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MINISTRY OF
NEW AND
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G20
भारत 2023 INDIA
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Decentralised Renewable Energy for SDG7

A Compendium of Global Good Practices

Report | July 2023

CEEW
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Acknowledgment

The Council on Energy, Environment and Water (CEEW) is privileged to support the Ministry of New and Renewable Energy (MNRE), Government of India, as Knowledge Partner for the Energy Transition Working Group of India's G20 Presidency.

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भूपिन्दर सिंह भल्ला, भा.प्रा.से.
सचिव

Bhupinder S. Bhalla, IAS
Secretary

भारत सरकार
नवीन और नवीकरणीय ऊर्जा मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

Foreword

The significance of Decentralised Renewable Energy (DRE) is a quintessential pillar for energy transition and achieving universal energy access. DRE not only offers sustainable and clean energy sources but also plays a pivotal role in economic development. By providing access to affordable and reliable energy, DRE technologies create new avenues for businesses, stimulate job growth, and empower communities.

India, at the forefront of the DRE revolution, has implemented several large-scale programmes that serve as notable examples of our commitment to sustainable energy. The Ujala scheme, for instance, has achieved remarkable success in promoting energy-efficient lighting solutions – millions of LED bulbs have been deployed across the country, resulting in significant energy and carbon emissions savings. The *PM - Kisan Urja Suraksha evam Utthaan Mahabhiyan* (PM-KUSUM) programme promotes solar-powered agricultural pumps, empowering farmers and reducing their dependence on conventional energy sources. These initiatives, among others, demonstrate India's leadership in championing DRE and showcase the transformative impact it can have on our society and economy.

Similarly, there are commendable success stories from around the world. For instance, the Bangladesh Solar Home System Programme has brought electricity access to millions of rural households, and Kenya's Off-Grid Solar Revolution has accelerated energy access and economic growth. These and many more global experiences underscore the potential of DRE in addressing energy poverty, combating climate change, and fostering inclusive development.

Global cooperation in the field of DRE is of utmost importance. By sharing knowledge, best practices, and lessons learned, we can collectively expedite the deployment and scale-up of DRE technologies. The G20, as a platform for international collaboration, offers immense opportunities to further the global support and commitment towards scaling DRE. Through shared experiences and collaborative efforts, we can ensure a sustainable and equitable energy future for all.

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The Compendium of Decentralised Renewable Energy (DRE) Good Practices for SDG7 is an endeavour to kickstart conversations and actions in this regard. This report serves as a valuable toolkit for policymakers and practitioners, providing insights and guidance for the Global South. It highlights the potential for regional cooperation and the importance of knowledge sharing in advancing the DRE agenda.

I extend my compliments to the Council on Energy, Environment and Water (CEEW) for their role in drafting this report. Their hard work for developing a compendium based on intensive research and a methodical approach has been instrumental in bringing this project to fruition. I would also thank all the contributors and partners who have generously shared their valuable insights and experiences.

This is a unique opportunity for all of us to engage in global conversations and catalyse action. Together, we can create a more sustainable, inclusive, and prosperous future, leaving no one behind. I am confident that this report will inspire stakeholders worldwide to embrace the transformative power of DRE.

(Bhupinder S. Bhalla)

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In Chhattisgarh, India, ~1,500 healthcare facilities — 785 primary health centres, 525 sub-health centres, 165 community health centres, and 26 district hospitals — have been electrified using solar-PV technology. Apart from meeting basic electricity demand, solar-PV technology also powers cold storage for medicines, critical vaccines, and diagnostic chemicals.

Image: Sanjeev Jain CREDA

Preface

Dr Arunabha Ghosh
CEO, CEEW

Decentralised renewable energy is an imperative to attaining universal energy access and a global clean energy transition. But how do we mainstream DRE? By the start of this decade, almost 91 per cent of the global population had access to electricity. Yet, in regions such as sub-Saharan Africa (SSA), the number of people without access continues to grow alarmingly. DRE has emerged as a key lever in such settings as it offers faster and more cost-effective solutions for increasing electricity access. In 2021 alone, 179 million people gained access to electricity from DRE solutions, up from 35 million in 2012 — a 5x growth.

DRE solutions also offer opportunities to capitalise on local resources and enable citizen-centric approaches to address a wide range of needs across residential, productive use, and institutional applications. DRE is increasingly being leveraged as a reliable and sustainable approach to meet the energy needs of industries, agriculture, healthcare, and education, in turn creating jobs and improving socio-economic development.

The DRE cases from around the globe studied for this report reveal that often, similar challenges are hindering deployment at scale, and there is significant value in learning from each others' experiences. Moreover, scaling up DRE technologies and accelerating the implementation of cross-border DRE programmes need global cooperation through knowledge sharing.

The G20 is a powerful platform to facilitate such global cooperation. This Compendium of Best Practices in DRE, covering policy, financing, technology, market creation, community engagemen, and innovation, will serve as an effective guide for policymakers, industry, and civil society in designing new DRE interventions to fast-track progress towards Sustainable Development Goal 7.

An Indian farmer using a solar-powered dryer to preserve perishable items such as fruits, vegetables, and flowers.

Image: CEEW/EmotiveLens

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A family using solar power on Peru's Lake Titicaca's Islas de los Uros, or Floating Tortora Reed Islands.

Image: Alamy

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Acronyms

ADEREE	Agency for the Development of Renewable Energy and Energy Efficiency
AIF	Agriculture Infrastructure Fund
ALTERRE	Agrocarburants Locaux TERritoires Ruraux et Énergie (Local Biofuels Rural Territories and Energy)
BOP	bottom of the pyramid
CDM	Clean Development Mechanism
CEFA	European Committee for Training and Agriculture
CER	Certified Emission Reduction
CO_2	carbon dioxide
CPEE	Comprehensive Plan on Energy Efficiency
CREDA	Chhattisgarh Renewable Energy Development Agency
CSR	corporate social responsibility
DEAT	Department of Environmental Affairs and Tourism
DRE	decentralised renewable energy
EESL	Energy Efficiency Services Limited
ELCOMA	The Electric Lamp and Component Manufacturers Association of India
EnDev	Energy for Development
ERRY	Enhanced Rural Resilience
ESD	Energy Service Delivery
EU	European Union
FiT	feed-in-tariff
GBA	Green Business Area
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
HH	Household
IDCOL	Infrastructure Development Company Limited
KazEE	Kazakh Energy Expertise
KW	Kilowatt
LAERFTE	Law for the Development of Renewable Energy and Energy Transition Financing
LDCs	least developed countries
LED	light-emitting diode
LiFE	Lifestyle for Environment
LMIC	low- or middle-income countries
MECCT	Ministry of Environment, Climate Change and Technology
MFIs	microfinancing institutions
MNRE	Ministry of New and Renewable Energy
MSEA	Moroccan Solar Energy Agency
$MtCO_2$-eq	metric tons of carbon dioxide equivalent
NDDB	National Dairy Development Board

NDDB MRIDA Ltd.	National Dairy Development Board – Milk Rural Infrastructure Development Agency Limited
NEP	Nigeria Electrification Project
NGO	non-governmental organisation
ONE	Office Nationale de l'Electricité
OPEC	Organization of the Petroleum Exporting Countries
PAYGO	pay-as-you-go
PERG	Renewable Energy and Global Rural Electrification Programme
PERMER	Renewable Energy for Rural Markets Project
PPHCs	Powering Primary and Community Healthcare Centres
PHCs	Primary and Community Healthcare Centres
PLN	Perusahaan Listrik Negara
PM KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
POISED	Preparing Outer Islands for Sustainable Energy Development
PPA	Power Purchase Agreement
PPP	public–private partnership
PSL	priority sector lending
PV	Photovoltaic
R&D	research and development
RBI	Reserve Bank of India
RE	renewable energy
REEP	Renewable Energy and Energy Efficiency Partnership
REPP	renewable energy-based power plants
REB	Rural Electrification Board
RERED II	Rural Electrification and Renewable Energy Development II
SAEDF	South African Export Development Fund
SDG	Sustainable Development Goals
SHS	solar home systems
SNV	Stichting Nederlandse Vrijwilligers
SSN	South South North
UJALA	Unnat Jyoti by Affordable LEDs for All
UNDP	United Nations Development Programme
USD	United States dollar
USAID	United States Agency for International Development
VSEs	very small enterprises

Use of solar water heater in Kenya. It enables access to hot water in remote villages of Africa

Image: Alamy

Executive summary

A just and inclusive global energy transition is incomplete without universal energy access. At the current pace of progress, the IEA estimates that 660 million people in the Global South will still lack electricity access by 2030 – the year targeted to achieve the Sustainable Development Goals (SDGs) (IEA 2022b). Even as the centralised grids expand, decentralised renewable energy (DRE) is playing a significant role in bridging the energy access gap, both as an alternative and as complimentary to centralised grid systems. In 2021 alone, 179 million people gained access to electricity from DRE solutions - up from 35 million in 2012 (IRENA 2022a). DRE offers faster and more cost-effective solutions to increasing electricity access in rural or remote areas with lower population densities. Additionally, meeting the energy demand of emerging economies via renewable sources allows for a 'double leapfrog' towards energy access and clean energy (Jain et al. 2021). Thus, it is essential to recognise and mainstream DRE in order to realise a citizen-centric global energy transition.

A. A compendium on 'good practices to mainstream DRE for SDG7'

The compendium meticulously identifies and collates the emerging good practices to mainstream DRE solutions. Envisioned as a **'practitioners' guide' for the public- and private sector leaders,** it synthesises 'replicable and actionable lessons' to fast-track DRE deployment for achieving the SDGs.

B. Research approach

The compendium employs a literature review, multi-stage case selection, and **'inductive reasoning'** to identify and analyse DRE good practices. More than 120 DRE case studies were identified across the globe through a snowballing technique. Multi-stage shortlisting criteria led to the final selection of **27 DRE case studies spanning 5 continents, 22 countries, and 10+ DRE intervention categories.**

C. Emerging DRE good Practices

The good practices span **five core areas** that are most critical for igniting and growing the DRE sector in any region of the globe. These include *an enabling policy environment, active community engagement, accessible and affordable financing, a thriving market ecosystem, and a conducive environment for innovations.*

Good practices to create an enabling policy environment:

An enabling policy environment often forms the basis for the adoption and scaling-up of DRE interventions, given the high upfront costs and perceived risks. The policy environment should aim to achieve one or more of the following three objectives: **providing long-term policy certainty**, the **flexibility to encourage innovation and adapt** as the market grows and new challenges arise, and **ensuring effective implementation**. Several good practices to create an enabling policy environment have been identified from the case studies, which help implementing countries in achieving these objectives, and, thus, lead to the successful adoption of the intended DRE technology among the beneficiaries. The most common five good practices are listed below:

- Formulate dedicated policies for DRE solutions with a long-term vision to provide market certainty.
- Complement the vision with DRE-specific targets (embedded within national energy access plans and strategies) and legislative action, which are adaptive, both at the national and sub-national levels.
- Ensure closer alignment between federal and regional agencies for effective planning and implementation.
- Build capacity of agencies and organisations involved in design, implementation, and monitoring of DRE programmes.
- Frame technical standards and regulatory frameworks to ensure the long-term sustainability of the DRE intervention

Figure ES1 Summary of emerging good practices for creating an enabling policy environment.

Essentials for an enabling policy environment

Long-term certainty	• Create long-term vision with time-bound targets • Back long-term vision with legislative action
Adaptive and market responsive	• Adaptive implementation approach provides an opportunity to improve policy components, in response to market dynamics
Effective implementation	• Align sub-national actors with national policy • Support capacity building of implementing agencies • Leverage regulatory frameworks and technical standards for quality assurance

Source: Authors' analysis

Good practices to encourage active community/end user engagement:

In order to ensure a citizen-centric approach to the energy transition, community engagement is a critical part of DRE interventions. The analysis reveals three levels of community engagement beyond stakeholder consultations that can be adopted to achieve higher community participation. These include **total buy-in from the community**, **a sense of ownership among the community members**, and **nurturing community leadership**. The most recurring good practices that can further these objectives are:

- Design with and for the community by involving them from the early stages of the intervention.
- Anchor the projects with community institutions for quicker outreach and to gain greater trust.
- Actively plan for community engagement across design, implementation, and monitoring to enhance the sense of ownership.
- Invest patiently in the community's capacity to spur local job creation and support the long-term maintenance of assets.

Figure ES2 Summary of emerging good practices for active community engagement.

What works for effective community engagement?

Create sense of ownership

- Enable community contributions
- Support local job creation and capacity building

Get community buy-in

- Community-centric design
- Engage prevailing community institutions

Nurture community leadership

- Foster local entrepreneurship
- Invest in local service ecosystem

Source: Authors' analysis

Figure ES3 Summary of emerging good practices for providing accessible and affordable financing.

Source: Authors' analysis

Good practices for providing accessible and affordable financing:

The adoption of DRE solutions is hindered by their substantial initial investment requirements. Access to affordable financing is essential at the programme, project, and individual-user levels. The case studies show that financing interventions have two common objectives: creating accessible financing options for the targeted beneficiaries and reducing the financing cost, especially initial investment costs. Good practices that can achieve either or both of these objectives are:

- Extend "targeted" fiscal incentives to reduce upfront cost of DRE solutions. Public financing instruments (e.g. grants, concessional debt) are also critical.
- Design tailored financing instruments rooted in local context and strengthen capacity of local financing institutions (e.g. cooperative banks, MFIs, banks) for long-term market development.
- Leverage a diversity of capital sources (public, philanthropy, development finance, private capital) to reduce financial risks and unlock greater capital.

Good practices to enable a thriving market ecosystem:

A thriving market ecosystem that supports DRE technology is essential for achieving adoption at scale and long-term sustenance. Such a market system requires ensuring skilled resource availability, financial viability, access to markets, revenue generation opportunities, and availability and access to the latest cost-effective technologies. This enables greater consumer choice and better services for citizens. The good practices that are effective in enabling thriving market ecosystem conditions are:

- Leverage DRE as an engine for job creation by complementing DRE initiatives with need-based skilling programmes.
- Direct public support to market actors.
- Build on the strengths of existing local markets and prevailing market ecosystems.
- Invest in technical collaborations, knowledge transfer, and capacity building to support the local market ecosystem.

Figure ES4 Summary of emerging good practices on thriving market ecosystem.

Source: Authors' analysis

Figure ES5 Summary of emerging good practices on conducive environment for innovation.

Essentials for a conducive environment for innovations

Indigenisation of supply chains

- Financial incentives to support manufacturing
- R&D initiatives
- Institutional partnerships

Cost reduction and scale

- Demand-side incentives
- Government procurement programmes
- Incentivising efficiency

Source: Authors' analysis

Good practices to create a conducive environment for innovations:

DRE is an emerging sector with many innovation opportunities on the technological, business, and financial fronts. A conducive environment for innovation can help reduce costs, enhance technology resilience, and create local economic opportunities. Two successful good practices to create a conducive innovation environment are:

- Deploy targeted public interventions to accelerate and promote innovative and indigenous value chains.
- Encourage and engage in cross-country partnerships at an early stage to trigger innovations in technology and business models.

D. Emerging lessons and recommendations

The analysis of DRE case studies around the globe has shown that there are similarities in the nature of challenges, particularly in the Global South, and that there is vast potential to learn from cross-country experiences. The good practices observed around policy, community engagement, financing, markets, and innovation may serve as an effective guide to designing new DRE interventions for policymakers, private players, and civil society. Based on these observations, the following recommendations are put forth:

- **DRE must be at the centre of just and inclusive global energy transitions** since it has emerged as a resilient and cost-effective approach to augment and achieve energy access in many developing countries — as showcased by a wide variety of examples in this compendium.
- As highlighted across several case studies, **DRE should no longer be looked upon as a last-mile energy access solution but should be leveraged as a reliable and sustainable approach to meet energy needs** for overall socio-economic development, furthering industries, agriculture, healthcare, education and job creation.
- **Public financing must address ecosystem-level needs of the DRE sector,** such as skills and capacity building, awareness raising, supporting technology innovation and more.
- The emerging lessons highlight the need for more active knowledge sharing across countries. **G20 should strengthen its support for mainstreaming DRE solutions across the globe by furthering avenues for active knowledge sharing among private and public sector stakeholders across countries.**

1. Background

Decentralised Renewable Energy (DRE) solutions play a crucial role in achieving universal energy access, meeting multiple objectives of a just and inclusive energy transition, and bridging the gap towards reaching our 2050 climate objectives. DRE solutions have been traditionally used to offer basic services like lighting; however, they are increasingly emerging as an alternative to centralised power generation. This is because, while DRE is environmentally friendly and contributes to cost effectiveness, lower risks, increased affordability, and reliability (van der Schoor and Scholtens 2015), it also improves quality of life by improving access to income-generating activities, healthcare facilities, and education, among others (IRENA and SELCO Foundation 2022). It is an attractive alternative as a fast and cost-effective solution to increasing electricity access in rural areas with low population density and thereby achieving global energy-access goals. Thus, meeting the energy demand of emerging markets via renewable sources allows for a 'double leapfrog' towards energy access and clean energy.

1.1 Why is DRE crucial for the global energy transition?

Progress has been made in improving electricity access and achieving universal energy access; as of 2020, almost 91 percent of global population have access to electricity (ESMAP 2022). However, we are not on-track to meet the 2030 goal and the progress has been uneven (IEA 2022c). The progress has been particularly impeded in vulnerable regions, such as sub-Saharan Africa, where the number of people without access continues to alarmingly grow (IEA 2022c). One of the key levers that can help achieve this goal are DRE solutions that are increasingly cost-effective and easy to deploy, leverage local resources, can be tailored to uses across residential, productive use and institutional applications, and are environmentally sustainable. Meeting the energy needs, therefore, through DRE helps meet multiple objectives.

DRE and the SDGs are inextricably linked. DRE has the potential to provide access to affordable and reliable electricity supply in low-income countries and to communities of low-income households (SDG 7), particularly in remote or underserved areas where access to the grid is limited or non-existent. This is salient in light of the worsening energy-poverty trends, as due to the unprecedented impact of COVID19 pandemic the number of people without access to electricity globally has begun to increase for the first time since the statistics began to be collected, according to the International Energy Agency's World Energy Outlook 2022 (IEA 2022a). This is because, up to 75 million individuals who have recently obtained access to electricity are expected to lose the capacity to pay for it due to the lingering impact of the pandemic. Meanwhile, the poorest families in emerging markets and developing countries use nine times less energy than the wealthiest households. Yet, they spend a far higher percentage of their income on energy (IEA 2022a).

