Decentralised renewable energy (DRE) technologies for livelihood creation

Decentralised renewable energy (DRE) applications[1] offer a reliable and sustainable solution to addressing the tripartite challenge of energy access, climate change mitigation, and growth priorities of India by ensuring last-mile access to energy for boosting rural livelihoods. Technologies such as solar water pumps, solar silk reelers and charkhas, biomass-powered cold storage, etc., are innovations that are powering sustainable livelihoods across the country. These clean-technology solutions have demonstrated the ability to enhance productivity, boost incomes, reduce drudgery, and bring about various social advantages, such as increased involvement of women in small businesses and entrepreneurial ventures. Odisha currently has ~11,000 DRE technologies deployed, with 10,729 deployments of solar pumps alone[2].

Opportunities for 2030

Jobs overview

Manufacturing and deployment of **7,00,366** DRE livelihood technologies in Odisha has the potential to generate **43,577 FTE[3] jobs** by 2030.[4]

Market opportunity

- **INR ~5700 crore (USD ~690 million)** is the market opportunity in Odisha for DRE livelihood technologies in 2030 alone.
- **INR ~10950 crore (USD ~1319 million)** is the market opportunity in Odisha for DRE livelihood technologies, which amounts to **7 lakh products** in terms of the product deployment potential till 2030.
- **High potential districts for DRE technology deployment:**
    - **Overall:** Ganjam, Mayurbhanj, Cuttack, Koraput, and Baleshwar.[5]
    - **Solar aerators:** Ganjam, Bargarh, and Puri[6]
    - **Solar-powered millet milling machine:** Koraput, Rayagada, and Sundargarh[7]
    - **Solar bulk milk chillers:** Cuttack, Baleshwar and Puri[8]
    - **Solar dryers and cold storage:** Koraput, Mayurbhanj and Ganjam[9]
    - **Solar sewing machines:** Ganjam, Khordha, and Cuttack[10]
    - **Solar silk reeling machines:** Mayurbhanj, Phulbani, and Ganjam (CEEW 2021)

[1] This note captures the following technologies: decentralised renewable energy-based refrigeration, cold storage, chillers, grain milling and processing, textile reeling and looming, sewing machines, fodder systems, aerators, pumps, charkhas and dryers.
[2] Stakeholder Consultations
[3] Full time equivalent
[4] These numbers are subject to the condition that the manufacturing of these technologies happens in Odisha itself. Jobs are calculated for activities that include design of the applications, procurement and assembly of components, installation, maintenance and corporate functions such as administration, marketing, etc. Jobs exist in the designing, procuring of components, assembling of the application and testing of the product, packaging of the product, installation and customer service.
[5] Authors' analysis
[6] Analysis of National Fisheries Development Board, Odisha data
[7] Shri Anna Abhiyan Dashboard
[8] Analysis of Dairying in Odisha: A Statistical Profile 2016
[9] Analysis of Agriculture Statistics Odisha 2013-14
[10] NSS 73rd Round

- **Solar-powered vertical fodder grow units:** Baleshwar, Mayurbhanj, Cuttack (CEEW 2021)
- **Solar micro horticulture processors:** Kendujhar, Mayurbhanj and Angul (CEEW 2022)

Investment opportunity

- **INR ~130 crore (USD ~16 million)** is the investment opportunity in Odisha for DRE livelihood technologies till 2030.

Why should Odisha invest in DRE livelihood technologies?

