STUDY THE FEASIBILITY AND POTENTIAL OF SOLAR APPLICATIONS IN MICRO, SMALL AND MEDIUM ENTERPRISES IN RURAL INDIA

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List of Abbreviations

ACE	Access to Clean Energy
CEEW	Council on Energy, Environment and Water
CFC	Chlorofluorocarbon
CGFTMSE	Credit Guarantee Fund Trust for Micro and Small Enterprises
CGS	Credit Guarantee Fund Scheme for Micro and Small Enterprises
CLCSS	Credit Linked Capital Subsidy Scheme for Technology Upgradation
CSR	Corporate Social Responsibility
DC	Direct Current
DIC	District Industries Centre
DISCOMs	Distribution Companies
DoHT	Department of Handloom and Textile
ESCOMs	Electricity Supply Companies
GDP	Gross Domestic Product
GEDA	Gujarat Energy and Development Agency
GMKRTI	Gujarat Matikam Kalakari & Rural Technology Institute
GTNfW	Grassroot Trading Network for Women
GVM	Gram Vikas Manch
INDCs	Intended Nationally Determined Contributions
INR	Indian rupee
JHARCRAFT	The Jharkhand Silk Textile and Handicraft Development Corporation Ltd
JREDA	Jharkhand Renewable Energy Development Agency
KSHDC	Karnataka State Handicrafts Development Corporation
KVIC	Khadi and Village Industries Commission
kWp	Kilowatt 'peak'
MNRE	Ministry of New and Renewable Energy
MSE-CDP	Micro and Small Enterprises Cluster Development Programme
MSEs	Micro and Small Enterprises
MSME	The Micro, Small, and Medium Enterprises
MSMED	Micro, Small and Medium Enterprises Development
NABARD	National Bank for Agriculture and Rural Development

NGO	Non-Government Organization
NRDC	Natural Resources Defence Council
NSS	National Sample Survey
PMEGP	Prime Minister's Employment Generation Programme
PMMY	Pradhan Mantri Mudra Yojana
PV	Photovoltaic
R&D	Research and Development
RETPRLs	Renewable Energy Technology Packages for Rural Livelihoods
SDGs	Sustainable Development Goals
SEWA	Self-Employed Women's Association
SFURTI	Revamped Scheme of Fund for Regeneration of Traditional Industries
SIDBI	Small Industries Development Bank of India
SSEF	Shakti Sustainable Energy Foundation
SSI	Small-Scale Industries
TEQUP	Technology and Quality Upgradation
TERI	The Energy and Resoruces Institute

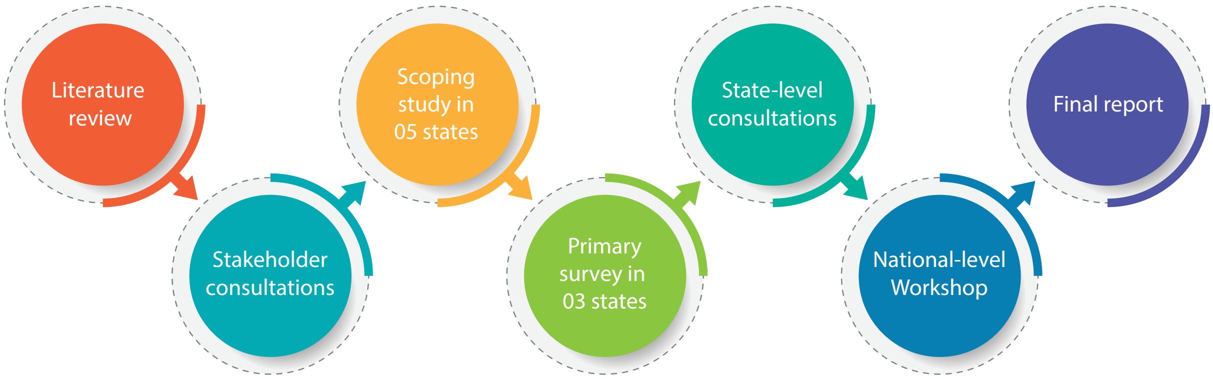
Executive Summary

Introduction

As per the 73rd Round National Sample Survey (2015–16), around 63.4 million unincorporated non-agricultural micro small and medium enterprises (MSMEs) are estimated to be engaged in various economic activities in India that contribute to 29% of the total gross domestic product (GDP) and employ nearly 111 million people. The micro-enterprises constitute more than 99% of the entire MSME sector alone. The central and state governments have been rolling out relevant policies and schemes periodically to enhance and improve the infrastructure, technology, financing, and institutional support for the growth of MSMEs. Further, access and availability of key energy sources are the critical inputs that determine productivity and competitiveness in the sector. The micro- and home- based enterprises in rural areas are particularly heavily reliant on a wide range of fossil fuel-based energy sources, such as coal, wood, diesel, and grid electricity to meet their daily processing energy needs despite the fact that these fuel prices and related pollution are increasing. While the Government of India has almost achieved universal households' electrification, the field studies undertaken by various research institutions in India including TERI, New Delhi have found that the gaps still exist in the quality and reliability of power supply in the rural areas of some of the major states that affect the day to day manufacturing at micro-enterprises clusters. At the same time, there are clear trends in terms of improvements in solar photovoltaic (PV) technology and its significant price reduction in the last few years. Solar energy, thus, not only reduces the dependency on fossil fuels but also makes cost of production competitive due to sustainable generation and decentralized management. Thus, it has been justified to carry out a feasibility assessment of solar PV applications in the MSME sector, particularly in the micro-enterprise and artisans-based clusters in rural areas to assess the scope for scaling up of solar energy.

The Study Framework

TERI with support from Shakti Sustainable Energy Foundation, New Delhi carried out a field study to explore the feasibility and potential of solar PV applications in the MSME sector in rural India. The objective of this study is to identify 8–10 micro- and home-based enterprise clusters, develop a road map for solar PV intervention in the feasible clusters, and influence evidence-based policymaking for scale up. To achieve this, the study carried out a situation analysis through literature review and preliminary stakeholder consultations. Based on the literature survey and consultations at the national level, five states were selected for scoping study. Finally, three states were shortlisted and a total of nine clusters (Khasbag-Belgam powerloom, Chhannapatna wooden toy, Sidlaghatta silk twisting, and Shivarapatna stone idol-making clusters in Karnataka; Gandhinagar and Kutch Pottery, Surendranagar and Patan salt clusters in Gujarat; Bishnugarh brass, Maganpur sewing, and Kharasawan silk reeling in Jharkhand) were identified for undertaking primary survey. The study findings were shared with all relevant stakeholders by organizing state-level roundtable as well as through one-to-one discussion.



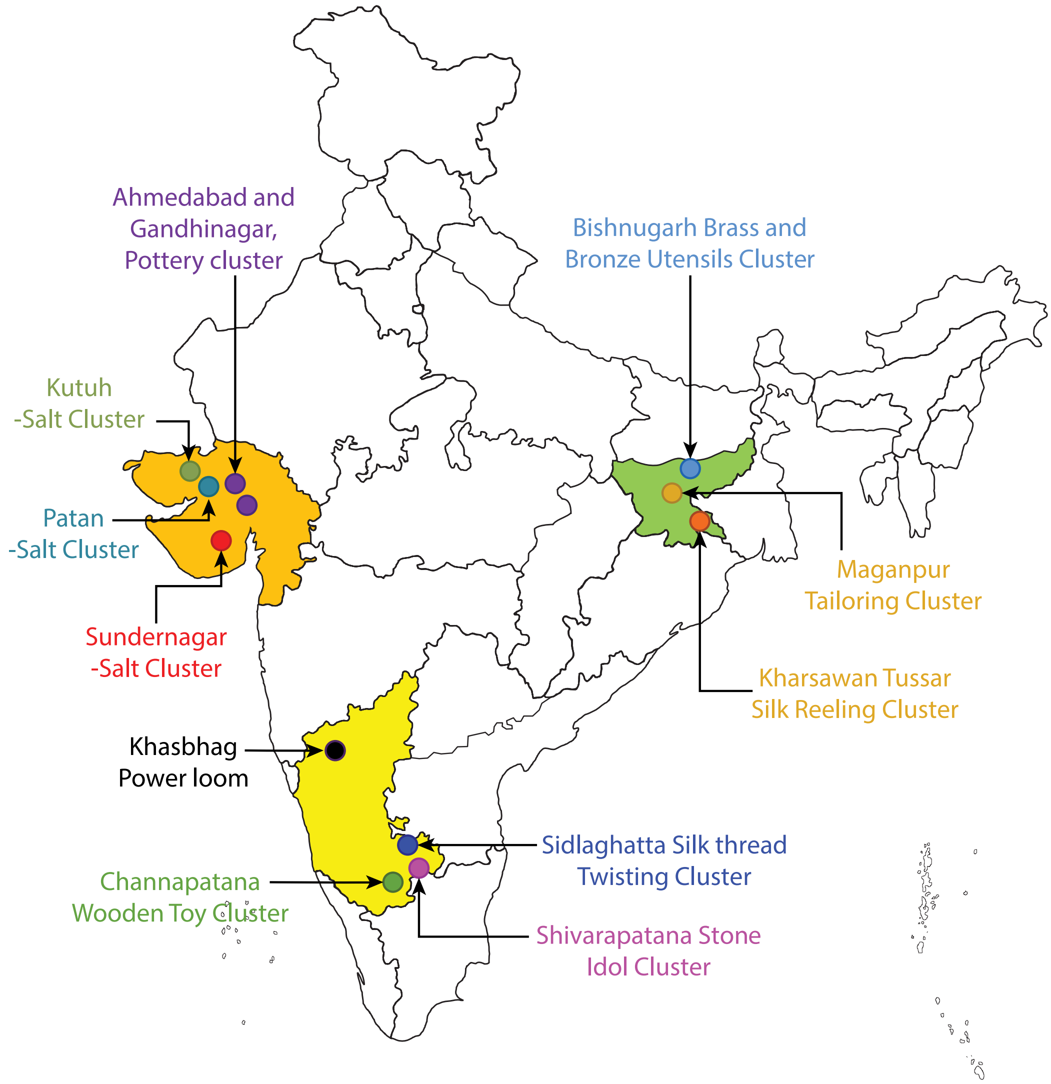
The analysis was carried out based on the information gathered through primary survey, such as sources of energy, consumption pattern, types of equipment and capacity utilization, hours of production, quantity and prices of products, revenue generation, energy-efficiency parameters, potential solar applications and incremental financial benefits if solar is introduced, as well as willingness of these micro-entrepreneurs to invest in solar energy. Thereafter, appropriately-sized solar PV systems were designed and potential business models were worked out for introduction of solar PV applications for all these clusters.

Key Findings

Most of these studied clusters are traditional and quite popular in their respective states. In fact, the salt cluster of Kutch and wooden toy cluster of Channapatna are nationally well known. Clusters such as wooden toy, silk thread twisting, and powerloom in Karnataka, and silk reeling and brassware in Jharkhand are already registered under different schemes of the Ministry of MSME for possible technical and financial assistance. Each cluster being unique has distinct set of challenges. The key findings of the study are following:

» Three (03) enterprise clusters of Jharkhand were surveyed, one each from Hazaribag, Ramgarh, and Sareikela-Kharsawan districts (all aspirational districts). Electricity supply has been found unreliable and intermittent and available only for 8–10 hours daily. In Bishnugarh brass cluster of Hazaribag, the enterprises are heavily reliant on diesel-run gen-sets and reluctant to apply commercial connection due to high initial deposit and monthly tariff (onetime deposit of INR 12,000 for every 1 HP load and more than INR 6 per unit). Access to interrupted and affordable electricity would surely replace diesel use and reduce cost of production. In Maganpur sewing cluster of Ramgarh, the entrepreneurs have to depend upon manual stitching for 3 to 4 hours daily. Access to solar power can enhance the working hours by 4 to 5 hours daily, and, hence, has the potential to increase production and income by around 30–40%. In Sareikela-Kharsawan district, the silk reeling units at common facilitation centres of JHARCRAFT, presently deprived of grid electricity, urgently need solar power and can enhance further mechanization to create more employment, production, and income of the women artisans.

» Four (04) enterprise clusters were surveyed in Karnataka, one each from Chikkaballapura, Belagavi, Kolar, and Ramanagara districts. Uninterrupted power supply, for almost 22–24 hours daily, has been found in all these clusters. The state Department of Handloom and Textiles (DoHT) has been providing 60% tariff subsidy to the entrepreneurs of Khasbag



powerloom and Sidlaghatta silk twisting cluster. Surprisingly, the entrepreneurs of all these clusters, including Channapatna wooden toy and Shivarapatna stone idol clusters, have wished for solar power system if made available at subsidized price.

» In Gujarat, the pottery clusters of Gandhinagar and Kutch districts are hardly facing any power issues. However, a shift to clean energy is expected to help in reducing their electricity bills and improve profitability. Electricity infrastructure is, however, absent in the salt clusters of Kutch, Sundernagar, and Patan districts of the state and holds huge scope for decentralized solar PV applications. The state government has also earmarked specific budget provision (2020–21) for purchasing solar pumps for the salt workers.

» Most of these enterprises have been facing many challenges including lack of raw materials, inadequate working capital, lack of investment capacity for advanced tools and equipment, expensive yet unreliable energy sources, etc. Hence, they lack the ability to invest upfront for solar PV as well. Small and affordable loans are not easily available from local commercial banks and financing institutions. Lack of awareness and sensitizations on solar potential have also led to little or no dissemination. The present national- and state-level MSME and solar policies encourage the use of non-conventional energy sources including solar in manufacturing sector, however lack of implementing guidelines discourage financing of solar PV system in the sector except silk sector scheme of Ministry of Textile, Government of India.

» The primary survey has enabled in the design of appropriately sized solar PV system across the clusters and enterprises. While the smallest solar PV size is needed in Maganpur sewing cluster (as small as 150 Wp) of Jharkhand, the biggest solar PV size is needed in Chhannapatna wooden toy cluster (as big as 14 kWp) of Karnataka. Similarly, the aggregate solar potential has been highest in salt cluster and lowest in the pottery cluster of Gujarat. All four clusters of Karnataka and salt cluster of Gujarat have significantly higher solar PV potential.

» The business models developed across the clusters and enterprises reveal the payback period of solar PV investment in Jharkhand is minimum (1 to 3 years) with zero subsidy which is an exception in comparison to all clusters of Karnataka and Gujarat where subsidy to the tune of 40% to 65% is needed to keep payback period in and around 5 years period with same bank interest rate (8% per annum).

» The survey interactions and findings reveal many direct and indirect impact benefits of solar PV that may of course vary from cluster to cluster. Adoption of solar PV is expected to replace conventional fuel and related expenses and reduce subsidy burden as well as enhance working hours, employment, and income.

