State of the Decentralised Renewable Energy Sector in India:

Indian DRE getting world-ready

www.thecleannetwork.org

CLEAN
Create. Connect. Collaborate.

Acknowledgements

CLEAN is deeply grateful to all who have contributed to this report - all the advisors, editors, reviewers, authors and also all the stakeholders and members whose data and insights have been used by the authors.

Authors

David Lecoque, Deepak Mohapatra, Alliance for Rural Electrification;
Elisa Lai and Sumedha Awasthy, CLASP; Reviewer: PK Mukherjee, CLASP;
Tauseef Ahmad and Akanksha Chaurey; Reviewer: Praviin Kumar, GOGLA;
Rekha Krishnan, WEFT Research LLP with Shashank Misra, Ekak Innovations and
William Brent, Husk Power

Knowledge Partner

WEFT Research LLP | www.weft.co.in

Report Concept

Rekha Krishnan, Akanksha Chaurey

Report Draft Review

Meera Rotti

Design

Callidus Pixels Pvt. Ltd.

Cover Image

SwitchON Foundation

State of the Decentralised Renewable Energy Sector in India:

Indian DRE getting world-ready

www.thecleannetwork.org

CLEAN
Create. Connect. Collaborate.

CLEAN in 2023

Participation in COP28 in Dubai

Roundtable on 'Strengthening Rural Livelihoods in Assam through Decentralised Renewable Energy (DRE)' (09 November 2023, Guwahati, Assam)

Consultation on 'Roadmap for DRE for Horticulture Processing in Meghalaya - Focus on Pineapple Processing ' (01 August 2023, Shillong, Meghalaya)

CLEAN Summit on 'Decentralised Renewable Energy : Accelerating India's Vision of Net Zero' (16 September 2023, Pune)

Contents

ASSOCIATION OF RENEWABLE ENERGY AGENCIES OF STATES
Ministry of New & Renewable Energy, Atal Akshay Urja Bhawan, Opp. CGO Complex, Lodhi Road, New Delhi-03
Tel/Fax: +91-11-20849116, Email: areasdelhi@gmail.com, Website: www.areas.org.in

MESSAGE

I congratulate CLEAN for its ongoing effort in bringing out comprehensive reports providing insights into the state of the Decentralised Renewable Energy Sector every year.

Decentralised Renewable Energy (DRE) has tremendous potential to deliver social as well as economic benefits in a carbon-neutral and equitable manner. This report strongly brings out the multi-faceted potential of DRE in India through inputs from various major stakeholders in the sector. The report presents useful national level statistics and also maps a number of case studies from the ground. It puts the state of the DRE sector in India in the context of the global state of the sector.

The report has succeeded in providing a comprehensive and contextualised picture of the DRE sector and is a useful information resource for a wide range of stakeholders from DRE entrepreneurs to policy enablers.

J K Jethani
Executive Director
24th January, 2024

Foreword by President, CLEAN

CLEAN
Create. Connect. Collaborate.

The DRE sector includes a diversity of technology and implementation approaches. It also results in a diversity of social, economic and environmental impacts. This makes it challenging to present a cohesive picture of the sector. The national level statistics of technology deployment, financing, etc., is one side of the story but the transformative local change brought in by the interventions is also an equally important other side of the story.

CLEAN has been bringing out the State of the DRE Sector reports for several years. Earlier the report was developed on the basis of data collected from the field and collated by a team within CLEAN. From this year we have changed the format by inviting various stakeholders in the sector to contribute their assessment of the state of the sector from the perspective of their own work. We hope that this new approach more effectively captures the diverse facets of this transformative sector.

Please do share your feedback and suggestions by writing to: support@thecleannetwork.org

Lt Col Monish Ahuja (Retd)
President – CLEAN
25th January, 2024

Pune Office: 771, Office No. 3, Mayur Apartment, Bhandarkar Road, Pune – 411004.
Delhi Office: F-5 Ground Floor Kailash Colony, New Delhi-110048
T: +91 7683047824 **E**: support@thecleannetwork.org

Regn.No.S/2450/Distt.South/2-18

List of abbreviations

- AC – Alternating Current
- BLDC - Brushless Direct Current
- CBG – Compressed Bio Gas
- CNG – Compressed Natural Gas
- CSC – Common Service Centre
- CSR – Corporate Social Responsibility
- DC – Direct Current
- DISCOM – Distribution Company
- DRE – Decentralised Renewable Energy
- EBITDA – Earnings Before Interest, Taxes, Depreciation and Amortization
- EMI – Equated Monthly Installment
- FPC – Flat Plate Collectors
- GHS/RWA - Group Housing Societies/ Residential Welfare Associations
- GW – Giga Watt
- HP – Horse Power
- INR – Indian Rupee
- IoT – Internet of Things
- kWh – kilo Watt hour
- kWp – kilo Watt peak
- LED – Light Emitting Diode
- MW – Mega Watt
- NE – North East
- OFT – On Field Trial
- P2P – Peer to Peer
- PayG – Pay as You Go
- PCM – Phase Change Material
- PPP – Public-Private Partnership
- PV – Photo Voltaic
- R&D – Research and Development
- RE-RTD - Renewable Energy Research and Technology Development
- RO – Reverse Osmosis
- RTS – Rooftop Solar
- SDG – Sustainable Development Goal
- SHP – Small Hydro Power
- SHS – Solar Home Systems
- SLS – Solar Lighting Systems
- SNA – State Nodal Agencies
- SSA – Sub-Saharan Africa
- SSLs - Solar Street Lights
- SWPS - Solar Water Pumping Systems
- TBT - Technical Barriers to Trade
- USD – United States Dollar
- UV – Ultra Violet
- VFD – Variable Frequency Drive
- WHO PQS – World Health Organization Performance, Quality and Safety

List of acronyms

- ARE – Alliance for Rural Electrification
- BIS – Bureau of Indian Standards
- C.T.R & T.I - Central Tasar Research & Training Institute
- CEEW – Council on Energy, Environment and Water
- CFA - Central Finance Assistance
- CLEAN – Clean Energy Access Network
- CSIR-CSMCRI – Council of Scientific and Industrial Research – Central Salt and Marine Chemical Research Institute
- DOS - Directorate of Sericulture
- DRC – Democratic Republic of Congo
- ESMAP – Energy Sector Management Assistance Program
- GOGLA – Global Off-Grid Lighting Association
- HRED - IIT Department of Hydro and Renewable Energy
- IEA – International Energy Agency
- IEC – International Electrotechnical Commission
- IIT – Indian Institute of Technology
- IREAP - India Renewable Energy Appliances Portal
- IRENA – International Renewable Energy Agency
- ISA - International Solar Alliance
- MRFR – Market Research Future
- MNRE – Ministry of New and Renewable Energy
- NCPRE - National Centre for Photovoltaic Research and Education
- NEA – Nepal Electricity Authority
- NECTAR - North-East Centre for Technology Application & Reach
- NIBE - National Institute of Bio Energy
- NIFTEM - National Institute of Food Technology Entrepreneurship and Management
- NISE - National Institute of Solar Energy
- NIWE - National Institute of Wind Energy
- PM-AJAY – Pradhan Mantri Anusuchit Jati Abhyuday Yojana
- PM-KUSUM - Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyaan
- PRESPL - Punjab Renewable Energy Systems Private Limited
- SRLM - State Rural Livelihood Mission
- UNDP – United Nations Development Programme
- UNHCR – United Nations High Commissioner for Refugees
- WEFT – Water-Energy-Food Transitions
- WHO – World Health Organisation

List of figures

List of tables

Executive Summary

The increasing affordability and efficiency of renewable technologies, coupled with advancements in energy storage and supportive policies, have accelerated the adoption of decentralised renewable energy (DRE) worldwide. This sixth edition of the DRE State of Sector (SoS) Report, CLEAN's flagship publication - in a renewed theme-focused and partner-based format - pays tribute to the **global opportunity for the Indian DRE sector**. The report contains six articles reflecting different aspects around this theme. The articles are authored by international and national partners of CLEAN, representing the government, NGO, and industry sectors.

The **first article contributed by ARE** gives an overview of global DRE sector covering deployment statistics, incentives and policies, and case examples of DRE as a game-changer in addressing energy poverty and energy access. As the world continues to prioritise sustainability and climate action, DRE will be at the centre-stage of this discourse. For instance, the latest press release from the World Bank estimates that connecting 490 million people to solar minigrids would avoid 1.2 billion tonnes of CO_2 emissions.

CLEAN's article draws on the DRE Information Hub recently launched on its website and provides an overview of the status, opportunities, and challenges of tracking the progress of DRE through measurable indices. It collates the statistics on DRE deployment in India, comments on the status and challenges around financing for the sector, lists government schemes to promote DRE, describes recent innovations in DRE applications and outlines gaps as faced by practitioners.

The importance of adopting harmonised international policies and standards is highlighted in the third article written by **CLASP team** based on its work internationally and in India. The harmonised standards not only promote innovation, safety, efficiency, and interoperability, but also prevent market spoilage. The article mentions key IEC and other standards that are applicable for DRE and concludes by giving a few suggestions to ensure that standards will play a catalytic role in scaling up DREs.

MNRE's article focusses on its R&D programme, describing in detail its purpose and achievements. The articles is enriched by providing four impact stories where the R&D scheme has been a driver of innovation in design and applications of DRE. The scheme aims to enable international diffusion of promising domestically developed DRE solutions and fostering strategic partnerships with DRE practitioners and industry.

Countering the perception of DRE as mainly for off-grid markets, **the article based on GOGLA's work** internationally and in India, highlights the growing importance and potential of DRE in weak-grid areas. Anchoring on a new technology segment that integrates distributed solar, storage, efficient appliances and modern controllers, the article identifies potential market segments for DRE in weak-grid areas and suggests a way forward for unlocking this market.

Based on discussions with four CLEAN members, the **article on transformational journeys of DRE**, describes innovations and growth in appliances, projects and applications of DRE. Special highlights of this article are experiences and insights by two CLEAN members on their approach at international market expansion.

Indian DRE is indeed getting world-ready. Read on!

Setting the context: a macro perspective of the global Decentralised Renewable Energy ecosystem

Authors: **David Lecoque, Deepak Mohapatra,**
Alliance for Rural Electrification

As of 2023, the global decentralised renewable energy (DRE) scenario has seen remarkable progress and widespread adoption, marking a transformative phase in the transition towards a sustainable and clean energy future. Across the globe, countries and communities are increasingly recognising the benefits of decentralising their energy systems, and renewable sources are playing a pivotal role in this paradigm shift towards achieving Sustainable Development Goal 7 (SDG 7).

It is evident that one of the key drivers behind the rapid growth of DRE is the increasing affordability and efficiency of renewable technologies. Solar photovoltaic (PV) and wind power systems, in particular, have experienced significant cost reductions over the years, making them competitive with or even cheaper than conventional fossil-fuel-based energy sources. As a result, individuals, businesses, and communities are investing in on-site renewable energy solutions, such as small standalone generation units e.g. solar home systems (SHS), solar lighting systems (SLS), mini- and micro-grids based on solar, wind, micro-hydro, bio-energy and hybrid sources to meet their electricity needs and reduce dependence on centralised grid systems. In parallel to that, new innovative technologies like green hydrogen and airborne wind technologies are also being explored in this space.

The ESMAP report shows that mini-grids have the potential to provide electricity to as many as 500 million people by 2030, with the right policies and about USD 220 billion of investment to build around 210,000 mini-grids[1]. Building on that, the latest press release from the World Bank estimates that connecting 490 million people to solar mini-grids would avoid 1.2 billion tonnes of CO_2 emissions[2]. More targeted approaches and actions can scale up the implementation of DRE around the world to support the energy infrastructure catering to decarbonisation and clean energy transition.

In developing countries, DRE has emerged as a game-changer in addressing energy poverty and improving energy access. Off-grid and remote communities that were previously left unserved by conventional grid systems are now benefiting from standalone renewable energy generation systems. These systems are providing clean electricity to schools, healthcare facilities, households and businesses, fostering economic development and enhancing the socio-economic standards of life in these areas. When it comes to the SHS market, a recent report identified that 5.2 million solar energy kits were sold in the second half of 2022, a 20% increase from the first half of the year and 18% higher than the previous peak in the second half of 2019[3].

1. The World Bank, Mini Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers, https://www.worldbank.org/en/topic/energy/publication/mini-grids-for-half-a-billion-people
2. The World Bank, Solar Mini Grids Could Power Half a Billion People by 2030 – if Action is Taken Now, https://www.worldbank.org/en/news/press-release/2022/09/27/solar-mini-grids-could-power-half-a-billion-people-by-2030-if-action-is-taken-now
3. GOGLA, Global Off-Grid Solar Market Reports, https://www.gogla.org/reports/global-off-grid-solar-market-report/

On the other hand, advancements in energy storage technologies have bolstered the feasibility of decentralised renewables. Lithium-ion and Lead-acid batteries and other energy storage solutions have become more efficient and cost-effective, enabling the capture and storage of surplus energy generated during sunny or windy periods. This stored energy can then be utilised during periods of low renewable energy production or high electricity demand, ensuring a consistent and reliable power supply which, as a result, also addresses the intermittency issues related with the renewables. Continued research and development efforts will further optimise the storage solutions and implement demand-response mechanisms to balance energy supply and demand effectively.