Thus, DRE solutions present a viable alternative to high energy costs by providing more equitable access to energy. This is of paramount importance for the realisation of secure, people-centred energy transitions. Additionally, the fundamental benefit of enabling access to electricity through DRE solutions has a multifaceted impact on communities.

Investments to DRE, to provide energy access, also translates to higher income and employment opportunities (SDG 8) for communities and enterprises (IRENA and SELCO Foundation 2022). In India in particular, there is an opportunity to create a USD 50 billion market for new livelihood appliances through the use of DRE (Waray et al. 2018). Sub-Saharan Africa offers an investment opportunity of USD 11.3 billion to boost the incomes of 12 million farmers (World Bank Group and Lighting Global 2019). This enhances the overall capacity and resilience of communities, ultimately enabling them to invest in their own development (SDG 9).

Box 1 Decentralised Renewable Energy (DRE) solutions

DRE solutions include stand-alone systems, such as solar PV system, solar thermal systems, solar lights, home systems; productive use systems, such as water pumps, grain milling machines; mini-grids deployed to improve access in unconnected/underserved areas; solar PV for institutions and communities, among others.

Source: Authors' compilation

DRE also provides an affordable and reliable solution to accelerate access to universal and sustainable healthcare (Yasir 2020). In South Asia and Sub-Saharan Africa, only around 12-15 per cent of health facilities have access to reliable energy sources, limiting health outcomes and endangering patients (World Health Organization, the World Bank, Sustainable Energy for All and the International Renewable Energy Agency, 2023.). Therefore, the use of DRE in LMICs can boost critical healthcare services (SDG 3), enabling services like immunisation, labour and deliveries, and antenatal and neonatal care. Lastly, greater electricity access enabled by DRE has also played a key role in drawing students and teachers to classrooms (SDG 4). Electrification of educational infrastructure has encouraged schools to positively impact the whole community by acting as an integrated service delivery hub (Sustainable Energy for All 2019). These children can reap the benefits of clean water (SDG 6), nutritious meals, and primary health services in such schools, which can also act as safe environments.

1.2 Why there is a need for compendium on 'good practices to mainstream DRE for SDG7'?

While DRE has been around for a while, the sector is rapidly evolving with technological, business, market, and policy innovations. The effort of the compendium, which is a **'practitioners' guide on good practices',** is to showcase practices that can be replicated by planning agencies and help leaders and influencers in the public and private sectors mainstream DRE for achieving the SDGs. This practitioners' guide attempts to compile and synthesise best practices from a wide variety of DRE interventions across the globe. If adopted at scale, DRE can help the G20 and other developing countries achieve **more environmentally sustainable economic and job growth.**

The guide's objective is twofold:

- To showcase select experiences on DRE interventions from across the globe.
- To enable public- and private-sector leaders to mainstream DRE through good practices that have worked elsewhere.

2. Methodology

2.1. Core framework

A thorough understanding of the core building blocks and structures of a sector such as policy, community, and infrastructure, among others, is crucial to ignite transition and transformation and enable a sector to thrive. A framework around such core elements can foster strategies for an enabling environment, which can boost confidence and attract interest in a sector.

Different studies in the DRE sector mention policy, finance, community, capacity building, market, infrastructure, technology, and institutional engagements as being core to enabling the deployment of DRE solutions (IRENA 2022b, WWF-India and SELCO Foundation 2015, CLEAN 2021). As per the findings, **we plan to capture the DRE 'good practices' by deep-diving into five core elements** that are consistently considered by the literature and experts as the most critical elements for igniting transition and transformation and promoting a thriving DRE sector in any region. These are:

- **An enabling policy environment:** A policy environment that facilitates the uptake and scaling of DRE interventions can take the form of national policy frameworks, including action plans, strategies, and programmes. It also includes laws, regulatory structures, and institutions that create an enabling environment.

  As a driver of 'Lifestyle for Environment' (LiFE), such an environment can help redefine aspirations, particularly for developing countries, such as a nation's definition of economic development and its commitment to reducing its carbon footprint as per their specific circumstances.

- **Active community engagement:** Engagement through stakeholder interaction maximises community participation and community ownership of technology/products. This may also include consulting beneficiaries during product development and involving local communities in execution and skill building.

As one of the tenets of LiFE, this engagement may nudge individuals to adopt specific steps and take ownership of their choices in consumption patterns.

- **Accessible and affordable financing:** The adoption of DRE solutions is constrained by their high capital cost. To address this challenge, public and private agencies must design and offer accessible and affordable financing to tap into the DRE-deployment potential. An accessible and affordable financing model must enable both the ability to pay and willingness to pay, as this would ensure a sustainable setup for scaling up DRE technologies.
- **A thriving market ecosystem:** This entails creating an economically competitive market system, facilitating finance, generating income opportunities, and incorporating local communities and their know-how. It may include public infrastructure, technology support, government subsidies, and capacity building.

  As another driver for LiFE, such a system of enabling markets makes it easier for consumers and producers to make sustainable choices in goods and services.
- **A conducive environment for innovations:** A favourable environment for innovations can improve products, services, and processes to deliver tailored DRE solutions to meet diverse end-uses across sectors. Government interventions can facilitate this by supporting innovative technologies and having financial instruments in place to drive adoption. This also includes setting technological standards, enforcing laws (such as intellectual property), prioritising research and development (R&D), leveraging existing technical capabilities, and fostering collaborations between the public and private sectors.

Alongside this, it is essential to note that DRE deployment is not an end in itself. Thus, interventions should strive towards achieving cross-sectoral outcomes at scale. To do this, interventions must be guided by cross-cutting principles, that will help achieve outcomes at scale (IRENA 2022b).

For the current analysis, we have considered four underlying principles that are consistently mentioned in the literature and by the experts as being crucial to ensuring replicability: market and impact potential, technology confidence, sustainability, and knowledge sharing.

The underlying principles include:

- **Impact at scale** *(given the magnitude of the problem being dealt with)*: This encompasses the impact on beneficiaries (households), microenterprises, and businesses, as well as the creation of livelihoods and jobs.
- **Citizen-centric approach** *(including a focus on the inclusion of women and marginalised communities)*: This includes the extent to which community members are involved in DRE interventions, with respect to the accommodation and prioritisation of end-user needs and cultural considerations, with a specific focus on women and marginalised communities.
- **Convergence to achieve impact** *(as isolated energy-focused interventions do not impact outcomes on the health, education, and income-generation fronts)*: This depends on the extent of stakeholder involvement in the DRE intervention and its focus. A broader focus with a larger breadth of impact and a higher number of stakeholders leads to higher convergence and vice versa.
- **Long-term sustenance** *(to avoid generating stranded assets and ensure long-term impact realisation)*: This involves the consideration of the longevity and intensity of the impact of the DRE intervention in terms of time and replicability.

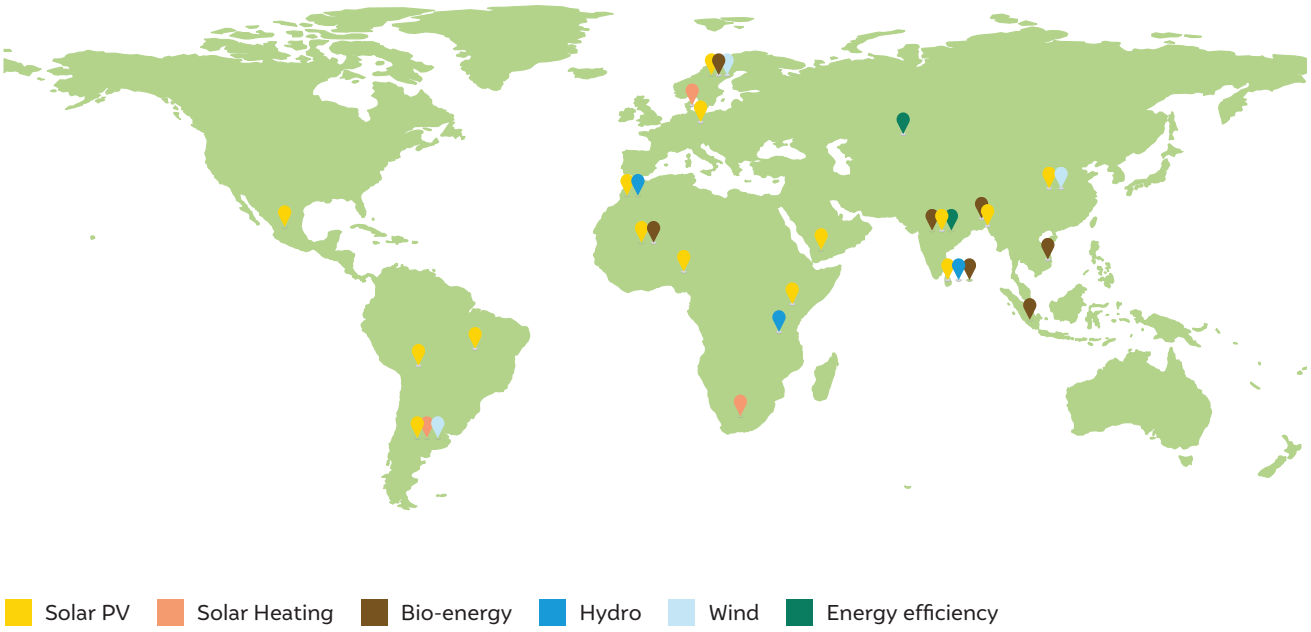
To conclude, good practices have been captured across the core elements that help further the DRE sector in any region or country, keeping in view the identified underlying principles.

Box 2 Inductive reasoning

It refers to the inference of general principles or theories from particular instances or observations. This method of reasoning is based on the assumption that patterns or trends that have been consistently observed in the past are likely to continue to hold true in the future. Inductive reasoning is useful for developing an understanding of complex systems to derive probable/possible suggestions and predictions about future events or outcomes.

Source: Authors' compilation

Figure 1 Final case studies span across 5 continents, 22 countries, and 10+ DRE technology types



Source: Authors' analysis

2.2. Research approach

I**nductive reasoning** has been used as the primary approach for the analysis. Based on the literature review, the 27 case studies from across the globe (Figure 1) has been identified and shortlisted. A thorough analysis of these case studies has been conducted to identify key good practices, through the emerging findings and common lessons. We have summarised the research steps in *Annexure I.*

Methodology followed for the selection of case studies

For this compendium, a total of 126 DRE interventions from across the globe have been identified. These 126 cases has been analysed using 'Case Study Rating Matrix', as shown in Table 1, to arrive at the final list of cases.

Step 1: From the list of 126 cases, around 90 cases that had at least one core element have been identified.

Step 2: The 90 identified cases were then rated using the matrix, as shown in Table 1. A detailed note on how we arrived at the ratings for each case is covered in Annexure II.

Step 3: Finally, cases with a rating of 70 per cent and above have been identified to arrive at the final list of cases to be analysed for generating learnings on good practices for DRE interventions.[1]

1 We made exceptions for a few cases, which are discussed in the Step 3 of Annexure *II*

Table 1 'Case Study Rating Matrix' for selection of the final list of cases to be analysed

Guiding principles	Intensity/Bands			Guiding principle weightage	Grade within intensity bands		
	Lowest rung	Middle rung	Highest rung	(%)	Lowest rung	Middle rung	Highest rung
Impact at scale 	Up to 5,000 HHs* or 500 alternative livelihoods/jobs created or 100 microenterprises/ businesses impacted	Up to 10,000 HHs or 1,000 alternative livelihoods/jobs created or 200 microenterprises/ businesses impacted	>10,000 HHs or >1,000 alternative livelihoods/jobs created or >200 microenterprises/ businesses impacted	30%	33%	67%	100%
Citizen-centric approach 	**False:** Project is implemented without any citizens consultations or needs assessment	**Partly true:** A focus on the inclusion of women and marginalised communities	**Fully true:** Citizens' needs and cultures are prioritised	25%	0%	50%	100%
Convergence to achieve impact 	Multiple Stakeholders (>2) beyond state agencies	Multiple buy-ins within federal/ state-government agencies;	It is not an isolated energy-focused intervention, i.e., it also affects the outcomes of health, education, income generation, etc.	25%	33%	67%	100%
Long-term sustenance 	The project was completed just a year or two back, and hence too early to comment	The project has led to the addition of or furtherance of 'end-user activities/ applications'	The project serves as a model for other similar projects across the region/ nation	20%	33%	67%	100%
Case study: Total % rating				**100%**			

Source: Authors' analysis

Note: *HHs: Households

Solar panels installed on the top of a metro station in Delhi National Capital Region (NCR), India.

Image: iStock

3. Emerging good practices to mainstream DRE for SDG7

This section highlights the emerging good practices across five core areas that are most crucial for igniting and growing the DRE sector in any part of the world.

3.1. To create an enabling policy environment

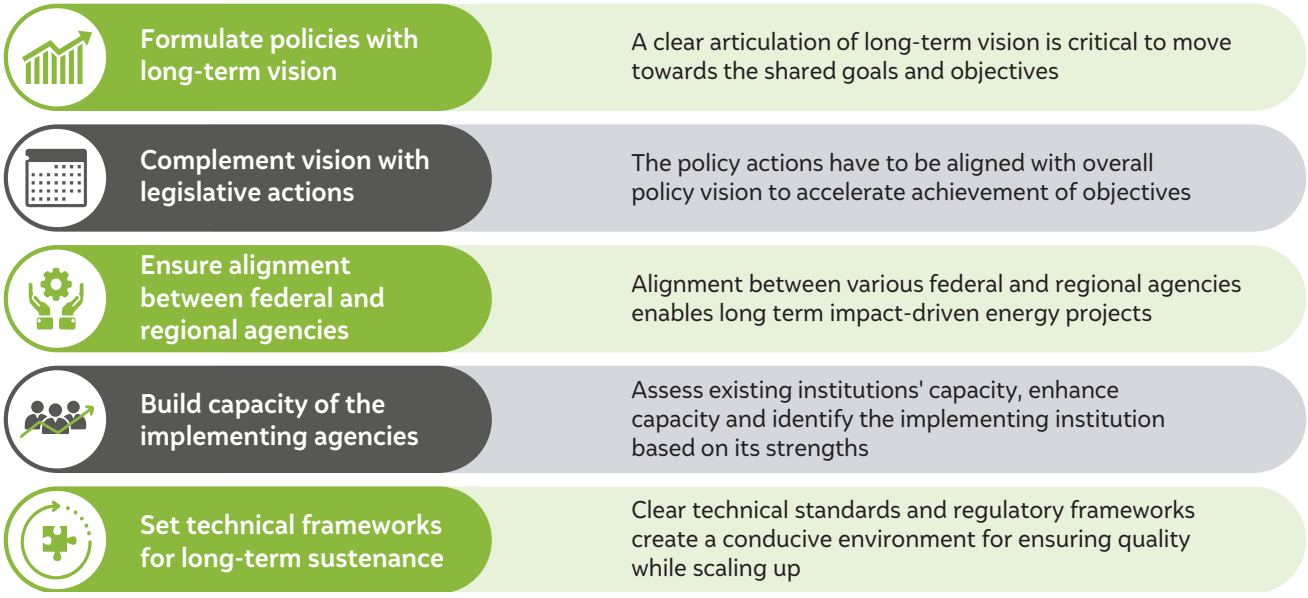
An enabling policy environment often forms the basis for the adoption and scaling-up of DRE interventions, especially given the high upfront costs and risk perception involved. It may exift in the form of a long-term vifion embedded within national energy access strategies/plans, dedicated policies , regulations, technical standards, and their effective implementation. It also entails assessing the capabilities of the agencies and organisations developing or implementing DRE interventions and building their capacity if a gap is identified. This makes the allocation of resources critical not only for scaling up the interventions but also for ensuring quality. It is crucial that this environment remain adaptive, ensuring that these policies evolve to changes in technologies, costs and other market dynamics over time yet offer a predictable environment for investment.

Thus, a policy environment that is most conducive to DRE implementation should aim to achieve one or more of the following three objectives: providing long-term policy certainty, being flexible enough to encourage innovation and adaptation as the market grows and new challenges arise, and ensuring effective implementation. Several good practices to create an enabling policy environment have been identified from the case studies that supported the implementing countries achieving these objectives, and thus led to the successful adoption of the intended DRE technology among the beneficiaries. In this section, we describe in detail five such good practices that were observed to be effective across the globe. The key findings are summarised in Figure 2.

Formulate policies with a long-term vision to provide market certainty

It is important to create a long-term strategic vision that outlines the intended sustainable development outcomes (for SDG 7 and other goals), scenarios, and actions to improve coherence between existing regulations and develop adaptive policies. A clear articulation of the vision is needed in order to direct the policy and associated stakeholders towards the shared goals and objectives. This vision can be developed, realised, and contextualised at any level (city, municipality, district, or country). For example, at the municipality level, in Denmark the municipality of Silkeborg had defined its vision of achieving carbon-neutral heating by 2030; at the city level, Sweden's city of Malmo had set an ambitious and compartmentalised vision of achieving carbon neutrality and running all of its municipal operations on 100 per cent renewable energy; and at the national level, Kazakhstan in 2010 had set a vision to reduce the energy intensity of its national economy by 25 per cent by 2020 (Georgiev, Ivo 2019, Smith, Emily Dowding 2013, The World Bank 2013a).

Figure 2 Summary of emerging good practices for creating an enabling policy environment.



Source: Authors' analysis

Image: CEEW/Emotive lens

An Indian farmer stores perishables in biomass-powered cold storage.

Detailed research and analysis must be conducted before formulating any policy vision in order to help generate a nuanced understanding of the needs and gaps. The importance of such detailed research work is demonstrated by the vision set for the city of Malmo, Sweden, where a study was conducted to understand the city's potential and capacity for its implementation before arriving at the vision. The city's research, which started in 2007, involved a thorough mapping of its environmental concerns, and also offered suggestions for establishing goals and benchmarks. Through this research, the overarching strategy and long-term vision were established through the release of two city-level policy documents in 2009 — the *Environmental Programme* and the *Energy Strategy*, which set ambitious goals. Subsequently, the municipality set itself the goal of running all its municipal functions on RE sources by 2030, which was supplemented by the requisite legislative- and executive-level steps (Smith, Emily Dowding 2013).