Study Recommendations

The feasibility study is expected to develop possible business models for the uptake of solar PV systems in the micro-enterprise sectors of India. Based on this study, the following key recommendations have been provided here:

i. Introduction of solar PV scheme for micro-enterprises

The Ministry of MSME (MoMSME) or Ministry of New and Renewable Energy (MNRE), Government of India may come up with a new 'solar PV scheme for MSME sector, particularly for targeting micro-enterprise sectors in rural areas'. Such schemes will encourage significant solar adoption, which will reduce the cost of production and increase profitability. It will further help in replacement of polluting diesel gen-sets usage in the micro/ home-based enterprises.

ii. Financial assistance under existing MSME schemes

MoMSME, Government of India schemes such as Micro and Small Enterprises Cluster Development Programme (MSE-CDP), Prime Minister Employment Guarantee Programme (PMEGP) and Revamped Schemes of Fund for Regeneration of Traditional Industries (SFURTI) as well as newly introduced 'Atmanirbhar Bharat Abhiyan' may facilitate credit-linked capital subsidy facilities for inclusion of solar PV systems in the micro-enterprises.

iii. Constitution of technical committee

State-level technical advisory committee may be constituted comprising experts from finance, technology, policy, and procurement to address the impediments that have been limiting the uptake of solar PV in the sector.

iv. Facilitating small loans for micro-enterprise clusters

Small loans at affordable rate should be facilitated to micro-entrepreneurs for adoption of solar PV systems. It would enable more attractive payback periods and reduce financial burden on micro-enterprises. Loans could be made available from financing scheme, such as 'MUDRA' by sensitizing all other financing agencies including MFI/RRBs/SFIs/cooperative, etc. for solar procurement.

v. Converting state power subsidy to one-time capital subsidy

It is proposed that the state government may allocate the power subsidy to respective DISCOM (in states such as Karnataka) in order to promote grid-interactive solar PV rooftop programme in the micro-enterprise cluster roping in organizations such as EESL and IREDA to facilitate financing.

vi. Awareness generation and demo piloting

Creation of awareness and sensitization among the micro-enterprise clusters have been recommended on existing solar PV schemes and incentives. Further, to ensure the quality of the solar PV system, a list of approved solar integrators should be made available from time to time to these prospective entrepreneurs. The solar integrators or other agencies may be encouraged with incentives for promoting solar PV in the micro-enterprise clusters. As a way forward, demonstration model of solar PV in the identified cluster may be considered to showcase the technical and business prospects of the system to the micro-entrepreneurs, financiers, and policymakers.

vii. Multi-stakeholders collaboration

Multipronged strategies may be needed through multi-stakeholder's collaboration including policymakers, consultants, local administration (e.g. district industry centers) suppliers, bankers, research institutions, and the civil societies for arranging resources for successful piloting and then scaling up of solar PV applications in rural micro-enterprise clusters.

1. Introduction

The micro, small, and medium enterprises (MSME) sector in India has been one of the most significant drivers of the Indian economy over the last 50 years. MSMEs were first formally defined in the Micro, Small and Medium Enterprises Development (MSMED) Act, 2006. The provisions of the Act defined and categorized enterprises into the manufacturing and service sectors, according to their investments. The definition was recently revised, basing it on annual turnover instead of investment, as part of the Government of India's special economic relief package, known as *Atmanirbhar Bharat Abhiyan* (self-reliant India movement), to counter the economic fallout of the on-going COVID-19 pandemic (Ministry of MSME 2020). A comparison of the old and new definitions of MSMEs is provided in Tables 1 and 2.

The MSME sector's contribution to different facets of the economy has been immense. The sector's share in India's GDP is almost 29% (2016–17) and it employs around 110 million people from rural, peri-urban, and urban areas. Moreover, the products of these enterprises form around 48% (2018–19) of India's total exports (Ministry of MSME 2019). Within the expansive MSME landscape, micro-enterprises account for 99% of the MSME sector with 63 million enterprises divided almost equally between rural (51%) and urban (49%) areas and employing around 107.6 million people (Ministry of MSME 2019),

TABLE 1: Old definition of MSMEs

Criteria: Investment in Plant and Machinery or Equipment			
Classification	**Micro**	**Small**	**Medium**
Manufacturing Enterprises	Investment <INR 25 lakh	Investment <INR 5 crore	Investment <INR 10 crore
Services Enterprise	Investment <INR 10 lakh	Investment <INR 2 crore	Investment <INR 5 crore

TABLE 2: Revised definition of MSMEs

Composite Criteria: Investment and Annual Turnover			
Classification	**Micro**	**Small**	**Medium**
Manufacturing and Services	Investment <INR 1 crore and Turnover <INR 5 crore	Investment <INR 10 crore and Turnover <INR 50 crore	Investment <INR 20 crore and Turnover <INR 100 crore

98% of total employment generated by MSMEs. Therefore, the MSMEs are rightly called the 'Engines of Growth'.

Recognizing this, the successive governments have made efforts to formalize the sector which was largely unorganized, through policies, programmes, and schemes, for addressing the specific challenges faced by the sector from access to finance to technology upgradation and employment generation. Also, several government institutions, such as Khadi and Village Industries Commission (KVIC), the Coir Board, National Small Industries Corporation, National Institute for Micro, Small and Medium Enterprises, and Mahatma Gandhi Institute for Rural Industrialization, were constituted for facilitating the development of this sector. These institutions work on a range of issues in the MSME sector and devise schemes for elevating their respective sectors' development.

It was also acknowledged that upgrading to modern technology is an essential pre-requisite for improving the quality and productivity of MSMEs and, thus, was prioritized as a key objective of these institutions' agendas. Consequently, various measures and research initiatives were introduced in this regard. Efforts were also made for the use of electricity in the micro-enterprises sectors towards mechanizing the production process to reduce the drudgery of the people involved in manufacturing, increase productivity, and enhance the general competitiveness of the sector.

However, despite achieving almost universal electrification, gaps still exist in the quality and reliability of power supply in some parts of the country, along with practical difficulties in obtaining commercial electricity connection, especially by household-based enterprises (Smart Power India 2019). These factors can restrict the efficiency of the production process. As a result, many of these units rely on fossil fuels – mainly diesel – to meet their power requirements, adding both to costs and emissions due to burning of fossil fuels. This also reduces competitiveness of micro/home-based enterprises.

Thus, there is a need of a reliable solution for meeting the power requirements of these units, which in addition to providing reliable, affordable, and quality electricity supply should also be less polluting. With the Government of India's focus on shifting to clean energy sources and energy-efficient production mechanisms, renewable energy finds a favourable position in transforming the energy choices of the MSME sector. Within renewables, solar photovoltaic (PV) technology is an apt solution, which can provide reliable and clean power supply, especially to the micro/households-based enterprises. Further, in states with policies for net metering, entrepreneurs will be able to sell surplus power to the grid, thereby providing an additional source of income and potentially improving their standard of living. In the long run, it will also reduce the technical and financial burdens borne by distribution companies (DISCOMs).

This feasibility study by TERI with support from Shakti Sustainable Energy Foundation (SSEF) was undertaken through secondary desk research, consultations with key stakeholders, supplemented with primary surveys in selected micro-enterprises clusters. As highlighted in the Inception Report, the study emphasized mostly on micro/household-based enterprises to enable them to make a transition to solar PV for powering their production activities.

1.1 Rationale of the Study

Micro-enterprises face many challenges in terms of technology, access to credit, market linkages, and competitiveness, among others. Further, it is generally seen that micro-enterprises lag when it comes to availing benefits and incentives provided to the MSME sector through various government schemes. Micro and small industries still rely mainly on conventional source of energy and due to higher cost of energy, their cost of production is very high. In recent times, solar PV technology has become a very popular source of energy due to its technology advancement and decrease in cost per unit. It has become attractive even in those states where power supply is reliable but due to cost advantage, industries want to switch over to solar. Some of the bigger industries with own resource have been able to shift to solar and reduce their cost of energy; however, micro/household-based enterprises lack the technical know-how and invest capacity to opt for cheaper source of energy, i.e. solar PV. In order to address these challenges, it is important to conduct an on-ground assessment focusing on micro-enterprise clusters operating in different parts of the country to understand their energy-use patterns, gaps, and opportunities for deploying solar PV technology to power the production activities. The findings from the study will help build understanding of on-ground technical, financial, institutional, and other aspects of micro-enterprises operations, and the role of solar PV in addressing energy challenges among various actors, such as renewable energy project developers, practitioners, NGOs, and government agencies working on developing and modernizing the MSME sector as well as government and private sector agencies working on augmenting livelihoods in rural and peri-urban areas. The study also provides insights for policymakers at the state/centre level for an extension of solar energy use in the MSME sector.

This report highlights the major findings from the primary survey that was conducted in three selected states. The survey covered nine micro-enterprise clusters, and the information obtained was used to understand the feasibility of deploying solar PV systems for production processes in the cluster. Accordingly, solar PV systems were designed for each cluster, catering to their energy needs. The individual cluster reports along with solar PV designs are provided as annexures in the main report.

2. Objectives and Methodology

2.1 Study Objectives

The overall objective of the project was to identify the various MSME clusters, especially micro-enterprises, in different regions of the country and explore the potential of solar energy use as a reliable and sustainable energy resource for enhancing income opportunities for such micro-enterprises. The main objectives were as follows:

» Identification of 8–10 micro and small industry clusters in different states of the country to explore the potential of solar energy use as a reliable and sustainable energy source.

» Develop a road map (along with detailed feasibility reports for the selected clusters) for possible market development to scale-up solar-based interventions in micro-enterprise sectors.

» Create evidence for policy/project intervention for augmentation of solar energy use in the micro-enterprise sector.

2.2 Study Approach and Methodology

The study adopted an approach of secondary research followed by primary surveys, supported by extensive consultations with sector experts and other relevant stakeholders. The information gathered from the secondary research and field visits was documented. In the inception phase, the documented data comprised situation analysis of the micro-enterprise sector and a review of relevant state policies, leading to the selection of five states for a scoping survey. In the next phase of the study, suitable clusters, based on pre-determined criteria, were chosen for primary survey from three states among the scoped states. The data collected during the primary survey were used to determine the feasibility to use solar PV intervention for powering production processes in each micro-enterprises cluster. Designs of potential solar systems catering to the power requirements of each type of cluster were also prepared.

The detailed descriptions of the steps followed for the study are as follows:

2.2.1 Secondary Research, Stakeholder Consultations, and State Selection

Secondary research was undertaken to identify micro-enterprise clusters engaged in different activities in key Indian states. The material analysed included government reports, project reports, case studies, websites of state and central agencies and departments, and previously conducted studies in this regard. Moreover, prior experience of the project team in this sector and preliminary enquiries with concerned stakeholders were also useful in identifying the parameters for state selection. The selection criteria for the scoping study of states were based on identified indicators. Each indicator was normalized to allow for comparisons among states and avoid biases. The indicators are as follows:

i. Daily average hours of power shortage

ii. Average solar irradiance for the state

iii. Aggregate number of MSMEs per household in a state

iv. Percentage of people engaged in the sector to the total state population

v. Promotion of renewable energy in MSMEs through policy support

The top 10 states were selected by applying a ranking methodology. Next, the second stage of screening was undertaken, wherein state policies corresponding to renewable energy/solar energy and MSME were studied.

Consultations with stakeholders from national-level institutions working for MSME development were also carried out. Accordingly, 5 states were finalized from the 10 selected states based on inputs from the consulted sector experts. The states selected for the scoping study were Gujarat, Karnataka, Jharkhand, Uttar Pradesh, and Telangana. A detailed inception report comprising a 'situation analysis' and a 'policy review', based on the findings from the secondary research, detailed state selection process for scoping, and consultations with national-level stakeholders, was prepared and submitted to the Shakti Foundation in December.

2.2.2 Scoping Study in Selected States

Scoping visits were undertaken in the selected five states for mapping of potential micro-enterprise clusters suited to solar electrification. During the scoping visits, engagements with state-level agencies, such as Directorate of Industries and Commerce, Agriculture Department, Khadi and Village Industries Commission (KVIC), Rural Development Department, Department of Energy, State Nodal Agency for Renewable Energy, state-level offices of National Bank for Agriculture and Rural Development (NABARD), Small Industries Development Bank of India (SIDBI), NGOs, research institutes, and sector experts were done. Inputs from these stakeholders helped identify apt micro-enterprise clusters and their compatibility for solar intervention.

2.2.3 Primary Survey in Selected Clusters

Consultations conducted during the scoping study helped the team in identifying nearly 15–20 clusters suitable for surveying in the scoped states. A process of screening was undertaken to shortlist three states (8–10 clusters) where the primary survey was conducted. The selected states were Karnataka, Gujarat, and Jharkhand. The clusters were primarily selected based on the interactions with various MSME stakeholders at the state level and a few key parameters were taken into consideration, such as (i) backward region of the district or state; (ii) largely micro/household-based enterprises; and (iii) usage of motorized equipment in the production processes, etc., among others. A total of nine clusters were finalized for the primary survey, namely (i) powerloom, (ii) silk twisting, (iii) stone idol making, (iv) wooden toy, (v) salt, (vi) pottery, (vii) sewing (readymade garment), (viii) silk reeling, and (ix) brass utensil. The primary survey conducted in each cluster included data collection of the sample enterprises of different categories. Based on the field assessment, enterprises in each micro or small cluster were further categorized into different classes based on their present turnover wherever applicable, such as (i) small, (ii) medium, and (iii) large. A total of six entrepreneurs were interviewed randomly from each cluster comprising at least two from each category of the enterprises classified. The primary survey in the shortlisted clusters entailed a detailed assessment of the process of production, existing energy usage, space available for solar systems, solar resource availability, share of energy required that can be provided by solar and the grid, supply scenario of electricity in the area, current coping arrangements to meet the electricity needs during power cuts, and expenditure on back-up energy sources, among others.

Detailed consultations were also held with the enterprise owners, cluster-facilitating agencies, as well as district and block-level government functionaries, etc. to understand their challenges and requirements.

2.2.4 Documentation and Workshop

The data from the primary survey was analysed and **detailed feasibility reports** were prepared for each micro-enterprise cluster, along with a **main report** providing the overall findings. The cluster reports detail out the profile of the clusters and propose solar models, best suited to meet the energy requirements of individual enterprises in the cluster, based on which the total solar potential for the cluster was estimated. The study also presents suitable business models for solar intervention in each cluster. The study also provides recommendations for taking forward prospective solar interventions in micro/home-based industrial clusters.

For dissemination of initial findings and to invite feedback on the study, a stakeholder workshop (attendees list attached as **Annexure I**) was organized in Ranchi, Jharkhand. Owing to the lockdown imposed in light of the COVID-19 pandemic, the proposed stakeholder consultation in Bengaluru, Karnataka could not be physically conducted and, thus, was arranged through one to one online consultation (list provided in **Annexure II**). A national-level consultation workshop was organized in the form of a webinar from TERI, New Delhi. The webinar saw participation of representatives from central and state government agencies, research institutions, financial institutions, local facilitating agencies, individual micro-entrepreneurs, renewable energy experts, suppliers and manufactures of solar industry, etc. The objective was to disseminate the findings of the study and seek expert opinions on policy, institutional, technical, social, financial, etc. aspects and future course of action for scaling of solar PV in MSMEs (workshop proceedings attached in **Annexure III**).

