustainable solar rooftop market, others have shown huge interest in following this path. At this stage, the most critical need for the scale up of the solar rooftop market is an integrated, systematic and simplified approach to design and deployment process.

The Program supported MNRE, state agencies (including state energy departments, distribution utilities and state nodal agencies), large public entities (Indian Railways and Indian Oil), financial institutions (Indian Renewable Energy Development Agency, Punjab National Bank and State Bank of India) and key training and capacity building institutions (National Institute of Solar Energy and Skill Council for Green Jobs) to build an enabling environment for solar rooftop. It assisted these stakeholders in the design and implementation of an integrated approach to solar rooftop market development with a focus on policy and regulation, interconnection framework, business models, solar rooftop procurement model, design of IT and other decision making tools, training program and roll out of integrated awareness and communication programs. The focus of the design of these interrelated interventions was to help establish a strong foundation for solar rooftop deployment in India and ease the way for scale-up of this technology. These interventions have served as catalysts for creation of the next generation of policies and regulations, interconnection guidelines, institutional capacity building for investment and procurement, awareness generation and training of key stakeholders.



### Creating an Enabling Environment

- Policy & Regulatory Framework
- Interconnection Framework for Utilities



### Transforming the Market for Mass Deployment

- Support to Public Sector
- Utility-based Business Models
- City-wide Program Design



### Building the Capacity of Stakeholders

- Training of Utilities, Entrepreneurs and Banks
- Tools and Knowledge Products



### Facilitating Finance

- Evaluation Tool and Credit Rating Framework

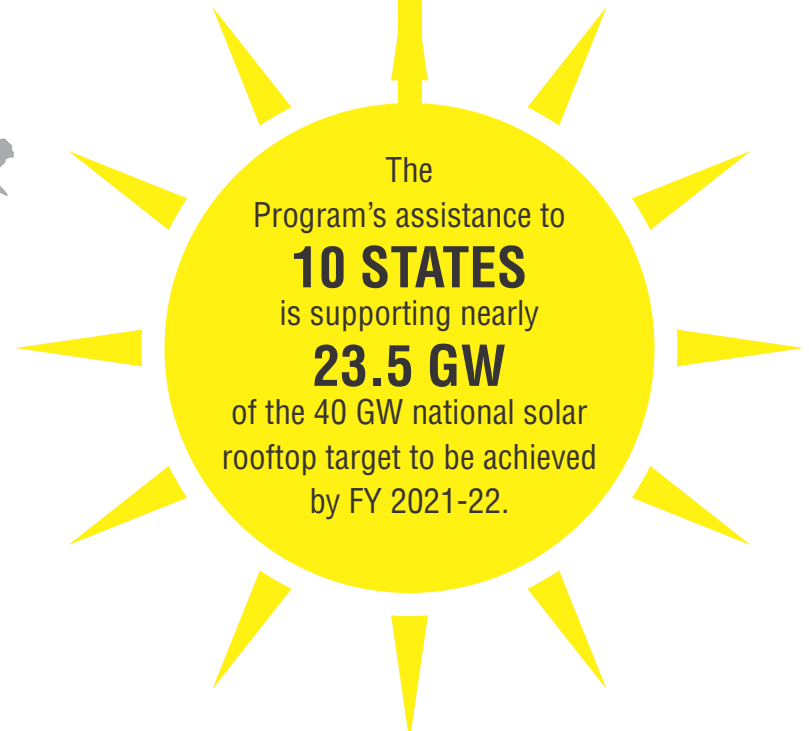
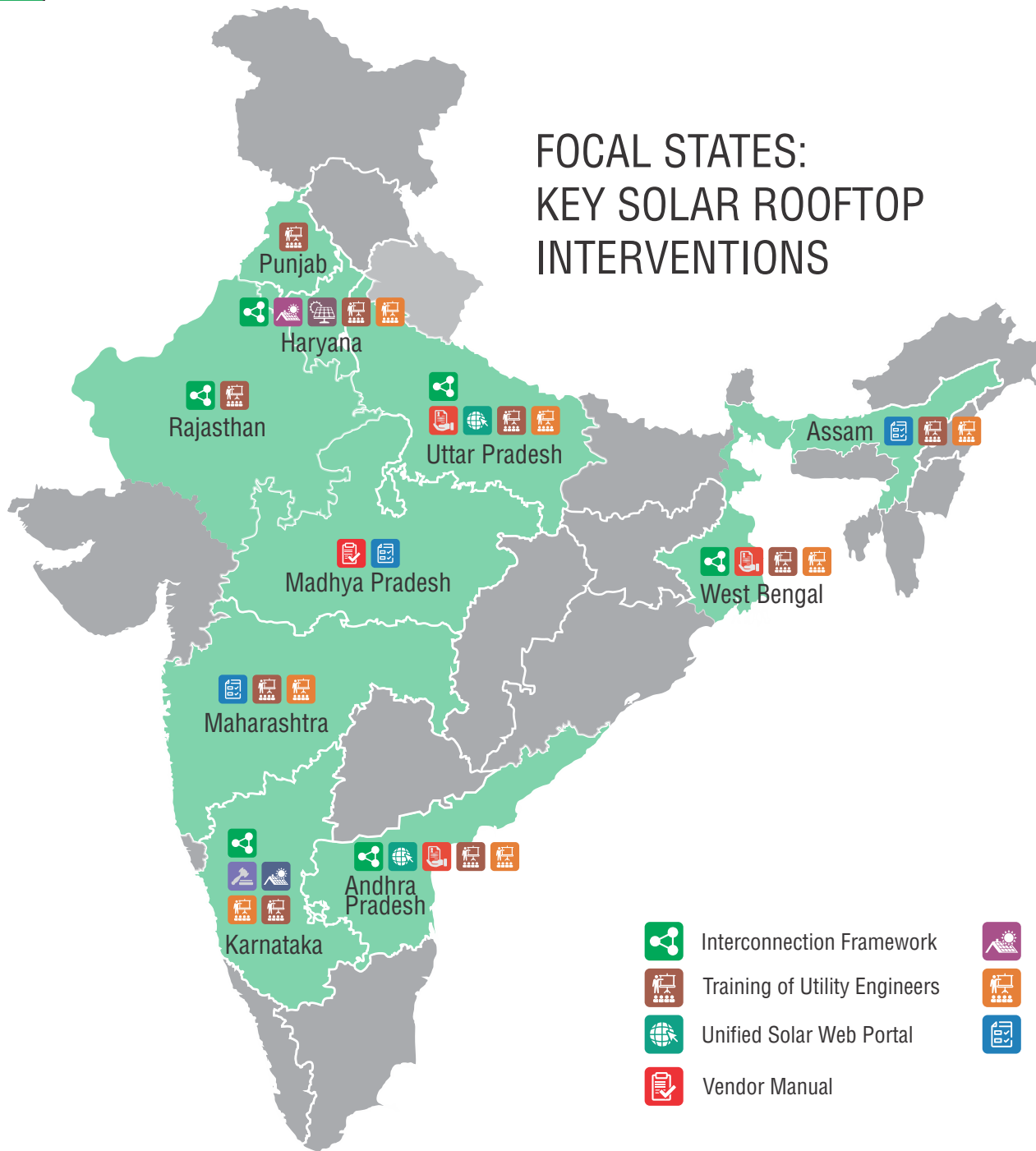


