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Decentralised Renewable Energy Technologies for Sustainable Livelihoods

Market, Viability, and Impact Potential in India

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Results and Conclusion

1. Results

In this section, we share key findings about the market and livelihood impact potential of mature DRE livelihood technologies across states and the feasibility of their impact realisation. We also provide guidance on business and financial models using the impact-feasibility framework.

1.1. Market maturity of DRE livelihood technologies

In recent years, many innovators and manufacturers have ventured into DRE livelihood technologies, developing energy-efficient technologies powered through clean energy. Table 1 captures various DRE livelihood technologies that are commercially available in the country, especially in the textiles, agriculture, and allied sectors. While we have attempted to capture all available DRE livelihood applications, the technologies listed (in Table 1) may not represent an exhaustive list. Moreover, several technologies are in various levels of early product development – ideation, design, technical pilots, etc. Such technologies are not included here.

Table 1: Few DRE livelihood technologies have scaled to reach thousands of users.

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		

Source: Authors' compilation; stakeholder consultation

Table 1 classifies the DRE livelihood technologies based on their current scale of deployments.[1] About 19 of these technologies already have at least 50 installations, some ranging into hundreds, others in thousands, and a few in the tens and hundreds of thousands. Focusing on commercially mature technologies can help create success stories for the sector, which can in turn attract and boost the confidence of key stakeholders such as governments, financiers, investors, and civil society organisations. These mature DRE technologies include higher-capacity water pumps, micro pumps, dryers, grain-milling machines, small (multipurpose) horticulture processors, small

[1] Estimated based on publicly available information and through consultations with ecosystem stakeholders like technology manufacturers, industry bodies, sector CSOs etc.

refrigerators/deep freezers, cold storages, silk-reeling machines, charkhas, looms, sewing machines, sugarcane crushers, fodder growing units, milking machines, and animal repellers.

Given the data, resources, and time constraints, we have analysed only 12 mature DRE livelihood technologies which find application in the agriculture and the textile sector. Going forward, we plan to expand our analysis to include other mature DRE livelihood technologies.

1.2. Current scale of deployments and livelihood impact of mature DRE livelihood technologies

We summarise the estimated number of current deployments and the associated livelihood impact of mature DRE livelihood technologies in Table 2. Just 12 mature DRE livelihood technologies have already impacted more than 566,000 livelihoods across India. Thus far, the solar-powered higher capacity water pumps are the most mature among these technologies (with more than 520,000 installations), followed by solar-powered silk reeling machines (with ~14,000 installations). Even though the gap between the two technologies is significant, government subsidy programmes have been key to the large-scale deployment of both technologies. In fact, solar pumps account for almost 95 per cent of the ~547,000 DRE livelihood technologies installed. Government schemes play a critical role in mainstreaming technology in its early adoption days through awareness creation and fiscal support.

Table 2: The 12 mature DRE livelihood technologies have already impacted more than 566,000 livelihoods across India

DRE powered technology	Existing installations (numbers)	Estimated livelihood impacted
Higher capacity pump	520,000	520,000
Silk-reeling machine	14,000	14,000
Dryer	8,000	16,000
Charkha	2,000	2,000
Micro pump	1,500	1,500
Small horticulture processor	600	1,200
Small refrigerator/deep freezer	500	500
Cold storage	350	10,500
Vertical fodder grow unit	210	737
Grain-milling machine	100	200
Loom	70	140
Bulk milk chiller	50	50

Total	547,380	566,827

1.3. Impact and market potential of mature DRE livelihood technologies

We estimate that the 12 commercially mature DRE livelihood technologies in the agriculture and textile sectors can potentially impact at least **37 million livelihoods**. This livelihood impact potential translates into a revenue opportunity worth **USD 48 billion** for enterprises deploying and commercialising such technologies. In Table 3, we summarise the estimated deployment and livelihood impact potential for each of the mature DRE livelihood technologies.