Additionally, governments and international organisations have played a crucial role in supporting the growth of DRE. Incentive programs, subsidies, and policy frameworks have been introduced to encourage the adoption of renewable technologies and promote investment in the sector. Furthermore, public-private partnerships (PPP) have facilitated the deployment of DRE projects, ensuring a collaborative approach to scaling up clean energy solutions worldwide. More technological and political efforts are required in the space of the integration of decentralised systems with the existing centralised grid infrastructure where relevant because seamless interactions between small-scale renewable energy producers and the grid require innovative technologies and grid management strategies.

Despite the progress across the aspects of energy access, the current pace is not adequate to achieve any of the 2030 targets. As in previous years, rates of progress vary significantly across regions, with some regions making substantial gains and some slowing their progress or even stalling. Among the major economic factors impeding the realization of SDG 7 globally are the uncertain macroeconomic outlook, high levels of inflation, currency fluctuations, debt distress in a growing number of countries, lack of financing, supply chain bottlenecks, tighter fiscal circumstances, and soaring prices for materials. The effects of the COVID-19 pandemic and the steady rise in energy prices since the summer of 2021 are expected to be a further drag on progress, particularly in the most vulnerable countries and those that were already lagging[4]. An estimated 675 million people around the world still lack access to electricity as of 2021. Figure 1.1 illustrates the percentage of the population having access to electricity.

India has made significant strides in DRE development, demonstrating remarkable progress and untapped potential. With a burgeoning population and growing energy demand, the country has actively embraced decentralised renewable sources, such as solar, wind, and biomass, to address both energy security and sustainability challenges. Numerous rural communities now benefit from small-scale renewable energy systems, providing access to electricity and enhancing livelihoods. India's ambitious policies, schemes and incentives have encouraged private investment and local participation in renewable projects, fostering a robust ecosystem for decentralised energy solutions[5].

As the country continues to invest in this sector, there is enormous potential for further growth, enabling India to transition towards a greener and more inclusive energy future as well as fulfilling its commitment to become net zero by 2070[6].

Due to the significant impact of energy on economic growth, the Indian government has allocated USD 12 billion for renewable energy initiatives in 2023. However, despite this investment, fossil fuels are projected to remain the primary energy source, potentially accounting for over 60% of total capacity by 2030. Furthermore, there is still a notable disparity in energy access, as rural households in northern and eastern regions receive less than 20 hours of off-

4. ESMAP, Tracking SDG 7: The Energy Progress Report 2023, https://trackingsdg7.esmap.org/data/files/download-documents/sdg7-report2023-full_report.pdf
5. MNRE, Overview, https://mnre.gov.in/solar-off-grid/
6. BBC, COP26: India PM Narendra Modi pledges net zero by 2070, https://www.bbc.com/news/world-asia-india-59125143

Figure 1.1: World Bank, Global Access to Electricity as of 2021

grid electricity per day, despite their contributions at both national and global levels[7]. Figure 1.2 outlines the power generation per state and generation type as of December 2021.

Alliance for Rural Electrification (ARE), being the leading global DRE association closely observes the development of DRE around the world. The growth of energy access in emerging markets like India is promising and ARE would like to laud its valued partner CLEAN in its remarkable efforts over the past years for contributing to India's energy access development. ARE also declares its keen interest in accelerating its efforts in South Asia, particularly in India together with partners like CLEAN in the direction of achieving energy access for all.

In conclusion, the global DRE scenario in 2023 reflects a paradigm shift in how energy is generated, distributed, and consumed. The increasing affordability and efficiency of renewable technologies, coupled with advancements in energy storage and supportive policies, have accelerated the adoption of DRE worldwide. As the world continues to prioritise sustainability and climate action, DRE is expected to play an increasingly vital role in shaping a greener and more resilient energy landscape for future generations.

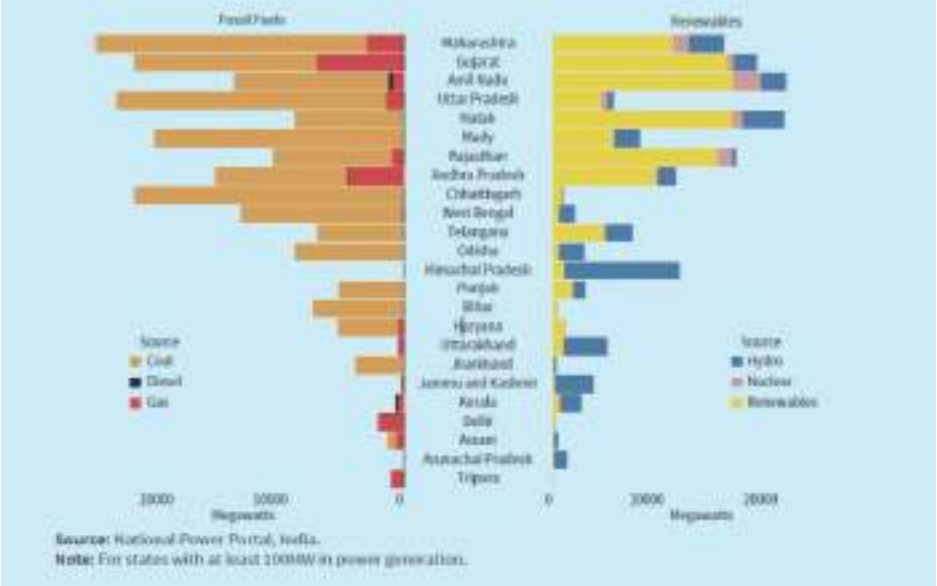


Figure 1.2: Power generation in Indian States in December 2021

7. AVPN, Decentralised Renewable Energy for India's Farmers, https://avpn.asia/case-study/decentralised-renewable-energy-for-indias-farmers/

The Indian DRE sector: tracking progress, traversing challenges

Authors: **CLEAN Team**

Introduction

Presently, the DRE market in India is small and fragmented. Nevertheless, there lies great scope for the sector to continually grow, especially in providing energy access to remote and rural areas. While there is some recognition of the relevance of DRE solutions from the government, the sector requires significantly more support and momentum in the form of financial incentives. The growth of the sector has also led to the emergence of numerous entrepreneurs, startups and small-scale enterprises that run their operations on clean energy. DRE solutions have also greatly benefitted women in reviving their businesses, generating income, increasing productivity of operations and reducing drudgery.

Current Status of Deployment of DRE Projects/Appliances

The data on the deployment of DRE applications is scarce and not readily available. Although, as per the details provided by the MNRE[8], currently the nationwide cumulative deployment of off-grid solar applications is: solar lanterns (Nos) - 1,01,82,598, home lights (Nos) - 17,23,479, street lights (Nos) – 9,44,802, solar pumps (Nos) – 5,01,673 and SPV plants (MW) - 217 MWp. Further, as per the MNRE report, the cumulative deployment of family-type biogas plants is 50,80,616 as of 31st Dec 2022. Annexure 1 provides more details on the DRE deployment in the country as furnished by MNRE[9].

Traditionally, DRE applications were centred around providing energy access mainly focusing on electricity, lighting and cooking-based solutions. This includes applications such as mini/micro grids, solar home lighting systems, solar lanterns, biogas and other cooking-based appliances, and solar pumping[9]. In recent years, DRE technologies are also being increasingly used for productive uses and livelihood generation purposes as well, especially in the rural areas of India. DRE applications for livelihood generation appear in several sectors such as textile, agriculture, animal husbandry, food processing, clean cooking, etc. A recent report[10] estimated the range of such DRE-based selected livelihood enhancing applications with their approximate number of deployments, as provided in Annexure 2. Further, CLEAN has also attempted to estimate the number of vendors (manufacturers/service providers) based on the registered information on prominent e-commerce portals. The compilation of the survey on the listed DRE vendors has been provided in Annexure 3.

Financing

Information on project and end-user finance for the DRE sector is very difficult to obtain

8. https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2023/08/2023080211.pdf
9. https://shaktifoundation.in/wp-content/uploads/2020/08/DRE-Annual-Compendium.pdf
10. https://www.ceew.in/sites/default/files/CEEW-Economic-Viability-Market-Impact-Potential-Technical-Doc-2-16May23.pdf

given the scarcity of data available in the public domain. An earlier CLEAN member survey attempted to capture fund raising mechanisms for DRE projects. As per the information collected, debt finance was the most popular form of fund raising adopted by DRE enterprises enabled by private and public sector banks for FY21 and FY22. This Debt funding was followed by private equity, grant capital and CSR funds.

For the DRE sector at the national level, MNRE has provided a few details on the Central Finance Assistance (CFA) disbursed under its various schemes[11]. In Phase II of Grid Connected Rooftop Solar Programme, CFA/incentives of INR 1323.57 crore have been released to various implementing agencies in FY 2022-23 as on 31.12.2022.

Policies and Regulations

Government has launched several initiatives and schemes in the DRE sector recently. Major initiatives at the Central government level are summarized in the Table 2.1:

Table 2.1: Government schemes to promote DRE

Sr	Scheme/Initiative	Description
1	Launch of National Portal on Rooftop Solar	MNRE developed a National Portal (solarrooftop.gov.in) for installation of RTS projects in residential sector to make it simple and easy for a residential consumer to apply and get the rooftop solar installed. After installation and inspection of the system, subsidy is released directly in the bank account of the consumer.
2	Women in RE: Call for Action	To acknowledge the role of women stakeholders in RE sector and strives to drive attitudinal change by recognizing their contribution across the RE value chain. An Inter-Ministerial multi-stakeholder Committee has been constituted to promote women-centric policies, programs, and intervention in the RE sector for convergence across women-centric schemes.
3	Solarization of Sun-Temple towns of Modhera (Gujarat) and Konark City (Odisha)	On 09.10.2022, Modhera emerged as India's first continuous solar-powered 'Suryagram', with Battery Storage. While at Konark City, several off-grid applications such as solar trees, off-grid power plant, charging stations, etc. have been successfully commissioned.
4	Framework for Promotion of Decentralized Renewable Energy (DRE) Livelihood Applications	MNRE issued a Framework on 14.02.2022 for the Promotion of Decentralized Renewable Energy (DRE) Livelihood Applications for promoting DRE access and sustainable livelihoods in the country including in rural and remote areas. The first Meeting of the Inter-Ministerial Coordination Committee for the Promotion of DRE Livelihood Applications was held on 10.06.2022. Subsequently, meetings were also held in the year 2023.

11. State of Decentralized Renewable Energy Sector in India – Insights from CLEAN (https://thecleannetwork.org/frontend/assets/resources/file/1693560072.pdf)

5	The National Bioenergy Programme	Launched on 02.11.2022. It includes (i) Waste-to-Energy Programme (Programme on Energy from Urban, Industrial, and Agricultural Wastes/ Residues); (ii) Biomass Programme (Scheme to support Manufacturing of Briquettes & Pellets and Promotion of Biomass (non-bagasse) based cogeneration in Industries; and (iii) Biogas Programme: for promotion of family type Biogas plants.
6	Phase II of Grid-connected Rooftop Solar (RTS) Programme	The Programme period has been extended till 31.03.2026. For individual households, CFA of Rs 18,000 / kW for plants upto project capacity 3 kW, CFA of Rs 9,000 / kW for plants having project capacity 3 to 10 kW. For Resident Welfare Associations / Group Housing Societies (RWA/GHS), CFA is Rs 9,000/kW, applicable for common facilities up to 500 kW @ 10 kWp per house CFA can also be calculated as per percentage of cost discovered under tender, as per scheme guidelines (40% for 1-3 kW and 20% for 3-10 kW and 20% for Group Housing Societies/RWAs upto 500 kW) Whichever is lower for that particular tender in that state/UTs
7	Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyaan (PM-KUSUM) Scheme	The Scheme consists of three components: Component-A: 10,000 MW of Decentralized Ground Mounted Grid Connected Solar Power Plants. Component-B: Installation of 20 lakh Standalone Solar Powered Agriculture Pumps. Component-C: Solarisation of 15 Lakh existing Grid-connected Agriculture Pumps. The Scheme was expanded during FY 2020-21 with an increase in targeted solar capacity addition of 30.8 GW and recently granted an extension till 31.03.2026. The total central financial support provided under the scheme is INR 34,422 Cr including service charges of 2% on eligible CFA to implementing agencies.
8	Atal Jyoti Yojana (AJAY) – Phase II	A total of 3,04,500 Solar Street Lights (SSLs) were proposed to be installed in North Eastern States including Sikkim and hilly States/UTs of Jammu & Kashmir, Ladakh, Himachal Pradesh and Uttarakhand and Island UTs and also in the aspirational districts of other states.
9	Solar Off-grid Programme in Ladakh	350 off-grid solar power plants of 5 kWp each have been installed in Kargil under the Prime Minister Development Package with financial support by MNRE.
10	Small Hydro Power (SHP) Programme for North Eastern Region	MNRE has been giving special emphasis for the development of small hydro projects in the NE region, with the aim to generate sufficient and uninterrupted electricity to power domestic household, schools and clinics in rural areas and trigger entrepreneurship activities.
11	Prime Minister's Package for Arunachal Pradesh	A package of INR 550.00 Crores for illumination /electrification of Villages located in Border Districts of Arunachal Pradesh lying along the international borders through a mix of grid-connected/ decentralized small/mini/micro hydel and solar photovoltaic Systems.

12	Off-grid Solar Programme for North Eastern Region	Solarization of pumps and installation of street lights are conducted under PM-KUSUM and AJAY Phase II schemes, respectively.
13	Biogas Programme for North Eastern Region	For providing clean gaseous fuel mainly for cooking, lighting, meeting the decentralized power generation needs of users and production of organic manure to rural and semi-urban households in the North East (NE) Region. 20% of additional CFA over and above the standard CFA is applicable for all the biogas plants installed in NE Region.