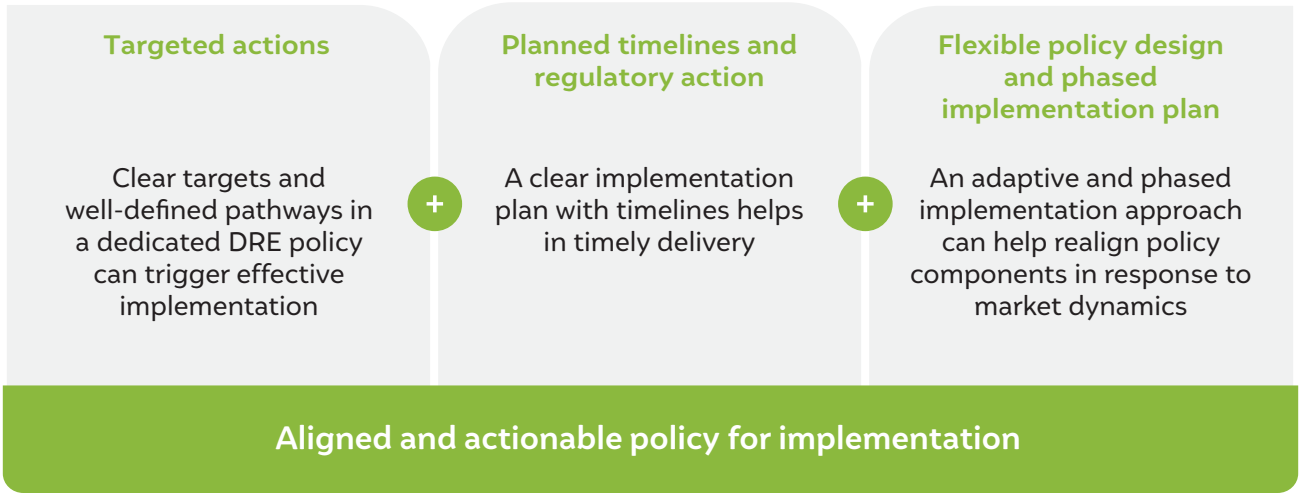
On the other hand, the Environmental Code of Kazakhstan, released in 2010, was the outcome of the country's past policy shortcomings and was aimed at addressing the need to provide energy security for its population while also improving industrial competitiveness and environmental performance. A law on energy savings was enacted by Kazakhstan as early as 1997 but faced problems due to the challenges in implementation and the difficulty in aligning policy frameworks and actionable targets. However, this did not deter Kazakhstan from pursuing its ambition for a clean environment. Learning from past experience, Kazakhstan established a set of environmental codes in 2010 with the ambitious goal of reducing the energy intensity of its national economy by 25 per cent by 2020 (The World Bank 2013a). This case illustrates how learnings from past policy shortcomings, enacting economic improvement initiatives, and establishing legal norms can serve as a foundation for setting ambitious goals for the country.

To conclude, having a long-term vision can unlock unique opportunities for integrating and guiding relevant short-term or immediate actions on a national or subnational scale. For instance, as seen in the city of Malmo, Sweden, having a long-term vision enabled the local administration to incorporate, synchronise, and mainstream this vision in the city's development plans – primarily in the master plan. This was also demonstrated by Denmark, where the long-term vision enabled the Silkeborg municipality to demonstrate that a renewable transition in the heating sector can be achieved rapidly and affordably.

Complement the vision with overarching targets and legislative action, which are adaptive, both at the national and sub-national levels

The appropriate and necessary policy actions – whether in the form of frameworks, strategy papers, legislation, or executive actions – should support the overall policy vision in order to speed up progress towards achieving the set vision and commitments.

Figure 3 Complement vision with targeted, time-bound and adaptive policy actions.



Source: Authors' analysis

Targeted actions

The case of Mexico demonstrated how the government's vision for rural electrification was strengthened through legislation on decentralised governance and power with policies on RE deployment and energy financing. For example, the *Law for the Development of Renewable Energy and Energy Transition Financing (LAERFTE*), established in 2008, mandated that a certain portion of the total energy supply come from renewable resources (Walters, et al. 2015). Similarly, the Mexican government also complemented its vision with the *National Energy Strategy* (2013–2027), which is aimed at improving energy access and promoting economic growth (Walters, et al. 2015).

The carbon neutrality programme in Denmark is similarly a strong example of how legislative action can effectively support long-term visions (Georgiev, Ivo 2019). The government supported its vision by passing stringent national laws on energy savings and heat supply. These laws were aimed at restricting the choice of fuel-combustion technologies in order to promote clean, (non-fuel) energy-efficient systems. This national legislative framework also supported the vision and executive actions of sub-national regions, such as the Silkeborg Municipality's carbon neutrality plan. The energy-saving laws obligated the municipality to shut down both its 100 MW nuclear power reactors and direct strategic investments in RE technologies.

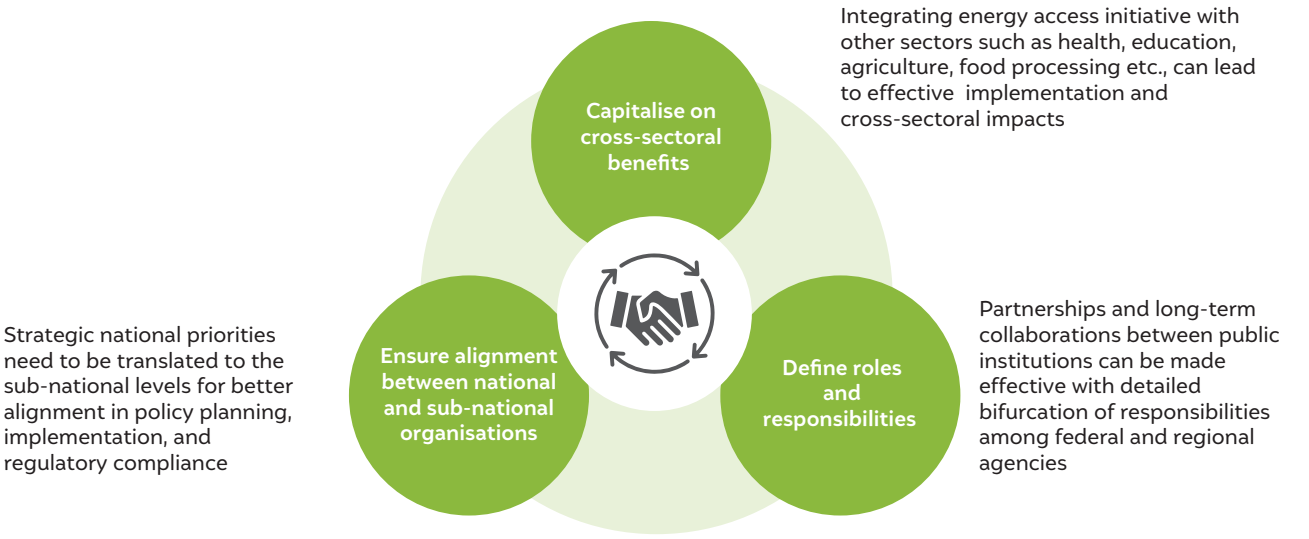
Time-bound plans and timely regulatory action

The Kazakhstan federal government, in line with its vision for environmental conservation (2007), passed a law – Kazakhstan Energy Conservation and Energy Efficiency Law – in 2012 to encourage and mandate energy efficiency (EE) (The World Bank 2013a). This was complemented by a separate implementation plan approved by the government called CPEE (*Comprehensive Plan on Energy Efficiency*), a time-bound action plan containing 47 policies and measures along with specific institutional responsibilities for its implementation, day-to-day operation, and monitoring. The government further complemented its vision by setting ambitious targets to reduce the national economy's energy intensity by 25 per cent by 2020, which they achieved. The Government of Kazakhstan has shown an excellent example of how a policy environment can be enabled for mainstreaming RE-based interventions and addressing issues around energy poverty at a national scale.

Re-developing or adapting policies based on market response and phased implementation:

To achieve household electrification through clean energy, the German government established a long-term framework – the Renewable Energy Sources Act 2000 – for implementation of grid-based solar rooftop programmes that guaranteed quick adoption, economies of scale, and long-term certainty to consumers (Matschoss et al 2019). This multi-decade policy package was implemented in a phased manner. Various mechanisms like feed-in-tariffs (FiTs) and priority grid access were introduced to scale up technologies. The phased implementation provided an opportunity to improve and modify policy components, such as the financial and non-financial mechanisms, in response to market dynamics. Having an adaptive approach allowed the government to capitalise on emerging technological and economic developments, leading to the successful implementation of the intervention which is largely considered as a catalyst for the global reductions in solar module costs.

Figure 4 Federal and regional entities need to coordinate efforts to ensure that a policy is implemented effectively.



Source: Authors' analysis

Ensure closer alignment between federal and regional agencies for effective planning and implementation

Federal and regional entities need to coordinate efforts to ensure that a policy is implemented effectively. Alignment between various federal and regional agencies can provide unique opportunities for collaboration, ensure the effective distribution of operational responsibilities, and institutionalise the arrangement for long-term, impact-driven energy projects.

Capitalising on or augmenting cross-sectoral benefits

The powering of primary and community health centres (PPHCs) through off-grid solar electricity in Chhattisgarh, India showcase the integration of electrification with the health programme. Integrating the energy access programme with the state health mission has been vital for the effective implementation of the project (Chaudhary, Juhi 2018, Ramji et al. 2017, SE4ALL 2019). Numerous organisations in the fields of health, energy, and environment conservation joined forces to facilitate the solarisation of the Primary and Community Healthcare Centres (PHCs). The state government (Chhattisgarh), state nodal agency – Chhattisgarh Renewable Energy Development Agency (CREDA), and the central National Health Mission were among the key stakeholders who developed the strategic plans and enabled the implementation of this project. The project helped in powering around 1500 healthcare facilities in Chhattisgarh (CREDA 2023). Additionally, this project demonstrates the policy mainstreaming of 'beyond electrification', with cross-sectoral impacts in sectors like health, agriculture, drinking water, education, and poverty.

Supporting regional-, state-, and provincial-level institutions

The strategic priorities at the national level need to be translated appropriately to the sub-national and regional levels for better alignment in policy planning, implementation, and regulatory compliance. The Moroccan government demonstrated this by providing support and backing to regional agencies for the *Renewable Energy and Global Rural Electrification Programme* (PERG) in the form of new organisational, financial, and technical policies. The government's *National Electrification Plan* has guided the PERG programme, with the main institutional backing coming from the Rural Electrification Board (REB), an institution set up for the programme, and the state-owned utility, Office Nationale de l'Electricité- National Electricity Board(ONE) (ONEC 2011). The PERG's five-year planning process has helped compartmentalise targets and improve coordination across agencies in a more regulated manner, impacting the overall success of the programme and allowing for timely monitoring of the impacts. Similarly, this approach has also been observed in India, where CREDA has been instrumental in establishing linkages and the much-needed cooperation between various government departments, including the state health mission.

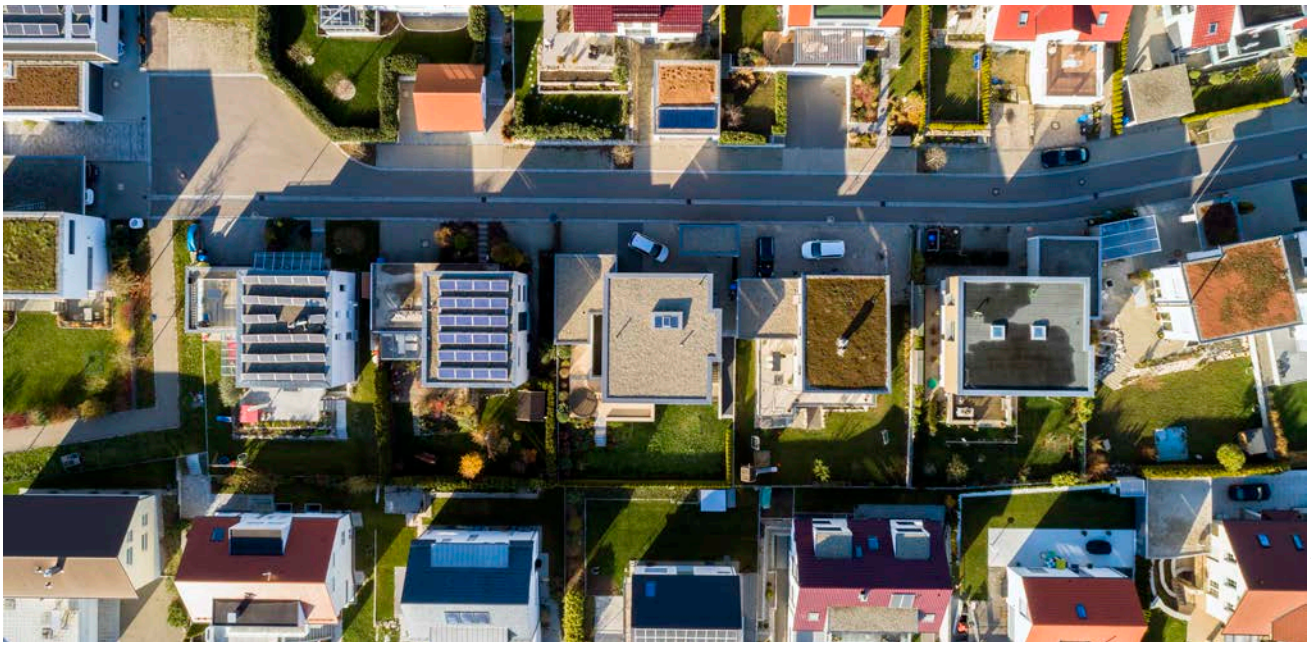


Image: iStock

In Baden-Wurttemberg, Germany, a residential area with rooftop solar deployment.

Defining roles and responsibilities

A crucial lesson learned from the Renewable Energy for Rural Markets Project (PERMER) in Argentina was the importance of collaborations between public, private and philanthropic institutions, to share the planning, funding and implementation responsibility of the programme (Covarrubias et al. 2013, Reiche et.al 2000). The federal agency created a framework to provide electricity for lighting and social communication (radio and television) (Reiche et.al 2000). The framework defined roles for regional (provincial) government, regulatory authorities, and concessionaires (private bidders). The provincial government and regulatory organisations were in charge of awarding and monitoring 'concession agreements' to concessionaires. EJSEDSA (Systemas Energéticos Dispersos S.A.) was formed to disperse agreements for off-grid markets (Covarrubias et al. 2013). Once the concessionaires were given the contract, they were responsible for choosing and deploying the DRE technologies best suited to meet the users' need and willingness to pay. The World Bank (US$30 million loan), the Global Environment Facility (US$10 million grant), Argentina's Electricity Development Fund for provincial projects (US$26 million), and the concessionaires, concessionaires — US$44 million, and the customers — US$10 million contributed to the US$120 million funding responsibility (Covarrubias et al. 2013). The project showcases the significance of institutional collaboration and cooperation between federal and regional governments, and private institutions to plan, finance, and implement a DRE project at scale. The alignment has been a key factor in **institutionalising financial mechanisms** to install solar home systems in more than 27,000 rural households and 3,000 public utilities such as schools and hospitals (The World Bank 2013b).

Build the capacity of agencies and organisations involved in the design, implementation, and monitoring of DRE programmes

The deployment of DRE technology is highly scattered, hence, scaling up a DRE programme involves multi-level planning, coordination, and monitoring. To do so, it is critical to assess present institution ability, increase existing institution capacity where necessary, and onboard supporting implementing institutions (if needed) at the early stages of the programme.

An institutional gap assessment at the concept stage can provide insights into areas of capacity building and resource allocation required for the successful implementation, monitoring and evaluation of the programme. Only when no existing institutions can undertake such responsibility should a new institution be created after careful consideration. Once the institutional arrangements have been finalised, the policy framework should ensure that the institutions receive the necessary capacity building support and resources allocation.

In the case of Bangladesh's *Solar Home Systems* (SHS) programme, which was under the World Bank–supported *Rural Electrification and Renewable Energy Development II* (RERED II) project, a government-owned entity – the Infrastructure Development Company Ltd (IDCOL)–was the

lead implementation agency (Sustainable Development Department 2012). At the planning stage, an external consultant conducted a **capacity assessment** of IDCOL and formulated an organisational structure for the institution. Accordingly, a dedicated SHS division was established within IDCOL under their RE department. The division further had **'relationship management'** teams that managed ongoing implementation and coordination, and a monitoring wing that took care of inspections and training. As the programme expanded in the country, IDCOL went on to establish regional offices and grew its ground teams. By 2017, the number of cumulative SHS installations in Bangladesh had grown to over 4 million from ~12,000 in 2003 (Centre for Public Impact 2017).

Similar institutional capacity-building efforts were evident in Morocco's *Renewable Energy and Global Rural Electrification* (PERG) projects as well. The PERG programme was implemented by ONE, the state-owned utility, which set up a new, dedicated rural electrification department to coordinate PERG (ONEC 2011). This department hired staff members with previous experience in the power sector, **thus enhancing ONE's institutional capacity** to implement the programme successfully. ONE's ability to design and implement the solar component of the programme through extensive pre-feasibility assessments that matched the demand with various supply options was a major reason for the programme's success, and attracted international solar developers into the country.

Frame technical standards and regulatory frameworks to ensure the long-term sustainability of the DRE intervention

Another clear factor that has emerged out of several impactful DRE interventions globally is the importance of **establishing clear technical standards and regulatory frameworks**. This will not only provide a conducive environment for the technology to scale up but also ensure quality.

The *Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan* (PM-KUSUM) scheme in India is an example of how the technical standards that were set ensured that the quality of the solar water pumping systems that were deployed under the programme met a minimum quality criterion(MNRE n.d) . The PM-KUSUM scheme also used a novel approach for ensuring long-term system performance by mandating that remote monitoring systems be included along with the solar water pumps. Data from these systems are being monitored via a centralised portal that is also synced with the state-level portals. While setting the standards, PM-KUSUM also provided enough flexibility and room for innovation through provisions to allow for the deployment of new mounting structure designs as long as they are certified by national-level institutions. .The Ministry of New and Renewable Energy (MNRE) has also issued guidelines for incorporating new innovative solar pumping solutions under the scheme. Thus, they ensure that the technical standards do not hinder innovation (PIB 2022b).