Table 3: The 12 mature DRE livelihood technologies have the potential to impact 37 million livelihoods across India

DRE livelihood technology	# of livelihoods that can be impacted (in million)	Market potential (in billion USD)
Vertical fodder grow unit	11.9	1.8
Higher capacity pump	8.2	26
Cold storage	4.3	2.5
Micro pump	3.4	2.0
Dryer	3.4	2.3
Grain milling	1.9	8.7
Loom	1.2	1.2
Small refrigerator/deep freezer	1.2	1.5
Small horticulture processors	1.1	0.8
Charkha	0.4	0.2
Bulk milk chiller	0.1	0.8
Silk reeling machines	0.1	0.03
Total	**37**	**48**

Source: Authors' compilation

Given the large number of farmers in the country, **solar-powered pumps—both higher capacity and micro pumps— have the maximum deployment potential**, followed by solar-powered vertical fodder growing units and solar dryers. Collectively, these 4 technologies alone can impact around 27 million livelihoods. Additionally, even though the deployment potential of solar-powered cold storages is lower (~142,000 units), they can impact **more than 4 million livelihoods,** as each unit can impact an average of 30 farmers.

Further, Table 4 shows the distribution of market and livelihood impact potential among Indian states.

Table 4: State-wise distribution of market and impact potential

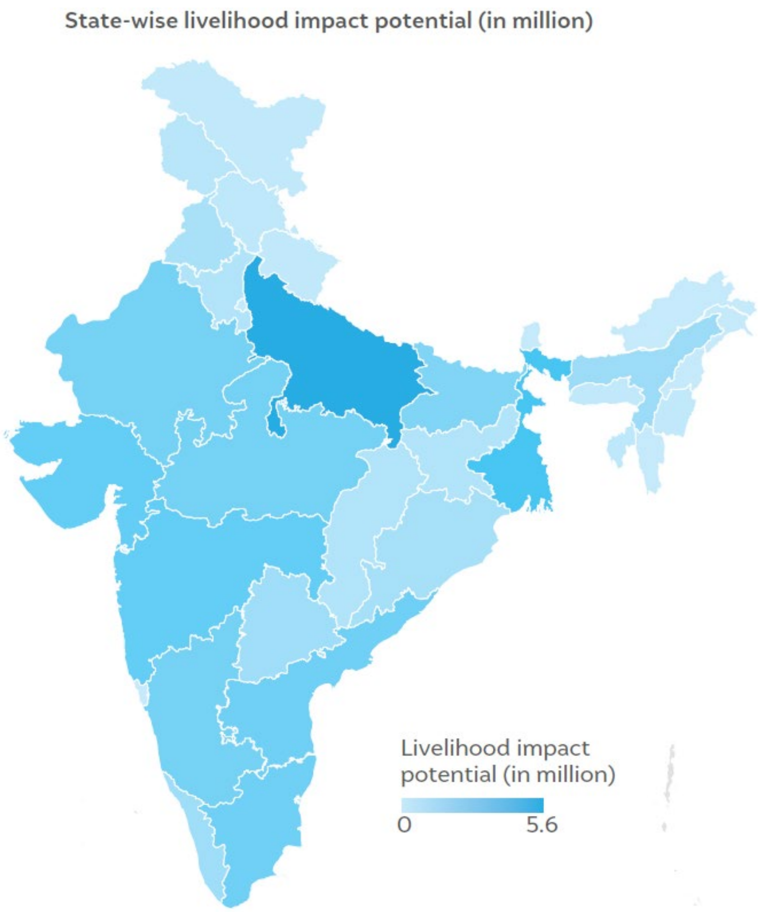
State	# of livelihoods that can be impacted	Market potential INR (in crore)	Market potential USD (in million)
A & N Islands	12,056	158	20

Andhra Pradesh	2,453,414	18,217	2,306
Arunachal Pradesh	21,462	362	46
Assam	1,235,600	18,346	2,322
Bihar	1,997,070	20,012	2,533
Chandigarh	4,618	15	2
Chhattisgarh	590,388	10,655	1,349
D and N Haveli	1,083	20	3
Daman and Diu	1,808	15	2
Delhi	41,932	532	67
Goa	35,748	377	48
Gujarat	2,825,884	34,413	4,356
Haryana	630,906	3,555	450
Himachal Pradesh	173,229	1,921	243
Jammu & Kashmir	433,207	3,519	445
Jharkhand	569,507	7,352	931
Karnataka	2,267,444	14,113	1,786
Kerala	1,054,177	6,535	827
Lakshadweep	856	14	2
Madhya Pradesh	2,409,300	38,367	4,857
Maharashtra	2,803,541	30,751	3,893
Manipur	110,469	1,306	165
Meghalaya	63,304	603	76
Mizoram	28,318	350	44
Nagaland	47,685	806	102
Odisha	884,670	14,471	1,832
Puducherry	8,010	80	10
Punjab	832,594	6,036	764
Rajasthan	2,339,375	18,928	2,396
Sikkim	10,251	108	14
Tamil Nadu	2,464,889	15,331	1,941
Telangana	1,115,238	6,639	840
Tripura	183,359	1,697	215
Uttar Pradesh	5,587,759	68,113	8,622
Uttarakhand	143,557	2,141	271