### Increasing Awareness across the Value Chain

- Integrated Outreach Framework



## FOCAL STATES: KEY SOLAR ROOFTOP INTERVENTIONS



- |  |                               |  |                           |  |                          |
|--|-------------------------------|--|---------------------------|--|--------------------------|
|  | Interconnection Framework     |  | Net Metering Framework    |  | Gross Metering Framework |
|  | Training of Utility Engineers |  | Training of Entrepreneurs |  | Support on Policy        |
|  | Unified Solar Web Portal      |  | Assistance in Procurement |  | Solar Rooftop Pilot      |
|  | Vendor Manual                 |  |                           |  |                          |

# CREATING AN ENABLING ENVIRONMENT

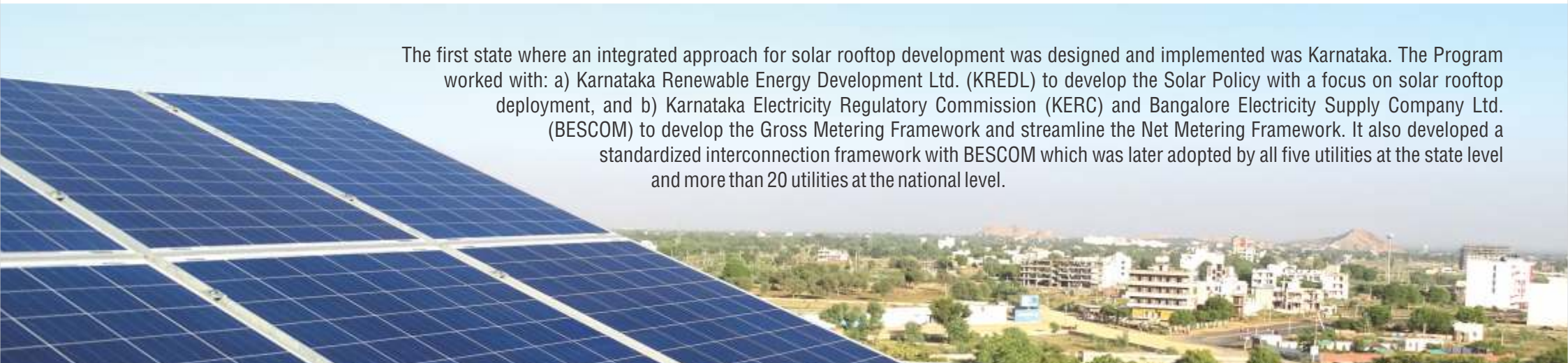
## POLICY AND REGULATORY FRAMEWORK

Today, the key responsibility of developing and deploying a sustainable market for a new technology like solar rooftop in India rests with the states. The states can encourage the development of solar rooftop through the design and deployment of a facilitating and robust policy and regulatory framework. A number of states have been proactive in promoting the use of solar rooftop and have undertaken several measures to ensure that the broad policy and regulatory framework for the adoption of solar rooftop is in place. However, several states still lack an appropriate policy and regulatory framework for solar rooftop deployment which has resulted in slow uptake.