Nigeria's 2016 Mini-grid Regulations and the Maldives' Rooftop Solar Net-metering Regulation are examples wherein setting up a regulatory framework that clearly laid down eligibility criteria, system standards, and application and approval processes ensured that the private developers and end consumers could execute and commission their projects without major delays or uncertainties (Wearne et al. 2021, ADB 2021). In both these examples, setting up the regulatory framework led to a major impetus in the market and had a clear positive impact on the scale-up of the technologies. These regulatory initiatives also emboldened international agencies and private developers to invest resources in the programmes. In the case of Nigeria, having the Net-Metering Regulation for mini-grid in place was a major reason for the World Bank's and the African Development Bank's commitment of over USD 550 million towards the Nigerian Electrification Program (NEP) (Wearne et al. 2021).

Figure 5 Frame technical standards and regulatory frameworks to ensure long-term sustenance.

Set clear technical standards for quality

- Clear qualifying criterion for quality of the technology
- Clear guidelines on certifications through government agencies
- Provide room for flexibility for new innovations to foster

Define regulatory framework for long-term sustenance

- Clearly lay out eligibility criteria, system standards, and application and approval processes
- Include regulations that emboldens private sector investment

Source: Authors' analysis

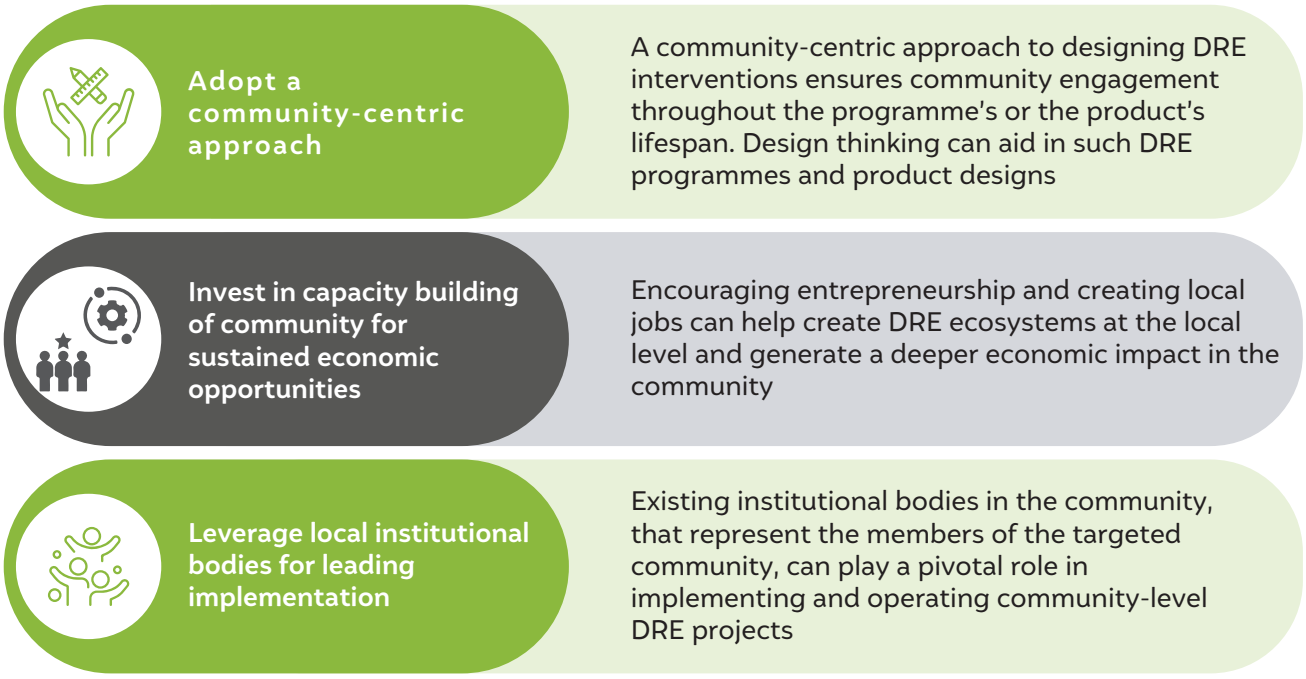
3.2. To enable active community engagement

Community engagement is, inarguably, a crucial factor for the success of any DRE intervention, given its decentralised nature. Be it for DRE technologies such as solar home systems, solar water pumps and rooftop solar systems (where the uptake happens at an individual or household level), or community-level interventions such as various micro- or mini-grid deployments, the role of the community and its involvement is quite consequential. For individual-level technologies, uptake by the end user would be a metric for success, and their behaviour and perceived barriers would determine the factors for their uptake. For those technologies that are implemented at the community level, the continuous and long-term operation of the plant becomes a more important factor and is **more dependent on community buy-in**.

Given the importance of community engagement, multi-stakeholder consultations with the targeted community and other actors at all stages of programme development should be the norm. However, analysis of successful DRE interventions across the globe has demonstrated that going beyond consultations and using programme design to ensure community buy-in and higher levels of engagement can aid in the long-term sustenance of the programme.

The analysis revealed that there are three levels of community engagement beyond consultations that can be adopted in order to achieve higher community participation. These include **total buy-in from the community**, **a sense of ownership among the community members**, and **nurturing community leadership**. Further, it has also revealed the most recurrent good practices that have proven to be effective and that can further these objectives. In this section, four such good practices have been observed and various approaches adopted across the globe for a higher level of community engagement are described in detail. The key findings are summarised in Figure 6.

Figure 6 Summary of emerging good practices for active community engagement.



Source: Authors' analysis

Figure 7 Adopt a community-centric design approach for DRE interventions.

Assess the real needs of the community by employing a participatory approach and conducting a needs assessment using tools such as surveys and in-depth interviews

Involve the community/potential users in product development and iterations process to ensure that the product/ programme caters to local needs

Source: Authors' analysis

Design with and for the community by involving them from the early stages of the intervention

Having a user-centric or community-centric approach to designing DRE interventions is an effective way to ensure community engagement throughout the programme's or the product's lifespan. The community-centric approach can be used at the product level, in the business and financing models, and at the programme-design level. Such an approach ensures that the real needs of the community are met with the intervention, and that the community members gain long-term benefits from it. Frameworks such as design thinking can aid in such DRE programmes and product designs.

Solar water-pump deployment in Kenya is a good example of a user-centric product and business-model development have significantly increased the demand among farmers. In Kenya, there are two major private players in the solar water pump market, namely, SunCulture and Future Pumps, that have been operating in the country since the early 2010s and played a pivotal role in scaling solar water pumps in the country (ARE 2022, Holthaus et al. 2017, Michaelowa et al. 2016, REEEP n.d.). Both players, through the process of iteration, have **developed product offerings and solutions that cater to the need and capacity of the farmers.** SunCulture launched a pumping solution along with a battery that can power lights and other household appliances based on the realisation that households do not have reliable electricity and are willing to pay an additional amount if the solar pumps can provide household electricity as well. They also rolled out Pay-as-you-Grow model where the payment cycles match the harvest patterns of the farmers (ARE 2022, Michaelowa et al. 2016, REEEP n.d.).

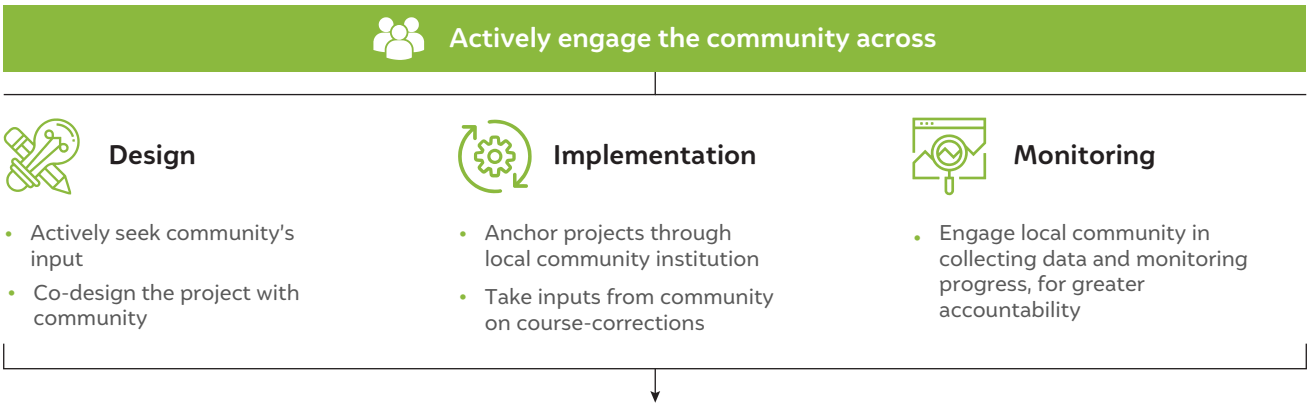
Similarly, Future Pump began offering a free remote-monitoring solution along with the pumps after they discovered how far the farms were from the dwelling areas (Michaelowa et al. 2016, REEEP n.d.).

In the case of Indonesia's bamboo-based community biomass power plant pilot in Mentawai's remote island villages, the design and the business model of the power plant were developed keeping the local community in mind (Wahono et al. 2022). Bamboo was chosen as a feedstock due to its acceptance and familiarity in the region. **The project design also created synergy between the local community, the electricity off-taker, and the project developer**. Each household was given 100 bamboo seedlings at the start of the project, which immediately ensured local participation. The feedstock was to be grown by the local community, and the power plant operator had a 20-year Feedstock Supply Agreement to buy all the bamboo grown, thus ensuring the availability of regular feedstock while incentivising the community to grow bamboo.

Anchor the projects with community institutions for quicker outreach and to gain greater trust

Existing institutional bodies in the community, such as co-operatives and farmer associations that represent the members of the targeted community, can play a pivotal role in implementing and operating community-level DRE projects. In the case of the biomass power plant in Mentawai, Indonesia, the bamboo farmers' association was a key stakeholder that represented the interests of the farmers and aided in all decision-making. The association also helped create accountability among the farmers for providing feedstock to the power plant (Wahono et al. 2022).

Figure 8 Actively engage with the community across the design, implementation, and monitoring.



Source: Authors' analysis

In Bolivia, ENER GETICA, a not-for-profit agency, reached out and interacted with municipality representatives, farmer union leaders, and community leaders (Eras-Almeida, et al. 2019). Familiarising with the different stakeholders helped build trust and eased the relationship with the community. This was followed by the identification of various energy requirements, which were then used to design bottom-up solutions. The process was followed across different administrative divisions.

There are also instances where new community institutions have been created to aid successful project implementation . In Tanzania, micro-hydropower plants were set up by the European Committee for Training and Agriculture (CEFA) in various regions, and region-specific village companies were set up for their continued operation and maintenance (Pendezza, J 2014). This proved to be a vital feature for the long-term success of the intervention. Village companies were set up by providing a series of technical skill-training courses for the village youth in the areas of hydro energy systems and engineering. The companies were also made responsible for revenue collection for the electricity that was sold to the community.

Actively plan for community engagement across design, implementation, operations, and monitoring to enhance sense of ownership

Another factor that helped create extended participation from the community was the **sense of ownership** created among the community members in some programmes. This was particularly true for community-level DRE interventions where the project was owned by a non-community public or private entity.

In Sri Lanka, during the implementation of the *Energy Service Delivery* (ESD) programme, community members were involved in the construction and monitoring of the projects (The World Bank 2003). People contributed their time in exchange for money that was deducted from their capital contribution. This novel approach not only made it affordable for the community, but also improved their sense of project ownership, which led to successful implementation to some extent.

Image: iStock

Small windmill and solar panels

The *Kuyasa Low-income Energy Efficiency Housing Project* in South Africa, implemented in 1999, targeted 2,309 low-income homes on the outskirts of Cape Town and was successfully completed with active participation from the Kuyasa locals (ESMAP 2012). The community benefited greatly from the job creation, technical training, and capacity building that was provided, creating an increased sense of ownership and responsibility among the community members.

Invest patiently in the community's capacity to spur local job creation and support the long-term maintenance of assets

Encouraging entrepreneurship and creating local jobs should be key priorities for all DRE interventions. This can help create DRE ecosystems at the local level and also generate a deeper economic impact in the community, going beyond DRE as a stand-alone intervention to improve the status of energy access. By creating a local ecosystem that is self-sustaining, this approach is also a more effective way to scale DRE technologies in remote and rural locations. Thus far, DRE is a prominent source of stable employment with an estimated 3,74,000 people employed in Africa and 80,000 in India (Power for All, 2022).

Building a local entrepreneurship ecosystem and skill building: The Barefoot College – founded in Rajasthan, India – trains women in the community to become solar engineers. Barefoot College has trained around 1,700 women across 96 countries who, in turn, have deployed solar solutions to over 75,000 households (The Barefoot College 2022). These women can assemble solar lanterns and solar home-lighting systems and sell them in the community. Encouraging such local entrepreneurship has proven to offer multiple benefits. It creates local jobs, and hence, contributes to the rural economy. The involvement of local entrepreneurs also accelerates the impact of these interventions, as it aids their acceptance and adoption of a programme. The active community engagement during Barefoot's solar engineer training programme for illiterate women from marginalised communities in least-developed countries (LDCs) resulted in natural trust building, which was evident in the success of the programme.

On the other hand, in Mali, West Africa, rural 'Green Business Areas' (GBAs) – bioclimatic professional buildings powered by RE – were implemented. These 'incubators' provided a 24/7 power supply and led to significant economic development in communities previously without access to energy (GERES 2022a). The GBAs provided additional support to the small businesses, micro-enterprises, and community entities that they housed, such as access to finance, business management, and capacity building. The pilot programme resulted in the creation of 37 'very small enterprises' (VSEs) across 2 locations in Mali (GERES 2022a).

Enhancing service provision by involving locals: In Bolivia, South America, on the one hand, a novel 'micro-franchising' approach was engaged to deliver energy products and services in rural areas. ENERGETICA organised the micro-franchise network, and the local entrepreneurs who served as the micro-franchisees worked as the last-mile energy service providers (IADB 2012). Since the local micro-franchisees possessed valuable knowledge and relationships with the community, it was a win–win relationship for both sets of participants. This model resulted in extra income generation, greater dissemination of energy products/services, and the provision of two-level service for repairs, to name a few features.

Figure 9 Invest in capacity building of the local community.

Build an ecosystem for local entrepreneurs, and enhance their skills

Encourage local businesses to participate in DRE interventions to benefit the local economy, as it fosters job creation and income generation. Furthermore, involving local entrepreneurs also accelerates the impact, as it aids acceptance and adoption of interventions

Enhance service provisions by involving local communities

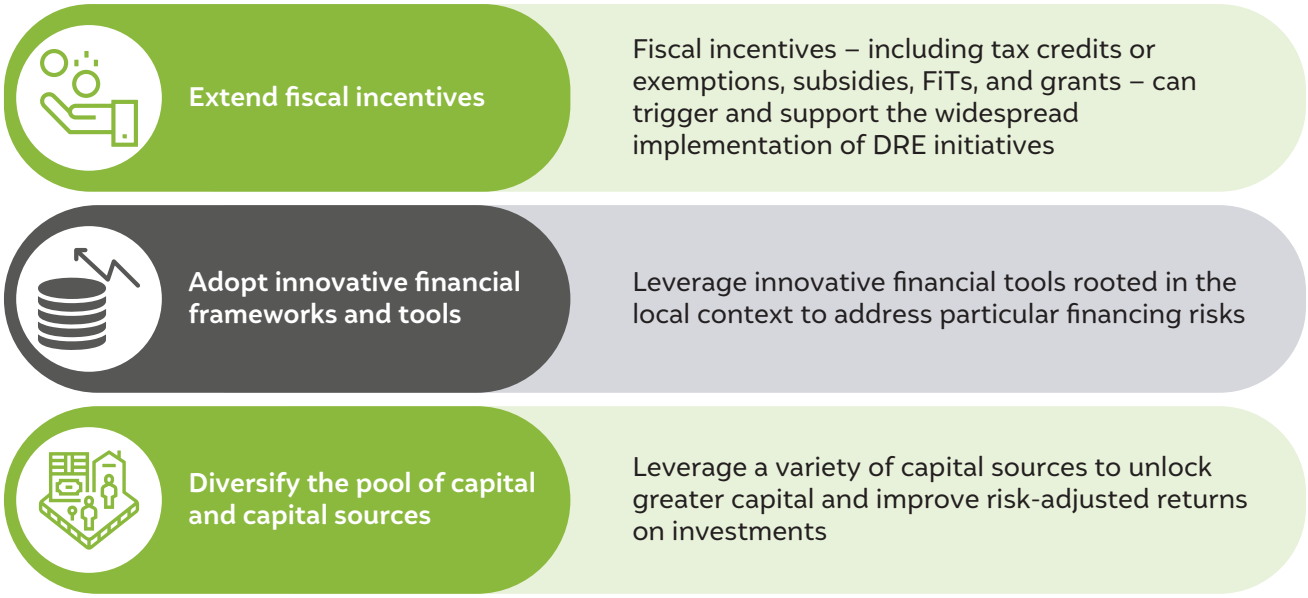
Engage community to support last-mile service deliveries. For example, local entrepreneurs can serve as the micro-franchisees and work as the last-mile energy service providers. The model results in local income generation, greater dissemination of energy services, and a provision of better service for repairs

Source: Authors' analysis

A bamboo forest in Indonesia. Bamboo is used to generate electricity through the biomass gasification process.

Image: Alamy

Figure 10 Summary of emerging good practices for providing accessible and affordable financing.



Source: Authors' analysis

3.3. To enable accessible and affordable financing

The adoption of DRE solutions is hindered by the substantial initial investment required. Access to affordable financing is critical across all levels: national programmes, community projects, and individual end users. A finance strategy must be both accessible and affordable, strengthening both the capacity to pay and the willingness to pay. Targeted fiscal incentives could play a key role. Focusing on creative financial mechanisms that are anchored in the local context and utilising a variety of instruments to decrease financial risk are also necessary.