West Bengal	3,735,555	32,719	4,142
Total	37,118,260	378,576	47,921

Among states, India's most populous state, **Uttar Pradesh**, has unsurprisingly the highest potential for impact, with the ability to benefit **5.6 million livelihoods**, followed by West Bengal **(3.7 million),** Gujarat **(2.8 million),** Maharashtra **(2.8 million)**, Tamil Nadu **(2.5 million)**, Andhra Pradesh **(2.5 million)**, Madhya Pradesh **(2.4 million)**, Rajasthan **(2.3 million)**, Karnataka **(2.3 million)**, and Bihar **(2 million)**. Figure 1 illustrates the relative livelihood impact potential of the 12 mature DRE livelihood technologies in the agriculture and textile sectors across these states.

Figure 1: Uttar Pradesh has the greatest impact opportunity for DRE livelihood technologies



Source: Authors' compilation

While Figure 1 represents the potential for all 12 DRE livelihood technologies, the potential of each technology varies among states. For example, cold storage has the highest market in West Bengal, whereas bulk milk chillers have the highest market in Uttar Pradesh, and so on. The state-wise distribution for each of the 12 mature DRE livelihood technologies is presented in the report.

1.4 Feasibility of impact realisation (How likely is it to realise impact)

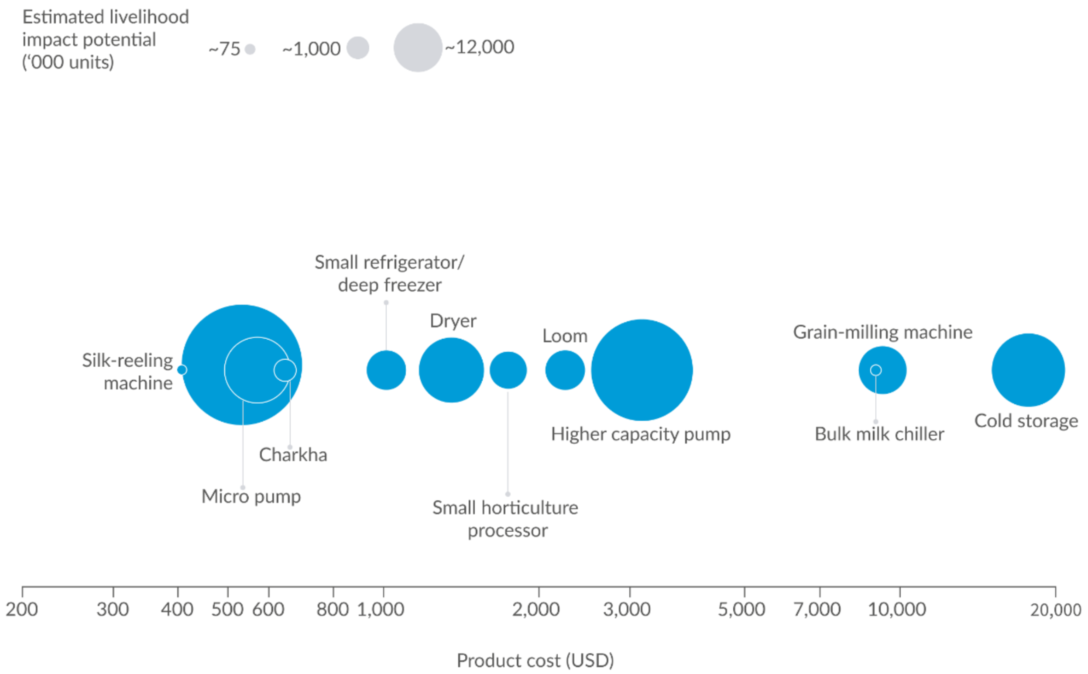
In this section, we evaluate the feasibility of realising the impact potential of each of the 12 mature DRE livelihood technologies.

We use four indicators – product cost, (typical) discounted payback period, TCO for ten years of operation, and market-linkage requirements – to reflect the relative ease of enabling the adoption of such technologies among potential customers.