- **Enhanced agricultural productivity and post-harvest management:** Odisha, despite its rich agricultural potential, faces significant challenges in the sector, which continues to grapple with low productivity due to reliance on traditional farming methods, limited capital formation, inadequate investment and the absence of sufficient irrigation facilities. Sixty-two per cent of the cultivable land in the region remains rain-fed, leaving it vulnerable to the unpredictable fluctuations of the monsoon (Economic Survey, n.d.). Similarly, the state is facing challenges in post-harvest management, resulting in substantial losses of fruits, vegetables, and flowers. According to the HAPIS[11] report (2019-20), Odisha ranks first in sweet potato production, second in brinjal and jackfruit production, fifth in watermelon and tomato production, sixth in lemon and bottle gourd production and seventh in mango production in the country. However, it experiences a considerable post-harvest loss of fruits and vegetables, exceeding six lakh tonnes annually according to an estimate by the Indian Council of Agricultural Research - Indian Institute of Horticultural Research. This substantial loss significantly affects the income of the farming community and the overall availability of produce in the state. Scaling DRE livelihood technologies in Odisha by powering irrigation systems, grain mills, cold chain technologies as well as dryers, etc., can help the state increase its crop yields, reduce post-harvest losses, and enhance food security for the rural communities.
- **Holistic development:** DRE livelihood technologies have enabled up to a 35 per cent increase in users' annual incomes, thereby improving access to education, and better nutrition (Gaur et al. 2023) and subsequently contributing to the fulfilment of a plethora of SDGs.[12] Given that Odisha ranks 22nd in India in terms of gross domestic product (GDP) per capita, scaling DRE technologies in the state has the potential to enhance the incomes of the population and subsequently other indicators of human development.
- **Mitigating brownouts and blackouts:** In Odisha, nearly, 64 per cent of households face two or more 24-hour blackout days per month, while 31 per cent experience three or more days of low voltage supply (Tripathi and Jain 2017).[13] According to ATLC,[14] 45 per cent of the total area of the state is classified as the Scheduled and Tribal Sub Plan Area. DRE technologies can provide a decentralised and reliable source of clean energy, reducing dependence on

[11] Horticulture area production information system (HAPIS)
[12] Sustainable development goals
[13] According to ACCESS, approximately two-thirds of the unelectrified households in the state are situated in habitations with grid connectivity. Based on GARV-II data, despite more than 98 percent of villages in Odisha being electrified, 37 percent of households lack electricity access.
[14] Academy of Tribal Languages and Culture

centralised weak grids, thereby mitigating the issue of brownouts and blackouts in tribal regions of the state.

- **Localising economies:**
    - Arresting migration: Distress migration due to lack of employment opportunities in Odisha materialises through informal channels under contracts that are highly exploitative (Sharma et al. 2014). Scaling up of DRE livelihood technologies in the state has the potential to employ **43,577** individuals in direct jobs till 2030 and impact **925,544** livelihoods in the farm and non-farm sectors. Tapping into this potential can reverse the migration trends in the state.
    - Localising production: By promoting the manufacturing and deployment of DRE technologies in Odisha, communities can gain more control over their energy resources and production activities, fostering a sense of empowerment and self-sufficiency.
    - Indigenisation of the supply chain: Manufacturing of DRE technologies within the state, many of which are currently import-dependent for key components, will incentivise research and development (R&D) on producing the components domestically, potentially indigenising the supply chain.
- **Convergence across government ministries and departments:** Scaling up DRE livelihood technologies aligns with the broader initiatives of the government of Odisha for sustainable development and clean energy adoption. It will potentially lead to inter-ministerial and inter-departmental convergence to extend policy support and incentives, further encouraging the growth of the clean energy sector in the state.

Inspiration from success stories

Case study 1: Silk reeling using solar technology in Odisha

- Market potential of solar-powered silk reeling machines: 569 (Jain et al. 2023)
- Market size: INR 18.208 million (INR 1.8208 crore)
- Weaving households: 3138 (CEEW 2021)

An illustrative example is Ms Kuni Dehury, a skilled silk reeler hailing from Keonjhar, Odisha. Drawing on her extensive experience in silk reeling from a young age, she has established a small centre in her village where she imparts training to women in the art of silk reeling. She has successfully trained over 500 women on solar silk reeling machines at the Tussar Silk Park. According to Kuni, these machines have proven instrumental in helping

women elevate their monthly incomes from approximately INR 1500 to around INR 6000. Moreover, they contribute to the centre's cost-cutting measures by reducing electricity expenses.