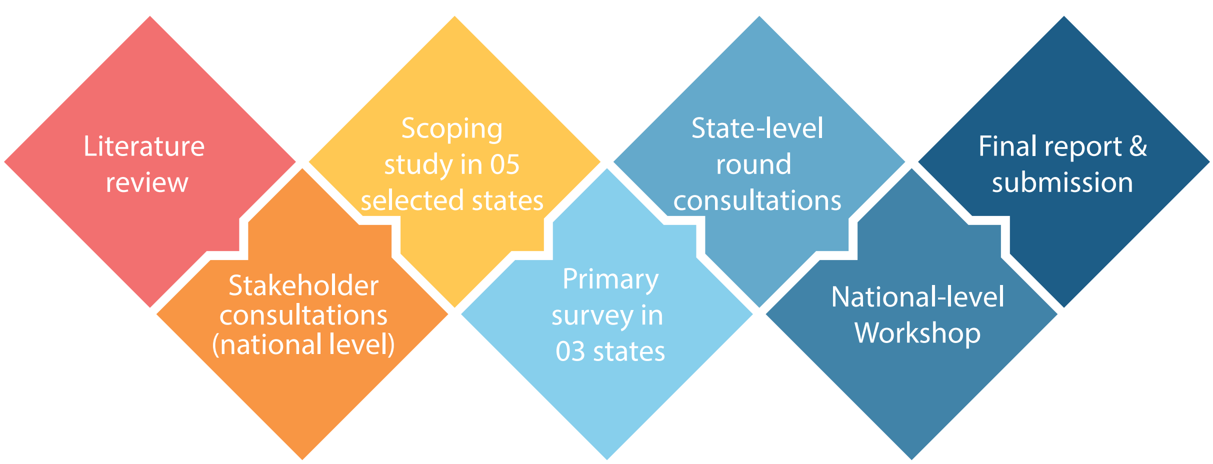


FIGURE 1: Flow diagram of the study approach

2.3 Report Structure

The report briefly introduces the MSME scenario in India, followed by a delineation of the study objectives and the methodology, as mentioned in Section 2. Section 3 of the report provides the details of key policies formulated at the central level for the development of the MSME sector and adoption of solar PV. The detailed findings from the primary survey in the selected clusters of Gujarat, Karnataka, and Jharkhand are given in Section 4. This section also includes the brief description of solar feasibility of each cluster. Finally, Section 5 presents key findings of the report, and then Section 6 provides some recommendations for disseminating solar PV in the micro-industries. The detail descriptions of individual cluster-wise report of all the three states have been attached in Annexure III.

3. Policy Landscape for MSMES in India

Small, cottage, and village enterprises were previously categorized as small-scale industries (SSI), which were scattered and governed by multiple laws and procedures, creating hurdles for the development of the micro, small, and medium enterprises (MSME) sector. Further, the fast-growing small services sector did not feature among industries but contributed significantly to the economy. Eventually, the government recognized these concerns and formulated the Micro, Small and Medium Enterprises Development Act, 2006 (MSMED Act) to provide a comprehensive mechanism for their development and regulation.[1] This Act brought together the hitherto scattered and unregulated sector facing multiple challenges under an appropriate legal framework for their governance and development, putting them on the path to modernization and enhancing their competitiveness in domestic and international markets. Post-enactment of the Act, the concept of enterprises in manufacturing and services was recognized.

Subsequently, in India, numerous schemes were initiated by the government covering various development dimensions, such as technology, credit, infrastructure, marketing, employment, among others. The government has been proactive in upgrading its policies and bringing out new initiatives as per the need of the hour and to suit the changing times. An example of this would be the push towards adopting cleaner technologies and energy- efficiency measures in the MSME and industrial sectors.

For this study, the policy landscape was examined under two broad guiding themes – general policy measures for MSME development and energy policies for MSMEs or the industrial sector. Some policies relevant to the study are further described.

3.1 Micro and Small Enterprises Cluster Development Programme (MSE-CDP)

Under this scheme, groups of micro and small enterprises within a contiguous area and producing same or similar products or services are clubbed into clusters as a strategy to collectively enhance their productivity and competitiveness (Ministry of MSME 2019). One of the main objectives of the programme is to create or upgrade infrastructural facilities in new and existing MSEs and set up common facility centres for testing, training, and complementing production processes, among others.

In terms of infrastructure development, this programme supports projects for power distribution networks and use of non-conventional sources of energy for common captive use. For this, the central government will provide assistance of 60% of the project cost, up to INR 100 million. The grant is 80% for north-eastern and hill states and industrial areas with more than 50% (a) micro,

[1] Details available at http://dcmsme.gov.in/LegalFramework_knowledge.htm, last accessed on 20 June 2020.

(b) women, and (c) scheduled caste/scheduled tribe (SC/ST) units. A total of 240 infrastructure development projects were approved by the Ministry of MSME, of which 168 were completed.

3.2 Credit Linked Capital Subsidy Scheme (CLCSS) for Technology Upgradation

This scheme provides an upfront capital subsidy to new and existing micro and small industries, including tiny, khadi, village, and coir units engaged in manufacturing for technology upgradation by modernization of their production equipment and techniques. The guidelines of the scheme provide for 15% of upfront capital subsidy or loan assistance of up to INR 1 crore to these small industries. The scope of the scheme is to induct well-established technologies into the enterprises belonging to the sub-sectors listed in the scheme, for which subsidy/loan can be availed. This list has been expanded with changing times to include more industries. The scheme defines technology upgradation in terms of improving productivity, quality of products, or the working environment for the unit. While it is not mentioned explicitly, solar PV can be used to improve the production process and working environment in places where power supply is unreliable or where diesel or fossil fuel generators are used. This scheme is currently under revision (Ministry of MSME 2006; Ministry of MSME 2019).

3.3 Technology and Quality Upgradation (TEQUP) Support to MSMEs

The scheme advocates the use of energy-efficient technologies (EETs) in manufacturing units to reduce the cost of production and adopt clean development mechanism. The nature of the assistance includes (a) capacity building of MSME clusters for energy efficiency/clean development and related technologies; (b) implementation of EETs in MSME units; (c) encouraging MSMEs to acquire product certification, etc. among others. The Government of India provides financial support to the extent of 25% for the implementation of EETs and the balance funding is supported through loan from Small Industries Development Bank of India (SIDBI)/banks/financial institutions.

3.4 Revamped Scheme of Fund for Regeneration of Traditional Industries

Scheme of Fund for Regeneration of Traditional Industries (SFURTI) is a major government scheme to support MSMEs through the development of adequate infrastructure. The scheme aims to organize traditional industries and artisans into clusters to make them competitive and sustainable and provide sustained employment to rural entrepreneurs. The scheme also supports interventions to improve the marketability of products, capacity building of artisans, developing common facilities and improved tools, among others. Under SFURTI, interventions are classified as 'soft', 'hard', and 'thematic'. The hard interventions include 'upgradation of production infrastructure', which comes with assistance of 75% of the project fund requirement and offers scope for solar PV intervention (Ministry of MSME 2019; Ministry of MSME 2017).

3.5 Solar Energy Scheme for Powerlooms, 2017

Under the umbrella of PowerTex India (Comprehensive Scheme for Powerloom Sector Development), a solar energy scheme was launched by the Ministry of Textiles to provide financial assistance for installing grid-connected and off-grid solar PV systems to meet the energy requirements of small powerloom units. Powerlooms having up to eight units with shade-free rooftop area are eligible for the scheme (Ministry of Textiles 2017). The capital subsidy provided to general category applicants is 50%, while SC and ST applicants are eligible to receive subsidies up to 75% and 90% of the capital cost, respectively.

3.6 Pradhan Mantri Mudra Yojana (PMMY), 2015

The Micro Units Development and Refinance Agency Ltd (MUDRA) was formed to provide financial assistance of up to INR 1 million to non-corporate, non-farm micro/small enterprises for their development. This scheme provides access to micro units to formal credit institutions with the vision of funding the unfunded. Loans are provided under three categories: Shishu (up to INR 50,000), Kishore (INR 50,000–500,000), and Tarun (INR 500,000–10,00,000) – denoting the stages of development and funding needs (MUDRA 2018). The stimulus package declared during June 2020 included 'Interest Subvention Scheme for MUDRA - Shishu loans' wherein MUDRA - Shishu loans would be given at interest subvention of 2% for a period of 12 months in the micro-enterprise segment in order to address business disruptions due to the Covid-19 pandemic and the consequent lockdown.

3.7 Prime Minister's Employment Generation Programme (PMEGP)

The Prime Minister's Employment Generation Programme (PMEGP) was launched with the objective of generating employment opportunities in rural and urban areas by supporting the establishment of new ventures or micro industries for self-employment. The scheme also envisages sustainable employment for the youth and traditional artisans of rural and urban areas. Projects under the manufacturing sector will be given assistance of up to INR 2.5 million, and a second loan of up to INR 10 million will be extended to existing and better performing units for upgrading their enterprises, with a subsidy of 15% (20% for hill and north-eastern states) (Ministry of MSME 2019).

3.8 Credit Guarantee Fund Scheme (CGS) for Micro and Small Enterprises

To provide collateral-free loans to existing and new micro and small enterprises, the Government of India launched Credit Guarantee Fund Scheme (CGS) in 2000, later updated up to 2018. The scheme was implemented through a trust established by the Ministry of Micro, Small and Medium Enterprises, Government of India and SIDBI, which is known as the Credit Guarantee Fund Trust for Micro and Small Enterprises (CGFTMSE). Fund and non-fund-based credit facilities are provided up to INR 10 million per eligible borrower. The guarantee cover under the scheme is up to 50%/75%/80% or 85% of the sanctioned amount to the credit facilities. Micro-enterprises get a guarantee cover of 85% (up to INR 500,000). Up to 80% guarantee coverage will be extended to micro and small enterprises (MSEs) owned and/or operated by women and all loans sanctioned by credit facilities in north-eastern states (maximum INR 5 million) (Startup India n.d.; CGTMSE 2018).

3.9 Mission Solar Charkha

The initiative on solarizing the charkha or spinning wheel was first implemented as a pilot project in Khanwa village of Nawada district, Bihar. The project's success motivated the government to extend the scheme and approve setting up of 50 solar charkha clusters, covering between 200 and 2024 beneficiaries, including spinners, weavers, and other skilled artisans. The project outlay is INR 5.5 billion for 2018–19 and 2019–20. Capital subsidies, interest subvention on working capital, and capacity building are the three key interventions formulated under the scheme. It is expected that the scheme will generate direct employment through the clusters (KVIC 2018).

3.10 Grid-connected Rooftop Solar PV Programme

This scheme, by the MNRE, promotes deployment of rooftop solar PV projects for optimal utilization of spaces on rooftops of domestic, social, institutional, commercial, and industrial establishments to save investment on distribution and transmission infrastructure, as well as reduce network loss and maintenance cost related to electricity supply. Besides, the eligible customers were provided with net or gross metering facilities by further reducing their electricity tariff; thus, encouraging them to adopt such green and clean energy systems on a large-scale basis (MNRE 2014). The central finance assistance (CFA) for individual residents is 40% of the benchmark cost up to 3 kW size of a solar plant and then 20% of the balance capacity. No subsidy is available beyond the size of 10 kW solar power plant (MNRE Notification 2019). However, no CFA is available for industrial sector including micro and small enterprises in rural areas.

3.11 Off-grid and Decentralized Solar PV Application Programme

As part of the National Solar Mission, the aim of the scheme is to promote off-grid solar energy systems, including hybrid systems to meet supplement power, heating, and cooling energy arrangements in rural and remote regions. The programme has been expanded across the country in order to increase energy access and reduce dependency on fossil fuels by adopting renewable energy. Besides, the scheme has tremendous potential to exploit the vast solar resource prospect of the country by utilizing available wasteland as well as unutilized space at domestic, community, institutional, commercial, and industrial buildings in a decentralized manner. The decentralized solutions include solar study lamps, streetlights, home lights, solar pumping, solar water heating, micro and mini grid, etc. (up to 25 kW). The central finance assistance includes subsidy of 30% of benchmark cost of the equipment for all states except north-eastern states, hill states, and islands, where CFA is around 90% of the cost (MNRE Notification 2018).

4. Findings of the Clusters Survey

Following the scoping phase, a primary survey was conducted in nine clusters in three states (Gujarat, Jharkhand, and Karnataka). The survey involved extensive field visits to each of these micro-enterprise clusters to collect energy-related data. The research team had prepared detailed questionnaires to guide the interviews with entrepreneurs, covering aspects, such as technology, production process, markets, energy consumption, and electricity scenario of the state, among others. A detailed questionnaire is provided in Annexure V. The micro-enterprises clusters surveyed in the states are as follows:

- Jharkhand: Sewing (readymade garment), silk, reeling, and brass utensil
- Karnataka: Powerloom, wooden toy making, silk twisting, and stone idol making
- Gujarat: Pottery and salt cluster

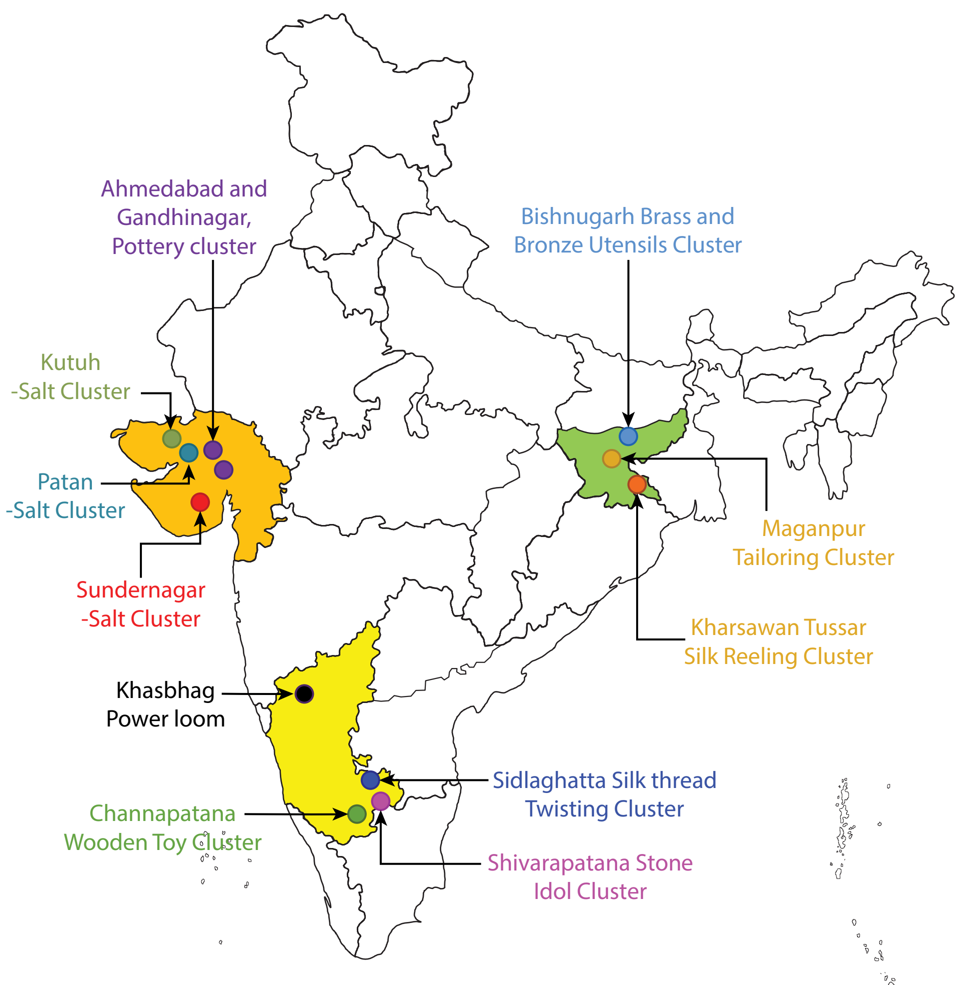


FIGURE 2: Micro-enterprises clusters surveyed as part of the study

These clusters were all distinct in terms of their history and evolution, product diversity, markets, current use of technology, and energy requirements. However, some of the clusters were connected by a common thread of being micro-enterprises, mostly run by families that have received the skill of traditional crafts over generations. All clusters dealt with some of the other challenge, for example, lack of skilled workers, irregular power supply/blackouts, market competition, low wages, or even health risks. Despite the odds, the micro-enterprise clusters are persevering to keep their craft alive and provide livelihoods to many workers while contributing to the economy.

The following sections give an overview of the states: the clusters surveyed, their energy requirements, and proposed solar designs. The solar systems were designed based on the assessment of energy requirements of different sizes of enterprises in a cluster. Further, **the solarization potential for the clusters was assessed based on the proposed solar system capacity and the number of units present in each cluster.** The sections also contain, in brief, the proposed business models to determine the financial feasibility of solar application and different sources of funding that may be used to arrive at reasonable payback periods.