There are several state wise schemes as well promoting the DRE sector. A number of states have their own policies, involving rooftop solar and net metering regulations[12]. For example, recently announced **Meghalaya CM Solar Mission**[13] targets harnessing solar energy to reduce power deficit in the State. It involves an investment of 500 Crore, mainly for rooftop solar projects and offers subsidy up to 70% for households and 50% for schools, hotels, hospitals and commercial entities. Another example is **Uttar Pradesh's Food Processing Industry Policy 2023**[14] which has a provision for up to 90% subsidy for women entrepreneurs for solar projects for electricity supply to food processing units.

DRE Applications – Innovations and evolution

As a continuously evolving sector, DRE undergoes continuous innovations in terms of technologies, end-use and business models. CLEAN surveyed its members to understand innovative solutions that they implement in their applications. A few such applications have been presented as case studies in Annexure 4.

Challenges and Way Forward

1. Unlocking finance

Unlocking finance is a major challenge for both the service providers as well as end-users. A majority of end users from rural areas are low on financial strength. Further, receiving unsecured financing from financial institutions is often difficult and most customers do not have access to easy credit. Besides, there is also a need to make easy finance available to the service providers in this sector. This includes the actors such as entrepreneurs, innovators, implementation agencies, local self-help groups, etc. A partnership with private financing institutions or private players would prove very crucial in developing, piloting and establishing such systems to further scale it for commercial operations.

2. Convergence with other government schemes

Several programs on DRE and livelihoods are being run by various ministries and departments across the country. They are being implemented both at the State and the Central levels. However, a need for convergence of these government schemes cutting across the ministries is strongly felt in promoting and creating sustainable programs through DRE intervention in rural areas. Often there is insufficient communication between the departments and ministries running the schemes in parallel, which in turn diminishes the outcome of the overall objective. Further, it hampers proper utilisation of funds and manpower as well. The stakeholders including State Nodal Agencies (SNAs), discoms, State Rural Livelihood Missions (SRLMs),

12. https://india-re-navigator.com/rooftop/policy-compendium
13. https://currentaffairs.adda247.com/cm-solar-mission-launched-in-power-deficit-meghalaya/
14. https://invest.up.gov.in/uttar-pradesh-food-processing-industry-policy-2023/

departments of agriculture and horticulture, tribal development departments, etc should work in coordination.

3. DRE for thermal needs

DRE for thermal needs, along with domestic cooking, also needs to be prioritized. However, based on the need and usage, thermal energy is on par or more in demand than electricity in several industrial and commercial applications. The use of solar thermal equipment is recommended for non-cooking applications when the processing temperature required is less than 80ºC, both for water and air heating. Biomass energy would be the preferred energy option for more intense heat applications and especially so for dispersed thermal energy needs. Thus, there is need to include DRE for thermal energy usages other than cooking in broad policy framework at the Central and the State levels.

4. Scarcity of reliable data on the DRE sector

DRE sector in India faces a challenge of the availability of reliable and up-to-date data. Such lack of real time information reduces users' access to the updated and well-informed choices of DRE products. Further, the scarcity of such details also hampers government's efforts in formulating effective policies. Although some information, such as the sector level trends in projects and installations for selected technologies, capacities installed, subsidies disbursed, tariffs, policies and regulations, etc., can be tracked in a comprehensive manner, mainly in the government-owned websites and reports; the other

Table 2.2 CLEAN's perception on DRE data availability in the public domain

DRE Verticals	Key parameters tracked				
Status of project deployments/ installations	No. of cumulative installations by type / capacity	Yearly trends of installed capacity/ installations	Locations (Statewise) of installed capacity	Status of operation/functioning	
Policy & regulations	State wise existing policies & regulations for DRE	Available technical and safety standards	Financial incentives in DRE	Certifications	Information around DRE: electricity tariffs, agencies, etc
Investment and cost of technologies	Average cost per technology	Yearly trend of average cost per technology	End-user financing	Investment - financing sources to projects (debt/equity/CSR/ grant)	Tenders/ Investment opportunities
Impact creation	Yearly/ Cumulative Jobs created per technology	No. of new business units created	GHG/other emission reduction	Drudgery reduction/ women empowerment: beneficiaries	Time saving/higher productivity
Technological innovation / Case studies /DRE Reports and Articles	Technological innovations adopted by DRE manufacturers	Potential new technologies applications	Case studies / success stories	General DRE reports and articles	

Data availability	Comprehensive	Moderate	Very less

information such as DRE products or services and their deployments, type and amount of finance raised, socio-economic impacts created and challenges faced by DRE enterprises is difficult to track. This is mainly because of the scattered nature of DRE project footprints but also due to lack of willingness to share data by the DRE project proponents.

CLEAN has developed an online tracker portal (https://thecleannetwork.org/public/dre-tracker) to address this challenge and has currently populated it with available datasets. In future, sustained effort will be carried out in collaboration with the members and associates of CLEAN to collate and present real time up-to-date anonymized data on various aspects of the DRE sector. Annexure 5 gives a preview of the tracker. Table 2.2 shows CLEAN's perception on DRE data availability in the public domain.

Based on the high number of vendors of some DRE products, it can be inferred that the number of mainstream DRE products and solutions is growing. These include solar water heaters, solar home lighting products, solar lanterns, biomass briquettes and pellets, biomass-based co-generation, bagasse and others. In such a scenario, tracking these numbers becomes difficult. New parameters, and not just numbers, have to be conceived to track them. These could include the number of vendors and their regional spread, an increase in the range of capacities of the DRE equipment, etc. A comprehensive DRE data platform, such as India Renewable Energy Appliances Portal (IREAP)[15] could go a long way in this regard.

Processed biomass is getting a lot of traction. While processed biomass replacing coal is welcome, some parameters or monitoring mechanisms need to be developed and tracked to ensure that this is not leading to deforestation. Also, it is worth tracking whether the free, easily collected fuel for the rural poor is getting scarcer, and whether they are going down the energy ladder by using dirtier fuels. Several equipment suppliers are offering high processing capacity for drying biomass for further conversion into briquettes and pellets. The end-use of the dried biomass could also be worth tracking to understand whether it is going for conversion to briquettes/pellets, ethanol or any other DRE fuel, or if it is also being used for power generation by thermal power plants, in furnaces and boilers to partially substitute coal.

5. Gender in DRE

DRE solutions, including standalone systems and mini-grids, are now recognised as vital for achieving universal modern energy access by 2030. The decentralised and modular nature of these solutions offers greater opportunities – compared to grid-based solutions – by engaging women in design, delivery and operations, and in realising co-benefits related to gender equality and empowerment. However, women face access-related barriers. As gathered from the online gender survey conducted in 2018[16], women working or seeking work in expanding access to renewable energy faced barriers which were (i) cultural and social norms (ii) lack of gender-sensitive policies and training opportunities and (iii) inequity in ownership of assets. This report has tried to understand the gender baseline for access to DRE in India but collection of sex disaggregated information is not the norm. Another report[17] states that "Out of the ~13,000 end-users using programme-supported DRE livelihood technologies, more than 80% were women (till August 2022)". This impact assessment survey found that 70% of women experienced an average increase of 33% in income and 92% of women

15. https://ireap.thecleannetwork.org/
16. https://www.irena.org/publications/2019/Jan/Renewable-Energy-A-Gender-Perspective
17. https://www.ceew.in/sites/default/files/Case-Study-On-Unlocking-Clean-Energy-Powered-Sustainable-Livelihood-Opportunites-For-Empowering- Rural-Women-In-India.pdf

believed that their business knowledge and skills have become more relevant. CLEAN members also had some suggestions for mainstreaming gender in DRE. These included: the practice of collecting sex disaggregated data and information, having gender sensitive DRE policies, and a positive gender bias for accessing training and skills. Government policies and financing schemes should be tailored for women. Women-led energy enterprises should be encouraged, and innovations and opportunities should have a gender focus.

DRE is emerging as the energy for women, and it must be positioned as that. This would enable schemes to be developed, or existing schemes to be accessed for DRE and / or women.

6. Operation and Maintenance related issues

DRE projects often suffer from maintenance-related issues. When appliances are handed out to the end-users, there is little commitment towards maintenance and replacements of parts[18]. As a result, the systems are often discarded well within their lifespans. This problem is further intensified by a shortage of supply material, especially in rural and far-flung areas.

Further, lack of enforcement of reliability-based standards has also resulted in substandard products entering the market. This is especially a problem for products invented recently. For this reason, for DRE enterprises to participate in government programs and avail benefits, BIS standards are required for new inventions as well. Existing BIS standards cannot be used for the new technologies, and hence new technologies will need new standards in place.

In a welcome move, MNRE has recently initiated the process for setting standards for various DRE system components and products. CLEAN is supporting this effort in its capacity as the industry association.

Acknowledgement

The CLEAN Team is grateful to Ms Svati Bhogle for her valuable guidance in putting together this article.

18. https://shaktifoundation.in/wp-content/uploads/2014/02/Paper-12-FINAL-Revised-13-1-14.pdf

Annexure 1

Details of various DRE installations in India (as on 31.12.2022)[8]

Scheme	DRE technology / option	Cumulative installed capacity (up to 31-12-2022)
PM KUSUM scheme (Component B)	Standalone solar pumps	1.81 Lakh Nos
PM KUSUM scheme (Component C)	Individual pump solarization	1174 Nos
National Solar Mission Roof Top Solar (RTS) Programme Phase-II	Grid connected Solar PV	2.22 GW
Solarization of Konark Sun Temple	Solar Trees	50 No
	Street Lights	200 No
	E-Rickshaws	20 No
	Off grid Solar Power Plant for Temple Illumination	50 KW
	Charging stations	2 No
	Drinking water kiosks	40 No
Simplified procedure roof top solar (individual residential consumers and resident welfare associations)	Solar PV	0.013 GW
Off grid and decentralized solar PV applications program	Lanterns and study lamps	1,01,82,598 Nos
	Home Lights	17,23,479 Nos
	Street Lights	9,54,663 Nos
	Solar Pumps	652539 Nos
	SPV Plants	217 Mwp
Solar Off-Grid Program in Ladakh	Solar PV	350 Nos of 5 kWp each

8. https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2023/08/2023080211.pdf

Atal Jyoti Yojana (AJAY) NE states	Solar street lights	137226 Nos
	Bagasse based co-generation	7.562 GW
	Non-bagasse-based co-generation	0.776 GW
	Waste to energy biogas	7,71,008 m^3 per day
	Waste to energy Bio-CNG/CBG	2 2,64,467 kg per day
	family type/ small biogas plants, under the New National Biogas and Organic Manure Programme	50,80,616 Nos
Small hydro power in the period 2022 - 2023	Micro / mini / small hydel	4935 MW
RE in the north east regions	Small hydro	349.5 MW
	Bio power	15.8 MW
	Solar power	208.3 MW
PM's package for Arunachal Pradesh	Solar home lighting systems	5758 Nos
	Small / mini / micro hydro projects	112 Nos
Off grid solar program for the North East	Solar home lights	1,82,288 Nos
	Solar lamps	16,28,589 Nos
	Solar street lights	1,45,504 Nos
	Solar pumps	1645 Nos
	Solar power plant	13270 KW

Table 2.A1.1: Details of various DRE installations in India (as on 31.12.2022)

Annexure 2

Deployment of DRE Livelihood Applications[10]

Deployment scale of DRE livelihood technologies				
Less than 50	**51-100**	**In ‘00S**	**In '000s**	**In '00,000S**
Carpentry machineries (wood lathe machine, power drill, side-planer)	Animal repeller	Blacksmith machineries (fan-blower, power hammer, angle-grinder)	Charkha	Water pump
Integrated energy centres	Bulk milk-chiller	Cold storage	Dryer	
Oil extractor	Butter churner	Food processors	Poultry machineries (incubators, lighting, brooders)	
Puffed rice processor	Grain-milling machine	Milking machinery	Silk-reeling machine	
Vaccine freezer	Loom	Pottery machineries (pottery wheel, blunger, pugmill)	Sewing machine	
		Small refrigerator		
		Sugarcane Juicer		
		Vertical fodder grow unit		

Table 2.A2.1: Deployment Scale of DRE Livelihood technologies

10. https://www.ceew.in/sites/default/files/CEEW-Economic-Viability-Market-Impact-Potential-Technical-Doc-2-16May23.pdf

Annexure 3

Assessment of the state of the sector as a function of the number of vendors for different DRE products

Product	Description	Number of vendors	Application	Source of information
Solar DC pumps	Range of power levels, submersible, etc	79	Irrigation, surface and ground water, domestic pumping	(suppliersplanet.com) https://dir.indiamart.com/
Solar cold storage	Capacity 1 to 100 tons	4	Agriculture, horticulture, Farmers and traders to preserve perishable foods like fruits, vegetables	
Solar refrigerators	Four different types of different applications	3	Health, dairy, fisheries, horticulture for preserving food products like dairy, fish and vaccines	
Solar dryers	151 products	88	For drying fruits, vegetables, spices, meat etc.	(fliarbi.com)
Solar water heaters	100 to 500 litres capacity	68	Water heater for residential and commercial spaces	https://dir.indiamart.com/
Biomass fired dryers for drying food products	Capacity range 20 kg to 500 kg / batch	4	For drying spices, coconuts, fruits and vegetables	
Solar milking machines	Typical size useful when there are four animals to be urgently milked	3	Dairy, fast milking of cows and buffalos	https://dir.indiamart.com/
Solar fence guard (does not include the fencing cost)	Variable	66	Agriculture, forestry for protection against invaders	https://dir.indiamart.com/