Case study 2: Small solar-powered refrigerator in Odisha

- Market potential: 50,841 units (Jain et al. 2023)
- Market Size: INR 4,067.28 million

Seventy per cent of the entrepreneurs using solar-powered refrigerators experienced a profit increase of more than INR 4000 per month (SELCO Foundation 2021). These estimates showcase a viable business opportunity with a visible socio-economic impact.
An illustrative example is Nibedita Nag, hailing from Kalahandi in Odisha. Faced with financial constraints, she had to give up on her dream to pursue her education after 10th standard. Due to an unreliable electricity supply to power a conventional refrigerator in her grocery store, she invested in a solar refrigerator and significantly increased her monthly earnings from INR 8,000-10,000 to INR 16,000-18,000. She attests that the refrigerator has enabled her to expand the shop's product range to include water bottles and cold drinks, thereby increasing her product sales by a substantial margin.

"I couldn't study, but with the help of this solar refrigerator, my brother is able to study".

– Nibedita Nag

Who could support in scaling DRE livelihood technologies?

1. Key government departments and their roles

- **Odisha Renewable Energy Development Agency (OREDA):** OREDA has piloted multiple clean-tech applications on the ground. Along with the Department of Energy, Odisha, OREDA may push for funding and policy support from the centre. It may work on a policy, in tandem with the MSME[15] and Industries Department to support the entire clean-tech ecosystem ranging from manufacturers to FPOs[16], SHGs[17] and users. A crucial insight gained from the *Odisha Millets Mission* was that every phase of the value chain received support, extending from cultivation to marketing and packaging, until a discernible demand for millets was established. Emulating these steps in the DRE sector, products with high demand could be manufactured not only for Odisha but for other states in the eastern region as well. OREDA can emulate the steps taken by CREDA[18] in implementing programmes such as the Solar Cold Storage, Solar Paiyjal Yojana, etc., to scale DRE technologies in the state.
- **Mission Shakti:** According to the National Rural Livelihoods Mission (NRLM), Odisha is home to **5,31,534 SHGs**. Mission Shakti, leveraging its network of SHGs, has the potential to collaborate with clean-tech companies to initiate the manufacturing of specific high-demand products within Odisha. Different SHGs may contribute at

[15] Micro, Small and Medium Enterprises
[16] Farmer Producer Organisation
[17] Self Help Group
[18] Chhattisgarh State Renewable Energy Development Agency

various stages of the value chain, including manufacturing and assembly, awareness generation, installation, marketing, and servicing of clean tech applications.

Odisha Livelihoods Mission under the Department of Mission Shakti can channelise institutional finance for scaling the uptake of DRE technologies in the state while building the institutional capacity of rural communities for sustainable livelihood generation through mainstreaming the clean-tech ecosystem.

- **Department of MSME:** Although there is an existing MSME policy, the MSME Department could collaborate closely with OREDA and Mission Shakti to effectively communicate incentives and support provided by the department to startups and companies in the sector. The exploration of cluster development for the silk industry and the active involvement of all stakeholders in the ecosystem could be contemplated.
- **Integrated Tribal Development Agency (ITDA):** ITDA can play a pivotal role in conducting a needs-based assessment in tribal areas of Odisha to identify requirements and gaps in value chains where clean-technology can be tapped in; awareness generation and capacity building of the tribal communities, infrastructure development and policy advocacy for support at the state and national levels. Special Central Assistance to Tribal Sub-Scheme can be leveraged to promote and implement DRE technologies in Odisha's tribal districts with high potential for deployment such as Mayurbhanj, Keonjhar, Koraput, Rayagada, etc.
- **National Bank for Agriculture and Rural Development (NABARD):** NABARD, the apex development bank of India, can play a pivotal role in unlocking finance for the sector. Its support in the form of interest subvention, first loss default guarantees (FLDG), etc., can act as a catalyst for scaling the uptake of DRE technologies by providing credit guarantees to the financing institutions.
- **Other line departments:** Although OREDA oversees small-scale renewables, it falls within the purview of various line departments to promote the adoption of these products. For instance, it is the responsibility of the Fisheries and the Animal Resources Development Department to mandate the use of solar-powered aerators in pisciculture and to facilitate the availability of subsidies or interest-free loans for potential users.