The case studies show that the financing interventions deployed usually have two objectives – to reduce the amount of upfront capital required and/or to create accessible financing options for the targeted beneficiaries. This section identifies and describes the good practices that can achieve either or both of these objectives. Figure 10 summarises the findings.

Extend 'targeted' fiscal incentives to jump-start initiatives – public investments and international grants are critical

Availability of fiscal incentives – including tax credits or exemptions, subsidies, FiTs, and grants – can help trigger and support the widespread implementation of DRE initiatives. The success of public financing tools for funding DRE interventions at scale can be illustrated by the case studies from Argentina, Denmark, Germany, India, Morocco, and Nigeria, among others (Covarrubias et al. 2013, Georgiev, Ivo 2019, Curry, Andrew 2013, MNRE n.d., AFBD 2011, Wearne et al. 2021).

In the case of Silkeborg, Denmark, the municipality provided up to 10 per cent of the initial capital funding via a supplement cap after the first year of operations. Public financing instruments that maximie efficiency and effectiveness while also catalysing private capital (when possible) are critical to meeting the needs of different stakeholders (Georgiev, Ivo 2019).

In India, the PM-KUSUM scheme by the Ministry of New and Renewable Energy (MNRE) is one of the largest DRE initiatives in the country and seeks to transform low-income farmers from being only *'annadata'* **(food producers)** to also becoming *'urjadata'* **(energy producers)**. To accelerate the adoption of solar irrigation pumps, the federal and state governments provide financial assistance of up to 60 per cent of the technology cost as a front-end subsidy to the end users (primarily farmers). Additionally, there are further provisions of bank loans to cover an additional 30 per cent of the technology cost (MNRE n.d.). The scheme includes the solarisation of existing conventional irrigation pumps as part of the Agriculture Infrastructure Fund (AIF), which provides farmers with subsidised loans. The scheme is also included in the Reserve Bank of India's (RBI) Priority Sector Lending (PSL) Guidelines to facilitate access to finance. Furthermore, many banks have issued lending guidelines for the scheme, allowing farmers to access basic financial assistance to ensure the success of this intervention.

Box 3 What does the term 'annadata to urjadata' mean?

The finance minister of India, in the 2019 budget, emphasised the narrative of transforming the annadata (the farmer) into an urjadata (producer of power), and how it has the ability to offer multifaceted advantages. The government sought to encourage value addition to farm products and products from related industries, such as bamboo and wood from hedges. It also aimed to support private entrepreneurship for generating RE.

Source: Authors' compilation

In the early 2000s, under the German Renewable Energy Sources Act, the German government introduced its pioneering guaranteed FiT financial mechanism to attract private investments for the adoption of DRE technologies (Matschoss et al. 2019). The success of the FiT mechanism in promoting and adopting DRE technologies can be attributed to its dynamic design in terms of incentives and cost reductions, which were adapted to the changing needs and challenges. This led to the design being modelled and replicated in various countries such as India, Morocco, and Indonesia.

These case studies reveal that public financing has been crucial for providing the necessary investment push to scale DRE interventions. For example, grants for solar home systems in Argentina assisted the local authorities in providing technology systems at a subsidised price (Covarrubias et al. 2013). However, countries have also used alternative fiscal interventions such as tariffs established through a minimum subsidy tender (in the case of Nigeria), fee-for-service models (in the case of Morocco), and FiTs (in the case of Germany) to ensure a project's financial viability while also making DRE technologies accessible and affordable for end users. As observed in the case of Indonesia, the combination of high FiTs, subsidised tariff structures for end users, and grants has made electricity distribution and utilisation for the end users affordable and has been crucial for the overall long-term viability of the project.

Beyond public investment, grants from philanthropic, multilateral, and bilateral organisations have been crucial to jump-starting DRE programmes and projects. As seen in Tanzania, Morocco, and Indonesia, grants enabled the establishment of many mini-grid plants (Wahono et al. 2022, ONEC 2011, Pendezza, J 2014). Grants, particularly in the form of results-based financing (i.e. USD per connection), continue to play a crucial role in catalysing DRE market development particularly in Sub-Saharan Africa. Typically, grants are co-financed by federal or provincial government departments, which cover a portion of the capital costs. The rest of the costs are shared by multilateral or developmental agencies such as such as UNDP, United States Agency for International Development (USAID), the EU, the Islamic Development Bank, the OPEC Fund for International Development, Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), etc.

Figure 11 Public investments and grants are critical for sectoral growth.

Fiscal incentives – tax credits or exemptions, subsidies, FiTs, and grants – help trigger and support the widespread implementation of DRE initiatives

Public financing instruments that maximise efficiency and effectiveness while catalysing private capital are critical to unlock larger capital

The federal and state governments can provide financial assistance through subsidies and loans to cover some part of the technology cost

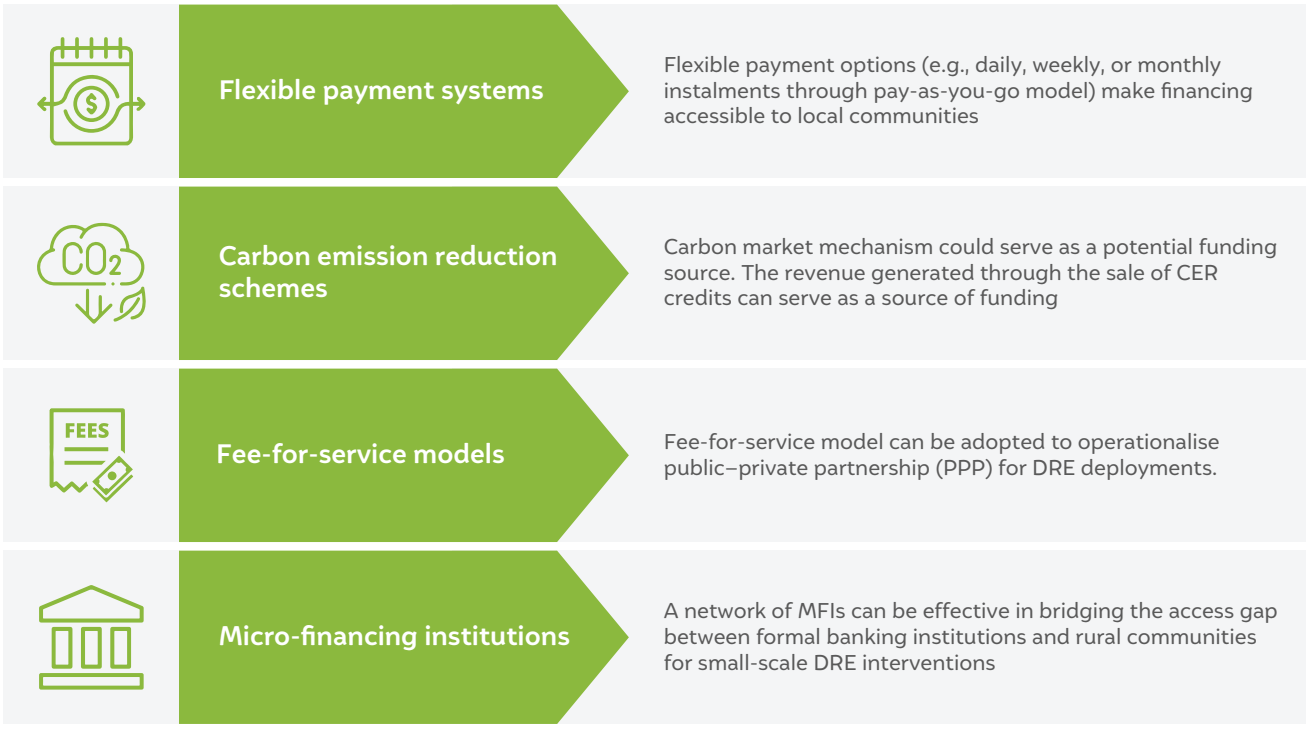
Source: Authors' analysis

Adopt a need-based financial framework and mechanisms rooted in the local context

Several DRE interventions across different countries have successfully developed, employed, and demonstrated the use of innovative financial frameworks and mechanisms that suit the local context to unlock financing. These frameworks can be developed for each DRE sub-sector with an attempt to address the technology and operational risks in that sub-sector.

Flexible payment systems: Pay-as-you-go (PAYGO), an innovative finance mechanism, has been crucial to enabling access to DRE solutions, particularly in Sub-Saharan African nations (Adwek et al. 2019, M-KOPA 2021, M-KOPA 2022). **PAYGO uses mobile phones to make monthly, weekly, or daily payments towards the purchase of DRE solutions or services.** More importantly, this method allows for widespread asset ownership, especially among bottom-of-the-pyramid (BOP) populations. To make the programme more accessible to local communities and populations, additional features such as product warranties, flexible payment options (e.g., daily, weekly, or monthly instalments), and annual maintenance contracts were provided. This helped in the large-scale acceptance and acceleration of PAYGO in the region. The use of PAYGO has been popular in Kenya for the purchase of solar home lighting systems. Moreover, PAYGO has been recently introduced for hospital and life insurance services as well. Thus, PAYGO provides an affordable and accessible means of obtaining energy and other services for populations lacking access to modern financing tools. The mechanism has also been replicated in countries such as Uganda, Nigeria, and Ghana (Adwek et al. 2019).

Figure 12 Financial frameworks and mechanisms can be developed to address the technology and operational risks



Source: Authors' analysis

Box 4 What are Certified Emission Reduction credits?

Certified Emission Reduction (CER) credits are a type of emission-unit credit or simply carbon credits issued by the CDM Executive Authority of Emissions under the Kyoto Protocol. The CDM allows emission-reduction projects in developing countries to earn these carbon credits, which can then be traded to meet emission-reduction targets.

Source: Authors' compilation

Linking emission reduction schemes to accrue benefits: Another innovative mechanism was witnessed in the *Kuyasa Low-income Energy Efficiency Project* in Cape Town, South Africa, where Certified Emission Reduction (CER) credits were sold under the *Clean Development Mechanism* (CDM) programme to fund energy-efficiency projects. Registered in 2005, this was South Africa's first CDM project, as well as the world's first Gold Standard CDM project (ESMAP 2012). The revenue generated through the sale of CER credits serves as the project's main source of funding and is anticipated to generate USD 3.08 million over the course of the project's 21-year loan term (ESMAP 2012). The project provides a proof of concept on how the carbon market mechanism could serve as a potential funding source for energy projects and be replicated and scaled in other geographies

Fee-for-service models: The *Renewable Energy and Global Rural Electrification Programme* (PERG) of Morocco uses an interesting public–private partnership (PPP) framework to provide electricity access to rural communities using RE sources. The model has been implemented through the support of private concessionaires, who were under an agreement with the municipal authorities (Usman et al. 2019). Due to its size and the need for integration of existing organisational and technical knowledge, the off-grid component has been outsourced to the private sector. The PPP contract comprises a fee-for-service business model. The fee covers the costs of marketing, contracting, installation, collection of payments, and maintenance of technology. The PPP model has been an integral factor in the flagship PERG project and serves as a replicable mechanism for implementing rural electrification projects. The electrification rate in Morocco has increased from 18 per cent in the 1995 to almost 100 per cent by 2017 (Usman et al. 2019).

Leveraging MFIs to enable financing access for DRE: Another innovative financial framework was of a tripartite agreement laid down in Sri Lanka under their *Energy Service Delivery* programme. Under this programme, a network of MFIs was engaged in bridging the access gap between formal banking institutions and rural communities. Initially, MFIs could only participate in the programme in association with a financial or credit institution. However, subsequently, they were allowed to directly apply for and be eligible for a World Bank line of credit (The World Bank 2003). This significantly changed the trajectory of the growth of solar home systems and created new markets. A new business model comprising of a tripartite agreement between the rural customer, the MFI, and the solar company emerged with clearly demarcated responsibilities. This framework provided access to affordable capital to households. Therefore, such approaches not only help in accessing capital for the DRE initiatives but also simultaneously open channels for financial inclusion.

Leverage a diversity of capital and capital sources (public, philanthropy, development finance, private capital) to reduce financial risks and unlock greater capital

Leveraging a variety of capital sources has emerged as a recurring theme across several cases to enable impact at scale and improve risk-adjusted returns on investments. Morocco's PERG leveraged multiple funding sources, including loans, equity, taxes, government funds, and international grants (bilateral and multilateral). These together accounted for about 75 per cent of the total funding. The remaining (25 per cent) was collected from the end user as a fee for service (Usman et al. 2019). Similarly, both Mexico's rural electrification project and Brazil's '*The Sun Shines for All*' (TSSFA) initiative successfully secured funds from impact investment funds (Walters et al. 2015, WBCSD 2004).

Figure 13 Leverage a diversity of capital and capital sources to reduce financial risks.

Source: Authors' analysis

At the sub-national level, the **effectiveness of leveraging funds from multiple sources** is evident in the case of Tanzania, where the commissioning of various micro-hydro power plants was made possible through a combination of cash, sweat equity, commercial loans, and grants. Grants were provided by the Italian Ministry of Foreign Affairs, the Belgian Ministry of Foreign Affairs, the European Union, and the European Committee for Training and Agriculture (Pendezza, J 2014).

Similarly, a bamboo-based power generation system was commissioned in Indonesia by utilising a combination of subsidised energy prices, a high FiT, and a grant (Wahono et al. 2022). This was made possible due to the abundance of bamboo in the local area. Firstly, a power purchase agreement (PPA) was established between the generation company and the Indonesian electrical utility PLN. The PPA price was set such that the FiT was financially feasible over the project's life. Secondly, the tariff regulations ensured that PLN resold the electricity to the community at a discount. Thirdly, the Millennium Challenge Corporation, an independent US government foreign aid agency, provided a grant that covered the capital costs of the project.

Bangladesh's megaproject – the *Rural Electrification and Renewable Energy Development II* – is another prime example, and leveraged different funding sources and mechanisms to provide energy access to 8.6 million (till March 2023) direct beneficiaries through the adoption of different DRE solutions like biogas, solar PV, mini-grids, etc. The project was financed by a combination of debt (IDCOL), equity (households), and grant funding from the World Bank's International Development Association and USAID) (The World Bank 2022). The aim was to create **regionally self-sustaining business models for supply-chain management** of the DRE interventions. In a synergistic manner, the project goals were strategically contextualised as components and subcomponents, each with its own funding source. Under 'access to electricity', for example, different subcomponents such as solar home systems (SHS), remote area power supply systems via mini-grids, household energy services, and EE in households were defined, each with their financing mechanisms and allocations of funds. As illustrated by this example, the project must be able to organise and allocate funding effectively at the design stage of various programmes through **compartmentalisation of the financing.**

Image: iStock

A small hydroelectric power station in a rural area

3.4. For a thriving market ecosystem

A thriving market ecosystem that supports DRE technologies is essential for scaling adoption and ensuring long-term success. Such a market system will have the availability of skilled resources, financial viability, access to markets, revenue-generation potential, and access to the latest cost-effective technologies. Under such enabling market conditions, making sustainable decisions regarding goods and services would be easier for consumers and producers.

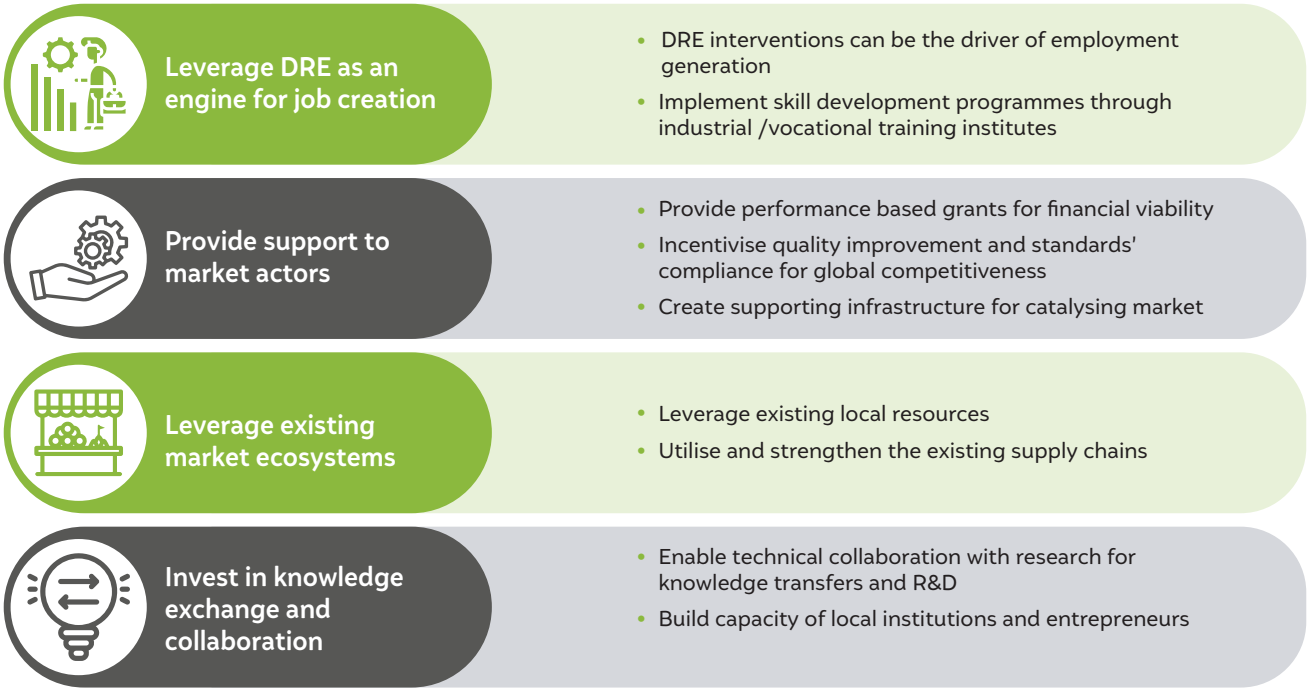
The effective good practices and strategies observed included focused government support, need-based skill-building programmes for job creation, and programmes that involve local communities and utilise existing supply chains/ Focusing on knowledge transfer through technical cooperation and research is also essential.

Key observations on the good practices from across the globe that have proven to be effective are described in detail in this section. Figure 14 summarises the findings.