Solar sewing machines	Standard size	3	Tailoring and garments,	https://dir.indiamart.com/
solar drinking water kiosks and supply	Can vary depending on the source of water and need	7	Health and safety in rural areas, rural schools etc.	https://dir.indiamart.com/
solar powered looms	Standard size	3	Garments	https://dir.indiamart.com/
Solar fans	Blade size 18 to 72 inches	65*	Residences	https://dir.indiamart.com/
solar street lights	1000 to 40,000 lumens	77*	For community needs, safety and along highways	https://dir.indiamart.com/
Solar home lighting	Wide range to choose from	88*	Residences	https://dir.indiamart.com/
Solar rice hullers	250 Wp 100 kg/ hr	4	Post harvest processing	
Biomass briquettes & pellets	1 -10 tons / day	99*	Fuel for boilers, furnaces and other applications	https://dir.indiamart.com/
Biogas plant installers		74*	Thermal energy for cooking and heat energy requirements	https://dir.indiamart.com/
Portable biogas plants	1 cu.m	66*	Thermal energy for domestic and commercial cooking	https://dir.indiamart.com/
Biomass cookstoves household and commercial		70*	Thermal energy for domestic and commercial cooking	https://dir.indiamart.com/
Micro hydro turbine manufacturers		64*	Mini grids / power generation	https://dir.indiamart.com/
Small wind turbines		32	Mini grids / power generation	

Table 2.A3.1: Assessment of the state of the sector as a function of the number of vendors for different DRE products

Annexure 4

Case Study 1: Eco friendly cremation using biomass briquettes at Chhatrapati Sambhaji Nagar (Aurangabad), Maharashtra

Figure 2.A4.1: Biomass briquettes used for cremation and demonstration of its use (Courtesy: PRESPL)

Aurangabad Municipal Corporation started using biomass briquettes by replacing wood in cremations under its jurisdiction since June 2022. For this, the pyres were modified at 34 crematoriums. CLEAN member Punjab Renewable Energy Systems Private Limited (PRESPL) provided biomass briquettes and technological support to the eco-friendly cremation drive of the Municipal Corporation. Till date, around 2000 funerals were done using 100% briquette as fuel. Per body biomass briquette used is in the range 200 to 250 kgs instead of 400 kg of wood/body. This saved cutting of 2000+ trees, mainly illegally, those otherwise would have been used for the funeral purpose. The use of briquettes also provides several other benefits: less pollution compared to wood, agri-residues used (available in abundance quantity) in briquette making are purchased from the farmers for which they get extra income, higher calorific value (3600 – 3800 kcal/kg) of briquettes than wood, thereby requiring lesser quantity of fuel, consistent size-shape and moisture contents, availability across seasons, and ease in handling and transportation since the briquettes are provided in the bags of 30 to 35 kgs to the crematoriums.

Case Study 2: Innovative forced draft biomass cookstove with high burning efficiency and reduced emissions

Figure 2.A4.2: Ecochulha 'Oval' demonstrating smokeless and efficient cooking (Courtesy: Ecosense Appliances)

CLEAN member Ecosense Appliances developed a forced draft energy efficient smokeless chulha called Oval. Oval uses biomass pellets as fuel and reduces emissions by 60%. Further, its use in cooking saves firewood by 88%.

Case Study 3: Installation of wind-solar hybrid system in Jammu & Kashmir

Figure 2.A4.3: Small wind – solar hybrid project at defence area in Jammu & Kashmir (Courtesy: WiSH Energy)

In remote area of defense establishments of Jammu and Kashmir, there is often no grid supply, hence no electricity. Thus, there is heavy dependency on diesel generators. However, there are challenges in using diesel for electricity generation in these areas, mainly its high transportation cost due to remote terrains, requirement to stock diesel in winter season, high maintenance cost and pollution caused by diesel generators. The use of small scale solar-wind hybrid DRE projects reduced diesel consumption by 70%, thereby also reducing diesel transportation cost, maintenance of DG sets and pollution.

Case Study 4: 10 KW solar power plant supplying power to water pump in a village in Uttar Pradesh

Figure 2.A4.4: Solar pump installation at Kandhapaar, Sant Kabir Nagar, Uttar Pradesh (Courtesy: OORJAgram)

CLEAN member OORJAgram installed solar water pumps across 22 Grampanchayats covering 72 villages in under Jal Jivan Mission (Har Ghar Nal Yojana) in district of Basti, Ayodhya, Sant Kabir Nagar Uttar Pradesh from November 2022 to February 2023.

Approximately 500-Kilowatt cumulative capacity distributed solar plants were Installed and commissioned by OORJAgram under this scheme. The use of solar energy for powering pumps ensured assured water supply to the communities in these areas.

Annexure 5

Preview of DRE Tracker

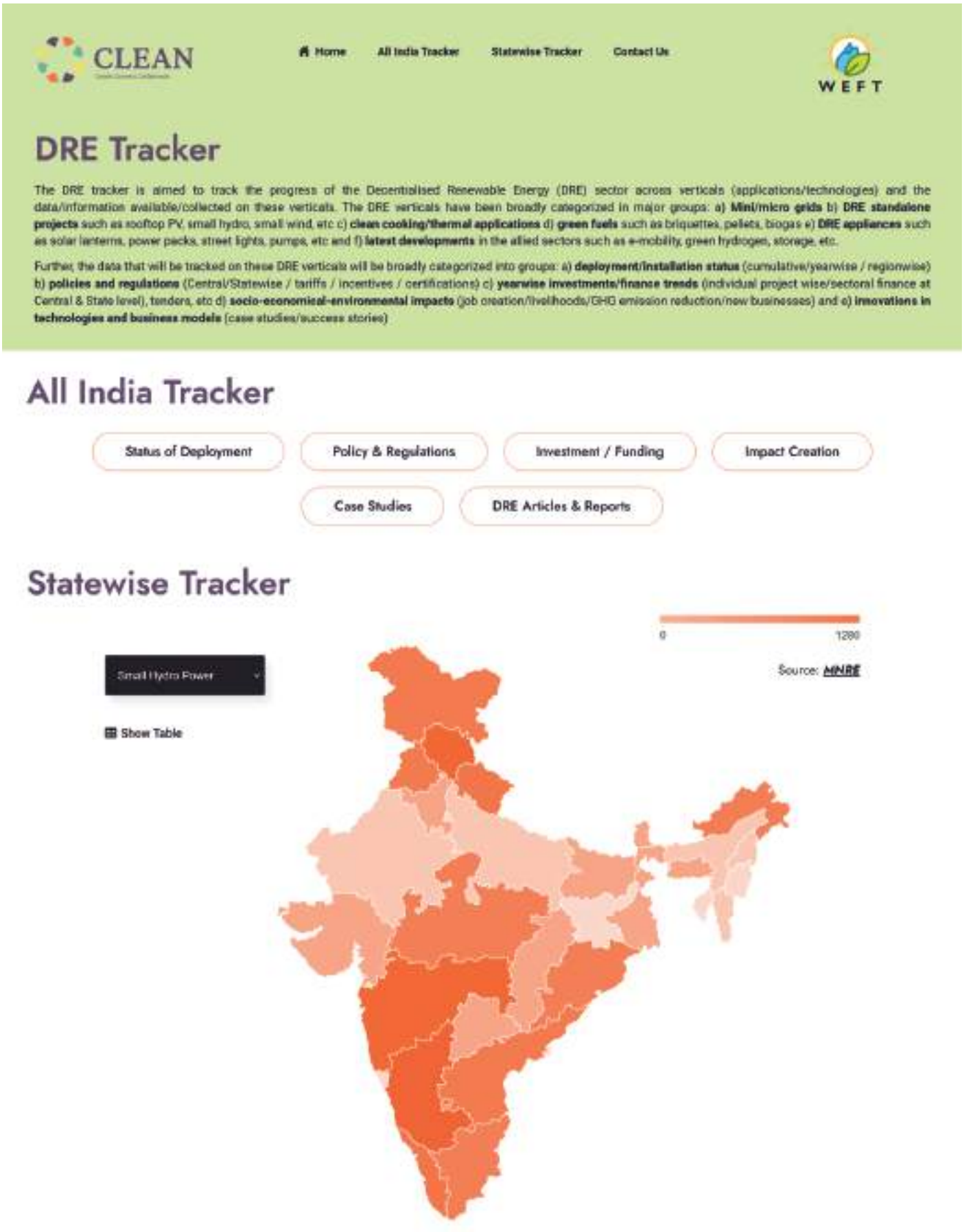


Figure 2.A5.1: Screenshot of the landing page of the DRE tracker

The data on various DRE verticals is broadly categorized into the following groups on the tracker portal:

a) Deployment/installation status (cumulative/yearwise/regionwise)

i) Mini/micro grids

ii) DRE standalone projects such as rooftop PV, small hydro, small wind, etc

iii) Clean cooking/thermal applications

iv) Green fuels such as briquettes, pellets, biogas

v) DRE appliances such as solar lanterns, power packs, street lights, pumps, etc

vi) DRE based livelihoods generation applications such as dryers, cold storages

b) Policies and regulations: Central/Statewise/tariffs/incentives/certifications

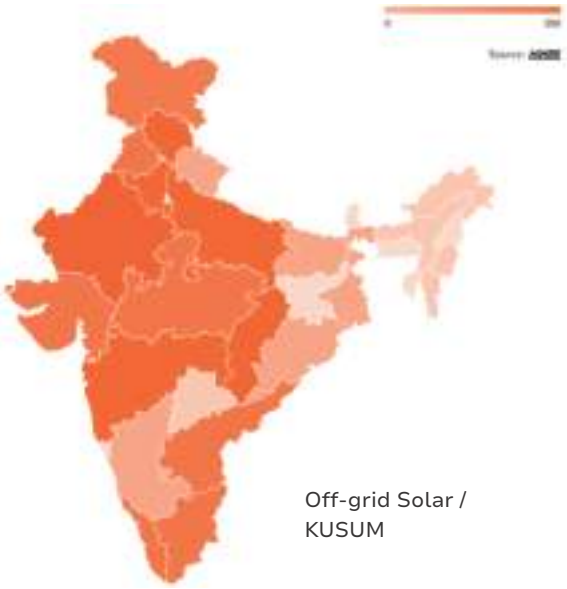
c) Yearwise investments/finance trends: individual project wise/sectoral finance at Central & State level, tenders, etc.

d) Socio-economical-environmental impacts: job creation/livelihoods/GHG emission reduction/new businesses

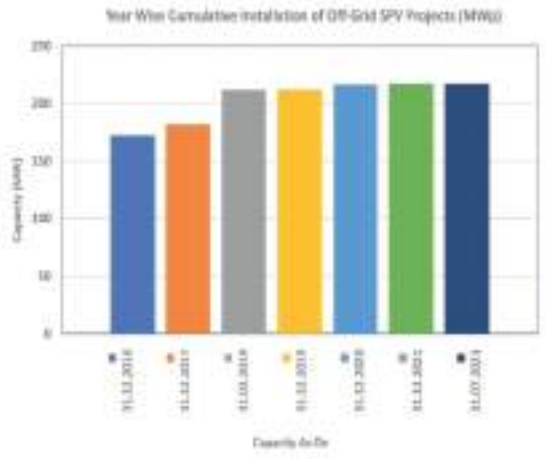
e) Innovations in technologies and business models: case studies/success stories/latest developments in the allied sectors such as e-mobility, green hydrogen, storage, agrivoltaics, etc.

f) DRE articles and reports

Some examples of the type of data currently available on the portal are shown here.



Off-grid Solar / KUSUM



S. No.	STATES / UTs	Off-grid Solar/ KUSUM (MW)
1	Andhra Pradesh	88.34
2	Arunachal Pradesh	6.18
3	Assam	9.44
4	Bihar	21.28
5	Chhattisgarh	386.73
6	Goa	1.12
7	Gujarat	54.30
8	Haryana	488.44
9	Himachal Pradesh	32.83
10	Jammu & Kashmir	25.29
11	Jharkhand	49.53
12	Karnataka	30.31
13	Kerala	23.23
14	Ladakh	0.00
15	Madhya Pradesh	94.03
16	Maharashtra	287.74
17	Manipur	6.08
18	Meghalaya	3.98
19	Mizoram	6.35
20	Nagaland	2.17
21	Odisha	28.25
22	Punjab	81.36
23	Rajasthan	595.55
24	Sikkim	1.92
25	Tamil Nadu	65.86
26	Telangana	8.71
27	Tripura	8.69
28	Uttar Pradesh	218.01
29	Uttarakhand	14.42
30	West Bengal	13.14
31	Andaman & Nicobar	0.27
32	Chandigarh	0.81
33	Dadar & Nagar Haveli/Daman & Diu	0.00
34	Delhi	1.46
35	Lakshadweep	2.52
36	Pondicherry	0.18
37	Others	45.01
	Total (MW)	**2703.53**

Figure 2.A5.2: Examples of DRE data presented in the tracker portal

International standards and DRE

Based on CLASP's work internationally and lessons for India

Authors: **Elisa Lai and Sumedha Awasthy,** *CLASP*
Reviewer: **PK Mukherjee,** *CLASP*

The recently concluded G20 India chapter underscored the imperative of pursuing a worldwide shift in energy practices to mitigate the increase in atmospheric temperatures and confine global warming to 1.5 degrees Celsius. The G20 countries, collectively responsible for 80% of greenhouse gas emissions, are urging for strategic measures to implement clean energy solutions. The G20 summit concluded with a distinct preference for a global strategy aimed at promoting the adoption of Distributed Renewable Energy and its various applications to expedite the transition to clean energy sources.