Detailed descriptions of the production activities of the clusters, along with details of the technical models and business models corresponding to the proposed solar designs are provided in Annexure IV.

4.1 Karnataka

Karnataka is ranked among the top 10 states in India in terms of number of micro, small, and medium enterprises (MSMEs). According to the 73rd round (2015–16) of the National Sample Survey (NSS), Karnataka has around 3.83 million MSMEs, which is 6% of the pan-India total (Ministry of MSME 2019). Of this, 99.7%, that is 3.82 million enterprises, belong to the micro-enterprises sector and the remaining is part of small industries. The NSSO further reveals that MSMEs in Karnataka provide livelihood to around 7 million people.

The policy environment for the development of MSMEs, especially in terms of energy provisions, is also supportive. The Karnataka Industrial Policy 2014–19 provides for 10% subsidy on the capital cost of using non-conventional sources for energy. Similar subsidies are available for adopting energy conservation measures (@10% subsidy on the capital cost) and for captive power generation through solar or wind energy sources (@INR 0.50 per unit). The Karnataka Solar Energy Policy 2014–21 actively promotes solar rooftop in industrial buildings through net and gross metering, as well as off-grid decentralized solar rooftop systems through Electricity Supply Companies (ESCOMs) and NGOs. Further, power supply infrastructure is readily available in Karnataka, and uninterrupted power supply is provided to all industrial units. In addition, the Karnataka's New Textile and Garment Policy 2019–24 provides support to weavers and twisters who use non-conventional energy sources for power production.

In Karnataka, it was observed that grid supply is regular and power charges are highly subsidized by the government. In light of this situation, it becomes important to establish the need for solar interventions. Foremost, solar PV offers clean energy alternative to conventional power, contributing to augmenting the share of renewables, especially solar, in the state, as well as help meet the country's targets for sustainable development. Next, a switch to solar and other clean technologies would greatly relieve the state government of huge amounts spent on power subsidies, which can potentially be diverted to provide subsidies on capital costs of solar systems. Moreover, it will also offset the current amount spent by unit owners on power bills.

The following are the brief findings of the surveyed clusters of Karnataka and their feasibility for solar deployment:

4.1.1 Khasbag (Belgam) Powerloom Cluster

Cluster profile

The Khasbag cluster is in Belagavi district of Karnataka and is more than 70 years old. It is one of the important hubs for weaving and textiles in the district. The cluster is known for several signature textiles, including Thanna sarees and the famous Shahpur sarees (Bijapur, 2017). Traditionally, weaving was done on handlooms by skilled artisans. With the advent of technology, many of the traditional handloom weavers were successfully able to make the transition to powerlooms, thereby increasing their productivity and maintaining uniform quality of the products, to meet the rising demands both locally and internationally. The powerloom sector has grown to become the source of livelihood for many weavers (more than 31,000[2]). The Khasbhag cluster has more than 1200 powerlooms, which is the highest in Belgaum taluka.

The powerloom clusters have a thriving production for most of the year, except the monsoon months. Individual units on average have operations running for up to 10 hours a day, and around 25 days a month. Each loom unit can produce 5–15 sarees in a day, or 150 to more than 400 sarees in a month depending on the number of looms in operation. Each unit owner manages to earn gross profit in the range of INR 45,000 to INR 120,000 per month based on the number of looms operating ,which includes expense towards labour, wrapping of the thread, power bills, and maintenance of unit.

FIGURE 3: Powerloom

Source: Karnataka State Textile Infrastructure Development Corporation

[2] *Department of Handloom and Textiles, Karnataka.*

Production process

The process of weaving a saree or any textile on the powerloom involves sequential steps; first of which is finalizing the design, colour, and material to be used. Next, threads are warped on to the weaver's beam by skilled artisans. The beam is inserted into the loom and filling or weft threads are interlaced perpendicularly to the warped threads. A jacquard machine in a powerloom helps recreate designs and patterns on the surface of the woven fabric. The final step involves finishing the woven textile using the wax process.

Energy consumption

In the studied cluster, the electrical capacity of motor used in individual powerloom is around 0.75 HP. Thus, for multiple looms operating within the same unit, the cumulative capacities of all motors range from 2.25 HP to 6 HP. All the studied units run their machines for around 10 hours daily. Units with three or four looms in operation consumed between 16 and 22 kWh of power per day, while the larger units having six and eight looms were found to consume 33 kWh and 45 kWh per day, respectively. The monthly electricity charges are subsidized approximately 60% by the Department of Handloom and Textiles (DoHT) of Karnataka to support the powerloom units. The average electricity bill across the units in the studied cluster has been provided in Table 3.

Daily power supply has been regular except occasional power cut for around 1–2 hour. The power cut increases up to 2–3 hour in the rainy and summer seasons during which the productivities are partially affected. Though the overall power supply is satisfactory in the region, power generation from solar would further reduce the power subsidy burden of the department. The weavers interviewed in the studied cluster expressed their interest in exploring the option of solar PV to reduce their current electricity bill. They were also willing to provide the available space for installation of the system and make partial capital contribution.

Design of solar PV

In this cluster, grid-fed individual solar PV system has been proposed (without battery back-up) for each and every powerloom unit. The design of the system has been done considering the space constraint and investment capacity of the studied cluster. Thus, it has been assumed that 50% of the energy will be met through solar and the balance 50% will be met through the grid. The solar systems for micro units (3 looms) and small unit (4 looms) have been proposed for 3 kWp and 4 kWp, respectively. Similarly, the capacity for solar system for medium units (6 looms) and large units (8 looms) have been proposed for 6 kWp and 8 kWp, respectively. The area needed for

TABLE 3: Electricity bills of powerloom units without subsidy

Categorization of powerloom unit	Monthly average electricity bill (INR)
Large (8 looms/unit)	7000 to 9000
Medium (6 looms/unit)	4000 to 5000
Small (4 looms/unit)	3000 to 4000
Micro (3 looms/unit)	2500 to 3000

solar installation for micro, small, medium, and large units are 20 m2, 27 m2, 40 m2, and 54 m2, respectively. Introduction of solar PV across the units is expected to save monthly electricity bill of around INR 1500- INR 4500 (approximately 50% of the current electricity bill) that includes monthly savings of power subsidy which amounts to INR 900–INR 2700 across all units. Thus, power subsidy savings would be around INR 54,000–INR 162,000 if assessed for a period of 5 years. Increase in productivity and revenue due to solar has not been assessed as daily working hours are not expected to increase much except partial gain during summer and rainy seasons.

Proposed business model

To introduce solar in the cluster, financial investment would be needed in the range of INR 162,000 (for three looms) to INR 432,000 (for eight looms). The estimation has been made as per the benchmark price (INR 54 per Wp) of grid-tied roof top solar as notified by MNRE, Government of India. The DoHT, Karnataka, which is the powerloom-promoting agency, can take a lead in arranging maximum subsidy of 40%–55% for incentivizing the entrepreneurs for solar installation so that the department can avoid recurring subsidy burden on electricity. Based on the analysis, the upfront subsidy proposed will be less than the power subsidy for 5–7 years (as per the current rate of power subsidy, i.e. 60%). While 20% would be mobilized from the unit owner, the balance 30% is proposed through loan from commercial bank or other financing institution. The most popular PMMY scheme can be explored for availing Mudra loan. A few scenarios have been worked out considering different proportions of subsidies and bank loans that may be offered to the unit owners, to make the solar system affordable. However, the feasibility of solar has been found only in the following scenarios:

In the Belgaum–Khasbag powerloom cluster, as part of this study, the existing units were classified as micro (3 kWp systems), small (4kWp system), medium (6 kWp system), and large (8 kWp system) based on the capacity of a solar PV system that is required to feed their power needs. Without a subsidy component, it was estimated that for each of these categories, a payback period of over 10 years was estimated. In a subsidy model for micro units, with an equity component of 20%, loan of 40% with an interest rate of 12% (5 years) and subsidy of 40% of the total hardware cost of solar PV systems, the payback period is calculated as 5.65 years. The payback period is 5.2 years if the interest rate is reduced to 8% per annum. For small units, with an equity component of 20%, loan of 35% with an interest rate of 12% (5 years) and subsidy of 45% of the total hardware cost of solar PV systems, the payback period is calculated as 5 years. The payback period is 4.65 years if the interest rate is reduced to 8% per annum. For medium units, with an equity component of 20%, loan of 25% with an interest rate of 12% (5 years) and subsidy of 55% of the total hardware cost of solar PV systems, the payback period is calculated as 5.19 years. The payback period is 4.85 years if the interest rate is reduced to 8% per annum. For large units, with an equity component of 20%, loan of 35% with an interest rate of 12% (5 years) and subsidy of 45% of the total hardware cost of solar PV systems, the payback period is calculated as 5 years. The payback period is 4.65 years if the interest rate is reduced to 8% per annum.

Solar potential of cluster

Solar potential has been estimated for business interest of solar manufacturer and suppliers which may further enhance the viability. There are around 1200 powerloom units in the entire cluster. If all the units are solarized, the cluster can provide solar PV potential of around 6.18 MW.

[3] *The solar potential for each cluster was calculated as:*
(capacity of solar system, as per proposed solar design) × (total number of units in the cluster)

4.1.2 Sidlaghatta Silk Twisting Cluster

Cluster profile

Karnataka is one of the major states for mulberry silk production in India. Sidlaghatta taluk in Chikkaballapura district is a prominent town and famous for trading of huge quantity of silk cocoons and twisted silk to other Indian cities. There are around 1200 home-based silk twisting units in Sidlaghtta cluster. The twisted yarn is in great demand among silk thread buyers, mostly from Kanchi, Harni, Dharmavaram, and Bengaluru. These buyers can also be silk saree and other silk apparel-making agencies.

The twisting units normally operate for 10–12 hour in a day and the production continues throughout the year in all the seasons. The small units (120–200 spindle) represent 80% of the total twisting units in the cluster, while the balance 20% are large units (500 spindle and beyond). These big units were found highly energy intensive, thus were not covered under the study. The average monthly revenue of small unit varies from INR 45,000 to INR 75,000 based on their volume of productions (100–150 kg of silk yarn).

Production process

Twisting is a process of preparing raw silk with desired strength and thickness for textile weaving in the loom. Normally, raw silk is extracted from the cocoons and then served into the reeling basin. The reeled silks are called skeins. These skeins are then wound onto bobbins through a winding machine. The wound yarn is then 'doubled', wherein threads from two separate bobbins simultaneously run onto a single bobbin, which is then taken for twisting. The twisted threads are

FIGURE 4: Silk thread twisting process

spooled onto bobbins, which are ready to be taken for weaving silk products.

The major technologies used in the processes are winding machine, doubling machine, and twisting machine. The cumulative electrical capacities of these machines are 3 HP. The machines can be operational for 30 years, provided proper maintenance is done. An average monthly maintenance cost of INR 600 is incurred by the entrepreneurs.

Energy consumption

In this cluster, grid power is supplied without much interruption except occasional power cut. However, during the summer and rainy seasons, the power cut increases by up to 2–3 hour a day. Though the overall power supply is satisfactory in the region, power generation from solar would further reduce the power subsidy burden of the department. The weavers interviewed in the studied cluster expressed their interest in exploring the option of solar PV to reduce their current electricity bill. They were also willing to provide the available space for installation of the system and make partial capital contribution.

Design of solar PV

In this cluster, 4 kWp grid-fed individual solar PV system has been proposed (without battery back-up) for each and every twisting unit. The design of the system has been done considering the space constraint and investment capacity of the studied cluster. Thus, it has been assumed that 50% of the energy will be met through solar and balance 50% will be met through the grid.

The area requirement for solar installation is around 27 m^2. Currently, the monthly average electricity expense is around INR 3500 out of which INR 2100 (60%) is paid by District Industry Centers (DIC) and the balance, approximately INR 1400 (40%), is paid by the unit owner. Introduction of solar PV in these units is expected to save monthly electricity bill of around INR 1750 (approximately 50% of the current electricity bill) that includes the monthly savings of power subsidy of INR 1050 per unit. Thus, power subsidy savings would be around INR 60,000 if assessed for a period of 5 years. Increase in productivity and revenue due to solar have not been assessed since daily working hours are not expected to increase much except partial gain during summer and rainy seasons.

Proposed business model

To introduce solar PV in the cluster, the investment would be around INR 216,000 for each and every unit (based on benchmark price (INR 54 per Wp) of grid-tied solar PV system notified by the MNRE, Government of India). The DIC can take a lead in arranging maximum subsidy of 40%–65% for incentivizing the entrepreneurs for solar installation so that the department can avoid recurring subsidy burden on electricity. Based on the analysis, the upfront subsidy proposed will be less than the power subsidy for 5–7 years (as per the current rate of power subsidy, i.e. 60% of the total electricity bill). While 20% would be mobilized from the unit owner, the balance 30% is proposed through loan from commercial bank or other financing institution. The most popular PMMY scheme can be explored for availing Mudra loan. A few scenarios have been worked out considering different proportions of subsidies and bank loans that may be offered to the unit owners, to make the solar system affordable. However, the feasibility of solar has been found only in the following scenario:

In this cluster, without subsidy component, and with an upfront investment of 20% of the hardware cost and loan component of 80% of the overall hardware cost, payback is estimated to be more than 10 years. However, with an upfront equity investment of 20%, loan (for 5 years) amounting to 30% of the total hardware cost, and a capital subsidy of 50% on hardware cost, the payback period is 4.83 years when a bank loan is disbursed at 8% interest rate per annum and it is 5.2 years when a bank loan is disbursed at 8% interest rate per annum.

Solar potential of the cluster

In the Sidlaghatta silk twisting cluster of Chikkaballapura in Karnataka, ☐960 micro-enterprise units are operating. With an installation of 960 units of 4 kWp grid-fed (individual) solar PV system, an aggregated solar potential of 3841 kWp can be realized in the cluster.

4.1.3 Shivarapatna Stone Idol-making Cluster

Cluster profile

Shivarapatna is a small artisanal village in Kolar district of Karnataka, which is situated around 60 km away from state capital Bengaluru. Patronized by the rulers of the ancient Western Ganga Dynasty, Shivarapatna became home to sculptors from various regions who settled down here, earning the title Shilpakashi (the Kashi of sculptures) of Karnataka. The present-day craftsmen of the village are preserving and carrying forward the 1000-year-old traditional knowledge and skill imparted to them by their ancestors. Today around 1000 people from 200 families are engaged in stone idol making in the village.

Intricately carved idols of gods and goddesses, pillars, and carved stone slabs for temples are the signature creations of the craftsmen of this cluster. The products receive uniform demand throughout the year. The artisans spend almost 25 days a month on a piece. Large and highly intricate pieces often require weeks, months, or even years to be prepared, while smaller pieces can be finished in a few days. The idols are supplied mostly to temples in Karnataka, Kerala, Andhra Pradesh, among others. The Karnataka State Handicrafts Development Corporation

FIGURE 5: Stone idols displayed at a workshop

(Cauvery Handicrafts) supported 20 craftsmen by registering them formally and providing skills training and technology for idol making. Craftsmen can sell their products at government-owned arts and crafts museums.

Production process

The process of idol making starts with choosing the right stone for carving. Then the selected stone is cut to an appropriate size using a band saw. Next, the master craftsman prepares a rough design of the idol on the stone using red oxide paint. The extra edges of the slab are removed using a hammer or cutter machine. The craftsmen chisel out the design on the stone slab and smoothens the surface using an electric grinder machine. Further, buffing of the idol is done to remove dust particles. Finally, the finished idol is polished and ready to be dispatched.