To address these challenges, the Program worked with ten states (Haryana, Punjab, Uttar Pradesh, Rajasthan, Madhya Pradesh, West Bengal, Assam, Maharashtra, Andhra Pradesh and Karnataka) to provide technical assistance for the design, development and implementation of around 23.5 GW of solar rooftop capacity by 2022.

The technical assistance provided by the Program focused on ensuring that a facilitating policy and regulatory framework existed at the state level. This was undertaken by working with relevant agencies at the state level to develop customized policy instruments, appropriate and forward looking regulations as well as efficient and effective interconnection frameworks which would encourage not only investment but would also ease the whole process of developing and deploying solar rooftop systems at the state level. The Program undertook detailed analysis and stakeholder discussions to identify and recommend specific policy and regulatory interventions which would facilitate a “pull effect” and aid in quick and efficient uptake of solar rooftop by all target consumer segments. For instance, the Program highlighted the need for Gross Metering at the state level to encourage solar rooftop development amongst domestic consumers, recommended the use of Virtual Net Metering for consumers living in large apartment blocks and developed the standardized interconnection process which would aid the consumers and the utility deploying solar rooftop.

The first state where an integrated approach for solar rooftop development was designed and implemented was Karnataka. The Program worked with: a) Karnataka Renewable Energy Development Ltd. (KREDL) to develop the Solar Policy with a focus on solar rooftop deployment, and b) Karnataka Electricity Regulatory Commission (KERC) and Bangalore Electricity Supply Company Ltd. (BESCOM) to develop the Gross Metering Framework and streamline the Net Metering Framework. It also developed a standardized interconnection framework with BESCOM which was later adopted by all five utilities at the state level and more than 20 utilities at the national level.




## INTERCONNECTION FRAMEWORK FOR UTILITIES

An interconnection framework helps the various stakeholders—consumers, developers and distribution companies—understand specific steps from the time a consumer applies for a connection, until the system is connected to the grid. The framework should be simple, transparent, and standardized; which in turn can help increase consumer confidence and encourage them to put solar panels on their roofs.

However, development and adoption of interconnection processes has been challenging for states and utilities. While some states did not have clearly defined processes; others had processes that were cumbersome and time consuming, resulting in poor adoption of solar rooftop.

In 2014, the PACE-D TA Program provided assistance to BESCO to develop an interconnection framework which laid down general conditions and technical requirements for connecting solar rooftop PV systems to its grid. The guiding framework, and standardized forms and formats provided a good start and captured a number of key components for the development and interconnection of solar rooftop systems. The Program's assistance to BESCO facilitated a cumulative capacity addition of around 93 MW of solar rooftop in BESCO's licensee area as of January 2018.



The interconnection framework developed in partnership with BESCO was replicated across distribution utilities in Rajasthan, and customized for other states.



# TRANSFORMING THE MARKET FOR MASS DEPLOYMENT

## SUPPORT TO PUBLIC SECTOR

The public sector is uniquely positioned to leverage the opportunity offered by the GOI's revised RE target. This is largely due to high cost of energy for their internal use, ability to invest, engineering prowess and access to land and infrastructure. As of date, a total of about 7 GW of solar capacity addition has been announced by leading public sector undertakings.

The PACE-D TA Program provided support to two of India's largest public sector organizations—Indian Railways and Indian Oil Corporation Limited—to design and develop solar PV rooftop programs. The interventions such as standardized bid documents, analysis of business models and design of solar PV rooftop programs, can provide valuable lessons to other public sector firms that plan to foray into solar PV rooftop, and help in scaling up solar PV rooftop deployment in India.



Indian Railways plans to install **1.1 GW** of solar rooftop by 2025.

## INDIAN RAILWAYS

Indian Railways is the backbone of Indian economy. It is also the largest consumer of electricity in India, consuming nearly 18 billion units annually. In order to control the demand and lower its burgeoning energy bill, Indian Railways has set aggressive targets to produce RE, particularly solar power.

The PACE-D TA Program initiated interaction with Indian Railways in June 2014 to understand the challenges faced by Indian Railways in their go-green initiative. At that stage, the cost of solar energy was significantly higher, and Indian Railways had limited implementation experience. Through 2015, the Program worked with Indian Railways and developed the basic framework for roll out of the solar rooftop program via the Renewable Energy Service Company (RESCO) route.

The next step was to develop model documents based on which RESCOs could be invited to bid for solar rooftop projects. These included Model Request for Qualification (RFQ), Request for Proposal (RFP) and a Power Purchase Agreement. The lessons learned from the 50 MW Scheme helped India Railways to design and launch additional schemes for solar rooftop. The Program also assisted Indian Railways to understand the RE procurement options that would help it scale up solar procurement from utility-scale installations.