India has set an aggressive target of increasing non-fossil energy capacity to 500 GW by 2030, and till date the country has developed the RE capacity to the tune of 179 GW[19]. Despite being the fourth largest installed capacity of RE as per Renewable Energy Statistics 2023, the locus of RE expansion has been the large-scale grid tied solar systems. To meet India's lofty renewable energy (RE) targets, distributed renewable energy (DRE) efforts must be expanded. The larger-scale implementation of these DRE initiatives becomes viable with the introduction of a more favourable regulatory and policy framework. DRE initiatives, despite their low scale, have significant scaling potential. Furthermore, they avoid the lengthy development delays and operational issues that are frequently associated with public-sector off-take procurement initiatives. They also provide economic advantages to the local community by producing jobs and stimulating economic growth. Furthermore, DRE improves grid resilience by lowering transmission losses and providing a consistent power source in places with limited grid connectivity. India should lead the way with a favourable regulatory and legislative environment for the expansion of DRE projects, including incentives, net metering, faster approval processes, standardized contracts, capacity building, and public awareness campaigns. This strategy will assist India in realizing its renewable energy potential while tackling energy access and sustainability issues.

The establishment of a strong regulatory framework is dependent on the adoption of a standardized international policy that tackles the technical complexities of Distributed Renewable Energy (DRE) solutions. This policy serves as the foundation for controlling DRE project deployment and operation, assuring uniformity and conformity to technical specifications. International standards play a crucial role by providing a common framework and guidelines that facilitate adoption of aligned and harmonized testing practice among industries and policy frameworks across countries. International Standards and public policy generally share similar objectives in enhancing market competitiveness, improving product quality and efficiency, and facilitating international trade. By referencing and using international standards, policymakers and other market actors can demonstrate their confidence in policies or compliance of products with the international benchmarks and best practices.

In a nascent market without international standards, like the decentralized renewable energy sector, there is a room for market actors and governments to develop their own standards and regulations. These

19. https://powermin.gov.in/en/content/power-sector-glance-all-india

uncoordinated efforts, even if with good intention, could create unintended barriers to market entry. By integrating international standards into market transformation interventions, like investment, procurement, and policy efforts, market actors can reduce the prevalence of sub-standard products more effectively while fostering innovation and maintaining consistency across international markets.

The key benefits of adopting harmonized international standards:

- **Prevent market spoilage:** Governments around the world can adopt the common test methods and standards to prevent sub-standard products from entering their domestic markets. Adoption of harmonized international standards helps create a fair marketplace for better products to compete and drive sub-standard products off the market.
- **Promote consumer protection:** When product manufacturers and suppliers demonstrate compliance to these international standards, consumers can have confidence that they are buying safe and reliable goods, and that their investment in the DRE technologies are protected.
- **Encourage market penetration and product innovation:** The technical barriers in international trade are caused by differences in technical regulations and standards developed independently and separately by each nation, region, or association at the national level. International standards help reduce technical barriers. This, in turn, encourages market penetration for businesses, leading to increased opportunities for innovation and growth.
- **Reduce resources and efforts needed to create standards:** Developing national or regional standards independently can be time-consuming and resource intensive. By adopting international standards, countries can save time, effort, and costs associated with creating their own unique standards, allowing them to focus on other critical aspects of development.

The WTO Technical Barriers to Trade (TBT) Agreement requires governments to use international standards as a basis for regulations[20]. However, there is a degree of flexibility with respect to the choice of standard and the manner of its use.

- Determining the appropriate stage for implementing standards is crucial to strike a balance between promoting innovation and ensuring market growth. When DRE technologies are still in early-stage market development, introducing standards too early in emerging industries or rapidly evolving technologies might stifle innovation. These industries often require flexibility to experiment, iterate, and discover the best solutions. Premature standards could lock companies into outdated approaches, hindering progress.
- As an industry matures and stabilizes, the benefits of standardization become more evident. At this stage, harmonized standards can help drive efficiency, interoperability, and consumer confidence. In such cases, introducing standards is appropriate and can lead to accelerated growth and widespread adoption.

Another important component of a robust regulatory framework is the conformance and compliance evaluation. These must be adjusted to accommodate the unique characteristics and applications of DRE technologies, while also ensuring that adequate testing processes and criteria are in place for proper evaluation and certification. Test methods define a set of standardized processes that are used by test laboratories, or others, to measure products performance and quality. They enable measurement and comparison of the quality and performance of products across markets in a consistent way and produce test results that are comparable and repeatable. Some of the existing standards for the DRE technologies are enlisted below. These standards are typically used in conjunction with other interventions – results financing, incentives, procurement opportunities – to encourage entry and

20. https://www.wto.org/english/tratop_e/tbt_e/tbt_info_e.htm

adoption of high-quality products.

- **IEC TS 62257-9-5** is a test method for stand-alone renewable energy products with DC system voltages not exceeding 35 V and peak power ratings not exceeding 350 W[21].
- **IEC 62253:2011** is a test method for stand-alone photovoltaic (PV) pumping systems that are connected to solar panels directly or via a converter[22].
- **IEC 63437 (in draft)** is a test method for refrigerating appliances that are used with distributed renewable energy sources or used in weak-grid context[23].
- **IEC TS 62257-9-8** is a quality standard that defines the baseline requirements for quality, durability, and truth in advertising for solar energy kits with power rating less than or equal to 350 Watts[24]. The standard is used in conjunction with the IEC TS 62257-9-5 test method.
- IEC is in the process of developing a new standard, IEC 63395, which will specify the requirements for sustainable management of electrical and electronic equipment waste[25].
- **WHO Performance, Quality, and Safety (PQS):** The WHO PQS process was created to prequalify health equipment that are suitable to be procured by UN agencies and others . To assess the qualification of health equipment, PQS is a series of testing methods for 11 health product categories, including refrigerators, freezers, and cold rooms, temperature monitoring devices, and others[26].
- **Global LEAP's test methods for off-grid appliances:** The Global LEAP Awards is an international competition to identify best-performing off-grid and weak-grid appliances and productive use equipment. To enable a fair comparison of product performance and quality, Global LEAP created a series of test methods covering various solar appliances, including TVs, fans, refrigerators, water pumps, and electric pressure cookers[27].

Case Example

The international quality standard for solar energy kits (IEC TS 62257-9-8) has been adopted by the Kenya Bureau of Standards (KEBS) and published as a national standard. All solar energy kits being imported into Kenya have to meet KS IEC/TS 62257-9-8:2020, requirements for stand-alone renewable products with power ratings less than or equal to 350 W.

To protect consumers from poor-quality products, several national governments across Africa and South Asia have already taken steps to adopt IEC TS 62257-9-5 and IEC TS 62257-9-8 – test method and quality standards for small-scale solar energy kits, respectively. As of 2023, more than 18 countries have adopted the IEC TS 62257-9-5 and IEC TS 62257-9-8 as either voluntary or mandatory standards (find the list of countries via CLASP Policy Resource Center).

Adopting of internationally-harmonized test method and quality standards gives national standard bodies confidence in the validity of a QA framework that has proven to be effective in other countries or regions and facilitate global trade without undergoing any repeat testing or certification process. The increasing number of countries adopting the same test methods may motivate more national governments to pursue a similar strategy.

When the world is seeking DRE technology solutions as an urgent climate action tool, developing DRE standards is critical to ensuring user safety. These standards establish the requirements for electrical, fire, mechanical, and environmental safety, as well as user training instructions. They encourage interoperability, certification, and compliance while lowering the hazards associated with electrical surges, accidents, and compatibility concerns. Standards also have an impact on liability, insurance, and customer confidence, making DRE technology safer for users in the long run.

21. https://webstore.iec.ch/publication/59747
22. https://webstore.iec.ch/publication/6636
23. https://www.iec.ch/blog/iec-plans-standard-weak-and-grid-refrigerators
24. https://webstore.iec.ch/publication/62431
25. https://standardsdevelopment.bsigroup.com/projects/2021-01421#/section
26. https://apps.who.int/immunization_standards/vaccine_quality/pqs_catalogue/index.aspx
27. https://efficiencyforaccess.org/publications/?publication_type%5B%5D=25

A few suggestions to ensure standard will play a catalytic role in scaling up DREs, not only in India, but globally:

Avoid overly customized and prescriptive standards. While it is tempting to customize standards for local market conditions, overly tailored standards could create unintended barriers for market actors. For example, different testing processes could increase the costs and timeline for manufacturers to obtain the necessary testing and certification for market entry, resulting in higher price for consumers. Similarly, over-prescriptive standards can stifle innovation, limiting a variety of technology and design options that consumers would have access to.

Voluntary programs leveraging standards have shown great success. Voluntary programs, such as result-based financing and other public procurement programs, often use international standards and certification as part of the evaluation criteria for companies to demonstrate their products meet quality requirements. For example, the Beyond the Grid Fund for Africa and UNHCR's Procurement Project require solar energy systems to have VeraSol certification that is based on IEC TS 62257-9-8. In these examples, standards play a pivotal role in ensuring product quality, consumer protection, and system performance. While these examples represent just a fraction of the initiatives leveraging standards in the DRE sector, as new renewable energy technologies continue to emerge, international standards created to address the performance and safety of the new technologies will remain crucial for fostering sustainable market growth and maximizing the benefits of these technologies for communities worldwide.

Implementation of standards is key to ensuring impacts. Once standards are created or adopted, governments need to establish measures that ensure that the standards are implemented effectively to bolster the market for good-quality products and inhibit the entry of sub-standard products. Standards can be implemented through voluntary measures, such as import duty and VAT exemption; or mandatory measures, such as conformity assessment, market surveillance, and standard enforcement (collectively referred to as a compliance framework). Implementing a combination of trade and commerce policy interventions through the adoption of aligned international standards has the potential to not only boost the Indian economy but also enhance the competitiveness of India-made products on a global scale.

Handholding of developing countries. India has successfully implemented DRE programs such as the PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan) Scheme, which aims to improve farmers' energy security. The lessons learned and challenges faced in such initiatives can provide significant insights for African countries actively engaged in the creation and implementation of DRE projects. These shared learnings can help cross-border adoption of sustainable energy solutions succeed.

In summary, the adoption of standardized international policies and standards is critical for the success of DRE projects, fostering sustainable market growth, and maximizing the benefits of clean energy technologies for communities worldwide. These standards not only promote innovation and safety but also contribute to achieving global climate goals and creating a fair marketplace for high-quality DRE products.

Experiences from MNRE R&D Programme in driving DRE innovation

MNRE

About the MNRE RE-RTD Programme:

Research & Development (R&D) is at the heart of a country's renewable energy ambitions. Taking cognisance of this, the Ministry of New and Renewable Energy (MNRE) has been deploying R&D programme since it came into existence. The ministry's research programme was christened Renewable Research and Technology Development (RE-RTD) in 2021 with a total budget Outlay of INR 228.00 Crore. The period FY 2021- 22 to FY 2025-26, aims to support R&D projects for technology development, indigenization, increasing the share of RE in the energy mix, enhancing industry competitiveness. In addition, it also aims at strengthening the MNRE's autonomous institutions, such as the National Institute of Solar Energy (NISE), National Institute of Bio Energy (NIBE), National Institute of Wind Energy (NIWE), and Centre of Excellence – National Centre for Photovoltaic Research and Education (NCPRE) at IIT-Bombay, and Department of Hydro and Renewable Energy (HRED) at IIT-Roorkee.

The scheme supports applied research, pilots, technology validation, and demonstration projects across various renewable energy segments. Decentralized renewable energy has notably been one of the key thrust areas of the RE-RTD scheme that has led to impactful projects and product development on the ground.

The RE-RTD scheme has been crafted with several standout features to ensure it is forward-looking and in sync with the evolving landscape. For example, the scheme encourages collaboration with international R&D institutes, labs, start-ups, and industry including member countries of the International Solar Alliance (ISA), promotes industry-academia collaborative projects, and extends funding to start-ups, with a major focus on TRL levels 4-8. Under the RE-RTD Scheme, the Ministry provides up to 100% financial support to Government/non-profit research organisations, and up to 70% support is available to Industry, startups, private institutes, entrepreneurs, and manufacturing units. Further details on the R&D scheme, and its projects can be accessedon MNRE website[28] and on the MNRE R&D Portal[29].

The Scheme's support towards DRE R&D projects has spanned various technologies such as solar, biogas, biomass, and small hydro, to name a few. The focus of the program has always been to nurture and promote DRE solutions that lead to multiple co-benefits and multiplier effects for the community in terms of livelihoods, social benefits like access to clean water, waste management, and so on. The MNRE works in collaboration and consultations with DRE practitioners and industry bodies such as CLEAN to meet the objectives of the scheme.

Given below are a few notable applications of decentralized renewable energy which

28. https://mnre.gov.in/
29. https://research.mnre.gov.in/home

were successfully demonstrated through MNRE's R&D funding. The key is to disseminate these success stories far and wide to ensure greater popularity and adoption.

MNRE R&D DRE Research Impact Stories

Industry-Academia Collaboration for Solar-Powered Clean Drinking Water Access:

With an aim to provide clean drinking water to communities, the National Institute of Solar Energy (NISE) collaborated with Saurya Enertech under the MNRE-funded project (2016-2019) that led to the development and deployment of Solar Powered Portable Drinking Water (WHO Standards compliant) ATMs equipped with IoT systems to monitor water quality, track health of the filter real-time on a dashboard, and cloud monitoring designed in-house for water quality monitoring and real-time display water quality parameters.