Indicator 1: Product cost

The prices of DRE livelihood technologies range widely, from USD 325 (INR 25,000) for solar-powered silk-reeling machines to USD 17,000 (INR 1,400,000) for solar-powered cold storages. All DRE livelihood technologies come in different sizes and customisations and thus at different price points. For our analysis, we consider the cost of the most popular variant of each technology. Additionally, the product cost may vary across different manufacturers. We show the broad ranges and relative cost trends in Figure 2. The size of the bubble represents the associated livelihood impact potential of each technology, whereas their location on the x-axis represents their relative costs. Please note that the X-axis values are in the log scale.

Figure 2: DRE livelihood technologies' costs are between INR 25,000 to INR 1,400,000



Source: Authors' compilation

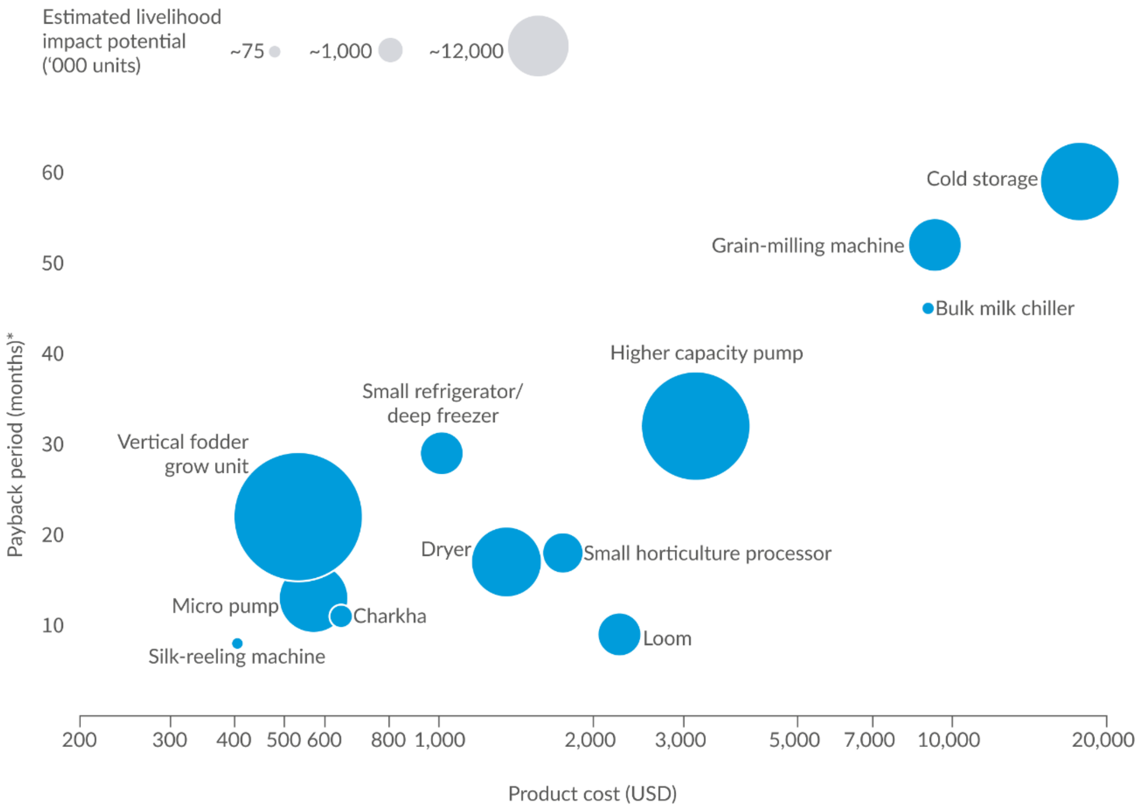
Ceteris Paribus, adoption of the products on the farther right on the chart is more difficult, given their steep upfront costs. However, several other factors also determine the likelihood of adoption, as discussed in the following indicators.

Indicator 2: Discounted payback period

The discounted payback periods for the DRE livelihood technologies are estimated based on the reported income increases by the users of these technologies. However, the income increase can vary greatly depending on the specific context of use. For instance, a solar-powered cold storage used to store potatoes would generate a very different level of income compared to one used to store high-value commodities such as lemons. Hence, for this analysis, we use the typical (i.e., median) income increases reported by the users. Since the variations in income increase is true for all these technologies, the estimated discounted periods broadly capture the relative trends across technologies.

We add the discounted payback period to Figure 2 to further prioritise high-impact, high-feasibility options (see Figure 3). The relative location of each technology's bubble on the y-axis now reflects its typical discounted payback period. *Ceteris Paribus*, the products lower on the y-axis, i.e., having shorter discounted payback periods, are more likely to find traction among the end users and financiers.