Energy consumption

The stone idol making includes equipment such as band saw, cutting machine, grinder, blower, buffing, and polishing. These machines with cumulative capacity of 5 HP are run for 8–10 hours a day. Most of the processes are carried out simultaneously. Low tension (LT) domestic connections are used for such power requirements. The average income of the units varies from INR 50,000 to INR 80,000 per month. The average monthly electricity bill of the stone unit is around INR 5000. Power subsidy is not available due to lack of commercial connection. Like other clusters, entrepreneurs in this cluster are also willing to explore the option of solar PV to power their production activities and contribute to 20–30% of the system cost from their end.

Design of solar PV

TERI proposes grid-fed individual 5 kWp solar PV system (without battery back-up) for each and every stone idol unit. The design of the system has been done considering the space constraint and investment capacity of the studied cluster. Thus, it has been assumed that 50% of the energy will be met through solar and the balance 50% will be met through the grid.

The area requirement for solar installation is around 40 m^2. To introduce solar PV in the cluster, the investment would be around INR 270,000 for each idol unit [based on benchmark price (INR 54 per Wp) of grid-tied solar PV system notified by MNRE, Government of India].

Proposed business model

In this cluster, without subsidy component, and with an upfront investment of 20% of the hardware cost and loan component of 80% of the overall hardware cost, payback is estimated to be more than 15 years. However, with 20% upfront equity investment from a micro-enterprise owner, a 5-year bank loan for 20% of the capital investment and a subsidy of 60% cost of the solar PV system, payback period comes down to 5.33 years and 5 years when the bank interest rate is 12% and 8% per annum, respectively.

The Karnataka State Handicrafts Development Corporation (Cauvery Handicrafts), which has been set up to preserve and develop the traditional handicrafts of the state, can be approached for the maximum subsidy of 40–50%. Besides, DIC can be approached for partial capital subsidy (10%) as per the industrial policy.[4] Also, the popular PMMY scheme can be explored for availing Mudra loan. It is also important to note that without subsidy and with an upfront equity investment of 20% and loan component of 80%, the payback period is estimated to be more than 10 years. Hence, it is likely that to advance the designed solar system in the cluster, a mix of subsidy, upfront investment, and bank loan will have to be explored.

[4] *Details available at https://kum.karnataka.gov.in/KUM/PDFS/Operative%20Guidelines%20for%20DIC%20KARNATAKA%20INDUSTRIAL%20POLICY%202014-19.pdf*

Solar potential of the cluster

Solar potential has been estimated for business interest of solar manufacturers and suppliers, which may further enhance the viability. There are around 200 units and each unit has been proposed with 5 kWp. It is estimated that the cluster has an aggregate solar potential[5] of 1000 kWp.

4.1.4 Channapatna Woodwork Cluster

Cluster profile

Channapatna is a town and taluk headquarters of Ramanagara district in Karnataka and located on the midway of Bengaluru–Mysore highway, 60 km and 80 km, respectively. It stands out for being a treasure trove of wooden toys and lacquer ware, giving it the endearing title of 'Gombegala nagara', literally meaning 'town of toys'. The artisans of the studied enterprises were adept in making wooden kitchen utensils, handicrafts, decorative pieces, lifestyle products, gift items, wooden stationery, and educational equipment. The ruler of Mysore, Tipu Sultan, is said to have encouraged the craft, but it was limited to serving local demands. Later, the market was flooded with cheap Chinese toys that led to slump in demand for original Channapatna toys. The state handicrafts corporation, local NGOs, and various designers are credited with reviving this age-old art and popularizing it with the younger generation and international market.

There are around 500 such units that employ more than 72,000 people in toy making. The enterprises

FIGURE 6: Colourful wooden toys of Channapatna

5 *Estimated based on 200 units of 5 kWp solar PV capacity*

operate for 10 hours every day, with smaller units producing up to 100–150 articles, medium units producing up to 200–300 articles, and larger units producing around 500–600 articles a day. The monthly production capacity also varies depending on the demand and the size of the enterprise. Each unit generates monthly revenue in the range of INR 30,000 to INR 1.5 lakh per month based on their level of productions.

Production process

Wood from Hale Mara tree, also known as ivory wood or soft wood, is cut into small-sized chunks or billets, and kept aside for 'seasoning' to remove moisture. The seasoned wood is again cut into small pieces of required length by a cutter, which is further shaped by a 'Lathe', a mechanical device used for rotating wood using chisels. The toys are coloured using lac. A lac stick of a chosen colour is pressed onto the rotating wood; due to friction, the lac melts and gets coated on the wood surface. A dried palm leaf is used to spread the applied lac uniformly over the surface and rendering the product a lustrous appearance.

Energy consumption

A lathe machine, circular cutters or band saws, and drilling machines are some of the motorized equipment used in toy production in this region, which are run for around 10 hours a day. The cumulative energy consumption of the motors is 2 HP, 6.5 HP, and 10 HP for small, medium and big units, respectively. There is no reported shortage of grid electricity, barring rare short outages.

The average monthly electricity bill has been checked for all different units and the details have been provided in Table 4.

Like in other clusters, entrepreneurs in Channapatna are interested to explore the option of solar to power their production activities and are willing to contribute 20–30% of the system cost from their end.

Design of solar PV

For this cluster, TERI proposes grid-connected solar systems (without battery back-up) for small, medium, and large capacity units of toy making that will power the machineries for woodworking. The design of the system has been done considering space constraint and investment capacity of the studied cluster. Thus, it has been assumed that 50% of the energy will be met through solar and the balance 50% will be met through the grid.

In the small unit, a grid-fed individual solar PV system with capacity of 3 kWp, in medium units, a grid-fed individual solar PV system with capacity of 6 kWp, whereas in the large unit, a grid-fed individual solar PV system with capacity of 14 kW will be required to meet the power needs. The area requirements for the installation of solar PV systems in the small medium, and large plants are 20 m^2, 40 m^2, and 95 m^2, and the systems' costs (calculated using MNRE benchmark prices – INR 54 per Wp and INR 48 per Wp) would be INR 162,000, INR 324,000, and INR 672,000, respectively.

Proposed business model

For this study, the micro-enterprise units in Ramnagara–Channapatna wooden toy cluster have been segregated into three categories (small: 3 kWp system, medium-6 kWp system, and

TABLE 4: Electricity bills of powerloom units

Categorization of power loom unit	Average monthly electricity expenses (INR)
Large (up to 6 lathe/unit)	11,000 to 11,500
Medium (up to 4 lathe/unit)	5000 to 5500
Small (up to 2 lathe/unit)	2000 to 2500

large-14 kWp system) depending upon the size of the solar PV system required to meet their power needs. For each of the three categories, with a mix of 20% equity, 65% capital subsidy on hardware, and a 5 years bank loan of the remaining 15% amount, the payback can be brought down to less than 6 years. It is evident that even after reducing the rate of interest on bank loan from 12% to 8% per annum, the payback does not drastically change. Out of the required subsidy component, 10% can be leveraged[6] through the DIC. The remaining subsidy amount will have to be leveraged through Karnataka State Handicrafts Development Corporation (Cauvery Handicrafts), CSR funds, and philanthropic institutions.

Solar potential of the cluster

Solar potential has been estimated for business interest of solar manufacturer and suppliers which may further enhance the viability. There are approximately 500 units which include around 300 small units, 100 medium units, and 100 large units. If all the units are solarized, the cluster can provide solar PV potential of around 1000 kWp[7].

Solar potential assessment across the clusters in Karnataka

The cumulative solar potential across all the studied clusters in the state was assessed and has been provided in Table 5. This information would be relevant for the solar suppliers or developers at the state or national level who might assess their business potential if they intervene in the identified clusters.

4.2 Gujarat

Gujarat is one of the most progressive and prosperous states in India, renowned for being the hub of industrial development and having a business- and investor-friendly environment. Enterprises, be it large industries or small units, have found space to progress in Gujarat. The state provides upgraded infrastructure, credit, technology, etc. to support its vibrant industrial ecosystem.[8]

With more than 3.3 million MSMEs, Gujarat features among the top 10 states for MSMEs in India, with a share of 5% of the total. The micro-enterprises form the major chunk of MSMEs with more than 3.2 million enterprises, according to the 73rd round of the NSS. The total number of workers engaged in the MSME sector exceeds 6.1 million (Ministry of MSME 2019).

The state has formulated a range of policies for fostering the development of MSMEs. The Gujarat Industrial Policy 2015 has provisions related to the use of non-conventional energy for MSMEs. For example, capital investment subsidy of 20% on a term loan and 7% interest subvention for MSMEs are mentioned in the policy.[9] Additionally, there is a provision for supporting energy-efficiency measures by subsidizing 25% of the cost of equipment. The RURBAN approach mentioned in the policy encourages sustainable business models that make use of non-conventional energy sources including solar technology. The policy also mandates research

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6 Details available at https://kum.karnataka.gov.in/KUM/PDFS/Operative%20Guidelines%20for%20DIC%20KARNATAKA%20INDUSTRIAL%20POLICY%202014-19.pdf

7 The solar potential for the cluster has been calculated as:

(capacity of solar system as per proposed solar design) × (total number of units in the cluster)

8 Details available at https://gujaratindia.gov.in/business/investment-destination.htm, last accessed on June 23, 2020

9 Details available at https://ic.gujarat.gov.in/documents/pagecontent/revised-GR-01-04-2017-08112017.pdf, last accessed on June 23, 2020

TABLE 5: Solar potential in the studied clusters in Karnataka

Cluster	District	Total number of units (machines/ unit)	Total number of units	Daily electricity consumption (kWh)/unit	Solar capacity (kWp)	Total solar potential in the cluster (kWp)
Khasbag Powerloom Cluster	Belagavi	Large 240 units (8 looms/unit)	1920	45	8	6180
		Medium 360 units (6 looms/ unit)	2160	33.75	6	
		Small 300 units (4 looms/unit)	1200	22.5	4	
		Very small 300 units (3 looms/ unit)	900	16.875	3	
Sidlaghatta Silk Twisting Cluster	Chikkaballapur	Small 120 spindles/unit	960	22.5	4	3840
Shivarapatna Stone Idol-making Cluster	Kolar	Unit size cannot be measured, (based on the idol's size, labours are hired by the unit owners)	200	30	5	1000
Channapatna Woodwork Cluster	Ramanagara	Small units (1 to 2 laths)	300	15	3	1000
		Medium unit (4 laths)	100	48.75	6	
		Large units (6 laths/unit)	100	75	14	

and development (R&D) support to institutions for injecting non-conventional energy sources in the MSME sector. Further, the Gujarat Solar Energy Policy 2015 has provisions for promoting solar rooftop in commercial and industrial buildings.[10]

Similar to the case of Karnataka, grid supply in Gujarat was reported to be regular, with minimal interruptions, and is available to consumers at low prices. Therefore, the need for solar intervention can be justified in terms of abating

[10] *Details available at https://guj-epd.gujarat.gov.in/uploads/Gujarat_Solar_Power_Policy_2015.pdf, last accessed on June 23, 2020*

carbon emissions that accompany conventional grid supply. Furthermore, a switch to solar and other clean technologies would relieve the state government of the burden of providing power subsidies, which can potentially be diverted to provide subsidies on capital costs of solar systems. Moreover, it will offset the current amount spent by unit owners on power bills.

For this study, two micro-enterprise clusters were surveyed, and their brief descriptions are mentioned further.

4.2.1 Pottery Clusters of Gandhinagar and Kutch

Cluster profile

Pottery and other forms of terracotta art can be found throughout Gujarat. Traditional works with clay are indigenous to the artisan communities of Gujarat who have mastered the art over centuries. Khavda pottery, done by a few families in Kutch district, is distinguished by its reddish hue and

FIGURE 7: Pots made in Veda village

intricate hand paintings made by the women. Products created by skilled artisans, such as pots, utensils, lamps, cupboards, glasses, lanterns, storage units, religious figurines, and decorative pieces are not only popular for local use but have gained national and international recognition as traditional handicraft of Gujarat.

The pottery clusters of the study sites, Gandhinagar and Kutch, are represented in Table 6.

TABLE 6: Cluster details

District	Village	Units	Products
Gandhinagar	Rupal	20	Pots (utensils and flowerpots), pans, glasses, storage units, lamps, decorative pieces, figurines
	Sardhav	20	
	Randheja	50	
	Veda	15	
Kutch	Khavda	27	

Pottery has received considerable backing from state government agencies, such as Industrial Extension-Cottage (iNDEXT-c), Gujarat Matikam Kalakari and Rural Technology Institute (GMKRTI), handicrafts department, and the Tourism Corporation of Gujarat Limited (TCGL). It is worth mentioning that GMKRTI has been instrumental in developing and incentivizing modern technologies for pottery, to improve productivity, and reduce drudgery.

Production process

On average, around 50 pieces of pottery are made per day in each unit of the cluster. If the demand increases, then the potters may make more pieces. The production ceases in the monsoon months, that is, from July to September, as drying of pottery becomes an issue. The work resumes in October or once the rains stop.

The mud required for making pottery is sourced from the banks of nearby water bodies and ground. Next, the mud is mixed with water in artificial ponds/enclosures to form clay. In Gandhinagar pottery clusters, the GMKRTI had provided the artisans electric pug mills for kneading the clay to make it soft and pliable. The kneaded clay is then 'thrown' on a potter's wheel for shaping into desired products. In the studied clusters, the artisans use motorized potter's wheel, which has increased the productivity manifold. Designs may be drawn on the articles and then they are kept to dry. Dried articles are then 'tapped' to even out the shape and smoothen the texture, before putting it in the kiln for firing.

Energy consumption

The modern technologies used in pottery making include electric pug mills, potter's wheel, and energy-efficient kilns. The GMKRTI has supplied these to selected pottery clusters at subsidized rates. The pug mill is operated for around 20 minutes a day, consuming one and half unit of power and the potter's wheel is operated for 4–5 hours a day, consuming around half a unit of power. As the power supply is uninterrupted throughout Gujarat, the potters did not face any trouble with operations. However, introduction of the solar PV will reduce their power bills and thereby lower the input cost of operations.

Design of solar PV

During the cluster visits, it was seen that enough open spaces (without shade) are available in the vicinity of the pottery-making units for installing ground-mounted systems. In Gandhinagar clusters, households, which were also pottery-making workshops, had sufficient roof area for fixing of rooftop solar systems.

For this cluster, TERI designed a grid-connected solar PV system of 0.5 kW to meet the power requirements of the pug mill and electric potter's wheel, along with auxiliary appliances, such as tube light and fan. The proposed intervention also suggests replacing the 2 HP motor of the pug mill with a 1 HP motor and the 0.5 HP motor of the potter's wheel with a 0.25 HP motor to achieve the same amount of work. The system would require an area of 5 m^2. The cost of the system is estimated to be INR 27,098, calculated using MNRE benchmark prices.

Based on preliminary consultations with the GMKRTI, field visits and stakeholder consultations were organized in pottery clusters of Gandhinagar. Subsequently, in consultation with the artisans, the following business model was developed to propagate solar PV technology in the cluster.

Proposed business model

For this study, micro-enterprise units have been classified as micro (0.5 kWp solar system) and medium (1.1 kWp solar system) depending upon the size of the solar system required. With a capital subsidy of 60%–65% on hardware, the payback period is estimated to be less than 5 years. In order to assess the variation in payback period with respect to interest rate, we reduced the interest from 12% to 8% per annum. However, not much difference in the payback period was achieved.