Leverage DRE as an engine for job creation by complementing the DRE initiatives with need-based skilling programmes

DRE-based interventions can be the precursor to the much-needed generation of employment through skill-development programmes. Customised training modules for locally applicable DRE technologies, as well as their operation and maintenance, could be used to improve the skills of local entrepreneurs. Additionally, industrial training institutes or vocational training centres in rural and urban areas should be used to impart relevant skills and serve as potential incubation centres (IRENA and SELCO Foundation 2022). Other countries could participate through visits and training programs, and take back these experiences to their country to create new lines of economies, thereby creating jobs.

Figure 14 Summary of emerging good practices for creating a thriving market ecosystem.



Source: Authors' analysis

Figure 15 Leverage DRE as an engine for job creation.

Source: Authors' analysis

In India, the *Barefoot Women Solar Engineers Programme* aims to train illiterate women to help them become 'Solar Mamas' who can supply their communities with electricity. Rural electronic workshops have been established to ensure that the equipment is maintained. The programme successfully promoted livelihood development by creating a fully sustainable artisan economy that provided more than 500 craft professionals with a stable source of income. Barefoot has now grown beyond India and has presence in around 96 countries and has trained over 1,700 women as solar engineers (The Barefoot College 2022).

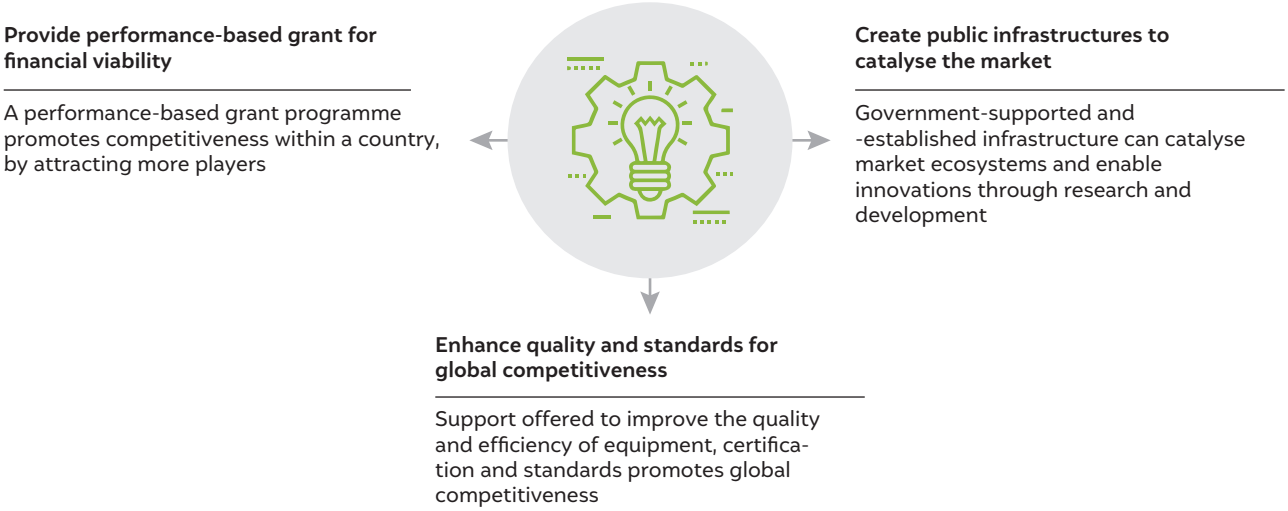
In Vietnam's *National Biogas Programme*, the project aided in the construction of nearly 158,500 domestic biogas digesters and resulted in around 16,800 full-time equivalent jobs (IRENA 2018). This was made possible by the engagement of the Netherlands' Ministry of Foreign Affairs, Vietnam's Ministry of Agricultural and Rural Development, and the Dutch not-for-profit agency SNV, that as the project implementer, provided technical assistance. The engagement of SNV ensured that relevant skills were imparted to the local masons and assistants who earn around USD 2,000 and USD 1,500 per year, respectively (IRENA 2018).

Direct public support to market actors

A market ecosystem develops when a critical scale of a product/service is attained. This is sustained only through constant innovation (in technology, process, finance, etc.) by the entities engaged in the ecosystem. Government support in the form of direct subsidies or grants, technology support and grants to improve quality standards, and public infrastructures are crucial for establishing the ecosystem, and allowing it to survive and thrive. These supports can be directed towards the market actors - manufacturers, distributors, retailers, and others across the value chain.

Performance-based grants for financial viability: The Nigerian solar hybrid mini-grid programme demonstrates the significance of government procurement via a grant-based method for developing mini-grids (solar or solar hybrid) with the assistance of the private sector. The government made focused efforts to provide electrification for selected communities that had high economic growth potential. Furthermore, **a performance-based grant programme that allowed developers to set up mini-grids in communities of their choice was critical to improving electricity access across rural Nigeria** (Wearne et al. 2021). The government intervention was vital to bringing in different private-system integrators, including Husk Power Systems, Havenhill Synergy Ltd., Green Village Electricity, and Nayo Tropical Technology Ltd., among others. Such a mechanism can help develop competitiveness within a country, pushing other regions to augment their performance to attract developers.

Figure 16 Enable government support to foster market innovation



Source: Authors' analysis

Enhancing quality and standards to enhance global competitiveness: The *Rural Electricity Development Project* in China, which was implemented by the National Development Reform Commission and financed by the World Bank, was crucial to supporting the PV ecosystem in the country (The World Bank 2001, 2009). This programme provided grants for the sale of PV systems with power output capacity of up to 10 MW, and also included grants to overcome PV market barriers. In addition, **grants were offered to improve the quality of PV equipment, certification and standards, and project management and monitoring.** In 1999 itself, there were 16 system integrators addressing the solar home-lighting system market in the remote and rural parts of the western, north-central, and southwestern regions of China. By the end of the programme in 2007, 74 component manufacturers that met quality standards were functional, as opposed to 0 (zero) at its inception (The World Bank 2009). Further, 18 companies offering different parts of the solar power system (module manufacturers, inverter manufacturers, etc.) went on to meet international standards. A few PV suppliers became major players in the international market. Some of these are listed on stock exchanges in Europe and the US and are also operating in these markets.

Creation of public infrastructure to catalyse the market: The National Dairy Development Board (NDDB) Manure Management Initiative in India is an example of public infrastructure development to catalyse the market, with the government supporting and establishing an institution to create a market for manure management (NDDB 2022). The Union Ministry of Fisheries, Animal Husbandry, and Dairying in India established a separate institutional body called NDDB MRIDA Ltd. with the goal of overseeing and supporting market actors involved in dung (manure) management, as well as assisting dairy farmers in generating additional revenue streams (PIB 2022a). The company also provides sales and marketing assistance to local businesses that manufacture biogas slurry-based fertilisers (also known as organic/chemical-free fertilisers).

Build on the strengths of existing local markets and leverage prevailing market ecosystems

It is relatively easier to develop an ecosystem when the nascent or rudimentary elements of a market are already present. Therefore, it is important that when implementing DRE programmes, the prevailing nascent or rudimentary local market ecosystems be leveraged instead of creating a whole new ecosystem altogether.

Figure 17 Build on the strengths of existing local markets and ecosystem.

Source: Authors' analysis

Leveraging locally available resources: In Indonesia, a bamboo-based community power plant was implemented in the Mentawai Islands regency in West Sumatra, primarily by taking into consideration the **local availability** of the fuel source (Wahono et al. 2022). Bamboo cultivation is known to the local community and is a socially well-accepted practice. The design of the project also ensured that the local community was incentivised to cultivate bamboo that was suitable for use in the power plant, thus ensuring a sustainable supply of the feedstock. This ensured the long-term supply of the feedstock and also addressed the potential impediment to the project's sustainability.

Utilising existing supply chains: In Mali, *Green Business Areas* (GBA) were established in rural areas with limited or no access to energy. These GBA buildings are bioclimatic commercial buildings with 24/7 electricity access, operating on renewable power. Several of the GBAs that were developed used solar power along with a power generator running on *Jatropha*, which is a locally available biofuel (GERES 2022a, 2022b). An earlier intervention – the *ALTERRE* project, implemented by Geres (a French environmental and development organisation), along with a local not-for-profit agency and a local private company – had led to the creation of short biofuel supply chains in the southeastern region of Mali. These were leveraged by the GBAs and integrated into its design. Since *Jatropha* was already being used as a biofuel, there was technical know-how and the fledglings of an ecosystem, and vendors, suppliers of the hybrid generators, and service networks were present locally.

Both these cases highlight the importance of local knowledge and the existing industry, which were easy to utilise and develop further for greater value addition (in this case, for power generation). Moreover, it was in the self-interest of the local citizenry/entrepreneurs to ensure the project's longevity as well as its sustainability.

Invest in technical collaborations, knowledge transfer, and capacity building to support the local market ecosystem

DRE technologies and services can only attain sufficient scale and replication if proper technical collaborations exist between the governments, development agencies, research institutes, and private institutions. Furthermore, knowledge transfer and capacity building on the most recent breakthroughs must occur on a regular basis.

Technical collaborations for knowledge transfer and R&D: In the Vietnam *Biogas Programme*, the Dutch Energy Agency's involvement facilitated **technical collaborations – including knowledge transfer and R&D collaboration –** with research universities in Vietnam. The Government of Vietnam's Ministry of Agricultural and Rural Development further ensured that the research benefits (knowledge) flowed to the local entrepreneurs (such as the material suppliers and masons) and thus had an on-ground impact (SNV 2012).

Capacity building to strengthen local market ecosystem: On a similar note, the capacity building of an organisation/entrepreneur is a key feature of the evolution and, thus, the sustainability of the market ecosystem. China's *Renewable Energy Development Project* funded the capacity building of the testing laboratories. The funds required to improve the capacities of testing facilities were set aside from the outset of the project. Funding was made available **for training, accessing international best practices, and in a few cases, accessing state-of-the-art hardware.** The project aided in improvement of four accredited PV-testing institutes' capabilities to international standards (The World Bank 2009).

Image: iStock

Rooftop solar water heater with hot water storage tank

Figure 18 Invest in technical collaborations, knowledge transfer, and market capacity enhancements to support the local market ecosystem.

Enable technical collaborations for knowledge transfers and R&D

Technical collaborations for knowledge transfers and R&D are crucial to scale RE deployment across geographies. It is crucial to ensure that the knowledge also flows to the community/end users

Build capacity to strengthen local market ecosystem

As DRE is a rapidly evolving sector, there is a need for constant capacity building of organisations, communities, users, and entrepreneurs. Also track technological progress and access international best practices while strengthening local capacities

Source: Authors' analysis

3.5. For a conducive environment for innovations

A supportive environment for innovations can enhance products, services, and processes. Government initiatives that invest in cutting-edge technologies and have financial tools in place to promote adoption can benefit. This entails implementing targeted public interventions to support indigenous value chains, fostering early collaborations, and grounding interventions in the local context to accelerate the innovation process.

Thus, a conducive environment for innovation can help in two ways: by indigenising the supply chain, and by achieving cost reduction and gaining scale. Both objectives can be met by adopting various approaches, as seen in the case studies analysed. Two such successful good practices that were identified are described in detail in this section. These good practices are illustrated with case studies, where the approach led to either the creation of a local supply chain, reduced cost (and increased scale), or both. Figure 19 summarises the findings in brief.

Deploy targeted public support to accelerate and promote innovative and indigenous value chains

Public support have proven to be critical to ushering indigenous innovation for any new technology in a country. Proper signals to the industry ecosystem and support on both the demand and supply sides would lead the local industry to invest in the setting up of a cost-effective value chain, resulting in increased investment in R&D and innovation throughout the value chain.

Figure 19 Summary of emerging good practices for creating a conducive environment for innovation.

Source: Authors' analysis

Figure 20 Deploy targeted public support to accelerate and promote innovative and indigenous value chains.

Provide targeted support on demand and supply side

Provide manufacturing subsidies, tax exemptions, low-cost credit lines etc., to help the domestic (DRE) industry flourish; and FiTs/net-metering regulations, interest subvention and other financial incentives to help increase demand

Incentivise efficiency for achieving technology shift

Offer incentives to the community/ users to enable adoption efficient DRE solutions

Expedite value chain development through public institutions

Leverage public institutions to stimulate and hasten the development of value chains by promoting early collaborations and grounding activities in the local context

Source: Authors' analysis

Long-term target setting, when backed by demand-side support to generate sufficient demand in the market for the technology (such as through FiTs/net-metering policies, interest subvention and other financial incentives, and upfront subsidies), can kick-start an industry. Supply-side support that support the industry could be in the form of subsidies for manufacturing, tax exemptions, grants for R&D, and lines of credit for low-cost financing. Mandates around domestic content requirements and import restrictions could be deployed at a later stage in a phased manner along with production-linked support when the domestic industry is mature, ensuring that there are no demand–supply mismatches while supporting indigenous value chains.

Targeted demand- and supply-side support for indigenisation: The development of the indigenous solar industry in Germany in the 1990s and 2000s, and later in China, are examples where clear target setting and a series of targeted demand-side and supply-side interventions seeded these new industries (Curry, Andrew 2013, The World Bank 2009). The rapid cost reduction and technological advancements in solar-PV technology, wind turbines, and other newer RE technologies across the world have been the result of the early government interventions and support given to the industry in these countries. Most of the world's oldest solar modules and other critical component manufacturers originate from Germany, and most of the younger large companies originate from China.

Incentivising efficiency for achieving technology shift: The Unnat Jyoti by Affordable LEDs for All (UJALA) programme was launched in India in 2015 with the goal of bringing energy-efficient LED bulbs to home customers and replacing 770 million incandescent lights with LED bulbs (IBEF n.d., PIB 2022c). The households receive a financial incentive to acquire LED bulbs. Customers can choose for the 'pay as you save' scheme under the UJALA programme, which allows them to pay a modest initial cost of USD 0.15 (INR 10) per bulb, with the remaining balance recovered by a monthly fee of USD 0.15 (INR 10) on their electricity bill. An individual household could use the scheme to purchase up to eight LED bulbs. Following the implementation of this programme, domestic LED bulb sales have surpassed 1.15 billion units, exceeding the program's goal of 770 million LED bulbs (IBEF n.d.).

In Denmark, the municipality of Silkeborg chose a much more targeted approach to nudge innovation and technology transition. Guided by an ambition to reduce the city's oil imports for heating, the municipality deployed a policy framework that **incentivised EE to encourage users to shift** from using solar PV–based heating solutions to more efficient and cost-effective solar-collector heating technology (Georgiev, Ivo 2019).

Setting up public institutions with mandates for value chain development: The NDDB MRIDA Ltd, a subsidiary of National Dairy Development Board (NDDB) in India's Ministry of Fisheries, has been mandated to establish a manure value chain across the country for biomass-based electricity generation (PIB 2022a). To accelerate the growth value chain development, the company will pursue research and development to deliver a low-cost solution for efficient manure management and utilisation (PIB 2022a). Several other initiatives are also in the works, all with the goal of improving manure management and establishing a well-organised value chain (NDDB 2022).

Encourage and engage in cross-country partnerships at an early stage to trigger innovations in technologies and business models

Institutional partnerships initiated at an early stage of a programme can help in developing new technological innovations as well as business models that are suitable for the target region. The partnerships could be for technical collaboration, knowledge transfer, capacity building, and cooperation in R&D. Partnerships with universities and research institutions, various modes of PPPs, sector specific coalitions, federal–local government partnerships, or international associations have proven to be extremely effective in bringing about innovations in a programme.

Public partnerships for procurement and distribution: India's *Unnat Jyoti by Affordable LEDs for All* (UJALA) scheme for distributing LED light bulbs to replace 770 million incandescent lights by March 2019 relied on partnerships to consolidate the supply chain and achieve scale through an innovative supply and distribution approach (IBEF n.d., PIB 2022c). The implementing organisation for this initiative, the Energy Efficiency Services Limited (EESL), was a government-owned business which consolidated the value chain to significantly reduce the retail cost of LED bulbs in the country. On the supply side, EESL collected open bids from manufacturers and paid them upfront. In contrast, on the demand side, they partnered with state governments and state electricity utility companies for public-distribution contracts. Because of this market consolidation, LED retail costs fell sharply, reaching as little as USD 0.8 (INR 65) in 2016. As a result, the domestic LED market grew from selling 5 million units annually in 2014 to selling 669 million units annually in 2018 as per the ELCOMA (Electric Lamp and Component Manufacturers' Association of India) India Report (Kamat et al. 2020).

Partnerships for knowledge transfer: The *Biogas Programme* in Vietnam is another example where early partnership for knowledge transfer proved to be of impact when it came to creating a commercial local biogas industry in the country. The Vietnamese *Biogas Programme* was born from an international partnership between Vietnam's Ministry of Agricultural and Rural Development and the Netherlands' Ministry of Foreign Affairs. The programme also benefited from a partnership with SNV, a global development organisation that provided the technical assistance required for the programme implementation (SNV 2012). The programme was also supported by EnDev, an energy-access partnership between six countries. These partnerships focused on local capacity building, and the programme was widely successful. Nearly 158,500 biogas digesters were constructed under the programme, and several new initiatives were born out of the original programme (IRENA 2018).

Partnerships for project implementation and scale: The social enterprise Iluméxico in Mexico has a business model that relies on various partnerships and aims to eradicate energy poverty by providing low-cost solar off-grid solutions to rural communities (Walters et al. 2015). The organisation partners with private entities for corporate social responsibility (CSR) and public entities to support their endeavours to bring solar solutions to their communities. This model has been widely successful in Mexico and has resulted in the installation of over 25,000 units, reaching over 110,000 individuals (Iluméxico, n.d.).

Figure 21 Undertake cross-country partnerships at an early stage to trigger innovations in technologies and business models.

Source: Authors' analysis

4. Emerging lessons and recommendations

The analysis of DRE case studies from around the world revealed similar challenges and a significant opportunity for learning from past experiences. The good practices observed around policy, community engagement, financing, markets, and innovations have emerged as effective guides to designing new DRE interventions for policymakers, private players, and civil society. Based on these observations, the following lessons and recommendations are put forth:

4.1 Owing to its resilience and cost-effectiveness, DRE must become an integral part of the energy ecosystem in developing countries.