The project supported 5 installations. The first system (500 LPH, AC pump) was installed at the NISE campus. Other 4 installations included: a 250 LPH system at the NISE campus, a 250 LPH system in Khurrampur village, a 250 LPH system at Delhi's Safdarjung Hospital, and a 250 LPH in the National Institute of Food Technology Entrepreneurship and Management (NIFTEM), Sonipat.

The cost of each system was approximately INR 6.87 Lacs. Saurya Enertech transferred the technology to Swajal which is currently a pioneer in the field of Solar Water ATMs in the country. The cost savings for customers versus conventional ROs/water purification systems varies depending on several factors, including the size of the system, the cost of water in the area, and the maintenance costs of the system. However, in general, this technology can save customers money in the long run. Additional factors to consider include climate of the location (in areas with hot climates, the solar panels will need to work harder to generate electricity which will increase the cost of the system), and water quality (higher cost involved in treating more polluted water).

Quotes from beneficiaries

- *Raju, a resident of Village Khurrampur, says that he and his family have been drinking water from the water ATM in their village on a regular basis. He says that the water is sweet and has helped to eradicate any type of illness they had been suffering from.*
- *Deepak Kumar, a regular visitor of Safdarjung Hospital for treatment of chronic bronchitis, used to buy water from an outside shop for INR 10/- per liter. However, after the installation of a solar-powered water ATM at the hospital, which provides filtered, sweet water free of cost, he now brings his own bottle from home and fills it up at the water ATM. This has helped him reduce his expenses.*
- *Ansi Devi, a resident of Khurrampur, has made a card to purchase purified water from the Panchayat. She buys 40 liters of water every day for INR 10/-. This has helped her reduce her household expenses and she now cooks all of her food with this water.*

As mentioned by Mr. Dipanker Podder, Swajal Water Pvt. Ltd.

Distributed Solar Drives Cleaner Tasar (Silk) Processing by Marginal Reelers in Jharkhand – one of India's leading Silk Production Hubs:

The Post Cocoon Technology Section of the Central Tasar Research & Training Institute (C.T.R & T.I) Ranchi, Jharkhand, Govt. of India in an MNRE-sponsored project (2016-2019) led the introduction of solar energy in Tasar silk post cocoon technology operations which are quite energy intensive. It installed a 10KWp rooftop hybrid solar power plant and one hot air dryer for stifling & drying of tasar cocoon.

The project observed that about 45% utilization of solar energy could be achieved during months of November to March (5 months), and 30% during April, May, September, and October (4 months) in a year; June-August being monsoon months availability of solar energy is low. This project proved that solar can be a cheap, localized source of energy for India's Tasar silk industry by successfully demonstrating that with 0.20 KW/0.25 HP for each machine, post-cocoon activities like cooking/softening, reeling, and spinning operations could be effectively pursued by harnessing solar energy without affecting productivity and yarn quality.
The developed solar-operated tasar cocoon

cooking device could be well utilized for softening of tasar cocoons with cooking efficiency of about 95% without deterioration of reeling performance and yarn quality. The cost of cooking is INR 55/- per 1000 cocoons which is lower by 15 to 30% vis-à-vis usage of firewood and LPG.

Being a cottage industry located mostly in small villages and towns, the industry depends on firewood, cow dung and other biomass for energy needs. The project affirmed that solar energy can be well utilized for operating tasar reeling and spinning machinery in rural/urban areas of states such as Jharkhand, Bihar, Madhya Pradesh which encounter issues of scarcity and interrupted conventional electricity. In addition, this source of energy does not create environmental pollution like the burning of coal, rice husk etc.

Next steps: A total of 60 demonstrations, attended by 300 participants, were organized from 2019 to 2023 for tasar reelers, spinners, stakeholders, students from Universities/Colleges, and officials from the Directorate of Sericulture of Jharkhand, Bihar, M.P., West Bengal, Maharashtra. After proper documentation i.e. publications in renowned peer reviewed journals in the later part of 2023, this technology will be popularized amongst the tasar silk reeling and spinning clusters as on-field trials (OFT) under the Central Silk Board project in association with the MNRE, National Institute of Solar Energy (NISE), and Directorate of Sericulture (DOS) of different tasar-producing states in India.

At present, preheated water from solar geysers is used for cooking/softening of mulberry cocoons in different silk clusters like Malda and Murshidabad (West Bengal), Mandala and Hoshangabad (M.P.), Amarabati and Bhandara (Maharashtra) etc. As per the opinion from reelers and stakeholders, they have achieved energy saving of 15 to 50% as compared to coal and firewood usage during cooking/softening in different months. The utilization of solar power plant-generated electricity for operating cooking devices as well as reeling and spinning machines in tasar sectors has to be explored.

As mentioned by Dr N.B. Chowdhary, DIRECTOR Central Tasar Research & Training Institute, Ranchi

State-of-the-art Solar Water Pumps Testing Centre:

The MNRE has recently supported NISE in the successful development of the first of its kind R&D facility for Solar Water Pumping Systems (SWPS) for up to 50 hp capacity which is now NABL accredited. The website link for testing: https://testing.nise.res.in/.

The facility is equipped with state-of-the-art equipment and testing rigs capable of testing solar pumps of up to 50 hp capacity and a maximum head of 450 meters with a high-capacity sump tank. It has testing rigs of up to 6-inch size fitted with compatible flowmeters, pressure transmitters and sensors. The facility at NISE is fully capable of outdoor and indoor testing of solar pumps.

A major milestone for the Centre has been its proactive collaboration with the industry on introducing technology innovations, and product improvement, e.g., development of the prototype of a high-efficiency controller including battery-based controller and VFD, exploring ways to increase the daily water output of a solar water pumping system using bifacial PV modules. The Testing Centre has supported the MNRE in formulating guidelines for solar-based micro-pumps for 0.1 hp, and is currently developing rugged micro-irrigation prototypes, as well as identifying the best salinity-tolerant materials for pumps. It is hoped that these newer innovations and developments could enhance the preparedness of the Indian SWP manufacturers to expand their footprint internationally.

"We are happy to refer to our experience about testing of our solar irrigation pumps at NISE. We had submitted all three models of our pumps; viz. SF2H, SF2 and SD3, that we have developed and have offered on the Indian market. All these are under MNRE Micro-Pumping Specifications (2016-17). The entire experience, right from CSC to PV Testing Lab to Pump Testing Lab has been very good. The team at Pump Testing Laboratory is courteous and cooperative without ever compromising on the requirements under relevant Standards. I will prefer having the Testing done at NISE for all our future models". - ***M/s Future Pumps***

"The test facility from National Institute of Solar Energy (NISE) affirms our system specific performance parameters and it has helped us in building more credibility among our customers".
- M/s Spowdi

Collaboration with industry: For the development of a low-cost and highly efficient controller, NISE has signed an MoU with three companies - M/S ABB India Pvt. Ltd, M/S Shakti Pumps India Pvt. Ltd., and M/S Rotosol Motors and Controllers Ltd.

Figure 4.1: Solar Pump Test Lab at NISE

Key outcomes

The project has enabled NISE to prepare guidelines and policies for high-capacity solar water pumping system up to 25hp. Tests have been conducted with different types of modules such as monofacial, bifacial and thin films for the enhancement of overall wire-to-water efficiency.

Various micro-irrigation systems have been tested and based on the analysis a draft specification for less than 1 hp pumps has been prepared and shared with MNRE and stakeholders for comments and suggestions. A solar-powered micro-irrigation farm is developed at the NISE campus in collaboration with Spowdi India as shown in Fig 4.2 which showcases a futuristic micro-irrigation system that can help deal with the challenges of watering farmland in a more efficient way.

Figure 4.2: Futuristic Solar Based Micro Irrigation Farm at NISE

Solar drying of Rubber Sheets in North-East:

The MNRE R&D Funds have led to the development and implementation of an innovative solar dryer having capacity of drying 6 kg/batch of rubber sheets at the campus of the National Institute of Technology, Agartala. The system was implemented in the field after the successful demonstration of a 1 kg/day system within the premises of the National Institute of Technology (NIT) Silchar, Assam.

Some of the most significantly innovative features of the developed dryer include: (a) Solar photovoltaic-operated dehumidifier for use during the night to prevent reabsorption of moisture and complete batch within 24h, Recirculation of spent dehumidified air to minimize thermal energy

loss; (b) 90% UV cutoff in the drying chamber leading to better colour retention of the product; (c) Induced draft fan at the chimney operated directly by the solar photovoltaic panels to prevent very high stagnant temperature.

Cost and Payback: The cost of the single unit stands to be around INR 5 lacs and considering 240 days of sunshine in a year, and 3 days to complete a batch of rubber sheets drying, the payback period could be 2.9 years.

Future Plans for this technology: This is a CSIR-CSMCRI patented technology. Looking ahead, CSMCRI plans the proliferation of this technology through more on-field demonstrations, technology transfer, etc. for the existing decentralized solar thermal dryers targeting livelihood expansion and sustainability. Focus would also be on improvements concerning (a) versatility (b) enhancement of thermal energy efficiency, (b) off-sunshine period operation, (c) economics and (d) maintenance issues etc.

CSMCRI is open to industrial collaboration for industry transfer. It has recently conducted an on-field demonstration of the hybrid solar dryer for drying farm and aqua products at Guwahati funded by the North-East Centre for Technology Application & Reach (NECTAR).

Figure 4.3 Natural rubber sheets hung for drying inside the solar dryer

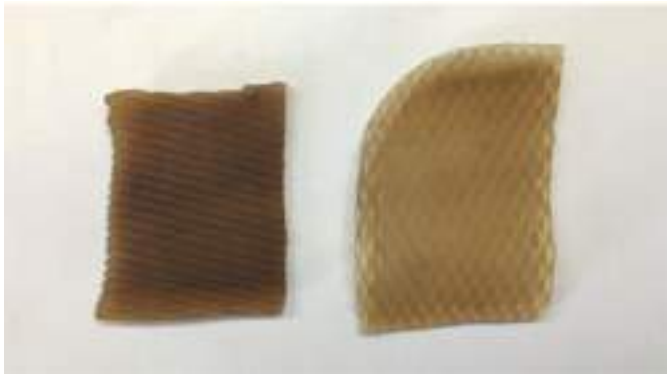


Figure 4.4 Open sun dried (left) and solar dryer dried (right) natural rubber sheet samples

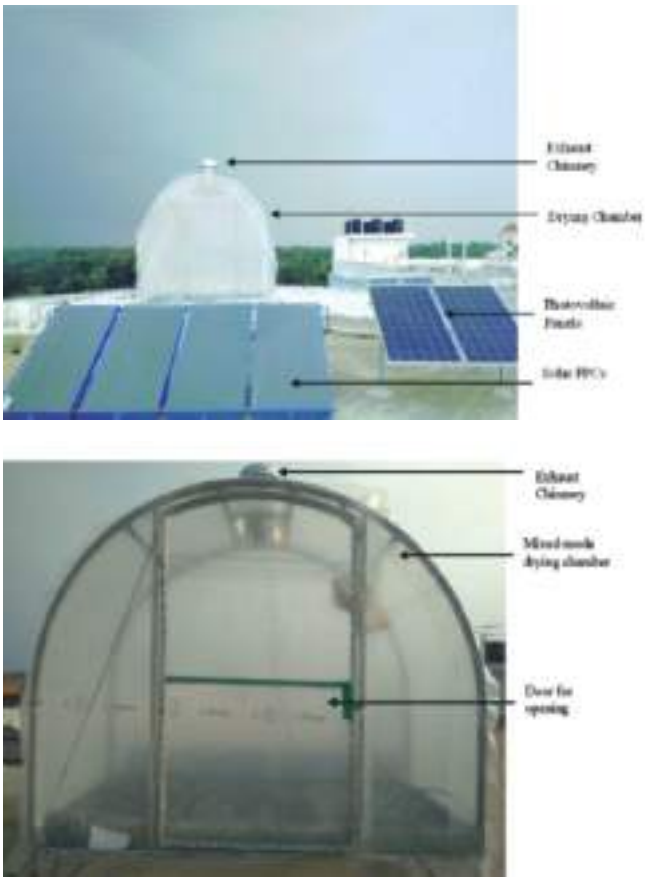


Figure 4.5 Photographs of the developed mixed-mode solar dryer installed for rubber sheet drying with front- and back-side views of drying chamber.

Future outlook

Enabling international diffusion of promising domestically developed DRE solutions through technology improvement, collaboration, and strategic outreach

MNRE's policy on DRE Livelihood Applications provided a much-needed fillip to the DRE segment. However, the

importance of practical and meaningful government-industry-academia collaboration on technology, innovation, standards, and outreach cannot be emphasized enough to help expand the footprint of India's DRE solutions internationally.

Climate change impacts have invoked demand for affordable **RE-powered cooling and heating solutions** across nations, and with government support, India could stand a chance to deliver on this promise with fast-tracked R&D improvements and industry collaboration. Regions like Ladakh in India provide a conducive environment for the deployment of geothermal heat pumps to further its carbon-neutral vision. R&D on solar thermal integrated with PCM storage has also been picking up momentum in India that could find wide applications in residential and commercial uses in India and internationally.

There is strong demand for Indian **RE-powered/green cold storage/cooling solutions** (e.g., cold rooms, milk chillers, cold storage, and solar refrigeration) not just domestically but also internationally, e.g., in Africa, South-East Asia, and ISA member countries. The government may adopt a technology-agnostic approach targeting both technology and business model innovation, R&D support for the private sector and academia in prioritizing R&D, pilots, and demonstration projects focused on recycled PCM, cooling solutions using natural refrigerants, setting up of standards and outreach programmes targeting different stakeholders.