## INDIAN OIL

Indian Oil Company (IOCL) is India's largest refiner and retailer of petroleum. It relies on captive generation of electricity to meet energy needs of its refineries, and purchases electricity from local electricity distribution companies (DISCOMs) to meet additional energy requirement for its operations.

The PACE-D TA Program began interactions with IOCL in 2013-2014 when the oil firm was deliberating on adoption of solar rooftop for its refineries and retail outlets. The Program outlined three potential areas for large-scale RE deployment: petrol pumps, plants, warehouses and other facilities of IOCL, and large-scale solar parks. Consequently, the Program assisted IOCL in the development of a 5 MW solar rooftop installation across three refineries (Barauni, Panipat and Vadodara). Based on the pre-feasibility reports, IOCL floated the tenders for Barauni (1 MW) and Vadodara (0.5 MW). The detailed project report for Panipat (2.75 MW) was finalized and the tender was floated. The Program also assisted IOCL and the Solar Energy Corporation of India to conceptualize and develop financial models for solarisation of 3,000 petrol pumps across India.

After its successful foray into solar rooftop, IOCL has now moved its focus to solar parks and energy storage.

## UTILITY-BASED BUSINESS MODELS

India's existing solar rooftop capacity installations have been almost entirely developed through customer-driven Capital Expenditures (CAPEX) as well as Operating Expenses (OPEX) models. These business models suffer from several challenges, especially high upfront and transaction costs, high off-taker risks, limited availability of finance from mainstream financial institutions and lack of standardized procurement processes. Utility-focused business models can help address these challenges as utilities have the inherent advantage because they are customer facing, and act as the interface between the customer and the grid.

### BSES: SOLAR CITY INITIATIVE

The PACE-D TA Program assisted BSES Rajdhani Power Limited (BRPL), a leading electricity distribution company, in the design of an innovative program which aims to accelerate solar rooftop by aggregating consumers and ensuring active participation of project developers. The initiative, named as "Solar City Initiative - Solarise Dwarka" was formally launched by BRPL on January 7, 2017.

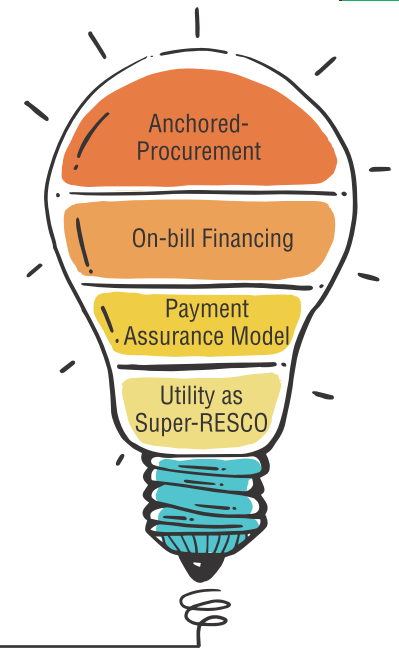


India's first solar rooftop consumer aggregation programme for community group housing.

The intent of the program was to standardize procurement process, bring in economies of scale and de-risk the execution, thereby directly benefiting consumers and vendors. This resulted in creation of a conducive business environment which saw interest from a total of 25 Resident Welfare Associations in Dwarka. As a part of this ongoing process, nearly 150 societies have been targeted in Dwarka under Phase I of this program. Subsequent plans for Phase II will accommodate commercial and industrial consumers.

## REPORT ON UTILITY-CENTRIC BUSINESS MODELS

As a part of its engagement with BRPL, the Program reviewed various utility-focused business models, analyzed their respective risk vs. benefit and implementation strategy, and presented the same to the utility. These business models and their analysis have been captured in a report “Utility Centric Business Model for Solar Rooftop Projects”. The report, available at [www.pace-d.com](http://www.pace-d.com), lists the various challenges for implementing solar rooftop—both for developers and utilities and analyzes the various utility centric business models. Utilities can use this report to understand the models, their pros and cons, and adopt them accordingly.



## CITY-WIDE PROGRAM DESIGN



While government buildings are prime candidates for solar rooftop projects, their potential has not been leveraged due to high upfront cost.

The PACE-D TA Program supported the State Government of Rajasthan and Rajasthan Renewable Energy Corporation Limited (RRECL) to design and implement a 5 MW city-wide solar rooftop program for Jaipur. The key objective was to aggregate the demand for solar rooftop at public buildings across the city; thereby reducing the overall project cost.

This included identification of an appropriate model for implementation, selection of efficient agencies to undertake the implementation, and operation and management through a transparent bidding process.

However, RRECL did not award any projects due to high price bids compared to the existing feed-in tariff for rooftop projects, and the lukewarm response from bidders. Based on the learnings, RRECL has revised the bid documents and plans to conduct the bidding process again.