Figure 3: Technologies with shorter payback periods may find more traction among users and financiers



Source: Authors' compilation

We observe a broad positive association between a product's unit cost and the discounted payback period. For instance, all low-cost products on the extreme left of the product cost (x-axis) spectrum – solar-powered silk reeling machines, solar-powered charkhas, micro solar pumps, and solar-powered vertical fodder grow units – have a shorter discounted payback period, whereas all of the high-cost products on the extreme right spectrum – solar-powered bulk milk chillers, solar-powered grain-milling machines, and solar-powered cold storages – have a longer discounted payback period.

At the risk of generalisation, we summarise that the costlier DRE livelihood technologies have longer payback periods. However, there are a few exceptions— solar dryers, solar-powered looms, and solar-powered small horticulture processors – that have shorter discounted payback periods even with mid-range product costs. The reason behind these exceptions is the higher median income increase that results from the use of these technologies.

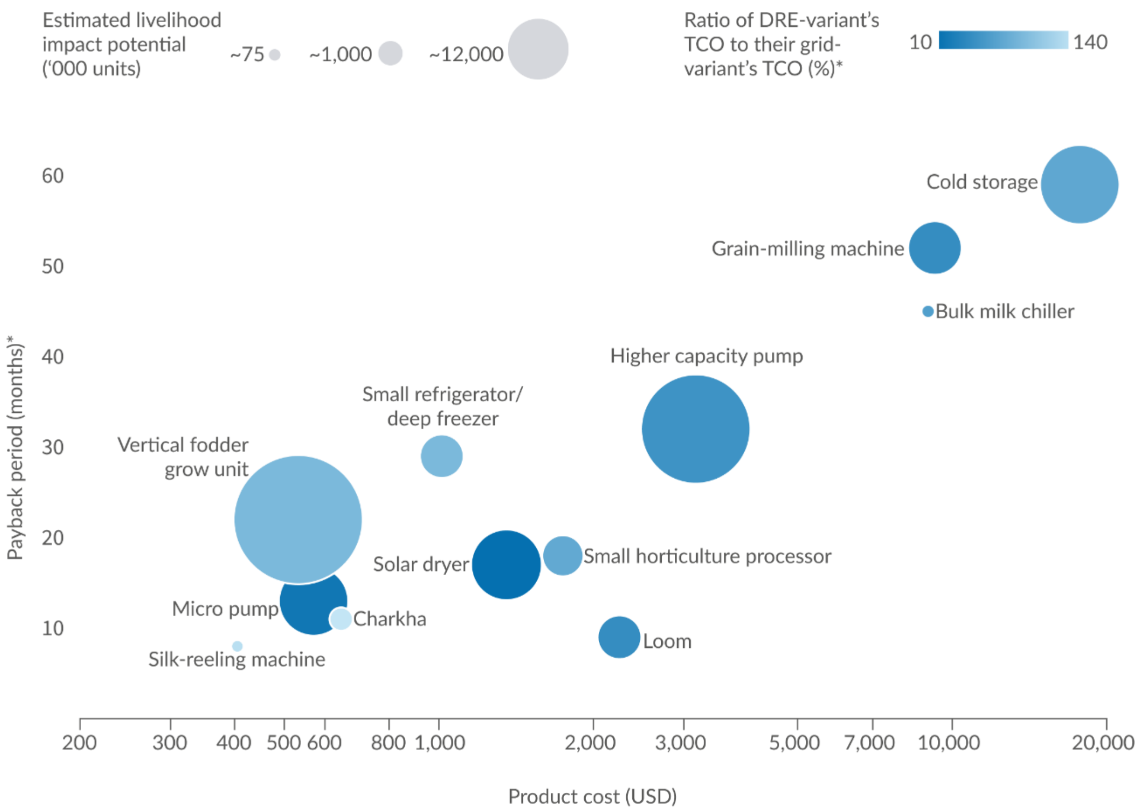
Indicator 3: TCO for ten years of operation

The next dimension of feasibility, long-term 'total cost of ownership', becomes important in the context where DRE products need to compete with alternatives: grid- or diesel-powered.

Total Cost of Ownership (TCO) for a product, across all variants – DRE, grid, and diesel – depends on the product's annual utilisation. Product usage differs for each user. We consider typical usage patterns for each product based on surveys with users to estimate these costs. We use the Net Present Value of TCO across all analyses.