Clean and Climate-Friendly Cooking: Affordable, Clean, and climate-friendly cooking solutions for household and community use could have widespread demand in various countries such as Africa where more than 850 million people still depend on wood and charcoal for cooking (as per UNDP). Several models of indoor/outdoor solar (PV and thermal), as well as biomass-based (improved cookstoves) cooking solutions, are available, however, their adoption is limited. Surya Nutan is the latest RE-powered cooking solution in the Indian market based on a solar PV-based indoor resistive heating system with a thermal battery (PCM) system for off-sunshine hour cooking. The government could adopt a basket of measures to scale up the development and adoption of these solutions in a technology-agnostic manner by setting up a Centre of Excellence on Clean and Climate-Friendly Cooking Technologies that undertake structured and collaborative R&D, pilots, demonstration, innovative funding such as carbon funding mechanisms, introducing policies and discussion forums on this subject.

Scaling up a Meaningful Partnership between MNRE and DRE practitioners/private sector

The power of **meaningful and strategic collaboration** between stakeholders in the DRE segment can bring about transformational gains that make Indian DRE solutions and its practitioners an international force to be reckoned with.

The Ministry is keen on meaningful and regular engagement with the industry and start-ups to better understand the emerging technologies and business models in the DRE segment, characterise the gaps so that policy, incentive framework, and technology/ecosystem support programs could be accordingly formulated.

Working more closely with platforms such as CLEAN to strategically disseminate the successful stories of MNRE-supported DRE pilots and applications would help to bring about wider adoption of these solutions for India's energy transition.

Finally, a closer cooperation between academia and industry to meet the international potential of technologies such as RE-powered cold storage, heating, cooling, and cooking solutions, which are increasingly gaining prominence in the backdrop of international commitments on climate change, SDGs, and energy transition objective, would help India in taking a global leadership in this sector.

Transformational role of DRE appliances in weak grid areas

Based on GOGLA's work internationally and lessons for India

Authors: **Tauseef Ahmad and Akanksha Chaurey**
Reviewer: **Praviin Kumar**, *GOGLA*

India has made tremendous efforts in electrification with nearly all urban (99%) and rural (95%) households having access to electricity[30]. A study by CEEW published in 2020 mentions that an Indian household receives 20.6 hrs of daily average power supply from the grid[31]. However, the study also points that households in some of the states face unanticipated supply interruptions and outages at least once a day, in addition to experiencing supply quality issues such as long blackouts, low voltages, or appliance damage due to voltage fluctuations. The Smart Power India and NITI Aayog study of 2020 also stated that 70% of household consumers of electricity grid have reported one or more power cuts in the past year and 28% of consumers remain dissatisfied over the quality of electricity[32]. Reportedly, the north eastern state of Meghalaya experienced up to 10 hrs of power cut in July 2023[33]. While the state has achieved 91.9% household electrification, its West Jaintia Hills district has below 80% access[34]. These are the characteristics of a weak grid market. The electricity supply for weak grid customers is typically inadequate, unavailable, unreliable, and unsafe - though the quality of supply varies significantly. This particularly constrains businesses from investing in appliances and machinery, since they would not be able to use them reliably for income generation. Weak grid customers are thus forced to rely on back-up solutions that are polluting, and expensive. At present, nearly 10 million agricultural pumps are operating on diesel gensets in India[35]. In neighbouring Nepal, a staggering 57.89 percent of industries have resorted to utilizing generators as an alternative power source on account of ongoing problems faced by the Nepal Electricity Authority (NEA) to provide consistent and high-quality electricity[36]. According to IFC/ World Bank study of September 2019, about 20-30 million small gasoline generators are being used in 167

30. https://main.mohfw.gov.in/sites/default/files/NFHS-5_Phase-II_0.pdf
31. https://www.ceew.in/publications/access-to-electricity-availability-and-electrification-percentage-in-india
32. https://www.niti.gov.in/sites/default/files/2020-11/Rockefeller-report-discoms.pdf
33. https://www.outlookindia.com/national/meghalaya-reeling-under-power-crisis-woes-may-continue-as-umiam-lake-water-level-down-minister- news-286871
34. https://www.downtoearth.org.in/blog/energy/access-to-electricity-improves-across-states-urban-rural-divide-remains-nfhs-5-74890
35. https://pmkusum.mnre.gov.in/about-scheme/8065c8f7b9614c5ab2e8a7e30dfc29d5.pdf
36. https://myrepublica.nagariknetwork.com/news/58-of-industries-resort-to-generators-due-to-inadequate-electricity-supply-cni/

countries across the world, and in many cases, these generators are the only or the main source of power[37].

Distributed renewable energy technologies have a good potential for solving the above challenges of weak grid or off-grid market. In 2022, distributed PV – or small solar PV installations that generate electricity for residential, commercial, industrial and off-grid applications – represented 48% of global solar PV capacity additions as per International Energy Agency (IEA)[38]. In this space, a new technology segment is emerging that integrates distributed solar PV, battery storage and efficient appliances with grid power to significantly improve the reliability, quality, and affordability of electricity access. The power can be used in low voltage (12V or 48V) mode on direct current (DC), or it can be at grid voltage with an inverter converting the DC power to AC. Digital technology is a key feature of the system with Internet of Things (IoT) based system monitoring and management, smart metering, billing, and payments[39].

The market segments where distributed solar and storage technologies would have potential for deployment are:

- Rural/ semi-urban households in weak grid/ off-grid areas with limited appliance ownership and usage
- Semi urban/ urban households and community/commercial consumers requiring 24x7 reliable supply
- Potential beneficiaries of PM-KUSUM component C[40]
- New/yet to be built buildings aspiring to be self-reliant/ Net Zero
- Small gasoline generator users spread in 167 countries
- Around 775 million people globally that are connected to an unreliable grid[41]

According to a recent survey conducted by GOGLA[42] in India, consumers are also now seeking technologies that offer seamless grid integration, prioritize safety, and ensure high energy efficiency. The increase in solar installations have also prompted consumer interest in system efficiency enhancement[43].

DRE manufacturers and system integrators in India are joining this segment of hybrid AC-DC infrastructure with new class of efficient appliances (including lights, fans, TVs, refrigerators, pumps, etc.) that use fundamental DC-run LED or Brushless DC (BLDC) motors and can be run on AC supply and/or DC supply.

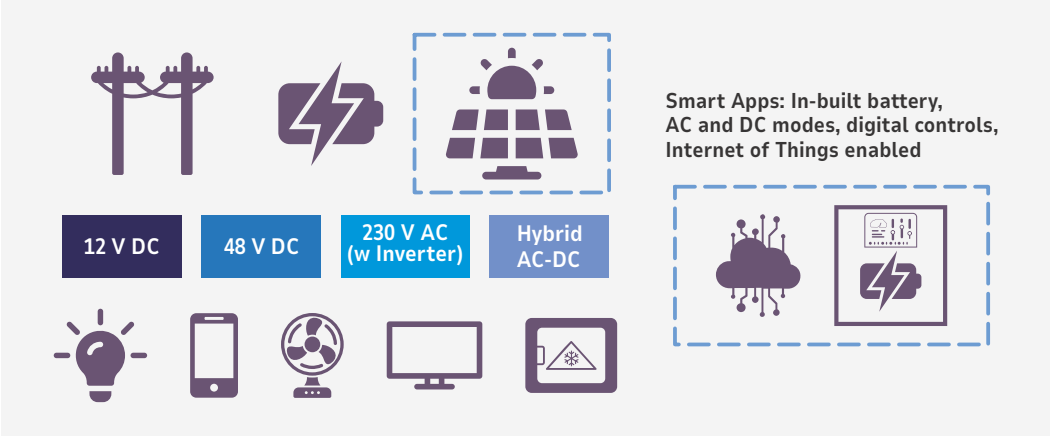


Figure 5.1: Smart Apps: In-built battery, AC and DC modes, digital controls, Internet of Things *Source: GOGLA*

37. https://www.ifc.org/en/insights-reports/2010/dirty-footprint-of-broken-grid
38. https://www.iea.org/commentaries/digital-tools-will-help-keep-distributed-solar-pv-growing-strongly
39. https://www.gogla.org/reports/off-grid-solar-market-trends-report-2022/
40. https://pmkusum.mnre.gov.in/landing-about.html
41. https://www.gogla.org/wp-content/uploads/2023/07/Gogla_PURE-Handbook_for_Governments_Development_Partners.pdf
42. GOGLA is the global association for the off-grid solar energy industry. It promotes, safeguards, and convenes the off-grid solar and efficient appliance industry and advocates for enabling policies and increased investment. https://gogla.org/about-us/
43. https://www.gogla.org/wp-content/uploads/2023/09/Indian-Market-Outlook-Solar-Lantern-and-Solar-Home-System.pdf

BLDC motors are widely used in many industrial and traction applications because of their high efficiency, high torque, low maintenance, less noise, and low volume. BLDC motors have an efficiency of 80% compared to 40-60% for single-phase AC induction motors.

BLDC fans have emerged as a strong DRE product that uses BLDC motors as a key component. Compared to conventional fans that consumes 75W at top speed, BLDC fans consume around 28-35W at top speed.

Source: atomberg

BLDC motor is also emerging as a better substitute for DC motors and AC induction motors in water pumping applications due to high efficiency, high reliability, and least maintenance requirement. The usage of BLDC motors in solar submersible pump systems is expected to increase.

Source: Amazon (Brand: RIPS technology)

Figure 5.2: Brushless DC Motor

Other innovations in appliances include those with in-built lithium-ion batteries and use AC input power for charging. In case of a power cut, the in-built battery can power the appliance for up to four hours. Such appliances may be particularly useful in weak-grid areas and can serve as an alternative to traditional power back-up solutions. Hybrid LED bulb is a good example of such an appliance.

The hybrid grid-tied inverter is also an upcoming technology in the market. This is a sustainable and eco-friendly power back

Women SHGs in Uttar Pradesh are now producing quality LED bulbs including inverter bulb that comes with battery backup up to 3 hours.

For normal LED bulb, women usually spend nearly Rs 40-45 in manufacturing the bulb and they sell it for Rs 70-80 which is much lower than the branded bulbs in the market. The inverter bulb is being sold for INR 320 through Prerna Ojus website and in the market.

Women received training under the UP State Rural Livelihood Mission to assemble/manufacture LED bulbs at their respective homes, without much use of heavy machinery.

Source: https://www.news18.com/news/buzz/led-bulbs-made-by-up-women-shine-light-on-their-self-sufficient-journey-4439396.html

Figure 5.3 : Inverter Bulb

Source: https://prernaojas.com/Product.php

up option, capable of simultaneously managing inputs from solar panels and battery banks, and can also charge batteries from both solar panels and electric grids. It can operate in both the on-grid and off-grid (only if battery is available) modes. Hybrid grid-tied inverters ensure that solar power is not wasted in case of a power cut. It also allows export of power to the main grid. According to a Comprehensive Research Report by Market Research Future (MRFR), "Solar Hybrid Inverter Market Information by Product, End-User, and Region - Forecast till 2030", Solar Hybrid Inverter Market could thrive at a rate of 8.90% between 2022 and 2030. The market size will be reaching around USD 13,462.01 Million by the end of the year 2030[44].

44. https://www.factmr.com/report/1073/hybrid-inverters-market

These innovations on the appliances side will further enable the growth of this segment and provide reliable energy supply in off-grid and weak grid markets. It will lead to transformation of future buildings into energy centres, supplying, and sharing energy to their surroundings[45].

The regulators in India are actively exploring new and innovative business models, such as peer-to-peer (P2P) trading, to support such innovations and transformations in the energy systems. In P2P trading, consumers of the same distribution company can trade excess solar power allowing energy consumers to become energy prosumers.

There is much innovation in this space targeting solutions that are affordable and scalable. However, it is a complicated and fragmented market making it challenging to standardize and commercialize. The technical standards and regulations for integrating distributed solar and storage with the grid are also in their infancy.

In sync with the above, GOGLA and CLASP[46] launched a market catalysing initiative in 2022 in India to prepare a roadmap for this technology[47]. The initiative, through extensive countrywide stakeholder consultations, assessed the viability of the technology and mapped the barriers, opportunities and required actions for advancing this market in India and globally.

Although the system costs are 2-3 times higher than conventional systems, there are opportunities in reducing annual electricity consumption by 10-40%. Distribution companies stand to gain significantly by redirecting saved electricity to higher tariff consumers. Also, since the technology enables improved availability and reliability of the electricity supply, there will be increased customer satisfaction. Besides, the costs of components, particularly the storage, are expected to come down making these options more attractive to the consumer. Bloomberg Nef's 2022 Battery Price Survey predicts that average pack prices should fall below USD100/kWh by 2026[48].

Introducing distributed solar and storage technologies at scale to the grid will require:

- Technological innovations to standardize the system, reduce cost, improve safety, aesthetics, and ease of use
- Active support of electricity distribution companies in piloting such initiatives to demonstrate the benefits and optimize system design, control technology, and cost
- Participation of DRE industry, livelihood missions, and boutique grass-root initiatives that offer an effective channel for supply distribution/ after-sales service
- Consumer finance (PAYGo or EMI with digital finance) to catalyse and enhance the affordability and uptake
- Policy & regulatory incentives to incentivize consumers and manufacturers to adopt

Strengthening the grid with distributed solar and storage technologies has a vast opportunity for the off-grid solar industry. It has the potential to unite off-grid and weak grid customers in Africa and Asia with a common technology base. It also benefits utilities by enhancing customer satisfaction, improving revenue, and offering ancillary services. Distributed solar and storage technologies, if deployed at scale, could transform electricity networks into smart grids that are less carbon-intensive, more resilient, decentralized, digital, and also more financially viable.