# BUILDING THE CAPACITY OF STAKEHOLDERS

## TRAINING OF UTILITIES, ENTREPRENEURS AND BANKS

In order for India to achieve its aggressive target of 40 GW of solar rooftop by 2022, it needs an army of solar professionals who can effectively design, develop, finance and implement solar rooftop projects.

To facilitate the development of a skilled and diverse solar workforce, the Program, in collaboration with the Skill Council for Green Jobs (SCGJ) and the National Institute of Solar Energy (NISE), designed and developed a standard set of solar training curricula for utilities, entrepreneurs and banks - three key stakeholders for scale up in the solar rooftop ecosystem. These three curricula have now been ratified by the National Skill Development Corporation and are being used as standard for training these three categories of professionals.

The design of these training programs have the genesis of the work undertaken by the Program with various stakeholders – the work of the Program with BESCO and other utilities, work with NISE and various SNAs for the Entrepreneurship Development Program and work with Indian Renewable Energy Development Agency (IREDA), Punjab National Bank and State Bank of India for the Bankers training program.

Post the development of these training programs, the Program also lead their roll out in partnership with NISE and SCGJ. The Program organized 21 Entrepreneurship Development Programs, 69 Utility Training Programs and three Bankers Training Programs across the country.



The Program also led the development of a Network of Training Institutions called Solar Energy Training Network (SETNET), in partnership with NISE. The focus of this network was to facilitate the scale up of the training programs developed by SCGJ and NISE. The partners identified under SETNET were also empanelled by SCGJ for the roll out of their solar training programs like Surya Mitra.

### Training Programs

- Utility Engineers
- Entrepreneurs
- Banks



Training of Trainers

### RESOURCES TRAINED

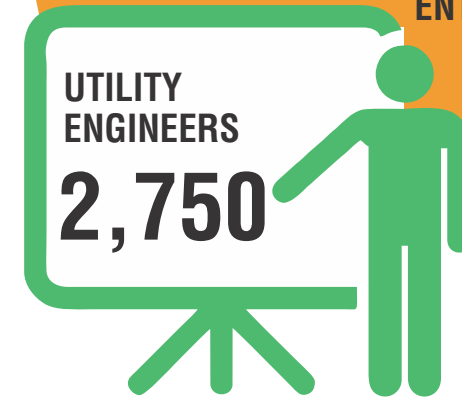
(AS ON MAY 2018)

UTILITY ENGINEERS

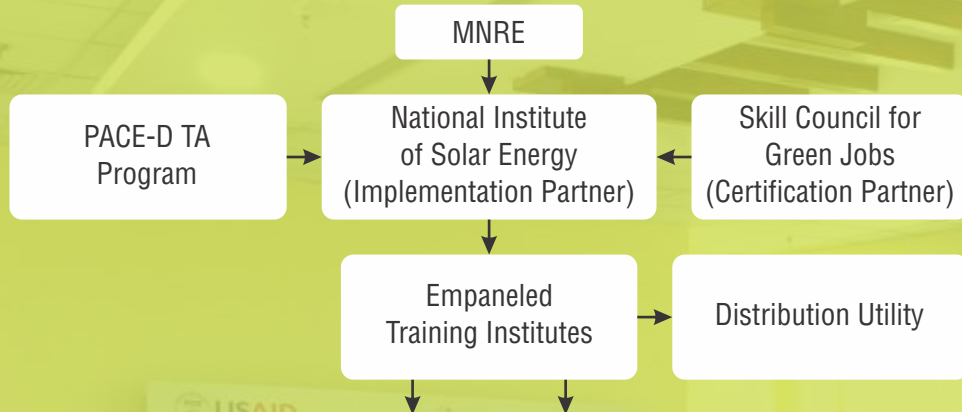
2,750

ENTREPRENEURS

866



## Solar Energy Training Network (SETNET)



- National Power Training Institute (NPTI), Faridabad
- Gujarat Energy Research and Management Institute, Gandhinagar
- Aligarh Muslim University, Aligarh
- NPTI, Guwahati
- NPTI, Durgapur
- Central Institute for Rural Electrification, Hyderabad
- Mahatma Gandhi Institute of Rural Energy and Development, Bengaluru
- Gandhigram Rural Institute, Gandhigram



## TAKING THE TRAINING INITIATIVES FORWARD

The standardized training packages have been handed over to the partners to scale-up the training of utility engineers, bankers and entrepreneurs on solar rooftop in India. Going forward, partner agencies such as the GIZ, World Bank, Asian Development Bank and the International Solar Alliance will roll out these trainings in collaboration with their partner state agencies and financial institutions.