We compare the TCO across different variants – DRE, grid, 'grid with backup', and diesel. We discuss the cost comparison across all variants in the subsequent sections. In Figure 4, the shade of the bubbles (from light to dark) is now determined by the ratio of the TCO of the DRE variant to the grid-with-backup variant – except in the case of pumps, where we compare the DRE variant with the diesel alternative. The darker the shade of the bubble, the lower the TCO of the DRE variant compared to the grid/diesel alternative.

Figure 4: Solar dryers, fodder-growing units, and looms are highly economically attractive than their grid variants.



*Note: The comparisons are made for the typical investment horizon (10 years) and the typical rural grid availability (4-hour backup requirement). For solar pumps, comparison has been made with diesel variant.

Source: Authors' compilation

In Figure 4, we observe that solar dryers, solar-powered grain-milling machines, solar water pumps, and solar-powered looms show a darker bubble shade, making them economically more attractive when compared to the grid/diesel alternatives.

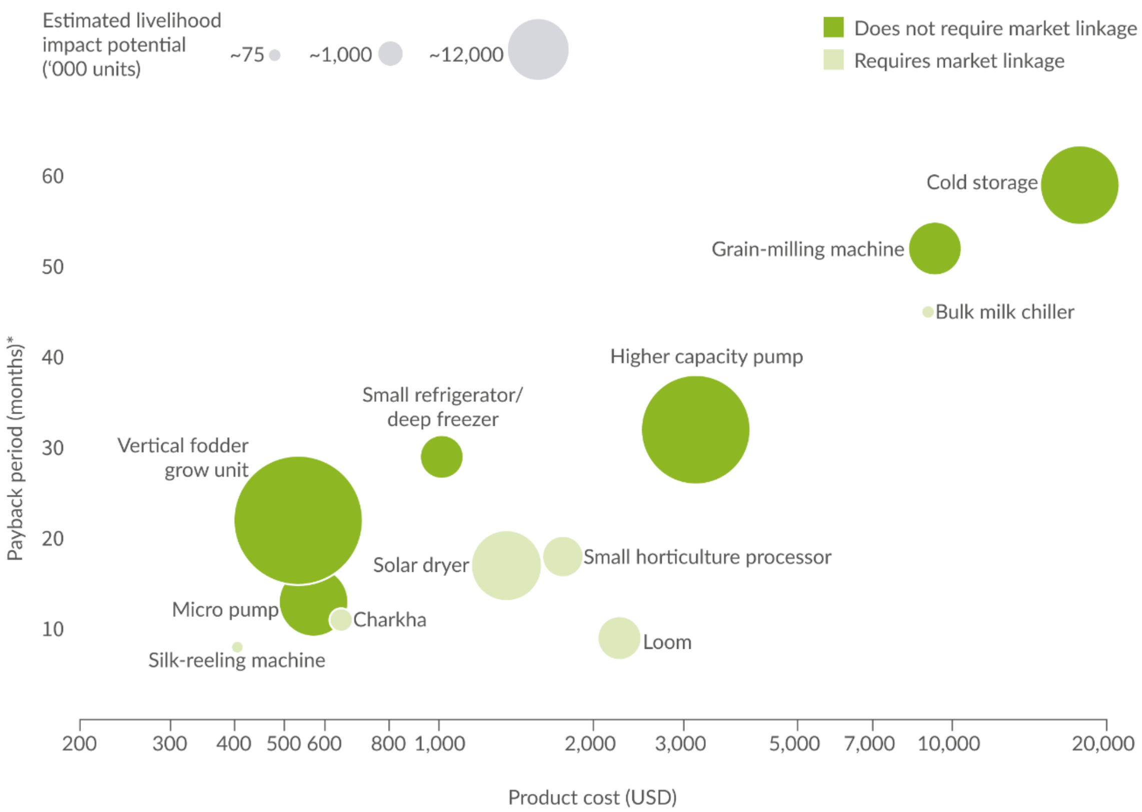
However, for small solar refrigerators, solar-powered vertical fodder grow units, solar-powered small horticulture processors, solar-powered bulk milk chillers, and solar-powered cold storages, DRE variants bring only marginal savings over a 10-year horizon compared to their grid-based alternatives. However, in a 15-year horizon, the DRE variants of even such technologies become much more attractive than the grid variants. So, if an end user is considering a business horizon of 10+ years, the DRE technologies could be economically more attractive.