45. https://download.schneider-electric.com/files?p_Doc_Ref=DistributedGeneration
46. CLASP focuses on appliance and equipment energy performance and quality, to mitigate and adapt to climate change and expand access to clean energy. https://www.clasp.ngo/
47. https://www.gogla.org/reports/low-voltage-smart-power-and-appliance-lvspa-study/
48. https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh/

Taking DRE to the world: transformational journeys

Author: **Rekha Krishnan**, *WEFT Research*
(featuring Q&A with *Ekak Innovations, Husk Power, Ecozen and Oorja Development Solutions*)

It is gratifying that there is now a global recognition of the potential of, and need for DRE. The Global State of Renewables, while lamenting persistent energy gaps - that the 2030 target for universal access to clean cooking may fall 30% short and that 770 million people continue to lack access to electricity – dedicates a chapter to Distributed Renewables for Energy Access. At the global level, the reports point out that distributed renewables have been growing rapidly: In 2021, 7.43 million off-grid solar lighting products were sold. Solar mini-grid capacity exceeded 365 megawatts (MW) in 2019 of which 60 MW in Asia and 54 MW in Sub-Saharan Africa.

DRE's journey of transformation has been quite remarkable, in recent years, across all its verticals. Here are some examples:

- The RE-powered appliances space has grown well beyond solar lanterns and solar pumps – RE-powered appliances now cater to common applications like cold storage, milling, grinding/ pulverising, drying, and also to niche but critical needs like insect repelling, spraying, yarn spinning. A portal dedicated to DRE appliances developed by CLEAN (ireap.thecleannetwork.org) is a testimony to the rapid expansion in this segment.
- DRE projects, in forms such as solar rooftop and mini grids, have created islands of energy self-reliance that are now able to feed back into the grid. Such a two-way electricity flow is also visualised in Component A of India's PM KUSUM scheme.
- The search for modern clean cooking space – an integral part of DRE - has witnessed the emergence of several new products, e.g. portable plug-and-play biogas plants and solar-powered induction cooking.

Modular and smart distributed renewables are finding favour in the developed world with installations (typically solar integrated with storage) at a local scale for residences and for commercial and industrial customers – helping them to build energy self-sufficient models around clean and reliable power. North America witnessed a 100-fold increase in distributed power (mostly small solar) over the last ten years[49].

Yet, DRE's place in energy transition continues to be focused on "off-grid", remote areas. In its continued energy poverty eradication role, DRE has found maximum traction in the Sub-Saharan Africa (SSA) region. SSA has seen the largest growth in mini grids, this is perhaps triggered by the unfortunate fact that, while major electrification efforts saw India and the rest of Asia rise to over 90%, SSA had electrification at under 50%, accounting for 75% of un-electrified households globally.

49. https://www.mordorintelligence.com/industry-reports/north-america-distributed-power-generation-market

CLEAN members go international

Not surprising, therefore, that this is also the region, where several Indian DRE companies are focusing their international forays. Two Indian DRE enterprises of the CLEAN network - Ekak Innovations and Husk Power – share their experiences of becoming world-ready. Though the two enterprises differ considerably in their area of work, scale, business model and international presence, there is a striking similarity in their prepping up for the global market.

Both the companies focused on:

- understanding the local context in great detail, and
- "smartening up" with digital technology

Business model innovations to make DRE affordable

Digital technology has helped make DRE more accessible and affordable through PayG (Pay-as-you-Go) models that remove the upfront investment barrier. The original PayG model was around solar home systems where customers used mobile money to pay small sums only for what they used in a day. PayG variants now include lease-to-own models and prepaid usage-based models. The GRS 2022 reports that a third of off-grid solar lighting was bought through PayG.

Making DRE affordable through such models, becomes more pertinent as DRE offerings include more sophisticated and expensive systems than solar lanterns and solar pumps. Solar-powered cold storage is emerging as an important need. It is estimated that 1.09 billion people annually are exposed to significant risk due to a lack of access to cooling, as inadequate refrigeration and storage lead to large wastage of food produce.

An Indian company, Ecozen, seeks to bridge this gap through its solar-powered cold rooms (Ecofrost), which reportedly increases shelf life by 5-6 times. Ecozen's solutions embed AI and IoT technology as a result of which various critical parameters (like temperature, humidity, numbers of door open, solar energy generation etc.) can be monitored across all installations 24x7. The company also runs remote fixes and diagnostics to ensure more efficient service visits and to reduce downtime. Ecozen's partner, Oorja Development Solutions India Pvt Ltd, provides "Cooling-as-a-service" to farmers, retailers and traders. In fact, Oorja positions itself as a "farming-as-a-service' company that owns, operates and maintains decentralised solar energy systems at the farm level for water pumping, milling and cold storage. Oorja ensures that there is no upfront cost charged to end-users. Such innovations make DRE more accessible and the use of technology enables such business models. Both, Ecozen and Oorja, are proud members of CLEAN.

Going beyond – creating markets for the farmer

IRENA's guide on Renewable Energy for Remote Communities points out that apart from financing and maintenance of the systems, DRE players can enhance productive uses of DRE by additional services like market linkages that go a long way in strengthening the ecosystem. Indian solar dryer company S4S, which provides rural communities with solar-powered conduction dryers, supports its users through market linkages. Female farmers who are customers of S4S are connected to commercial buyers of dried products in arrangements that help the farmer to retain most of the profits. Another Indian solar food processing company, Raheja, engages with farmers for training and buyback support and takes on itself the supply of farm-fresh dried products to conscious consumer brands.

Going international: CLEAN member experiences

Ekak Innovations, a boutique company, carefully crafting an international presence.

Ekak Innovations (www.ekak.in) sees itself as a "product development company dedicated to creating innovative solutions for today's most pressing challenges." Its focal areas include renewable energy, IT transformation, 3D printing.

Which countries does Ekak operate in?

Ekak Innovations has been working in Tanzania since 2019. They have partnered with a company in Uganda, and are in talks with an organisation in Kenya to reach their targeted beneficiaries for DRE solutions. Their offerings are solar-powered lanterns (9W and above), solar-powered charging hub with lock/unlock mechanism, solar power bank for digital appliances and mobile charging, and lastly, PayG hardware with code generation for DRE asset security. With their solutions, they have saved the beneficiaries close to ~USD 300 per year in direct expenses on fuel.

Figure 6.1: Solar powered Lanterns by Ekak Innovations

How did Ekak "prepare" for the international market?

Ekak's focus has always been on the international market since its inception, primarily the developing nations. Their expertise has been in taking ideas to prototype and then scale them to production levels through their partner network. As a part of the offering Ekak comes in when there is a potential need for technology intervention to improve livelihood, standard of living or lack of accessibility to essential services. To prepare for the international market, they first understand the root-cause to build an effective solution. In this phase, they work with a community engagement organisation / last mile solutions company. They do site visits and evaluation visits to gauge the level of intervention needed. To make a particular solution sustainable and affordable they scout for resources available locally - human capital assessment (in terms of skill), raw material or processed materials and lastly, potential for assisting their local partner with assembly of the final solution in the country. All these considerations go into their design phase for a potential international market solution.

Ekak's view on major opportunities for DRE

Pre-pandemic, They had observed interests from last-mile beneficiaries as well as customers in moving up the energy ladder. Decentralised Renewable Energy is in the midst of a revival since the pandemic - with productive use-cases as the centre of it. However, major concerns remain on the affordability, scalability and maintenance aspect of productive use cases. They believe that the DRE sector can borrow learnings from other sectors to make a reasonable business - moreover economic - case for productive use cases. They are observing a shift towards charging-as-a-service for electric 2-wheelers, refrigeration-as-a-service, water-as-a-service for irrigation as well as drinking water, and lastly, productive appliances with remote monitoring as potential DRE interventions. DRE is transforming from lighting/consumer loads to energy-as-a-service with Ekak becoming an enabler.

Which regions and segments are attractive and why?

In East Africa, Uganda is seeing quite an uptick in the Mini-grid space and DC Appliances seeing adoption. One cause as cited by the community is lack of reliability with the government electricity supply.

Irrigation-as-a-service has continued to be in demand in Tanzania, Uganda and Kenya. Being agrarian economies, this is likely to increase, especially with low level of electrification in the region. Electrification - even renewable energy interventions of Milling operations still remain an opportunity to be unlocked.

The question remains on asset security in this space. Some major players have addressed this concern, however, for scalability - telecom internet network limitation still poses high risks. There have been requests around targeted solar appliances from some regional partners. They were looking for portable power banks charged by renewable energy for their digital equipment. This is observed in Uganda, as the country has seen a sharp rise in IT technology related jobs such as software developer, front-end designers.

Overall, there's a brewing opportunity in healthcare powered by DRE in the East African Economic Areas. This is primarily driven by the digitalisation of the healthcare sector focused on tracking, monitoring and enabling timely critical care sparked by the COVID-19 pandemic.

Figure 6.2: Portable solar system for charging digital equipment

The "Husk" story - a mini grids major making a mark in Africa

Husk (www.huskpowersystems.com) is among the world's leading mini grid companies. It started operations in India just fifteen years ago and now operates over 200 mini-grids in Asia and Africa. In Sub-Saharan Africa including Nigeria, Husk operates at 12 sites and plans to up this to 500 by 2026.

Building on the India lessons

Companies from the Global South know well the unique challenges faced by peers in other emerging markets: regulatory hurdles, logistics and supply chain bottlenecks, customer behaviour and access to finance. As such, there is a growing opportunity for collaboration and the transfer of knowledge, technology and business models, especially between India and Sub-Saharan Africa. Solar mini-grids are a prime example.

Husk Power Systems ("Husk"), which pioneered the mini-grid industry when it was founded in Bihar state in 2008 and now owns and operates the largest fleet in the world, first entered the Africa market in 2015 starting in Tanzania, followed by Nigeria in 2020, the largest off-grid solar market in the world with 90 million people still living without electricity.

Its 15 years of trial-and-error in India allowed Husk to avoid reinventing the wheel when entering Africa. As a result, Husk announced at the end of 2022 that it was EBITDA positive in both of its primary markets - Nigeria and India.

Success factors in Sub-Saharan Africa

Husk was able to successfully expand to Sub-Saharan Africa for a few reasons:

- Clarity of business model: Husk's integrated approach includes power supply from its solar hybrid mini-grids, appliance sales and finance, turnkey solar for rural C&I, and energy services. It is a standardized ecosystem model that fits the Africa context and ensures long-term viability;
- Site selection: Having confidence in its business model, Husk has also been able to develop a proprietary system for evaluating future mini-grid sites, which significantly reduces investment risk by ensuring site-level unit economics, and allows for developing and building out a scalable pipeline.
- Supply chain management: Husk's scale in India has allowed it to develop robust supply chain relationships which have been applied to Africa.
- Digital technology: Husk has invested heavily in both - supply-side and demand-side technology, and this digital platform allows for near-automation of asset management, which is essential for scale in

Africa where population density is lower and sites are farther apart.

- Local capacity: Husk's national teams are 100% local, allowing the company to seamlessly transfer knowledge and efficiently manage scale-up while navigating national and sub-national conditions.

Tapping the "energy access" opportunity

According to the World Bank, powering 380 million people in Sub-Saharan Africa by 2030 will require construction of more than 160,000 mini-grids at a total cost of $91 billion. At the current pace, only about 12,000 new mini-grids serving 46 million people will be built. Further acceleration is urgently needed to meet Sustainable Development Goal 7 (SDG7).

Using its standardized model, Husk is now expanding into new markets in Sub-Saharan Africa, including the Democratic Republic of Congo (DRC), the second largest off-grid market, and is exploring entry into 4 additional markets, with a goal of having 2,500 mini-grids on the continent over the next 5 years. Besides electricity provision, Sub-Saharan Africa also is ripe for scaling productive-use energy services, including e-mobility and agro-processing, appliance sales (household and commercial) and rural commercial and industrial establishments, all of which are under-served opportunities.

Figure 6.3: Husk distribution poles and transmission lines

Figure 6.4: Husk customer using the solar mill

Figure 6.5: HUSK Solar Plant

CLEAN
771, Office No. 3, Mayur Apartment, Bhandarkar Road, Pune - 411004
P: +91-7683047824 E: support@thecleannetwork.org

CLEAN website: https://thecleannetwork.org/
https://www.instagram.com/cleanenergyaccessnetwork/
https://www.youtube.com/@clean-networkfordreenterpr6603/featured
https://www.linkedin.com/company/clean--clean-energy-access-network/
https://twitter.com/thecleannetwork
IREAP: https://ireap.thecleannetwork.org/

Disclaimer

The views/analysis expressed in this report/document do not necessarily reflect the views of CLEAN. CLEAN does not guarantee the accuracy of any data included in this publication nor does it accept any responsibility for the consequence of its use.

Please scan the QR code to send us your feedback and suggestions.

Images acknowledgements

1. Clean Cooking (Courtesy: Ecosense Appliances Pvt Ltd)
2. Micro Hydro Project in Odisha (Courtesy: Desi Technology Solutions)
3. Rooftop Solar (Courtesy: EnergyBae Pvt Ltd)
4. Solar Dryer (Courtesy: Rudra Solar Energy)
5. Solar Cooking (Courtesy: OrjaBox LLP)
6. Home Biogas Plant (Courtesy: SwitchON Foundation)
7. Off-Grid Solar Plant (Courtesy: E-Hands Energy (India) Pvt Ltd)

CLEAN
Create. Connect. Collaborate.