### Standardized Training Package

- ii Qualification Pack
- ii Agenda for Training Program
- ii PowerPoint Presentation
- ii Feedback Form
- ii Training Aids (Activities & videos)
- ii Standard Training Guide



## TRAINING WORKSHOPS







## STUDY TOURS

As India strives to scale up solar rooftop deployment, it is critical to adopt relevant experiences, best practices, technologies and initiatives adopted internationally. The PACE-D TA Program organized two study tours to facilitate such knowledge transfer on solar rooftop and provide participants an opportunity to obtain first-hand experience of large-scale solar rooftop projects in the U.S. The first study tour, held on April 4 - 13, 2016, was designed to focus on solar rooftop, energy storage and innovative policies and regulations for RE deployment. Participants included representatives from the MNRE, SNAs and utilities. The second study tour, held on December 12 – 21, 2017, focused entirely on knowledge sharing on solar rooftop for utilities. Participants included representatives from MNRE and state utilities. The study tour provided participants with learnings and best practices to scale-up deployment in solar rooftop by learning of the experience of the U.S. market which is ahead in the learning curve.



## STATE KNOWLEDGE SHARING WORKSHOPS

Over the course of its six-year engagement, the Program worked substantially on institutional strengthening of State Development Agencies, SNAs and State Electricity Regulatory Commissions to effectively design, deploy and monitor solar rooftop deployment. As a part of this initiative, it organized five knowledge sharing workshops for stakeholders in partner states. These workshops got together representatives from partner states to understand each other's innovative policies, regulations, best practices, success stories, learnings and programs under implementation. They also helped share the Program's work in focal states, discuss progress and brainstorm potential ideas to overcome state specific implementation issues on EE and RE technologies including solar rooftop.



February 24-26, 2014 (Puducherry)



February 18-19, 2015 (New Delhi)



June 30-July 1, 2016 (Bengaluru)



September 6-7, 2017 (Chandigarh)



March 15-16, 2018 (Goa)

## TOOLS AND KNOWLEDGE PRODUCTS

### CENTRALIZED MONITORING CENTRE

Exponential capacity addition of solar rooftop is envisaged under the National Solar Mission. One of the biggest challenges going forward will be to understand the performance of these systems and their impact on the performance of a wide variety of stakeholders like distribution utilities, developers and consumers, and policy makers .

The stakeholders will require real time or as close to real time data on the performance of these systems to plan for the management of the grid, formulate policies and regulations at national and state level and to make better investment decisions.

The Program assisted NISE in the design of the overall framework of a National Centralized Monitoring Center (NCCM) and the subsequent implementation of the pilot phase of the NCCM in Delhi and Chandigarh. The NCCM is essentially an online monitoring system, which will capture data (remotely), collate data at a central point (central server) and process the same data to provide relevant information related to the performance of solar projects especially solar rooftop projects. The NCCM will provide real time data, information and analysis using a wide array of analytical tools available to different stakeholders. The application of the process at National Level i.e. capturing solar generation from all the grid-connected solar PV systems installed in the country is envisaged as one of the key functions of the NCCM.

### BEST PRACTICES GUIDE

As SNAs and DISCOMs embark on their solar rooftop journey, they face challenges – most of them being teething troubles such as lack of clarity in policy/regulation, technical uncertainty or long administrative procedures. There is no documented go-to guide that can provide them information on all aspects of solar rooftop, which in turn can help them make informed decisions.

To address this knowledge gap, the PACE-D TA Program developed a “Best Practices Guide” on solar rooftop that includes a comprehensive and efficient solar PV rooftop implementation support process into a single document. The Guide, available at [www.pace-d.com](http://www.pace-d.com), captures global and national best practices and learning.