Several case studies across countries showcase how DRE interventions such as mini-grids (solar PV, wind, micro-hydro, and biomass) and off-grid solar have played a significant role in improving energy access. In countries like Morocco, Nigeria, Sri Lanka, and Bangladesh, DRE has been an integral part of the rural electrification strategy. It continues to play an important role in the electrification efforts of many countries, as evidenced by its growing adoption. The lessons learnt can immensely help many developing countries that struggle with ensuring affordable and reliable power supply to all their citizens formulate rural electrification plans with DRE as a founding pillar.

4.2 DRE must be leveraged beyond energy access for overall socio-economic development, including for industries, agriculture, healthcare, education and job creation.

Analysed DRE case studies from around the globe show that DRE provides a reliable and sustainable approach to fulfilling energy needs for overall socioeconomic growth in many developing countries. As seen in India, DRE is used for healthcare, irrigation, microenterprises, and enhancing farmer incomes; In Kenya, DRE is used for irrigation, home lighting and productive use applications; In Indonesia, DRE is used for biomass management and job creation; and in Bangladesh, DRE is used for supporting healthcare, education and income generation.

4.3 Public financing must prioritise DRE to address the ecosystem-level needs of the sector

The DRE sector needs ecosystem-level interventions such as skills and capacity building, awareness raising, supporting technology innovation, building markets and value chains, carrying out monitoring and evaluations, etc. Grants, subsidies, loan facilities, incentives (such as tax exemption), and other forms of public finance can help meet these needs. As seen in China, financial incentives by the government were critical in building the PV component manufacturing ecosystem; in India, government subsidies and a loan facility were critical in scaling solar irrigation systems; in Argentina, federal government financial mechanisms were critical in scaling off-grid solutions.

4.4 G20 should support avenues for the active sharing of knowledge and lessons from DRE experiences to fast-track DRE deployments in the Global South.

A key takeaway from the case studies is that the challenges that impede DRE adoption remain similar across geographies to an extent. For example, diverse financing tools and mechanisms have been adopted by different countries to address the common challenge of affordable financing. These include PAYGO in Kenya, blended finance in India, and carbon emission reduction certificates in South Africa, among others. Accordingly, a lot can be learned from experiences across countries. Higher levels of global cooperation and partnerships for knowledge sharing can usher in a new era for DRE.

Case studies: How countries are deploying DRE

ARGENTINA

Renewable Energy for Rural Markets Project (PERMER I)
1999–2012

Enabled policy environment and made financing accessible and affordable for

SOLAR PV | SOLAR THERMAL | SMALL WIND

Image: iStock

A farm with a windmill in Argentina.

Objective

To support the provision of reliable electricity services in dispersed and poor areas using DRE technologies; to establish a nationwide delivery model of concessionaires; to strengthen provincial regulatory agencies.

Stakeholders

Funding agencies

World Bank, Global Environment Facility (GEF), Argentina's Electricity Development Fund

Partners

World Bank, GEF, and the federal government

Implementing agencies

Secretariat of Energy (Argentina), and the governments of 15 provinces

Beneficiaries

Rural households, schools, medical centres, and public buildings

Project brief

The Renewable Energy in the Rural Market Project (PERMER) promoted the use of DRE technologies to supply dependable power services in remote and underdeveloped areas. PERMER aimed to deliver energy to remote household and public buildings, such as schools and health clinics (The World Bank 2013b). The initiative's primary target was to install solar home systems (SHS), small solar power-generating systems, and mini hydro and wind power plants in households as well as in public institutions such as schools and healthcare centres. The World Bank (US$30 million loan), the Global Environment Facility (US$10 million grant), Argentina's Electricity Development Fund for provincial projects (US$26 million), and the concessionaires, concessionaires — US$44 million, and the customers — US$10 million contributed to the US$120 million funding responsibility (Covarrubias et al. 2013). In this fee-for-service model, the concessionaire owned the technological components like the battery and the SHS module. The internal installation was paid for and owned by the user or the local government. The major accomplishment of the project was the development of a sustainable and replicable model for the distribution of DRE at scale with the cooperation between federal and provincial governments.

Key takeaways

- Served as a flagship case study on institutional collaboration and cooperation between federal and regional governments to plan, finance, and implement a DRE project at scale.
- Featured an elaborate regulatory structure that offered the appropriate incentives through cost-based tariffs and subsidies, as well as an efficient operation and maintenance system.
- Innovative financial mechanisms in the form of a concession-based framework supported by World Bank loans and GEF funding were critical to the success of the interventions, as they reduced the payment default rates.

Scale and replicability

As of March 2013, the project delivered renewable energy services to over 27,000 rural households (100,000 citizens across 15 provinces) in dispersed rural areas (The World Bank 2013b). It supported installation of 21,000 SHS (3,600 kW), mini-grids for 2,400 households, 410 solar thermal applications (mostly water heating) in schools, solar systems for 2,100 public buildings (school, health, etc), and 1,050 in wind home systems (The World Bank 2013b). Through these installations there has been as reduction of 3,200 tons of CO_2 equivalent emissions. The case study offers a replicable framework and serves as a source of inspiration for similar interventions in other countries. It also serves as a motivation to scale up the intervention in provinces with low performance. The project provides a sustainable and replicable model for scaling the implementation of DRE projects targeted at rural electrification. The model strengthens and leverages both policies as well as innovative financial mechanisms to build inter-institutional collaborations to undertake planning and implementation responsibilities.

Guiding principles' performance

Scale	**Highest rung:** 27,000 rural low-income HHs impacted; DRE services enabled to about 3,000 public facilities, predominantly schools.
Citizen-centric approach	**Middle rung:** A focus on inclusion of women and marginalised communities. The project was modelled around extending clean energy access to the rural population by design and hence has been a focus on marginalised communities through their poverty-centric energy programme.
Convergence to achieve impact	**Middle rung:** Multiple buy-ins by the federal and state government agencies; along with energy influence on other outcomes of health, education, income generation, etc.
Long-term sustenance	**Highest rung:** The project serves as a model for similar other projects across the region/nation. The project has been able to demonstrate and provide a replicable DRE intervention through a successful partnership model between federal and regional agencies.

Source: Authors' compilation

Image: iStock

A farmer using a solar pump for irrigation in Bangladesh.

Bangladesh

Rural Electrification and Renewable Energy Development II Project

2013–ongoing

Enabled policy environment, engaged community and made financing accessible and affordable for

SOLAR PV OFF-GRID AND MINIGRID | SOLAR WATER PUMPS | BIOGAS

Objective

To increase access to clean energy in rural areas through RE and to promote more efficient energy consumption.

Stakeholders

Funding agencies

World Bank; USAID; GIZ; kFW; Islamic Development Bank; Bangladesh Climate Change Resilience Fund (BCCRF); Global Partnership for Output Based Aid (GPOBA)

Implementing agencies

Infrastructure Development Company Limited (IDCOL) – a government-owned infrastructure finance company; Ministry of Power, Energy and Mineral Resources; Rural Electrification Board; and NGOs

Beneficiaries

Rural households, women in rural areas

Project brief

The project's development goals include encouraging greater energy efficiency and expanding access to clean energy in rural areas. In Bangladesh's rural areas where grid energy has not yet reached or is not anticipated in the near future, the project plans to provide electricity to 2.5 million people. The project aims to increase access to electricity primarily by assisting with the installation of SHS, as well as remote power supply via mini-grids (Sustainable Development Department 2012). The project's second and third components aim to increase household EE by distributing compact fluorescent lamps (CFLs) and promoting clean cooking solutions (Sustainable Development Department 2012). The final component aims to provide technical assistance to the relevant agencies (Power Cell, Sustainable and Renewable Energy Development Authority and Bangladesh Energy Regulatory Commission) involved in the project's planning and execution (Sustainable Development Department 2012). To ensure successful implementation, this component would also provide technical assistance to IDCOL for capacity building, inspection and monitoring, impact evaluation, training, and other relevant activities. The project has been financed through a range of multilateral mechanisms and institutions such as IDA, USAID, BCCRF, and IDCOL, each targeting different components.

Key takeaways

- Highlighted the key principles and common factors that contribute to the success of a DRE programme, such as establishing key institutional and implementational arrangements, supply-chain management, creating markets through innovative financing, the importance of the sense of community ownership of the products, and effective monitoring and evaluation after the deployment of the intervention.
- These principles have been particularly evident in the solar home systems and mini-grid programmes.

Scale and replicability

As of March 2023, the project has over 8.6 million direct beneficiaries by installing 1.2 million SHS, 85 MW off-grid RE capacity, 9,082 mini-grid, 1,303 SIPs (solar irrigation pumps), and 10,907 biogas plants; and disseminating 3.1 million efficient cookstoves (The World Bank 2022). The project incorporate crucial high-level lessons from prior SHS programmes with bank financing, and uses a range of innovative mechanisms to make the current programmes, particularly the SHS component, successful. Crucial learnings on product quality, SHS affordability, social acceptance of the participating organisations, and technical capacity building have been applied in order to make the programme scalable and replicable in the longer term. However, in recent years, the programme's progress has been hampered by competing on-grid expansion and subsidies (Hellqvist et al. 2023). As a result, inter-governmental coordination throughout the policy formulation phase is critical to the success of programmes.

Guiding principles' performance

Scale	**Highest rung:** As of March 2023, 8.6 million direct beneficiaries. 5.3 million people provided with access to electricity; 3.1 million people provided with access to clean cooking; other beneficiaries include businesses and other entities.
Citizen-centric approach	**Middle rung:** 67 per cent female beneficiaries; the partner organisations, which were established for the project execution, have increased female staff capacity to 458.
Convergence to achieve impact	**Middle rung:** This is not an isolated energy-focused intervention, i.e., also influences the outcomes of health, education, income generation, etc.
Long-term sustenance	**Highest rung:** This is a model programme as it leads to the support of seven different projects. In addition, the establishment of the SREDA (Sustainable Renewable Energy Development Authority) was a key outcome of the project as the core staffs were hired and it was made operational during the programme tenure.

Source: Authors' compilation

Solar panel at school in Bolivia

Bolivia

Access to clean energy through a micro-franchise model
2014–present

Engaged community and made financing accessible and affordable for

SOLAR HOME SYSTEMS | SOLAR FOR PRODUCTIVE USE

Objective

To provide energy access across in remote rural areas of Bolivia through the implementation of a micro-franchise business model.

Stakeholders

Funding agencies

Multilateral Investment Fund and the Inter-American Development Bank (MIF-IDB), Spanish Agency for International Development Cooperation (AECID), and GIZ

Implementing agencies

ENERGETICA (a not-for-profit agency) and municipalities

Beneficiaries

Rural households and communities

Project brief

The project was launched in 2014 to provide energy products and energy services to households and enterprises located in remote and rural areas of Bolivia. A micro-franchising model was engaged to deliver energy products/services (Eras-Almeida et al. 2019). Micro-franchising offers a distribution network to the micro-franchisor (the energy product distribution company) to leverage a network of local micro-franchisees (small entrepreneurs with basic electronics skills) for the sales and services of energy products (IADB 2012). In this case, ENERGETICA (a not-for-profit agency) employed the micro-franchise principle. MIF-IDB offered a senior loan with a term of 72 months with a moratorium of 36 months to ENERGETICA; AECID and GIZ provided grants towards institution and capacity building; and municipalities along with local entrepreneurs engaged in the sale and distribution of energy products (IADB 2012).

Two types of sales approaches were employed in the project. The first involved direct sales by 60 micro-franchisees (local entrepreneurs) to end users. The second consisted of distribution and sales through agreements with municipalities. Both forms offered solar power kits, which included batteries and luminary (like LEDs), and other equipment such as bulbs, TVs, and radios, to name a few. In addition, water pumps and productive systems were offered to the farmers, along with equipment maintenance services (Eras-Almeida et al. 2019). The model provided an opportunity for local entrepreneurs to offer extra products and generate new sources of income. More importantly, it eliminated the risk of product unreliability (poor quality) and also included financing of the energy product, which further facilitated sales (Eras-Almeida et al. 2019). Further, the product-/service-design phase included deliberations with representatives of municipalities, leaders of farmer unions, community representatives, etc., to develop the solar energy systems.

Key takeaways

- Inclusion of government agencies (national and regional), local representatives, leaders, and entrepreneurs enabled broad population cooperation and participation, which helped establish a lasting commitment to implement long-term projects.
- Demonstrated that the higher the local participation in the project(s), the greater the user confidence.
- Micro-franchising has several benefits — increased local incomes, ease in access to a wide range of electrical services, and ease in provision of operation and maintenance services.
- Initially, grants are required to support capacity building and institutional strengthening

Scale and replicability

In 2017, the project had 12,510 beneficiaries: 11,800 families acquired SHSs, 650 micro and small businesses acquired productive systems (grain mills, water pumps, and electric fences), and 60 communities acquired systems for pumping drinking water, lighting schools, and health centres (Eras-Almeida et al. 2019). During the same period, the project generated 60 jobs with a minimum 20 per cent increase in incomes. The total sales during this time exceeded USD 2.09 million (Eras-Almeida et al. 2019). The micro-franchise model offered several elements of energy supply under one umbrella – technology access, technology service, and technology financing. Further, the framework in its design tenet was community focused and supported income generation (entrepreneur-led effort). Moreover, being technology agnostic, the model can be replicated across low-income, low-energy access and low productivity regions.

Guiding principles' performance

Scale	**Highest rung:** Overall 12,510 beneficiaries; 650 micro and small businesses supported; generated 60 jobs with an increase in incomes of 20 per cent or more.
Citizen-centric approach	**Middle rung:** A focus on inclusion of women and marginalised communities.
Convergence to achieve impact	**Middle rung:** It is not an isolated energy-focused intervention, i.e., it also influences the outcomes of health, drinking water, education and income generation.
Long-term sustenance	**Highest rung:** The micro-franchise model can be engaged to deliver energy as well as financial services for similar remote and rural areas across the globe.

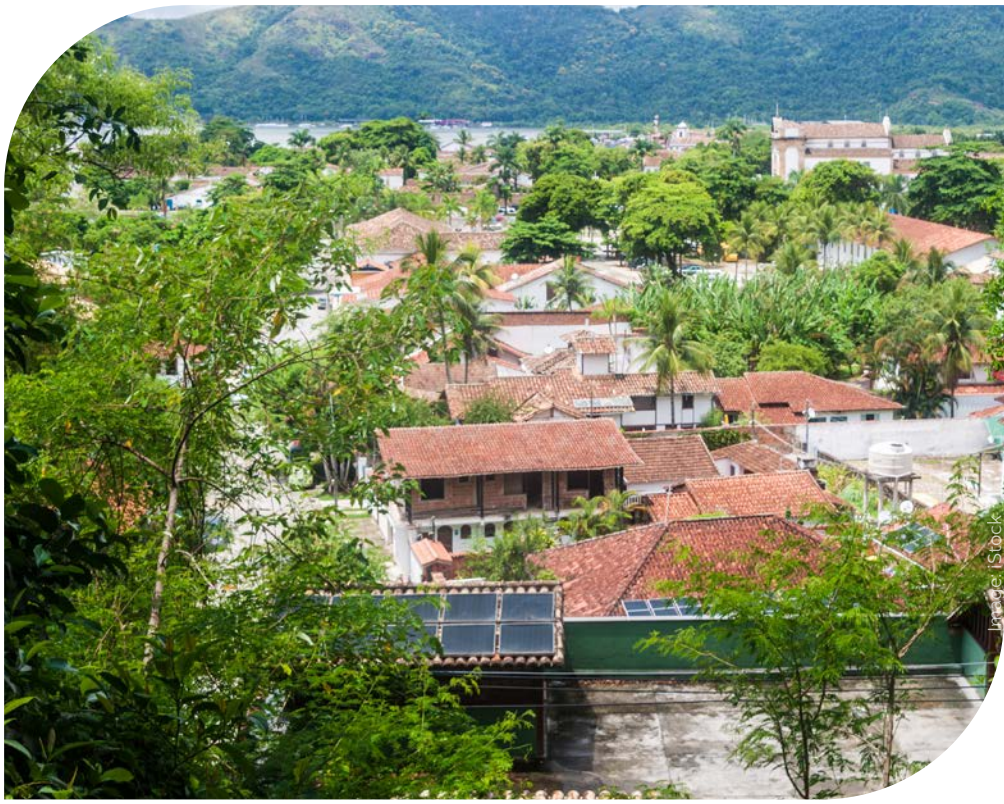
Source: Authors' compilation

Brazil

The Sun Shines for All
2001–2007

Made financing accessible and affordable for

SOLAR PV



Homes with solar panels in a Brazilian village.

Objective

To provide energy services to low-income populations in rural areas of Brazil through a leasing model.

Stakeholders

Funding agencies

Solar Development Foundation

Beneficiaries

Rural low-income households

Implementing agencies

Institute for Development of Natural Energy and Sustainability (IDEAAS: a not-for-profit, social enterprise); Agroelectric System of Appropriate Technology (STA: a for-profit technology provider)

Project brief

Fabio Rosa, an agronomist, founded two organisations: the for-profit Agroelectric System of Appropriate Technology (STA) in 1992, and the not-for-profit Institute for Development of Natural Energy and Sustainability (IDEAAS) in 1997. **Through STA, Rosa launched 'The Sun Shines for All' (TSSFA) initiative in 2001 to provide affordable energy solutions to low-income households without access to electricity.** STA provides customers with different models of solar home-lighting kits and only charges a monthly rent for the energy services engaged over 36 months. The monthly lease excludes the installation fee, which can either be paid upfront or as a lease over 12 months. This was followed by the *Quiron* project managed by IDEAAS, which supported DRE technologies for income generation activities – such as solar fencing for efficiently managing grazing activities. The initiative increases the milk and meat production from buffaloes and, in the past, has increased yield by up to 200 per cent.

Key takeaways

- The direct purchase of an energy technology and the lease of 'energy-as-a-service' are two different business models, and the latter is preferable for low-income households as the monthly rental terms align with their existing monthly energy expenditures.
- The success of the productive and income-generation activities from renewables is primarily due to the technology's ability to increase yield, which results in higher income.

Scale and replicability

STA was estimated to have installed over 6,000 solar kits over a 4- year period (2004-2007) to impact about 13,000 families ((Mugica, Yerina n.d., WBCSD 2004). TSSFA model was to electrify remote and rural regions that are not covered by conventional models. Their business model involved a for-profit organisation offering technology and services, and a not-for-profit agency implementing a lease-based model. The capital costs and liability would be managed by the not-for-profit, and monthly rentals would be affordable for low-income households. The learning gathered through this project led to the creation of Quiron project that expanded the offering by including higher-wattage solar technologies, and opportunities for income generation.