2. Private sector

- **Financial institutions (FI):** End-user financing is critical for the uptake of DRE products. Financiers should increase their risk appetite and increase loan tenures for DRE users. Many of the current manufacturing and service companies tie up with financial institutions in order to ensure end-users can afford DRE products. FIs such as SBI, NABKISAN Finance Limited, Samunnati, and Rang De, among others, can collaborate with DRE technology manufacturers to facilitate loans for the purchase of these technologies in Odisha.
- **Industry players:**

- Technology Manufacturers can work on technology customisation to tailor these to suit the specific needs and conditions in Odisha. They can help realise the potential by providing after-sales services and maintenance support to ensure the reliability and continued functioning of DRE technologies in remote areas of the state.
- Distributors and market enablers**:** Distributors such as Dharma Life and Essmart can expand their operations to Odisha by providing technical assistance to customers, helping them understand their needs and recommending the most suitable DRE solutions. They can invest in training programmes for their staff as well as the end-users and enable forward and backward linkages for the end-products of DRE technologies.

- **Incubators:**

  Social enterprise incubators can strengthen their existing partnerships and initiate new collaborations with various market-enabling entities and financing institutions. Such collaborations will facilitate the establishment of market linkages, distribution networks and access to affordable finance for scaling the manufacturing and deployment of DRE products in Odisha.

3. Potential role of CSOs[19]

- **Ensuring market linkages:** One major challenge in sustaining livelihoods within the DRE sector is ensuring demand and sale for the end products. CSOs such as Harsha Trust in Odisha could facilitate closing this gap.
- **Onground implementation:** SHGs, FPOs and CSOs such as PRADAN, SELCO Foundation and Livelihood Alternatives, etc., can play a pivotal role in bolstering the ecosystem support for the DRE sector. They can contribute to building awareness and communicating the benefits of clean tech applications, generating demand, providing training and guidance to users, facilitating connections with financial institutions, and participating in the buy-back of products, among other activities.

Overcoming challenges to scale DRE livelihood technologies

1. **Low awareness and demand ignition:** The majority of potential customers and rural populations are unaware of DRE livelihood technologies and their positive impact on livelihoods, creating an environment of low demand for the same (Jain et al. 2023)

   Sector stakeholders can collaborate to implement concerted efforts for awareness generation through targeted campaigns and community engagement, thereby generating demand for DRE livelihood technologies (Jain et al. 2023).

2. **Limited end-user financing:** High upfront costs coupled with a lack of affordable financing hinders the adoption of DRE livelihood technologies among rural communities (Jain et al. 2023). The price of solar-powered bulk milk chillers, for instance, ranges between INR 7,09,015 and 25,00,000, which is a substantially high expenditure for the rural poor to incur out of pocket.

[19] Civil Society Organisations

- Point-of-sale financing, innovations in financing mechanisms such as first loss default guarantee (FLDG), Pay-As-You-Go, etc., to mitigate risks for financiers, including collaborations with financial institutions, can enable affordable credit for end-users in Odisha (Jain et al. 2023).
- Philanthropic organisations and government departments can redirect capital towards financing institutions such as Odisha Gramya Bank supporting wider adoption (Jain et al. 2023).
- The convenings of the State Level Bankers' Committee (SLBC), Odisha can be leveraged for disseminating information and supporting physical demonstrations to build financiers' trust in DRE livelihood technologies. Technology manufacturers and suppliers must provide reliable after-sales and demonstrate strategies to mitigate seasonal income variations to ensure financiers' confidence (Jha, Patnaik and Jain 2019).
- In Odisha, small finance banks such as Ujjivan and ESAF can extend loans of three years or beyond to ensure loan repayments from DRE end-users. They could be supported by banking correspondents to reach rural areas (Jain et al. 2019).
- Institutions like NABARD and Small Industries Development Bank of India (SIDBI) can establish a revolving fund for clean energy to be disbursed by regional rural banks (RRBs) in the state (Odisha Gramya Bank and Utkal Grameen Bank). Microfinance institutions (MFIs) such as Adhikar can establish separate credit lines for DRE livelihood appliances (Jain et al. 2019).