To leverage subsidy, the state government's provisions for 25% subsidy on the capital cost of energy-efficient equipment (as mentioned in the Industrial Policy 2015) can be explored.[11] Further, the GMKRTI can be approached to explore the possibility of introduction of a scheme relevant for pottery workers to enable their uptake of solar PV systems.[12] The remaining subsidy amount, if required, will have to be leveraged through CSR funding or philanthropic institutions.

It is noteworthy that direct current (DC)-powered electric potter's wheels are also available in the market; however, they are much higher priced than their AC counterparts.[13] Though it would be a more efficient option, the high costs make it unaffordable to small potters. Promotion of DC potter's wheel would thus require adequate support from government agencies, such as GMKRTI, in the form of subsidies as well as investment in R&D to make the DC variants more affordable.

Solar potential

It is estimated that there are over 132 artisans' units spread across Kutch and Gandhinagar in Gujarat. During the field study, the artisans showed interest to install the solar PV system. Considering all the artisans install a 0.5 kWp solar power plant, the solar potential is estimated as 66 kWp.

4.2.2 Salt Cluster in Kutch, Surendranagar, and Patan

Cluster profile

India is the world's third largest salt producer and 77% of the country's salt production is done in Gujarat (Legislative and Parliamentary Affairs Department 2014). Out of the 33 districts of Gujarat, 14 have salt farming and processing enterprises.[14] Kutch has the highest salt production in the state. Most of the salt workers here are from a de-notified tribal community and are designated as Agariyas, which means labourers, who work in salt farms. The salt industry is regulated by the

[11] Details available at https://ic.gujarat.gov.in/documents/pagecontent/revised-GR-01-04-2017-08112017.pdf, last accessed on June 23, 2020

[12] This model of 75% subsidy is inspired from the state government's financing model for the introduction of electric wheel and pug mill in pottery clusters of Gujarat.

[13] Details available at http://www.kisanagroworks.com/DC-Potter-Wheel.html, last accessed on June 23, 2020

[14] Details available at https://ic.gujarat.gov.in/others.aspx, last accessed on June 23, 2020

central government, and the Salt Commissioner's Office under the Ministry of Commerce and Industry is the nodal agency for managing all aspects related to salt manufacturing, supply, distribution, and regulation of these activities.[15]

The *Agariyas*, who have been traditionally doing salt farming, engage in the activities for 7–9 months in a year. In the farming process, the entire family works during the cultivation season and it accounts for the primary annual income source of most of the landless *Agariyas*. Moreover, *Agariyas* do not require a license to carry out salt farming.

Production process

Salt that is produced using sea brine is labelled as marine salt and salt that is produced using subsoil and lake brine is known as inland salt. In Gujarat, both marine and inland salt cultivation is practiced. The basic process of salt production involves solar evaporation of brine water. The brine, which is of 4–16 Baumé density, is exposed to fractional crystallization in sunlight, which increases its density. Beyond 20 Baumé, different salts begin to precipitate and at 25 Baumé, sodium chloride or common salt precipitates in the form of crystals. Starting from September, production begins by laying salt pans followed by digging of brine wells near the salt pans. Pumps are installed to lift brine into the salt pans. Reservoirs that are prepared by bunding the land, known as condensers, are used for salt crystallization. As salt crystals begin to appear, the crust formed is raked repeatedly using a wooden rake. The ready salt is collected in heaps, and later sent for processing in a refinery. The entire process lasts around 45 days.

Energy consumption

Salt farming undertaken by Agariyas is majorly non-mechanized and labour intensive. The use of pumps for lifting and channelling brine water in the salt farm requires electrical or diesel-powered pumps. However, as the electricity infrastructure is missing in most of the salt pans, diesel is used to operate the pump. For several decades, small salt workers in Kutch and other districts have remained trapped in the vicious cycle of poverty. A major chunk of their annual income, which is often less than INR 0.1 million in the case of a majority salt workers, is spent on procurement of diesel to operate the pumps. Feasibility exists of introducing a hybrid pump that operates on solar as well as diesel in the salt cultivation areas of Gujarat. SEWA, a trade union of self-employed women, has already successfully demonstrated the technical and financial feasibility of introducing solar technology in the salt farms. As per a 2018 report[16] published by the Natural Resources Defence Council (NRDC), SEWA began working with 14 salt pan workers in 2013 and has already scaled up their work with thousands of them so far. The same report mentions that, between 2014 and 2018, with loan tenure of 5–7 years and by leveraging financial support from the Government of Gujarat, Bank of Baroda, and others, a solar diesel hybrid pump enabled salt workers to enhance their incomes by almost 94% per salt pan as compared to the salt cultivation using diesel pumps only. A cut in diesel consumption has a direct linkage with climate change mitigation and Sustainable Development Goals (SDGs) of the United Nations. The transition of salt workers to clean and low carbon technology feeds to India's Intended Nationally Determined Contributions (INDCs).

Design of solar PV

Motors of 2 HP, 3 HP, 5 HP, and 7 HP are mostly used in the cluster. In the proposed design for each of the existing motor capacities (2 HP/3 HP/5 HP/7 HP), standalone solar-powered alternatives, which could draw the same amount of water making use of effective sun hours available (5–6

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[15] *Details available at http://saltcomindia.gov.in/about_department.html?tp=html, last accessed on June 23, 2020*

[16] *Details available at https://www.nrdc.org/sites/default/files/worth-their-salt-improving-livelihoods-of-women-salt-farmers-through-clean-energy-in-the-salt-pans-of-gujarat_2018-09-10.pdf, last accessed on June 23, 2020*

hours per day), were suggested. These solar pumps will be portable and can be used at their house or at other locations as and when required. For instance, it is proposed to replace the 2 HP existing pump, which operates on diesel for 18 hours a day, with a more efficient pump of 3 HP drawing the same amount of water. Such a pump would require a solar PV system of around 4 kWp capacity. The area requirements for installation of the solar-powered 3 HP, 5 HP, 7 HP, and 10 HP pumps are estimated to be 35 m^2, 58 m^2, 82 m^2, 123 m^2, respectively. The costs for the systems were estimated using MNRE benchmark cost for solar pumps, which is INR 56,000 per HP.

Proposed business model

In salt clusters of Kutch, Patan, and Surendranagar, where diesel is used for powering motors, replacement of diesel with electricity is technically viable. For the promotion of the solar PV technology in salt pans of Gujarat, business models were developed with a mix of funding scenarios, including subsidy, equity, and loan components to arrive at the corresponding payback periods for solar systems powering 3 HP, 5 HP, 7 HP, and 10 HP water pumps. The micro-enterprise units were categorized into four types: micro (3.5 kWp solar PV system), small (6 kWh solar PV system), medium (8 kWh solar PV system), and large (12 kWh solar PV system).

In a model without subsidies, solar standalone system was calculated to have a payback period of over 5 years which is not likely to be attractive for either entrepreneurs or financial institutions.

In a model with a mix of subsidies (20% micro, 40% small, 40% medium, and 50% large), upfront equity investment (10% in the case of micro and small unit and 20% in the case of medium and large units), bank loan at 12% or 8% rate of interest per annum for 5 years (70% micro, 50% small, 40% medium, and 30% large), payback periods of less than 5 years were estimated[17]. This is likely to be attractive for financial institutions.

The calculated payback periods for the different systems were found to be less than 4 years, even with a bank loan term of 5 years.

Solar potential

As a solar PV system is easy to deploy and requires minimal maintenance, it is convenient to use in the salt pans where electricity infrastructure is a challenge. Overall, in Kutch, Patan, and Surendranagar, there is an aggregate solar potential[18] of 140,000 kWp.[19]

Solar potential assessment across the clusters in Gujarat

The cumulative solar potential across all the studied clusters in Gujarat was assessed and provided in Table 7. This information would be relevant for the solar suppliers or developers at the state or national level who might assess their business potential if they intervene in the identified clusters.

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17 *For the purpose of calculation of payback period, it was assumed that the per unit rate of diesel is INR 70. It is also assumed that 900 units of diesel is consumed in a salt season where a 2 HP pump is used (conservative estimates have been made based on http://www.sewa.org/pdf/SEWA-Solar_Water_Pump_RFP.pdf).*

18 *Estimated based on 40,000 units and solar PV capacity of 3.5 kWp per unit*

19 *Based on conservative estimates assumption that there are 40,000 Agariyas who would need a 3.5 kWp solar PV system*

TABLE 7: Solar potential in different studied clusters in Gujarat

Cluster	District	Total number of units	Daily electricity consumption (kWh)/unit	Solar capacity for individual units (kWp)	Total solar potential in the cluster (kWp)
Pottery cluster	Ahmedabad and Gandhinagar	132	1.5 kWh	0.5 kWp	66kWp
Kutch and Surendranagar Salt Cluster	Kutch, Surendranagar, Patan	40,000 Agariyas (estimated)	11.2 kWh (by 2 HP pump)	3.5 kWp (for 2 HP pump)	140,000 kWp

4.3 Jharkhand

Jharkhand is known for its vast forest covers and significant tribal population. Rich in mineral resources, the state is home to some of India's premier industries, such as Bokaro Steel Plant, Tata Steel, Tata Motors, Bharat Coking Limited, ACC Limited, Central Coalfields Limited, among others. Apart from large industries, Jharkhand is also home to a sizeable number of MSMEs (1.58 million), of which the maximum share is of micro-enterprises (1.57 million). The MSME sector of Jharkhand employs around 2.5 million people.

Much emphasis is laid on the development of industries in the state. The Industrial and Investment Promotion Policy of 2016 has ample provisions to create an enabling environment for fostering industrial growth. In terms of energy, the policy encourages the use of clean energy in business. Capital incentives in the form of subsidy (33%) for pollution reduction and energy saving in MSMEs are mandated in the policy. The policy also aims to attract private investment in solar rooftop projects. The Jharkhand State Solar Policy, 2015 also promotes and incentivizes installing off-grid, decentralized solar plants and rooftop solar in industries.

The micro industry clusters studied for solar feasibility in Jharkhand are detailed further.

4.3.1 Maganpur Tailoring Cluster

Cluster profile

Maganpur is a village in the Gola Block of Ramgarh district, Jharkhand. It is located 34 km east of the district headquarters and 63 km from Ranchi, the state capital. The Maganpur tailoring cluster consists of Maganpur, Gola, and Sisokala villages, which are mostly dominated by traditional tailoring communities who have been practicing garment stitching for more than a century. According to Agragati, a local not-for-profit organization, there are more than 350 tailoring households in the village.

The garment stitching largely includes basic women's wear, such as blouses and petticoats. The tailors of the Maganpur village receive large chunks of standard-sized cut pieces of cloths designed for women wear from towns and cities, such as Ramgarh, Ranchi, Purulia, and Kolkata. The tailors are required to stitch the pieces together to form garments, ready to be delivered. The daily production among the units differs significantly depending on whether the stitching machine is manually operated or motorized. In the presence of reliable power, around 40–50% more stitching is possible using machines as compared to manual operations. Around 20–25 blouse or petticoat cut

FIGURE 8: A woman tailor in Maganpur village

pieces are stitched by a tailor's household (single machine owner) in a typical working day using manually operated machine, while around 30–35 blouses or petticoats cut pieces are stitched with motorized machines. Table 8 shows the monthly production capacities in the cluster.

Energy consumption

All the units in this cluster have motorized sewing machines (approx. 50 Wp capacity of motor). But, during power cuts, tailors operate the machines manually (pedal operated) to complete the

TABLE 8: Cluster details

Category of enterprise	Approx. Number	Average number of stitched material in a month by a typical household of a tailor/ entrepreneur
Small (01 unit of sewing machine)	100	500
Medium (02 units of sewing machines)	200	1000 to 1200
Large (03 units of sewing machines)	50	1200 to 1500
Total	350	

garments. Motorized sewing machines are much faster and enhance the productivity by around 1.5 times, besides reducing drudgery.

The cluster experiences power cuts that last for almost 8–9 hours (4–5 hours during daytime), a condition exacerbated during monsoons. Left without alternatives, tailors are forced to pedal the machines to finish their work. Thus, solar energy is a viable and reliable option in this cluster to complement the existing power source that would not compromise with the available working hours for the tailors.

Design of solar PV

Taking into account the assumptions that the tailoring units operate for around 10–12 hours a day and power backup of at least 3 hours is needed to compensate for rainy or cloudy days, the solar PV systems were designed based on the number of tailoring machines possessed by different households (1–3 numbers). The solar capacities of 150 Wp, 300 Wp, and 450 Wp were designed for small, medium, and large sewing entrepreneurs, respectively. While designing the solar hybrid system, the following assumptions or parameters were taken into consideration:

» Daily operation hours are 12 for all the households. Electrical load of one motor and one LED light was considered for the households with one sewing machine. Similarly, electrical loads of two motors + two LED lights and three motors + three LED lights were considered for the households having two and three sewing machines, respectively.

» The estimated cost considered the benchmark cost for off-grid solar PV system circulated by the Ministry of New and Renewable energy (MNRE), Government of India, that amounts to INR 74 per watt and applicable for 2019–20. This includes the entire cost of systems, supply, installation, and 5-years annual maintenance as per the prescribed quality and system specifications.

Proposed business model

Further, business models were developed for different scenarios of funding to arrive at payback periods for solar interventions. As part of this study, solar PV size and prospective business models have been estimated for micro-enterprise units that have been categorized into three types — small (0.15 kWp solar PV system), medium (0.3 kWp solar PV system), and large (0.45 kWp solar PV system) — based on the size of the solar PV system. In each of these categories, with an investment portfolio of upfront equity of 10% of overall hardware cost and bank loan of 90% of hardware cost (2-year term), a payback period of less than 1.5 years was estimated. In this case, grants and subsidy can still be leveraged to reduce the bank loan component, wherever it is required. In Jharkhand, KVIC, DIC, or KVIB can provide subsidy under PMEGP scheme (15–35%) to these micro-enterprises and the loan amount could be availed through MUDRA scheme from local financing institutions.

Solar potential assessment

The solar potential was calculated based on the numbers of households engaged in sewing activity and solar power pack designed. The cumulative solar potential of the cluster would be nearly 96.8 kW, that is, 100 kW.

4.3.2 Kharsawan Tussar Silk Reeling Cluster

Cluster profile

Kharsawan block is part of the Saraikela Kharsawan district of Jharkhand and is home to the Tussar silk reeling cluster. Silk production is one of the most important economic activities of the state. Jharkhand is the largest producer of Tussar silk in the country. The Santhal Pragana consisting of Dumka, Sahibganj, and Godda in the north-eastern region and the Kolhan Pragana including West Singhbhum and Seraikela Kharsawan in the southern part of the state are the two major clusters for Tussar silk production.

FIGURE 9: Silk reeling in Unnati machine

Seraikela Kharsawan is known for its organic cocoons and Kuchai silk fabric.

The Directorate of Sericulture is the principal agency responsible for promoting tussar sericulture in the state and has already established around 30 common facility centres (CFCs) in Kharsawan cluster alone and there are around 176 CFCs in the entire Kolhan Pargana. The CFCs provide necessary building infrastructure and machinery for spinning and reeling. The Jharkhand Silk Textile and Handicraft Development Corporation Ltd (JHARCRAFT) works for creating sustainable livelihoods in rural areas based on sericulture, handloom, handicrafts, and other allied activities.

Production process

In reeling process, the cocoons are 'cooked' in hot water to loosen their outer portion (sericin), which makes unwinding easy without breakage. Traditional *chulhas* using firewood are used for cocoon cooking. The cocoons after cooking are reeled in different types of machines. Many cocoons are reeled simultaneously to find an unbreakable single thread. The CFCs in the cluster are equipped with 30 'Unnati' machines for reeling and 3 re-reeling machines for the production of hanks/skeins. Hanks are directly utilized as a wrap during the weaving process.