Finally, the solar-powered silk reeling machines and solar-powered charkhas have lower upfront costs and shorter discounted payback periods, but higher 10-year TCO compared to their grid-based alternatives.

Indicator 4: Market-linkage requirements

Finally, instead of colouring the bubbles with the comparative costs of the grid alternatives, we colour the bubbles based on whether the DRE livelihood technologies need an explicit market linkage for users to earn income. Therefore, based on the market linkage requirements, we have categorised the DRE livelihood technologies in Figure 5 into two categories – light shade for products requiring market linkages and dark shade for products not requiring market linkages. The products with the darker shade (i.e., which do not need a market linkage) would have lower barriers to adoption, *ceteris paribus*.

Figure 5: DRE livelihood technologies for local demands may experience better adoption



Source: Authors' compilation

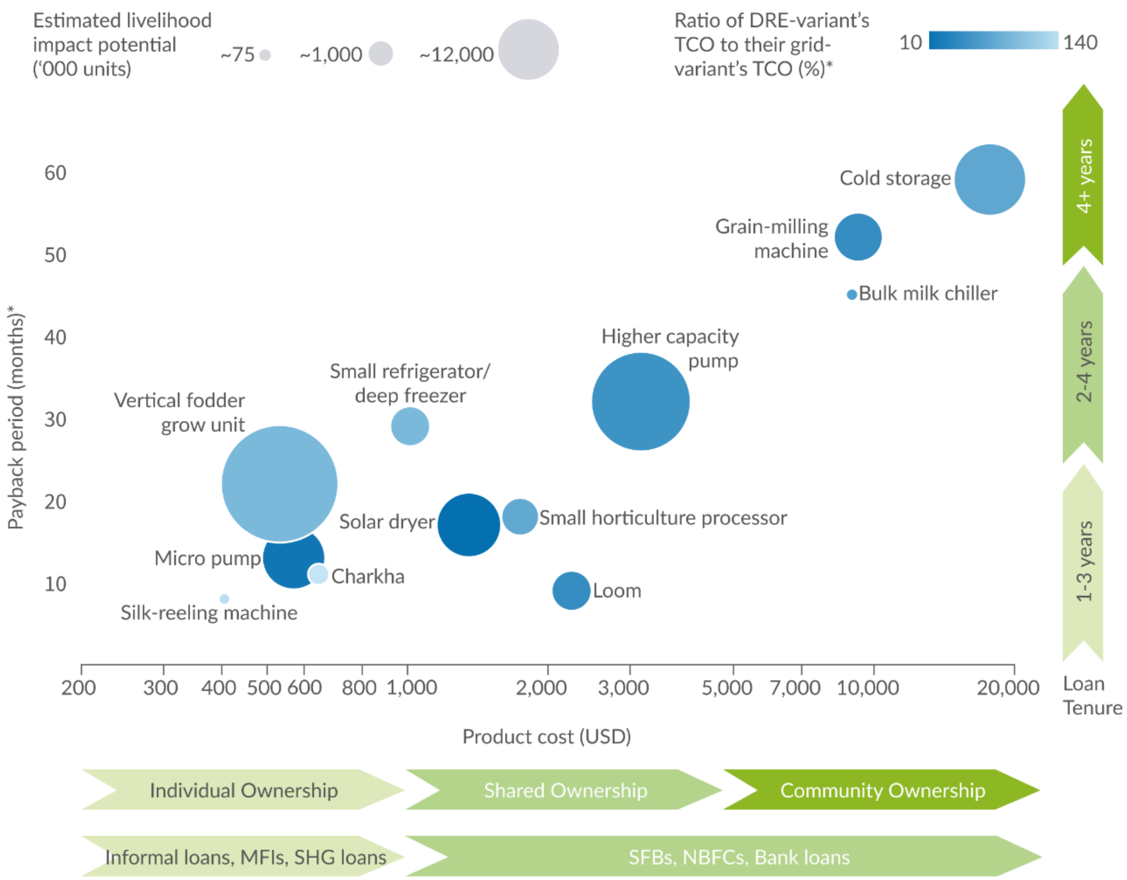
As shown in Figure 5, the products with dark green bubbles, i.e., solar water pumps, solar-powered vertical fodder units, small solar refrigerators, solar-powered grain-milling machines, solar-powered cold storages and solar-powered bulk milk chillers, would have lower barriers to adoption since there are typically no market-linkage requirements.