3. **Lack of ecosystem support for capacity building and market linkages:** Users employing DRE technologies for new livelihoods face constraints in acquiring skills and market linkages due to a lack of ecosystem support (Jain et al. 2023).[20]

    - Convergence with livelihood-support departments (such as the Department of Mission Shakti) and organisations such as Harsha Trust is crucial to mainstreaming DRE technologies in Odisha. Implementing organisations and technology manufacturers can collaborate with relevant government (such as Odisha Rural Development and Marketing Society - ORMAS and the Department of Mission Shakti) and private stakeholders for forward and backward linkages, which are critical for ensuring the availability of raw materials and creating demand for final products (Gaur et al. 2023).

    - Ongoing training and capacity-building programmes (such as the Odisha Tribal Empowerment and Livelihoods Programme - OTELP) can target stakeholders involved in the deployment and use of DRE-livelihood technologies. Capacity building is essential to build trust among stakeholders (Gaur et al. 2023). According to a joint report by the World Wide Fund for Nature (WWF)- India and SELCO Foundation, programmes such as the Pradhan Mantri Kaushal Vikas Yojana (PMKVY) initiated by the Ministry of Skill Development and Entrepreneurship (MSDE) and the "Livelihood in Full Employment (LIFE)" Project, a segment of the MGNREGA[21] present significant opportunities for enhancing the capabilities of DRE micro-entrepreneurs.

[20] Based on stakeholder consultations
[21] Mahatma Gandhi National Rural Employment Guarantee Act

4. **Trust deficit:** Knowledge gaps arising due to inadequate capacity building spanning across the sector create mismatch between user needs and deployed technological solutions, reducing uptake and thereby distorting perception of stakeholders regarding DRE solutions (Gaur et al. 2023). Financing institutions, for instance, have a low risk appetite when it comes to extending loans to DRE end-users as there is no clarity on the efficacy and viability of these technologies.

5. **Lack of technical support:** Unavailability of timely technical support to DRE-end users due to the nascent nature of the DRE sector creates distrust amongst end users as well as financiers (Gaur et al. 2023). A solar-powered small refrigerator user in Odisha may lose potential income from the sale of his fishery products due to a lack of timely post-sale technical support.

    - Technology manufacturers can train and engage local youth on a fee-based model to provide timely technical support (Gaur et al. 2023).
    - Market-enabling ecosystem can expand the scope of their activities to provide timely technical and after-sales support to the end-users. A few locals in each district can be trained and employed by the market enablers to provide after-sales support for a plethora of DRE technologies deployed in the district.

6. **Lack of dedicated policy support:** Due to lack of dedicated policy support for DRE livelihood technologies, the sector faces several challenges including a dearth of space to set up manufacturing units of these products. This, coupled with the focus on large-scale renewables, has pushed the decentralisation of clean energy to the sidelines of the narrative of transitioning to net-zero by 2070.

    Some of the ways through which the Odisha Government can bolster the ecosystem of clean technology solutions for livelihoods in the state include extending active support for the DRE sector by providing space for manufacturing units and ensuring ease of doing business; devising schemes to enable affordable access to loans for DRE end-users; government subsidising initial upfront costs of high-priced DRE technologies such as solar-powered cold storages; and creating a robust mechanism for testing of products and issuing quality certifications for enhancing reliability in the efficacy of these livelihood solutions.

Risk proofing the scale-up of DRE livelihood technologies

- **Environmental risks:** DRE livelihood technologies as compared to non-DRE products, have additional components such as solar modules, motors, batteries, etc. Dumping or disposal of these components in ecologically sensitive areas may lead to degradation of the area and pollution.

  Mitigation - It is critical to ensure users are aware of the safe disposal/recycling of the components. Additionally, take-back initiatives to collect and properly dispose of the components can help in mitigating the risk.

- **Market risks:** Due to the nascent nature of the sector, many of the enterprises are struggling for survival. If new enterprises set up their units in the state and enough demand is not generated for the technologies, these enterprises may exit the industry, leading to the closure of an entire product line.

Mitigation - Targeted marketing campaigns, demonstration projects and setting up experience centres can help mitigate such market risks.