During the survey, it was found that each woman worker prepares around 1 kg of hank in a period of 6–7 days by working around 7–8 hours a day. The monthly production of the hank fibre varies from 3 kg to 6 kg depending on the skill of the worker and un-interrupted operations of reeling machines. The prepared hanks are delivered to JHARCRAFT that supplies those to various weaver clusters operating in different parts of the state.

Design of solar PV

At present, the reeling machines (Unnati) are powered by solar PV systems installed at the CFCs. The installed solar capacity is around 900 Wp for 30 Unnati machine and is already more than 10 years. It has been reported that the systems are not performing as per expectations, which adversely affects the production. Some components including batteries and panels which are already quite old and partially damaged need immediate replacement. Thus, there is a need to replace and redesign them to improve their performance.

Considering that each solar unit operates for around 8 hours a day and requires power backup of at least 6 hours to compensate for rainy or cloudy days, a solar PV system with capacity of 2.2 kWp was designed for the silk reeling unit at CFC. The proposed system is a standalone solar system and the following parameters were considered while designing the system:

» Daily hours of operation are 8 hours. Electrical load of 30 Unnati machines (20 Wp each) and 6 LED luminaries (9 Wp each) for CFC building (500 ft^2) were considered

» The estimated cost considered the benchmark cost circulated by the MNRE that amounts INR 94 per watt (6 hours of battery back-up) applicable for 2019–20. This includes the entire cost of systems, supply, installation, and 5-year annual maintenance as per the prescribed quality and system specifications.

Proposed business model

Further, a business model, based on the field survey and consultations with local stakeholders, was developed. It is proposed to redesign the present solar systems in order to meet additional load of equipment and lighting. The current scenario will thus be changed and lead to utilization of the remaining underutilized Unnati reeling machineries owing to availability of power. Assuming only 20% additional machines are made operational by way of new procurement or upgradation of existing Unnati machines, if successfully done, the utilization factor will improve from 60% to 80%, leading to an increase in productivity by 33%. Hence, by introducing solar energy, the monthly average incremental income per woman entrepreneur would be nearly INR 1125, including the possibility of employment of additional six women in the silk reeling unit at CFC.

It is likely that with an upfront equity investment of 15% and a loan amounting to 85% of the hardware cost (loan term of 3 years), a payback of less than 1 year can be achieved.

Solar potential assessment

The solar potential was calculated based on 30 CFCs that are engaged in silk reeling activity in the Kharsawan cluster. The cumulative solar potential of all the identified CFCs is estimated as 66 kWp. The existing solar systems at CFCs can also be utilized in case mechanization is introduced for replacing existing hand-operated re-reeling units (8 to 9) at the same CFC level. This would further enhance the productivity and scope for additional engagement of the women entrepreneurs.

4.3.3 Bishnugarh Brass and Bronze Utensils Cluster

Cluster profile

Situated in Hazaribagh district, the Bishnugarh brass and bronze utensils cluster comprises Achaljamu, Ramua, Nawadi, and Bishnugarh villages. The cluster is said to be one of the oldest in the state with brass-making skills being passed over generations for more than 100 years. According to Gram Vikas Manch (GVM), a not-for-profit organization active in the area, the population of the cluster is more than 700–800 who are engaged in brass-making products. Around 220 artisan households were found active and engaged in day-to-day operations during the survey. Out of these, around 150 households are engaged in making brass and bronze utensils, while the rest 60–70 households are engaged in the production of brass utensils only. The brass community has been re-classified based on their daily productions and the number of people engaged. Around 30–35 households are classified as large artisans whose monthly turnover is

FIGURE 10: A brass vessel made in Bishnugarh cluster

relatively higher than other artisans. These large artisans operate in a separate workshed by employing around 10–15 labourers. Around 150 households are of medium artisans whose productions are carried out at their own houses by engaging their family members. Their turnover is relatively lesser than the former. The remaining 30–35 households are of also household-based small artisans whose turnover is the least among all the other two category of artisans. The daily volume of brass products across the households vary from 0.5 to 2.5 quintal per day.

The production takes place for around 10–12 days a month. According to GVM, the aggregate volume of the brass utensil production is around 200 quintals per day from the Bishnugarh cluster, which amounts to around INR 1 crore turnover in a day. The average working days in a month are around 20–25 including both manufacturing and finishing of the products. Tables 9 and 10 represent the type of brass products made and their approximate volumes in the cluster.

TABLE 9: Artisans and their products

Artisans category	Products
Small artisan (brass utensils)	Frying pan *(Kadai)* or *Matka (Gagra)*
Medium artisan (brass and bronze utensils)	Tray *(Thali)*, plate *(Thari),* big size bowl *(Katora)*, serving spoon *(Chholni)*, flower pot *(Phuldeliha)*, etc.
Large artisan (brass utensils)	Tray *(Thali)*, *glass, Lota*, bowl (both small and big size), etc.

TABLE 10 : Artisans and their average productions

Artisans category	Approx. number of households	Average volume of production per day (qtl)	Average monthly production (qtl)
Small artisan (brass utensils)	35	0.6 to 0.70	9–10
Medium artisan (brass and bronze utensils)	150	0.75 to 1	10–15
Large artisan (brass utensils)	35	1.5 and above	18 and above
Total	**220**		

Production process

The artisans use mostly two different alloys for making utensils, namely brass and bronze. Copper is the major raw material while zinc and tin are mixed in different proportions to make brass or bronze, respectively, depending on the type of utensils to be produced. The production process of brass and bronze utensils involves melting, casting, rolling, cutting, beating, etc., to provide the desired shape of the utensils. Thereafter, the products go through finishing processes, such as grinding, buffing, and polishing, after which they are ready for market delivery.

Energy consumption

Copper smelting and casting processes are highly energy intensive; hence, they can be economically viable and affordable only if conventional fuels and local technologies are used. Brick or clay-based furnace (*bhatti*) and sand or clay-based casting moulds are the local technologies adopted, hence, do not need much financial investment. Grinders and buff machines (scrapping and polishing) are used in finishing, which run on diesel generators, and thus provide scopes for solar intervention. While the large artisans have more machines that need more power, the home-based small and medium artisans have a few machines, thus require less motor power.

The cleaning and finishing process of making brass products offers scope for introducing energy-efficient technologies. The production units do not use grid electricity due to lack of reliability and affordability, hence are dependent on diesel generators. The cluster has immense potential to replace diesel generators with cleaner, reliable, and affordable energy systems, such as solar PV systems.

Design of solar PV

The present loads for small, medium, and large artisans are around 0.75 kW, 1.5kW, and 7.5kW, respectively. Keeping these factors in mind, solar PV systems were designed by considering operating hours and their schedule of operation of different brass artisan units along with the provision of additional power backup of at least 3 hours for rainy or cloudy days. The proposed solar PV capacities include 1.0 kWp, 2.0 kWp, and 5.0 kWp for small, medium, and large artisan units, respectively.

The proposed system is a solar hybrid version for small and medium artisans and standalone for large artisans. While designing the solar system for all these three categories, the following assumptions or parameters were considered:

a. The existing hours of operation is 6 and 8 for medium and large artisans, respectively.

b. The solar design for a medium artisan unit can meet the energy requirement of casting and finishing processes in alternate days with equal share of energy from grid electricity. Diesel can be replaced completely. Solar will address the quality issue.

c. The solar design for a large artisan unit can meet the entire energy requirements of finishing processes (energy for the casting process was excluded). Further, grinding and buffing (scrapping) are proposed to be operated in 1 day, while the buff polishing machines are proposed to be operated in the next or alternate day. Diesel is proposed to be replaced completely. Solar will also address the issue of non-availability of a commercial connection.

d. The existing hours of operation is 8 for the identified small artisan units, which includes 5 hours for blower operation in the casting and 3 hours for grinding machines in the finishing process. Both solar and grid electricity are proposed to meet energy requirement in the proportion of 80% and 20%, respectively.

e. The estimated cost considered the benchmark cost for off-grid solar PV system circulated by MNRE amounts to INR 74 per watt and is applicable for 2019–20. This includes the entire cost of the systems, supply, installation, and 5-year annual maintenance as per the prescribed quality and system specifications.

Proposed business model

For this study, the brass cluster units were classified into small (1 kWp solar PV system), medium (2 kWp solar PV system), and large (5 kWp solar PV system) types based on estimated solar PV capacity that is likely required for powering these units. In small units, a model with 20% upfront investment and loan amounting to 80% of the hardware cost having interest of 12% per annum (3 years) would yield a payback period of 1.92 years. The payback period is estimated to be 1.82 years when the interest rate is reduced to 8% per annum. For medium units, a model with 20% upfront investment and 80% loan having interest rate of 12% (3 years) would yield a payback period of 1.58 years. The payback period is estimated to be 1.5 years when the interest rate is reduced to 8% per annum. For large units, a model with 20% upfront investment and 80% loan having interest rate of 12% (3 years) would yield a payback period of 2.79 years. The payback period is estimated to be 2.64 years when the interest rate is reduced to 8% per annum

In this cluster, grants and subsidy can still be leveraged to reduce the risk of bank loan component, wherever it is required. KVIC, DIC, or KVIB can provide subsidy under PMEGP scheme (15–35%) to these micro-enterprises and the loan amount could be availed through MUDRA scheme from local financing institutions.

Solar potential assessment

The solar potential for this cluster was calculated based on the number of households engaged in different brassware production and the solar power pack designed for corresponding artisan units. An estimated aggregate solar PV potential[21] of 500 kWp in the cluster is likely to be an attraction for investors and technology developers.

Solar potential assessment across the clusters in Jharkhand

The cumulative solar potential across all the studied clusters in the state was assessed and

[21] *Estimated based on 35 units of 1 kWp solar PV capacity systems, 150 units of 2 kWp solar PV capacity systems, and 35 units of 5 kWp solar PV capacity system*

provided in Table 11. This information would be relevant for the solar suppliers or developers at the state or national level who might assess their business potential if they intervene in the identified clusters.

TABLE 11: Solar potential in the studied clusters in Jharkhand

Cluster	District	Total number of units	Daily electricity consumption (kWh)/unit	Solar capacity for individual units (kWp)	Total solar potential in the cluster (kWp)
Maganpur Tailoring Cluster	Ramgarh	Small 100 Medium 200 Large 50	Small 0.71 kW Medium – 1.42 kW Large 2.12 kW	Small 0.15 kW Medium 0.3 kW Large 0.45 kW	98
Kharsawan Silk Reeling Cluster	Seraikela Kharsawan	30	5.232 kW	2.2 kW	66
Bishnugarh Brass Cluster	Hazaribagh	Small 35 Medium 150 Large 35	Small 3.074 kW Medium 9.096 kW Large 12.08 kW	Small 1.0 kW Medium 2.0 kW Large 5.0 kW	500

5. Conclusion

MSMEs are a thriving entity in the Indian industrial ecosystem, gainfully providing livelihoods to millions of people. Micro/home-based industries, which cover around 99% of the MSME landscape, not only engage many enterprises that are based in the vicinities of people's homes but also bear witness to innumerable heritage works that have been passed down through generations with skills possessed only by a few. However, the unique enterprises of the micro-enterprises sector, which often represents the distinct culture of different geographically diverse peoples, face several threats. Access to credit, infrastructure, institutional support, among others, are some of the many issues faced by micro/home-based enterprises. With markets opening up globally, many of these enterprises struggle with competition. Moreover, micro-enterprises, being less organized and scattered, often operating individually, lag in terms of availing the benefits of the numerous schemes and initiatives launched by the government for their development. In relation to infrastructure, access to electricity at cheaper cost is an important prerequisite for seamless production and competitiveness wherever mechanization has taken place. In some states where power supply situation is satisfactory, the state government provides subsidy to a few clusters to make the enterprises competitive. Still a substantial cost of electricity is being borne by the enterprise owners themselves. In states where unreliable supply of electricity affects production, many enterprises use fossil fuels for power backup, leading to high costs of production and carbon emissions.

Most of the studied clusters are traditional and popular in their respective states. In fact, the salt cluster of Kutch and wooden toy cluster of Channapatna are nationally well known. Clusters, namely wooden toy, silk thread twisting, and powerloom clusters of Karnataka, and silk reeling and brassware clusters of Jharkhand are already registered under different schemes of the Ministry of MSME for possible assistance. The present study has undertaken extensive survey in the nine micro-enterprise clusters to understand their energy requirements and potential for solar application. Each cluster is unique and has distinct set of challenges. The following major findings were observed during the study:

» Three (03) enterprise clusters of Jharkhand were surveyed, one each from Hazaribag, Ramgarh, and Sareikela-Kharsawan districts (all aspirational districts). Electricity supply has been found unreliable and intermittent and available only for 8–10 hours daily. In Bishnugarh brass cluster of Hazaribag, the enterprises are heavily reliant on diesel run gen-sets and reluctant to apply commercial connection due to high initial deposit and monthly tariff (Onetime deposit of INR 12,000 for every 1 HP load and more than INR 6 per unit). Access to interrupted and affordable electricity would surely replace diesel use and reduce cost of production. In Maganpur sewing cluster of Ramgarh, the entrepreneurs have to depend upon manual stitching for 3 to 4 hours daily. Access to solar power can enhance the working hours by 4 to 5 hours daily, and hence has the potential to increase production and income by around 30–40%. In Sareikela–Kharsawan district, the silk reeling units at common facilitation centres of JHARCRAFT, presently deprived of grid electricity, urgently need solar power and can enhance further mechanization to create more employment, production, and income of the women artisans.

» Four (04) enterprise clusters were surveyed in Karnataka, one each from Chikkaballapura, Belagavi, Kolar, and Ramanagara districts. Uninterrupted power supply, for almost 22–24 hours daily, has been found in all these clusters. The state Department of Handloom and Textiles (DoHT) has been providing 60% tariff subsidy to the entrepreneurs of Khasbag powerloom and Sidlaghatta silk twisting cluster. Surprisingly, the entrepreneurs of all these clusters, including Channapatna wooden toy and Shivarapatna stone idol clusters, have wished for solar power system if made available at subsidized price.

» In Gujarat, the pottery clusters of Gandhinagar and Kutch districts are hardly facing any power issues. However, a shift to clean energy is expected to help in reducing their electricity bills and improve profitability. Electricity infrastructure is, however, absent in the salt clusters of Kutch, Sundernagar, and Patan districts of the state and holds huge scope for decentralized solar PV applications. The state government has also earmarked specific budget provision (2020–21) for purchasing solar pumps for the salt workers.

» Most of these enterprises have been facing many challenges including lack of raw materials, inadequate working capital, lack of investment capacity for advanced tools and equipment, expensive yet unreliable energy sources, etc. Hence, they lack the ability to invest upfront for solar PV as well. Small and affordable loans are not easily available from local commercial banks and financing institutions. Lack of awareness and sensitizations on solar potential have also led to little or no dissemination. The present national- and state-level MSME and solar policies encourage the use of non-conventional energy sources including solar in manufacturing sector, however lack of implementing guidelines discourage financing of solar PV system in the sector except silk sector scheme of Ministry of Textile, Govt. of India.

» The primary survey has enabled in the design of appropriately sized solar PV system across the clusters and enterprises. While the smallest solar PV size is needed in Maganpur sewing cluster (as small as 150 Wp) of Jharkhand, the biggest solar PV size is needed in Chhannapatna wooden toy cluster (as big as 14 kWp) of Karnataka. Similarly, the aggregate solar potential has been highest in salt cluster and lowest in pottery cluster of Gujarat. All four clusters of Karnataka and salt cluster of Gujarat have significantly higher solar PV potential.