Without market linkages or a buyback guarantee, users may struggle to increase their incomes by using products with light green bubbles. Solar dryers, solar-powered silk reeling machines, solar-powered charkhas, solar-powered looms, and solar-powered small horticulture processors may therefore witness relatively limited uptake – *ceteris paribus* – unless supported with market linkage.

1.5 Leveraging the impact-feasibility framework to guide business and financing models

In addition to identifying high-potential and high-feasibility technologies, the impact-feasibility framework also provides insights for developing strategies for business, financing, and stakeholder-engagement models for these DRE livelihood technologies.

Figure 6: The product cost and payback period can help guide ownership models, source of financing, and loan tenures



*Note: The comparisons are made for the typical investment horizon (10 years) and the typical rural grid availability (4-hour backup requirement). For solar pumps, comparison has been made with diesel variant.

Source: Authors' compilation

For instance, the cost of a product can be used to identify target customer segments. As shown in Figure 6, products with lower costs (on the left side of the spectrum) would be relatively easy for rural households to adopt under individual ownership models. As the cost of products rises, shared and group ownership models would become more prevalent. Accordingly, entrepreneurs and promoters can target farmer cooperatives, producer organisations, etc., to sell such technologies. Of course, there will always be exceptions. For example, individual large farmers may still be able to independently own cold storages, and even a micro solar pump may be owned by four to five marginal farmers together.

Similarly, the product cost can also guide the engagement strategy for the kind of financiers that should be targeted for different products. Lower-cost products may be best supported by loans from self-help groups (SHGs), micro-finance institutions, and small finance banks. In contrast, relatively costlier products would be best supported by NBFCs and banks.

Next, the typical payback periods for these technologies can help guide financiers on the design of the loan products and loan tenures, ensuring that loan tenures are long enough for the product owners to effectively repay the EMIs.

2. Conclusion

DRE livelihood technologies provide a significant opportunity to impact tens of millions of livelihoods nationwide. Many of the technologies also offer reasonably attractive economic returns. Yet, we have not seen the adoption of these technologies at scale. Based on this research, but also our experience with the Powering Livelihoods programme, we see three critical gaps that need to be bridged to translate this impact into reality.

One: generating awareness and igniting demand for these technologies. The vast majority of the potential customers and rural population are unaware of the DRE livelihood technologies and how they can positively impact their lives and livelihoods. Sector stakeholders must put concerted efforts towards awareness generation among target population groups.

Two: enabling end-user financing for these technologies. Customer awareness and demand ignition are necessary but not sufficient to enable the adoption of these technologies. Given their high upfront costs, most DRE livelihoods need point-of-sale financing to enable adoption among rural communities.

Three: convergence to ensure ecosystem support to end users. Where a DRE livelihood technology improves an existing livelihood, the users may not need much support beyond adopting the product to ensure effective additional income. However, for new or additional livelihoods, the users may need skilling and market-linkage support to realise the income impact. Thus, the convergence with livelihood-support departments and organisations can go a long way in mainstreaming such technologies and realising their impact.

To conclude, DRE livelihood technology offers the potential for a significant impact and market opportunity. The report helps decision-makers – policymakers, investors, donors, enterprises, and community-support organisations – navigate the space to unlock maximum impact for marginalised communities.

To access the full report, Decentralised Renewable Energy Technologies for Sustainable Livelihoods: Market, Viability, and Impact Potential in India, please scan the following QR code
or visit https://www.ceew.in/publications/decentralised-renewable-energy-technologies-for-sustainable-livelihoods-india

Acronyms

AC	alternating current
CEEW	Council on Energy, Environment and Water
CGWB	Central Ground Water Board
DC	direct current
EMI	equated monthly instalments
DAC&FW	Department of Agriculture, Co-operation and Farmers Welfare
DRE	decentralised renewable energy
HP	horsepower
INR	Indian rupee
kW	kilowatt
MFI	microfinance institutions
MNRE	Ministry of New and Renewable Energy
MoMSME	Ministry of Micro, Small and Medium Enterprises
MSME	Micro, Small and Medium Enterprises
NBFC	non-banking financial companies
NIC	National Industrial Classification
NSS	National Sample Survey
NSSO	National Sample Survey Office
PL	Powering Livelihoods
SHGs	self help groups
TCO	total cost of ownership
USD	United States dollar
VA	volt-ampere

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Shifting from conventional to solar pumps results in significant reductions in emission & input costs for farmers, impacting the lives of as many marginal farmers.

Source: CEEW Analysis

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