- **Supply chain risks:** Several of the components of DRE technologies are imported from countries such as China. Any disruption in the supply chain due to geopolitical instability can lead to delays in production, subsequently transferring the high costs to end-users.

  Mitigation - Local sourcing and diversification of suppliers for critical components to reduce dependency on a single source or a country can help mitigate the risk.

- **Absence of market linkages:** For some of the end-products of DRE technologies, forward and backward market linkages may not be in place in certain pockets of the state. As a result, the potential income increment may not be realised, which can even result in non-utilisation of the asset and reduced demand for the technology.

  Mitigation - Enabling the extension of government support to DRE technology manufacturers and end-users in establishing market linkages and distribution networks as well as leveraging existing networks and channels to reach target markets effectively can help mitigate this risk.

- **Under-utilisation of the product:** The product may be under-utilised after purchase, substantially reducing the realisation of the technology's impact potential. This can significantly hamper the ability of the end-users to repay the loans availed for purchasing the product, thereby disincentivizing the financing institutions from financing the sector.

  Mitigation - Enhancing capacity building through training programmes and facilitating timely technical support to maximise the utilisation of the technologies can help mitigate this risk.

- **Limited reach and resources:** DRE technology manufacturers have limited reach and resources to expand into new regions (Singhal et al. 2023). Due to the incipient nature of the DRE enterprises, a successful solar-powered charkha manufacturer, for instance, may face infrastructural and monetary challenges in expanding its operations to hilly areas of Odisha.

  Mitigation - Supporting expansion initiatives to help DRE enterprises overcome infrastructural and financial constraints through incentives, grants, loans, etc., can help mitigate this risk.

Annexure

The methodology employed to estimate the market, investment and employment opportunity in Odisha for scaling the manufacturing and deployment of DRE livelihood technologies is described below:

Identification and scoping of the DRE livelihood technologies value chain

In light of the vast opportunity in the sector with the total addressable market for farm and non-farm products estimated to be USD 40.9 billion and USD 13.2 billion, respectively (Waray et al. 2018), DRE livelihood technologies was chosen as a green economic value chain for the study. National level interest was identified through the Ministry of New and Renewable Energy's (MNRE) 'Framework for Promotion on Decentralised Renewable Energy Livelihood Applications' to guide the scoping of the value chain in terms of the product categories to be adopted for the research. The product categories include irrigation, textiles (silk and cotton), fisheries and aquaculture, millets and pulses processing, rice milling and processing, cold storage and refrigeration, horticulture produce processing and vertical farming system.

The value chain was scoped to enable estimations. Accordingly, the following activities/stages were accounted for: manufacturing, installation, maintenance, marketing and building market linkages (market enabling ecosystem) for DRE products.

Jobs and market estimation

Jobs estimation:

- The employment coefficient is the proportion of the employees to the total output produced in a particular year. Data on employees, total output and other qualitative inputs were collected through semi-structured interviews. **Key informant interviews (KIIs)** were conducted with identified players in the ecosystem. Sampling strategy used to identify respondents was a mix of **purposive and convenience sampling**.
- The interviews focused on the number of people employed in the facility and annual production capacity, etc. The tools used to conduct these KIIs were questionnaires prepared with the following themes – activities to understand the different processes undertaken by companies and teams therein, employment numbers from different activities, production in units for the value chain. Further, other information included qualitative parameters like skill requirement and other related information, challenges, benefits and risks associated with the technology, location preference and reasons for setting up in a particular state.
- The calculation of employment factor accounted for the following activities: design of the applications, procurement and assembly of components, maintenance and corporate functions such as administration, marketing, installation, and after-sales, etc. Employment factors were calculated separately for the technology manufacturing ecosystem as well as the DRE market enabling ecosystem.
- For the 10 clean tech applications, top management at **12 companies** was interviewed for estimating the manufacturing ecosystem FTE. Additionally, 3 stakeholder consultations with prominent market enablers were conducted to arrive at the employment factor for the market enabling ecosystem for the value chain.