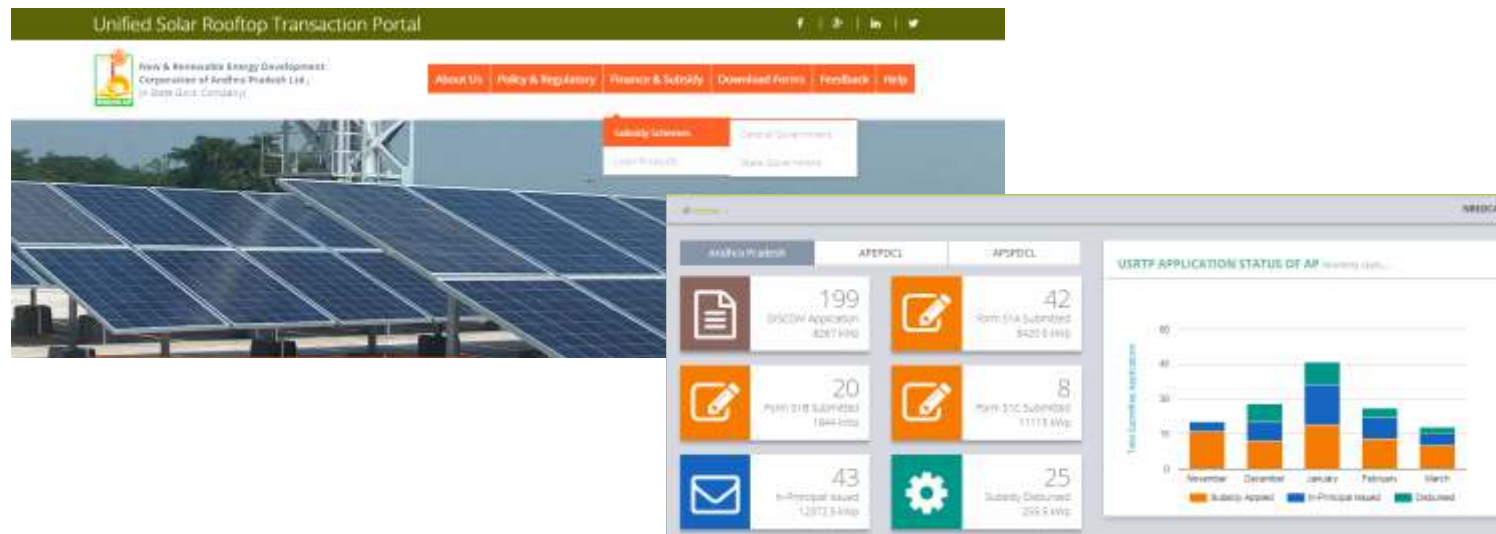


## UNIFIED SOLAR ROOFTOP TRANSACTION PORTAL

One of the major challenges for the roll out of the solar rooftop has been the limited bandwidth of the distribution utilities to facilitate quick processing and turnaround of applications and other approvals. On the other hand, consumers face huge transaction costs as they have to undertake multiple follow-ups with the utility for approvals, information and payments. The use of IT tools has the potential to make this whole process more efficient and comfortable for the utility as well as the consumer.

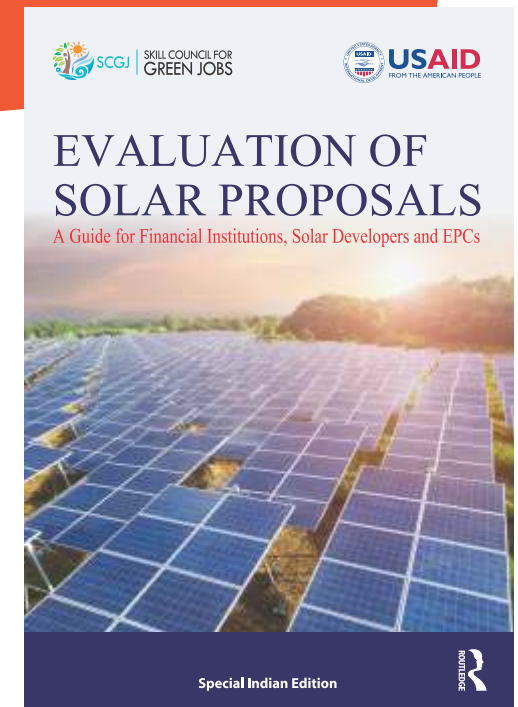
The Program, while assisting BESCO, identified the need for an IT-based portal which could facilitate online interaction between the consumer and the utility, allowing huge savings at both ends. The idea was that any consumer who wishes to install a solar rooftop system should have on their command (and at one place) all the detailed information for setting up these systems, forms and formats for applying for system interconnection, availing subsidy and finance to name a few. This could be done through an online portal which would be accessible to the utility, the consumer, SNA and any other stakeholder necessary to implement the system.

The PACE-D TA Program, in partnership with the New and Renewable Energy Development Corporation of Andhra Pradesh Limited (NREDCAP), developed a Unified Solar Rooftop Transaction Portal. The portal unites multiple stakeholders involved in solar rooftop interconnection process on a single platform, makes all related information available to them and even allows online transactions between multiple stakeholders.



## HANDBOOK ON EVALUATION OF SOLAR PROPOSALS

As a part of its knowledge sharing initiative, the PACE-D TA Program, in partnership with the SCGJ, developed a handbook on "Evaluation of Solar Proposals". The handbook serves as a guide for financial institutions, solar developers and engineering, procurement and construction stakeholders. It provides an overview of how an individual can review and evaluate a detailed project report of a solar PV power plant, including feasibility study of the site for installation, assessing the techno-commercial feasibility, and determining the financial viability of setting up a solar PV power plant.



# FACILITATING FINANCE

## EVALUATION TOOL AND CREDIT RATING FRAMEWORK

Financing for solar PV rooftop development has not taken off in a big way in India, largely due to the limited knowledge, understanding and awareness of the opportunities and risks for lending in this market segment.

With this in mind, the PACE-D TA Program developed the Solar Rooftop Evaluation Tool (SRET) in 2016. The tool aims to help the financing community understand the key parameters that drive the viability and sustainability of commercial and industrial solar PV rooftop projects; and also help enhance understand the different business models, and technical architecture and commercial terms of engagement for these projects. The investors and financiers can use the SRET to identify key risks associated with the solar PV rooftop projects and make the Go/No-Go loan decision. The SRET, meant for commercial and industrial solar rooftop projects, can also be customized for the evaluation of any solar rooftop project including urban residential and institutional.

Following the launch of the SRET in September 2015, the Program worked with IREDA and its credit rating agencies to map the key technical, financial, commercial, policy and regulatory parameters impacting the viability and risks associated with solar rooftop deployment. The Program used the tool to customize IREDA's rating framework for solar rooftop projects. IREDA and its credit rating agencies are now using the framework to evaluate the solar rooftop loan applications.