» The business models developed across the clusters and enterprises reveal the payback period of solar PV investment in Jharkhand is minimum (1 to 3 years) with zero subsidy which is exception to all clusters of Karnataka and Gujarat where subsidy to tune of 40% to 65% is needed to keep payback period in and around 5 years period with same bank interest rate (8% per annum).

A brief summary of the solar potential and business feasibility of the studied clusters is provided in Table 12.

TABLE 12: Cluster-wise details of the solar PV potential and feasibility

S No.	Name of the cluster	Solar PV capacity and cost (benchmark cost of MNRE, Government of India)	Prospective business model		Mobilization of funds from potential schemes/ agencies
			Scenario 1	Scenario 2	
1	Kolar - Shivarapatna stone idol cluster Estimated number of units: 200 aggregate Estimated solar potential: 1000 kWp	Micro: 5 kWp grid-fed (individual) system @INR 2.7 lakh	E -20% L- 80% S- 0% 5-year loan term Payback > 15 years @12% interest Payback >15 years @8% interest	E -20% L- 20% S-60% 5-year loan term Payback: 5.33 years @12% interest Payback: 5 years @ 8% interest	District Industry Centre (DIC) and Karnataka State Handicrafts Development Corporation (KSHDC) for 10% and 40% subsidy, respectively. MUDRA and SIDBI financing schemes for loan

TABLE 12: Cluster-wise details of the solar PV potential and feasibility

S No.	Name of the cluster	Solar PV capacity and cost (benchmark cost of MNRE, Government of India)	Prospective business model		Mobilization of funds from potential schemes/ agencies
			Scenario 1	Scenario 2	
2	Ramanagara-Channapatna wooden toy cluster Estimated number of units: 500 aggregate Estimated solar potential: 1000 kWp	Small: 3 kWp grid-fed (individual) system @ INR 1.62 lakh	E -20% L- 80% S- 0% 5-year loan term Payback >15 years @12% interest Payback > 15 years @8% interest	E-20% L-15% S-65% 5-year loan term Payback: 5.52 years @12% interest Payback: 5.2 years @8% interest	DIC and KSHDC for 10% and 40% subsidy, respectively. MUDRA and SIDBI financing schemes for 30% loan. Remaining can be leveraged through CSR fund or philanthropic institutions
		Medium: 6 kWp grid-fed (individual) system @ INR 3.24 lakh	E- 20% L- 80% S- 0% 5-year loan term Payback >15 years @12% interest Payback >15 years @8% interest	E -20% L- 15% S-65% 5-year loan term Payback: 4.9 years @12% interest Payback: 4.65 years @8% interest	
		Large: 14 kWp grid-fed (individual) system @ INR 6.72 lakh	E- 20% L- 80% S- 0% 5-year loan term Payback: 12.9 years @12% interest Payback: 11.88 years @8% interest	E- 20% L- 15% S-65% 5-year loan term Payback: 5.87 years @12% interest Payback: 5.56 years @8% interest	

TABLE 12: Cluster-wise details of the solar PV potential and feasibility

S No.	Name of the cluster	Solar PV capacity and cost (benchmark cost of MNRE, Government of India)	Prospective business model		Mobilization of funds from potential schemes/ agencies
			Scenario 1	Scenario 2	
3	Belgaum - Khasbag powerloom cluster Estimated number of units: 1200 aggregate Estimated solar potential: 6180 kWp	Micro: 3 kWp grid-fed (individual) system @INR 1.62 lakh	E -20% L-80% S-0% 5-year loan term Payback: 12.18 years @12% interest Payback: 10.77 years @8% interest	E-20% L-40% S-40% 5-year loan term Payback: 5.65 years @12% interest Payback: 5.2 years @ 8% interest	Department of Handloom and Textile can take the lead in providing upfront capital subsidy of 40%–55% of the hardware cost of solar PV systems. MUDRA or SIDBI financing schemes for 25–40% loan for the hardware cost of solar PV systems
		Small: 4 kWp grid-fed (individual) system @INR 2.16 lakh	E-20% L-80% S-0% 5-years loan term Payback: 12.19 years @12% interest Payback: 10.76 years @8% interest	E-20% L-35% S-45% 5-year loan term Payback: 5 years @12% interest Payback 4.65 years @8% interest	
		Medium: 6 kWp grid-fed system (individual) @ INR 3.24 lakh	E-20% L-80% S-0% 5-years loan term Payback > 15 years @12% interest Payback > 15 years @8% interest	E-20% L-25% S-55% 5-years loan term Payback: 5.19 years @12% interest Payback: 4.85 years @8% interest	
		Large: 8 kWp grid-fed (individual) system @ INR 4.32 lakh	E-20% L-80% S-0% 5-year loan term Payback: 12.19 years @12% interest Payback :10.77 years @8% interest	E-20% L-35% S-45% 5-years loan term Payback: 5 years @12% interest Payback: 4.65 years @8% interest	

TABLE 12: Cluster-wise details of the solar PV potential and feasibility

S No.	Name of the cluster	Solar PV capacity and cost (benchmark cost of MNRE, Government of India)	Prospective business model		Mobilization of funds from potential schemes/ agencies
			Scenario 1	Scenario 2	
4	Chikkaballapura - Sidlaghatta silk twisting cluster Estimated number of units: 960 aggregate Estimated solar potential: 3840 kWp	Small: 4 kWp grid-fed (individual) system @ INR 2.16 lakh	E-20% L-80% S-0% 5-years loan term Payback: 12.9 years @12% interest Payback: 11.88 years @8% interest	E-20% L-30% S-50% 5-year loan term Payback: 5.2 years @12% interest Payback 4.83 years @8% interest	District Industry Centre for 40–65% subsidy for the hardware cost of solar PV system MUDRA or SIDBI financing schemes for 15–40% loan for the hardware cost of solar PV systems
5	Gandhinagar pottery cluster Estimated number of units: 132 aggregate Estimated solar potential: 66 kWp	Small: 0.5 kWp grid-fed (individual) system @INR 27000	E-25% L- 75% S- 0% 3-year loan term Payback > 15 years @12% interest Payback > 13 years @8% interest	E-25% L-15% S-60% 3-year loan term Payback: 3.88 years @12% interest Payback: 3.77 years @ 8% interest	Gujarat Energy and Development Agency (GEDA) (Solar Rooftop scheme) for 40% subsidy of hardware cost of solar PV system. Out of the remaining 35%, CSR funds can be leveraged to get 10% and the remaining 25% can be leveraged as part of the Gujarat Industrial Policy 2015
		Medium: 1.1 kWp grid-fed (individual) system @INR 60000	E-25% L 75% S 0% 3-year loan-term Payback > 15 years @12% interest Payback > 15 years @8% interest	E-25% L-10% S-65% 5-year loan term Payback @12% interest: 4.49 years Payback @8% interest: 4.33 years	

TABLE 12: Cluster-wise details of the solar PV potential and feasibility

S No.	Name of the cluster	Solar PV capacity and cost (benchmark cost of MNRE, Government of India)	Prospective business model		Mobilization of funds from potential schemes/ agencies
			Scenario 1	Scenario 2	
6	Kutch, Patan and Surendranagar salt cluster Estimated number of units: 40,000 aggregate Estimated solar potential: 140,000 kWp	Micro: 3.5 kWp standalone (individual) system @INR 1.68 lakh	E -10% L- 90% S- 0% 3-Year loan term Payback > 3.77 years @12% interest Payback > 3.54 years @8% interest	E -10% L- 70% S-20% 3-Year loan-term Payback 2.9 years @12% interest Payback 2.74 years @8% interest	The Gujarat government has a scheme for provisioning 80% subsidy on hardware cost of solar PV system to salt workers who wish to instal a solar pump
		Small: 6 kWp standalone (individual) system @INR 2.8 lakh	E-10% L- 90% S-0% 5-year loan term Payback: 9 years @12% interest Payback: 8 years @8% interest	E-10% L-50% S-40% 5-year loan term Payback: 4.52 years @12% interest Payback: 4.12 years @8% interest	
		Medium: 8 kWp standalone (individual) system @INR 3.92 lakh	E-20% L-80% S-0% 5-years loan term Payback: 9 years @12% interest Payback: 8.05 years @8% interest	E-20% L-40% S-40% 5-year loan term Payback: 4.44 years @12% interest Payback: 4.1 years @8% interest	
		Large: 12 kWp standalone (individual) system @INR 5.6 lakh	E -20% L-80% S-0% 5-year loan term Payback: 12.19 years @12% interest Payback: 10.77 years @8% interest	E-20% L-30% S-50% 5-year loan term Payback: 4.43 years @12% interest Payback: 4.12 years @8% interest	

TABLE 12: Cluster-wise details of the solar PV potential and feasibility

S No.	Name of the cluster	Solar PV capacity and cost (benchmark cost of MNRE, Government of India)	Prospective business model		Mobilization of funds from potential schemes/ agencies
			Scenario 1	Scenario 2	
7	Ramgarh tailoring cluster Estimated number of units: 350 aggregate Estimated solar potential: 98 kWp	Small: 0.15 kWp solar hybrid (individual) system @INR 11,100	E-10% L-90% S-0% 2-year loan term Payback: 1.12 years @12% interest Payback: 1.06 years @8% interest	The payback period is less than 3 years (max. in the case of brass cluster), hence scenario 2 (subsidy requirement) has not been needed.	State-level KVIC/ DIC/Khadi and Village Industries Board(KVIB) (under PMEGP scheme), Jharkhand Renewable Energy Development Agency (JREDA) under MSE support scheme, and loan under MUDRA scheme
		Medium: 0.3 kWp solar hybrid (individual) system @INR 22, 200	E-10% L-90% S-0% 2-year loan term Payback: 1.11 years @12% interest Payback: 1.07 years @8% interest		
		Large: 0.45 kWp solar hybrid (individual) system @INR 33,300	E-10% L-90% S-0% 2-year loan term Payback: 1.11 years @12% interest Payback: 1.07 years @8% interest		
8	Kharasawan tussar silk reeling common facilitation centre (CFC) Estimated no of CFC units: 30 aggregate Estimated solar potential: 68 kWp	Small: 2.2 kWp standalone (centralized) system @INR 2.06 lakh	E-15% L-85% S-0% 3-year loan term Payback: 0.79 years @12% interest Payback: 0.75 years @8% interest	The payback period is less than 3 years (max. in the case of brass cluster), hence scenario 2 (subsidy requirement) has not been needed.	Directorate of Sericulture and JHARCRAFT, Jharkhand provides subsidy. Loan is provided under MUDRA scheme

TABLE 12: Cluster-wise details of the solar PV potential and feasibility

S No.	Name of the cluster	Solar PV capacity and cost (benchmark cost of MNRE, Government of India)	Prospective business model		Mobilization of funds from potential schemes/ agencies
			Scenario 1	Scenario 2	
9	Bishnugarh brass and bronze utensils Estimated number of units: 220 aggregate Estimated solar potential: 500 kWp	Small: 1 kWp solar hybrid (individual) system @ INR 74000	E-20% L 80% S 0% 3-year loan term Payback: 1.92 years @12% interest Payback: 1.82 years @8% interest	The payback period is less than 3 years (max. in the case of brass cluster), hence scenario 2 (subsidy requirement) has not been needed.	State-level KVIC/DIC/KVIB (under PMEGP scheme), JREDA under MSE support scheme, and loan under MUDRA scheme
		Medium: 2 kWp solar hybrid (individual) system @ INR 1.48 lakh	E-20% L-80% S-0% 3-year loan term Payback: 1.58 years @12% interest Payback: 1.5 years @8% interest		
		Large: 5 kWp solar hybrid (individual) system @INR 3.7 lakh	E-15% L-85% S-0% 3-year loan term Payback: 2.79 years @12% interest Payback: 2.64 years @8% interest		

Note:

i In prosperous states, such as Gujarat and Karnataka, a higher initial capital subsidy will be required to drive interest of micro-enterprise clusters where incremental income from use of solar technology is not very high.

ii Unlike prosperous states, in Jharkhand, where micro-enterprises use diesel or face power reliability issues, the business case for solar PV technology is more obvious. There is a need for small loans at easy and affordable rates through MFIs/RRBs/Development Banks and SHG networks.

The survey interactions and findings reveal many direct and indirect impact benefits of solar PV that may of course vary from cluster to cluster. Adoption of solar PV is expected to replace conventional fuel and related expenses and reduce subsidy burden as well as enhance working hours, employment, and income.

6. Recommendation

Recommendations

The feasibility study by TERI is expected to facilitate the uptake of solar PV systems in the micro-enterprise sectors of India. Based on this study, recommendations, for advancing solar PV technology in the micro-enterprise clusters, have been provided:

i. Introduction of solar PV scheme for micro-enterprises

The Ministry of MSME (MoMSME) or Ministry of New and Renewable Energy (MNRE), Government of India may come up with a new 'solar PV scheme for MSME sector', similar to Ministry of Textiles, Government of India that is providing solar subsidy for the powerlooms and the silk sector. Such scheme may encourage significant solar promotion and contribute to the achievement of the solar target envisaged under the National Solar Mission by 2022. Besides, it would pave the way for replacement of polluted diesel gen-set usage in the micro/home-based enterprise sector (applicable for brass and salt industry).

ii. Financial assistance under existing schemes

Schemes such as MSE-CDP, PMEGP, and SFURTI as well as newly introduced 'Atmanirvar Bharat Abhiyan' may facilitate inclusion of solar energy for the micro- and artisan enterprises. The capital subsidy mentioned under PMEGP (15–35%) may be applied for procurement of solar PV system through implementing agencies, namely KVIC, KVIB, and DIC.

iii. Constitution of state-level committee

Besides, state-level technical advisory committee may be constituted comprising finance, technology, and policy and procurement experts. The committee can address the impediments that are limiting uptake of solar PV technology (applicable for all clusters studied).

iv. Facilitating small loans for micro-enterprise clusters

Small loans at affordable rate should be facilitated to micro-entrepreneurs for adoption of solar PV systems. It would enable more attractive payback periods and reduce financial burden on micro-enterprises. Loans could be made available from financing scheme such as 'MUDRA' by sensitizing all other financing agencies including MFI/RRBs/SFIs/Cooperative, etc. for the solar procurement.

- Corpus fund available with state agencies, such as the State Livelihood Mission could be deployed for financing solar PV for micro-enterprises, run by a women-led self-help group, in joint liability model.

v. Converting state power subsidy to one time capital subsidy

Introduction of solar PV systems in many states is expected to reduce the subsidy burden of state government such as in Karnataka and Gujarat. It is thus proposed that the state government may allocate the same subsidy to respective DISCOMs in order to promote grid-interactive solar PV rooftop programme in the micro-enterprise cluster roping in organizations, such as EESL and IREDA to facilitate financing.

vi. Awareness generation and piloting

Creation of awareness and sensitization among the micro-enterprise clusters has been recommended on existing solar PV schemes and incentives. Further, to ensure the quality of the solar PV system, a list of approved solar integrators should be made available from time to time to these prospective entrepreneurs. The solar integrators or other agencies may be encouraged with incentives for promoting solar PV in the micro-enterprise clusters. As a way forward, demonstration model of solar PV in the identified cluster may be considered to showcase the technical and business prospects of the system to the micro-entrepreneurs, financiers, and policymakers.

vii. Multi-stakeholders collaboration

Multipronged strategies may be required through multi-stakeholder's collaboration including policymakers, local administration (e.g. district industry centres), suppliers, bankers, research institutions and the civil society bodies for successful piloting, replication, and scaling up of solar PV interventions in rural micro-enterprises.

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