Market sizing (in units):

- Total market opportunity for all the technologies in the state except solar sewing machines and solar aerators is based on the previous studies conducted by CEEW. The potential for deployment of solar sewing machines was determined by identifying relevant livelihood activities (linked to an NIC code), distinction of activities into 'household' and 'non-household' and further distinction of relevant activities into 'direct' and 'indirect use'. For calculating the potential of solar aerators in the state, the total area of usable water area was calculated, followed by estimating the necessary aeration and the number of aerators that could be deployed. For all other products, deployment numbers were adapted from previous CEEW studies.
- Projections on market or product deployment opportunities for each technology except solar aerators and solar sewing machines from 2024-2030 were made using the assumption that Odisha currently has a 2.07 per cent share in the total deployments at the national level. This share is based on the current solar pump deployment in the state as a proportion of the total solar pump deployments in the country. Projections for solar aerators and solar sewing machines were made using the current deployment proxy, that is, the proportion of current deployment to the total market potential of solar pumps in the state and dividing it by 2. This is based on the assumption that the government push and demand for solar aerators and solar sewing machines is half of that of the solar pumps. Given these assumptions, CAGR (compounded annual growth rate) was calculated by using the total market potential of the state for each technology as a reference to arrive at ambitious projections till 2030. Total market potential for all the technologies in the state except solar sewing machines and solar aerators is based on the previous studies conducted by CEEW. Potential for deployment of solar sewing machines and aerators were determined using the below method. For all other products, deployment numbers were adapted from previous CEEW studies as mentioned in the references.

Table 1 Approach to estimate the market potential for solar sewing machines and solar aerators

DRE technology	***Dataset***	***Approach***
Solar-sewing machine	NSSO 73rd round survey. It gives insights into the economic and operational characteristics of 64 million unincorporated non-agricultural enterprise	Step 1- Identification of the relevant livelihood activities (linked to a NIC code) in which the microenterprises are engaging where there is a possibility of using the respective DRE livelihood technology. Step 2- Further distinction of activities were done whether they were a household activity or a non-household activity Step 3- The relevant activities were then categorised into either 'direct use' or 'indirect use'. a. 'Direct use' activities: Encompasses

		all the microenterprises engaged in the activity to arrive at the market potential. b. 'Indirect use' activities: It considers only enterprises reporting electricity as a bottleneck.
Solar aerators	Fisheries data https://fisheries.odisha.gov.in/upload/files/Fishery%20Resources_04_07_19pm6934e22d85734596265a346de1b2be72.pdf	Step1- Calculation of total area of usable water area Total Areas (Acres) Formula: ha x 2.471 Step 2 Necessary Aeration 1 acre foot displacement of water every 24-48 hours= Addition of min 3.2 lbs of oxygen per horsepower per hour Normal water conditions 1 or 1.5 hp aerator/surface acre Warm/Excessive Algae Growth 2 hp aerator/surface acre Step 3- calculation of Number of Aerators (according to stakeholder consultation)

Table 2 Relevant NIC Codes - Solar sewing machine

Codes	Activity
13921	Manufacture of curtains, bed covers and furnishings
13923	Manufacture of mosquito nets
13924	Manufacture of bedding, quilts, pillows, sleeping bags, etc.
13925	Manufacture of tarpaulin
13926	Manufacture of blankets
13929	Manufacture of other made-up textile articles, except apparel n.e.c
13998	Manufacture of waterproof textile excluding tarpaulin
14101	Manufacture of all types of textile garments and clothing accessories
14103	Manufacture of hats, caps and other clothing items such as gloves, belts, ties, cravats, hairnets, etc
14104	Manufacture of wearing apparel made of leather and substitutes of leather
14105	Custom tailoring
14109	Manufacture of wearing apparel n.e.c.

Market opportunity (in value) estimation

- Market opportunity is the dollar value of the market potential in Odisha. Prices of the product were determined through searches on the companies' websites, online marketplaces such as InstaMART and from previous CEEW reports (Jain et al. 2023)
- The price of each DRE product except solar aerators and solar sewing machines was derived from past CEEW studies. For solar aerators, and solar sewing machines, current prices as per IndiaMART were used.
- The following formula was used to estimate the market opportunity in terms of price.