LOAN  
APPLICATION  
FOR  
**SOLAR ROOFTOP**



# INCREASING AWARENESS

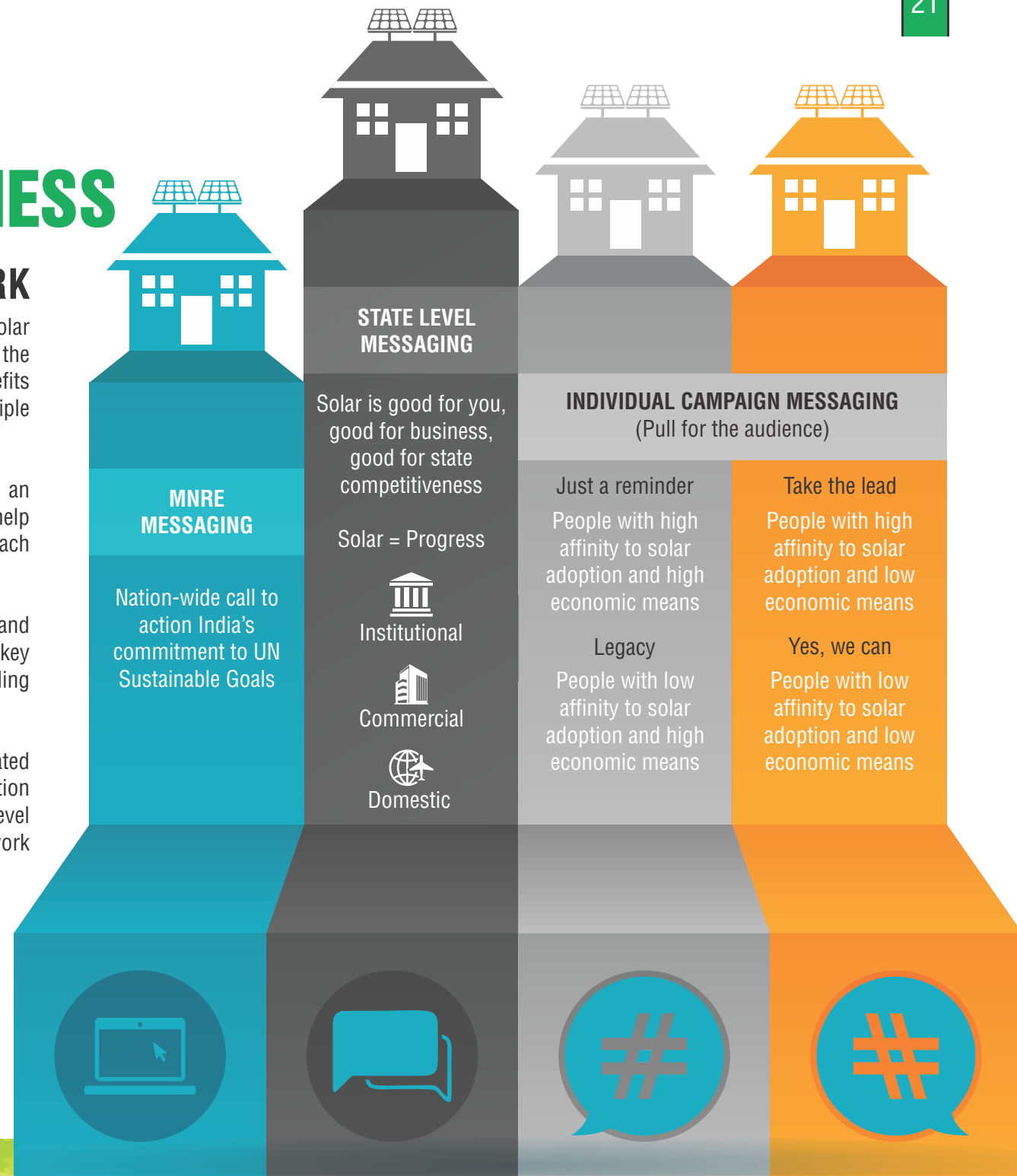
## INTEGRATED OUTREACH FRAMEWORK

Lack of awareness is a key deterrent to deployment and scale-up of solar rooftop in India. It is essential to make the masses understand the importance of switching to Solar PV Rooftops by highlighting the benefits to adoption; a process that needs to be initiated and addressed at multiple levels.

To address this knowledge gap, the PACE-D TA Program developed an integrated communication and outreach framework that can help stakeholders such as SNAs and utilities design and implement outreach interventions to scale up solar rooftop.

As a first step, the Program reviewed the existing communication tools and practices of stakeholders across seven focal states and interviewed key representatives to understand their challenges and perspectives regarding solar rooftop outreach.

Based on the findings of this research, the Program developed an integrated outreach framework that addresses the identified barriers to adoption through outreach at three key stages: Unified National Message, State Level Message, and Targeted Individual Message. This standardised framework can be localised and adapted by the states as per their requirement.



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