Market opportunity = Total market potential (in units) x Price of each unit

Investment opportunity estimation

- The total investment opportunity for each DRE livelihood technology was estimated using the following formula:

Investment opportunity = CAPEX required to manufacture 1 unit of technology x Product deployment potential of the technology in Odisha

- The total investment opportunity for the value chain was estimated based on the sum of the investment opportunity for the 12 technologies.
- Stakeholder consultations were conducted with 10 enterprises to understand the capital expenditure required for setting up one manufacturing unit of the respective DRE technology. The data on capital expenditure for setting up a manufacturing unit for solar refrigerators was derived using the solar cold storage number as a proxy. Further, the production capacity number for a solar refrigerator manufacturing unit was arrived at by multiplying the cold storage number by 5 to account for the difference in inherent capacities of the two technologies. Similarly, cold storage data was also used as a proxy to estimate the investment opportunity for solar bulk milk chillers. However, since bulk milk chillers are of higher capacities similar to that of cold storages, the production capacity was assumed to be the same. Assuming a constant production capacity for each technology from 2024-2030, the numbers were multiplied by 7 to estimate the projected units of DRE livelihood technologies that can be manufactured in Odisha by 2030. The projected production capacity till 2030 was multiplied with the product deployment potential (market potential) of each technology in the state and summed to calculate the investment opportunity in the sector.

Table 3 Market size (based on total potential of the state)

DRE technology	Product deployment potential	Price (In INR)	Market size (INR)	Market size (USD Million)	Market size (USD Billion)
Bulk milk chiller	**55**	709,015	38,995,825	0.470	0.00047
Solar cold storage	**2,762**	1,400,000	3,866,800,000	46.588	0.04659
Solar dryer	**44,881**	107,000	4,802,267,000	57.859	0.05786
Grain milling	**28,006**	730,986	20,471,993,916	246.651	0.24665

Solar loom	**16,517**	177,600	2,93,34,19,200	35.342	0.03534
Solar refrigerator	**50,841**	80,000	4,067,280,000	49.003	0.04900
Micro food processing	**11,158**	137,780	1,537,349,240	18.522	0.01852
Vertical fodder unit	**17,897**	42,000	751,674,000	9.056	0.00906
Reeling	**569**	32,000	18,208,000	0.219	0.00022
Charkha	**20,116**	50,950	1,024,910,200	12.348	0.01235
Micro solar pump	**55,949**	45,000	2,517,705,000	30.334	0.03033
Higher HP pumps	**410,338**	250,000	102,584,500,000	1235.958	1.23596
Sewing machines	**7,056**	16,000	112,896,000	1.360	0.00136
Aerators	**46,100**	60,000	2,766,000,000	33.325	0.03333
Total	**712,245**		**147,493,998,381**	**1777.04**	**1.77**

Table 4 Market size calculations from 2024-2030 (based on projections)

DRE technology	Product deployment potential	Price (In INR)	Market size (INR)	Market size (USD Million)	Market size (USD Billion)
Bulk milk chiller	**54**	709,015	38258829	0.5	0.00046
Solar cold storage	**2755**	1,400,000	3856613247	46.5	0.04647
Solar dryer	**44715**	107,000	4784471366	57.6	0.05764
Grain milling	**28004**	730,986	20470474248	246.6	0.24663
Solar loom	**16516**	177,600	2933160748	35.3	0.03534
Solar refrigerator	**50831**	80,000	4066448428	49.0	0.04899
Micro food processing	**11146**	137,780	1535630631	18.5	0.01850
Vertical fodder unit	**17893**	42,000	751490638	9.1	0.00905
Reeling	**278**	32,000	8894397	0.1	0.00011
Charkha	**20074**	50,950	1022791771	12.3	0.01232
Solar pumps	**455558**	147,500	67194805000	809.6	0.80958
Sewing machines	**6975**	16,000	111597163	1.3	0.00134
Aerators	**45570**	60,000	2734177953	32.9	0.03294
Total	**700,366**		**109,508,814,420**	**1319**	**1.32**

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