Guiding principles' performance

Scale	**Highest rung:** Estimated impact on about 13,000 families (the actual numbers can't be determined, as the available literature indicate only estimation)
Citizen-centric approach	**Highest rung:** People's needs and culture were prioritised. The project engaged with low-income communities and designed a solar home-lighting system which matched their existing energy expenditure.
Convergence to achieve impact	**Lowest rung:** The project was privately funded, led by non-state actors, and there was no state intervention.
Long-term sustenance	**Middle rung:** The project made way for the productive use of solar technology, which led to an increase in the incomes of its clients.

Source: Authors' compilation

China

Renewable Energy Development Project 2003–2020

Enabled thriving market ecosystem and conducive environment for innovations for

SOLAR PV | WIND

Setting up wind turbines in China.

Objective

To develop a sustainable market for PV technologies and demonstration of the viability of commercial wind developments in coastal regions.

Stakeholders

Funding agencies

World Bank

Beneficiaries

Households, solar module manufacturing supply chain; Shanghai Wind Power Company (a private company)

Implementing agencies

National Development and Reform Commission (Federal Agency); and Shanghai Municipal Electric Power Company (State Grid)

Project brief

The project was supported by a loan and a grant from the World Bank. The initiative was led by the Project Management Office (PMO), which operated under the State Economic and Trade Commission (SETC, currently known as the Ministry of Commerce) (The World Bank 2001, 2009). As a part of the objective, the PMO was tasked with executing three components:

- **Wind component:** This involved the commissioning and installation of a 750 MW wind plant.
- **PV component:** This involved the installation of 600,000 solar PV systems benefiting ~200,000 households.
- **Technology-improvement component:** This involved sub-grants to supported testing and certification projects, and contributed to the development of quality standards.

The project led to further scale-up, and two more phases were initiated – the China Renewable Energy Scale-Up Phase I (CRESP I) from 2010 to 2015, and CRESP II from 2015 to 2020 (The World Bank 2012, 2020). CRESP I's primary objective was to implement a legal and regulatory framework to increase the share of RE-based electricity generation and to support its effective implementation in four pilot provinces. CRESP II emphasised efficiency improvement and reduction of incremental costs of RE technologies, especially solar photovoltaic power.

Key takeaways

- Establishing a market requires skilled and unskilled labour, and good infrastructure.
- Government subsidies, technology support, lower energy costs, and easy credit are critical for creating an ecosystem that promotes innovation through reduced costs.
- Sustainability is ensured through a focus on quality, institutional strengthening, and evolving processes.

Scale and replicability

The electricity generation from wind increased from 416 GWh/year(through 168 MW installed capacity) in the year 1998 to 103,400 GWh/year (through 5900 MW installed capacity) in 2008 – an increase of CAGR of 69 per cent (The World Bank 2009). The project directly led to the installation of 625,000 solar PV systems (installed capacity of 80 MW). The wind and solar-PV components were together responsible for the reduction of 140 million $MtCO_2$-eq. The initiative led to the strengthening of 74 PV-component manufacturers, including manufacturers of solar modules, solar charge controllers, and inverters, to name a few. This also led to increased competition, with the market share of the 4 largest PV supply companies reducing from 51 per cent before the start of the project to 37 per cent. This resulted in cost reductions of PV systems, which fell from USD 16/Wp in the year 1998 to USD 9/Wp by the project's close in 2008. Further, quality standards were developed, and laboratory testing capacity was strengthened. Finally, China's interest in scaling up RE grew stronger, and the project was extended to two other phases. The desired outcome of the three phases was to enable commercial renewable electricity suppliers to provide energy to the electricity market.

Guiding principles' performance

Scale	**Highest rung:** 625,000 solar PV systems; 74 PV system or component manufacturers that reached quality standards established.
Citizen-centric approach	**Middle rung:** The project catered to needs of remote and rural parts of northwest, north-central, and southwest China.
Convergence to achieve impact	**Middle rung:** Multiple buy-ins by the federal and state government agencies
Long-term sustenance	**Highest rung:** Chinese PV-component manufacturers (solar modules, solar charge controllers, and solar inverters) became global players.

Source: Authors' compilation

Solar thermal energy panels in Denmark.

Denmark

Solar Heating in Silkeborg
2014–present

Enabled policy environment and conducive environment for innovations, and eased affordable financing for

SOLAR THERMAL-HEATING

Objective

To install solar collectors for cost-effective heating in the district and moving towards 100 per cent carbon-neutral heat by 2030.

Stakeholders

Implementing agencies

Municipality of Silkeborg, Silkeborg Supply (municipality-owned utility); , and the Danish government

Beneficiaries

Households

Project brief

The Silkeborg municipality in Denmark has a target of becoming carbon-neutral by 2030, resulting in the commissioning of the world's largest solar thermal plant. **The project involves the creation of a solar thermal plant for heating the district by a local municipally-owned utility Silkeborg Supply, which caters to 20 per cent of the annual district heating demand.** The plant has a minimum lifespan of 25 years, a configuration of 12,436 solar collectors, and is responsible for reducing CO_2 emissions by 14,000 metric tonnes per year (Georgiev, Ivo 2019). The project has demonstrated the importance of PPPs to scale up RE projects and programmes for a large population. The project has also resulted in multiple positive outcomes, not just in terms of providing low-cost heating services using renewable technology, but also by increasing EE by 20 per cent, generating local employment, and decreasing the overall risk of poverty by reducing the reliance on price volatile natural gas, which is, in turn, responsible for significant emission reductions.

Key takeaways

- The project showed that transitioning to RE in the heating sector can be cost effective, with solar collectors being three to four times more efficient than solar panels.
- It also showed the significance of legislative incentives, visionary goals (like the municipality's goal of being carbon-neutral by 2030), and PPPs to promote the adoption of energy-efficient technologies and reduce energy consumption.

Scale and replicability

The project demonstrated the scalability of solar-collector technology over solar panels in catering to the heating needs of a large population (in this case, around 4,400 households) (Georgiev, Ivo 2019). The municipality of Silkeborg has already achieved a 45 per cent emission reduction by 2020, in line with its goal of reaching 100 per cent carbon neutral heat by 2030 for its 22,000 residents in the district who are connected to the current heating network (Georgiev, Ivo 2019). The project has also provided a proof-of-concept for a solar heating intervention in the Latvian city of Salaspils.

Guiding principles' performance

Scale	**Middle rung:** Solar collectors powered heat supply to 4,400 HHs
Citizen-centric approach	**Lowest rung:** The government's policy efforts positively impacted citizens.
Convergence to achieve impact	**Highest rung:** It has multiple outcomes in terms of fuel savings; employment generation; and reducing the risk of poverty
Long-term sustenance	**Highest rung:** The project has been a huge success and is now being extended to connect the rest of the district to the renewable heating system.

Source: Authors' compilation

Germany

On-grid Rooftop Solar Programme Under The Renewable Energy Sources Act (EEG) 2000–present

Enabled policy environment for

SOLAR PV (ROOFTOP)

Image: Alamy

A farm shop fitted with solar panels in Germany

Objective

To scale rooftop solar with conducive policy support and a systemic approach.

Stakeholders

Implementing agencies

German government

Beneficiaries

Households and the solar rooftop industry

Supporters and others

Electricity market private sector stakeholders

Project brief

Germany's policy intervention is often recognised as the most effective in promoting the rapid expansion of renewable energy, particularly rooftop solar. Germany is the leading solar PV market in Europe as of 2023 (Bateman, J 2023). Germany has the second-highest per capita solar electricity generation (707 kWh) in Europe as of 2022 (Our World in Data n.d.). As of 2022, it also has the world's second-highest rooftop PV installation (668W) per capita (Chandak, P 2022).

Germany's Renewable Energy Sources Act (EEG) is a multi-decade policy package that has resulted in the country's rapid scale-up of RE (Curry, Andrew 2013). The programme deployed several policy tools such as FiTs, priority grid access, and RE targets, and further promoted the ecosystem with grants, low-interest loans, R&D incentives, etc. (Matschoss et al. 2019). The installed capacity of renewables in Germany rose to 93 GW in 2014 from a mere 4.7 GW in 1990 (IRENA 2015).

Key takeaways

- Germany's Renewable Energy Sources Act (EEG) has been a multi-decade policy package which has been implemented in phases and has led to the rapid scale-up of RE in the country.
- The core policy instrument used was the guaranteed FiTs for 20 years, along with priority grid access. The attractive FiTs led to the proliferation of rooftop solar in the country along with other renewable energy sources.
- The dynamic nature of the FiT design resulted in long-term success FiTs were designed with a yearly reduction in tariffs to incentivise cost reduction.
- Across three phases of EEG, the programme continuously went through adjustments depending on the changing needs and challenges.

Scale and replicability

Germany's Renewable Energy Sources Act (EEG) and the subsequent rise in the adoption of RE in the country is considered a model for policy-led market transformation worldwide. Germany institutionalised a strong incentive framework which led to the faster adoption of DRE technologies like rooftop solar. Additionally, an evolving but long-term policy framework ensured the rapid adoption and scale of new technology. Such a policy programme would provide long-term certainty; it would also be flexible to adapt and evolve as the market conditions evolved and could aid in rapidly scaling new DRE technologies in a region.

Guiding principles' performance

Scale	**Highest rung:** >>10,000 HHs – impact has been countrywide.
Citizen-centric approach	**Lowest rung:** The government's policy efforts positively impacted citizens..
Convergence to achieve impact	**Lowest rung:** An isolated energy-focused intervention, that focused on scaling the DRE technologies and reducing dependence on imports and nuclear
Long-term sustenance	**Highest rung:** It is a replicable model for policy support to scale a new technology, and the FiT as a policy tool has been replicated across the globe.

Source: Authors' compilation

India

Powering Primary And Community Health Centres Through Off-grid Solar Electricity 2012–2016

Enabled policy environment for

SOLAR PV

Image: Sanjeev Jain/CREDA

A solar-powered primary health care centre in Chhattisgarh, India.

Objective

To install off-grid solar-PV rooftop systems at various PHCs and CHSs spread across Chhattisgarh, and establishment of a system design for supporting cold-storage facilities along with other basic types of equipment.

Stakeholders

Implementing agencies

Chhattisgarh Renewable Energy Development Corporation (CREDA), Chhattisgarh Health Department, State National Health Mission

Supporters and others

Ministry of New and Renewable Energy (MNRE), India

Beneficiaries

Primary and community health centres

Project brief

In Chhattisgarh, over one-third of PHCs are reported to have no regular supply of electricity. **The project targetted these centres by making them self-reliant in the ways they produce and use electricity through off-grid solar-PV system installations.** The PHCs and CHCs are fitted with 2 kW and 8 kW of solar-PV cells, respectively, with sufficient battery backup. Apart from providing basic electricity to meet the centres' operational demands, cold storages for medicines, critical vaccines, and diagnostic chemicals have also been powered, maintaining their quality and potency. The project generated multiple outcomes, not just to health, but also to employment opportunities, women's security and empowerment, financial savings, access to regular water supply, etc. In terms of health, the PHCs have recorded a 50 per cent increase in the number of admitted patients, twice the number of neonatal deliveries, and improvements in maintaining the cold chain (Ramji et al 2017).

Key takeaways

- The project has demonstrated the scalability of off-grid solar PV technology beyond household use.
- The health centres also reported significant cost savings compared to the previously used diesel-based systems, showcasing the economic affordability of these low-cost alternate energy solutions with incentives and schemes.

Scale and replicability

Under this project, around 1,500 healthcare facilities — 785 primary health centres, 525 sub-health centres, 165 community health centres, and 26 district hospitals — have been electrified using solar-PV technology (CREDA 2023). The project has resulted in a total of ~4.8 MW installed PV capacity (CREDA 2023). The cost-effectiveness of the interventions, as well as their ability to achieve multiple impacts at the same time, provided proof-of-concept for scaling it to other PHCs across India and even to sub-health centres at the village-cluster level, allowing for last-mile connectivity. The involvement of state and central governments to ensure the proper implementation of schemes through the state-owned utility CREDA has been instrumental in producing beneficial outcomes for millions of individuals accessing those basic healthcare facilities.

Guiding principles' performance

Scale	**Highest rung:** 1500 healthcare facilities have been electrified using solar
Citizen-centric approach	**Highest rung:** The interventions were designed and implemented according to people's needs and provided access to basic healthcare services such as emergency responses, and neonatal delivery.
Convergence to achieve impact	**Highest rung:** Multiple buy-ins by the federal and state government agencies; and it is not an isolated energy-focused intervention, i.e., also has multiple outcomes on employment, women's security, and empowerment etc.
Long-term sustenance	**Highest rung:** The project establishes itself as a model for other such projects in different states.

Source: Authors' compilation

India

PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan) 2019–present

Enabled policy environment and eased affordable financing for

SOLAR PV AND IRRIGATION

An Indian farmer using solar-powered irrigation system.

Objective

To remove the need for diesel- and kerosene-powered pump sets by farmers, and to connect pump sets to solar power. It also seeks to encourage the use of RE in the agricultural industry and enable Indian farmers to take advantage of solar farming.

Stakeholders

Implementing agencies

Ministry of New and Renewable Energy (MNRE), Government of India; electricity distribution companies (DISCOMS); State Electricity Regulatory Commission (SERC)

Supporters and others

State Nodal Agencies (SNAs)

Beneficiaries

Farmers/cooperatives/ panchayats/ farmer producer organisations (FPOs)/ water user associations (WUA)

Project brief

PM-KUSUM consists of three components (MNRE n.d.). Component A promotes the installation of 10,000 MW of decentralised ground-mounted solar power plants connected to the grid with individual plant sizes of up to 2 MW (MNRE n.d.). Component B promotes the installation of 17.50 lakh independent solar-powered agriculture pumps, with a capacity of up to 7.5 HP (MNRE n.d.). Component C involves the solarisation of 10 lakh grid-connected agriculture pumps with individual pump capacities of up to 7.5 HP (MNRE n.d.).

- Under Component A, plants with a capacity of up to 2 MW that can be linked directly to existing 33/11 kV, 66/11 kV, or 110/11 kV sub-stations of the distribution company. Further, the discoms will purchase the generated RE at a FiT set by the relevant State Electricity Regulatory Commission (SERC).
- For components B and C, the MNRE will once a year distribute state-by-state allocations for solar pumps and the solarisation of current grid-connected pumps. Under these components, the farmer will cover 10 per cent of the cost, banks will finance up to 30 per cent as a loan, and the Central and State governments will cover 60 per cent of the project cost as a front-end subsidy. The scheme is also covered under the Reserve Bank of India's (RBI) Priority Sector Lending (PSL) Guidelines, which provide easy access to financing. Several banks have also released lending rules for the scheme (PIB 2022b).

Key takeaways

- Setting technological requirements/frameworks is essential for scaling DRE solutions and guarantee the longevity of the policy intervention. Along with design and components of the equipment (such as Universal Solar Pump Controllers), guidelines on the testing of the DRE solution (solar water-pumping systems) were also established.
- In order to speed up the process of extending benefits under the scheme, PM-KUSUM relaxed the requirements for performance bank guarantees under component A and component C (feeder-level solarisation). Additionally, the tender conditions have been revised to increase the installer base.

Scale and replicability

The PM-KUSUM project is one of the largest global efforts, aiming to provide farm power to more than 35 lakh farmers by solarising their agricultural pumps. In 2021, the programme was expanded so that 20 lakh farmers could receive financing for the installation of standalone solar pumps. When presenting the budget for 2020–2021, the finance minister also announced that farmers would receive assistance to install 15 lakh grid-connected solar pumps. This programme has high replication potential for countries that require reliable power for their irrigation needs, especially in off-grid areas.

Guiding principles' performance

Scale	**Highest rung:** 147,367 solar agriculture pumps of capacity up to 7.5 HP installed for individual farmers under component B of the programme.
Citizen-centric approach	**Middle rung:** Prioritisation of small and marginal farmers when selecting beneficiaries.
Convergence to achieve impact	**Highest rung:** Multiple buy-ins by the federal and state government agencies; it is not an isolated energy-focused intervention: reduce dependence on diesel; provide reliable electricity to farms and remote areas; and boosts farmer's income
Long-term sustenance	**Middle rung:** The scheme expanded its scope after taking the learnings from the first year of operation and expanded scope of components A, B, and C.

Source: Authors' compilation

India

Barefoot College Solar Engineers
1996–present

Enabled thriving market ecosystem and active community engagement for

SOLAR SYSTEMS

A group of women being trained at 'The Barefoot College'.

Objective

To prepare women to work as solar engineers who can construct and maintain solar-powered lighting systems for homes

Stakeholders

Implementing agencies

The Barefoot College; the Ministry of New and Renewable Energy (MNRE), Government of India

Beneficiaries

Marginalised women from LDCs

Supporters and others

Ministry of External and Ministry of Rural Development, Government of India; ADB; UNDP; UNWOMEN; Norwegian Church Aid; European Union; Government of Zanzibar

Project brief

The Barefoot College, a non-profit organisation incorporated in February 1972 under the name of Social Work and Research Centre, in the state of Rajasthan, India in a remote village named Tilonia. **The Barefoot Women Solar Engineers programme, started in 1996, aims to train marginalised women in order for them to become 'Solar Mamas' who supply their communities with electricity (The Barefoot College 2022).** Numerous women from disadvantaged regions throughout the world attend Barefoot College in Rajasthan, India, for five months each year. Through the training, 'Solar Mamas' gain knowledge on how to operate intricate charge controllers and inverters, set up a local electronics workshop where they can handle all major and minor repairs to the solar power system, install solar panels and connect them to batteries, build solar lanterns, and more (The Barefoot College 2022).

Key takeaways

- Skilling efforts and investments in capacity-building collaborations are essential for DRE interventions to be successful. Barefoot College provided five-month training modules to women in Rajasthan to make them and their communities self-sufficient for solar electrification.
- Providing such support to the local community goes a step further in doubling the impact of these interventions, as it aids their acceptance and adoption in the ecosystem.
- The natural trust built as a result of active community engagement was evident in Barefoot College's solar engineering training to illiterate women from marginalised communities of LDCs.

Scale and replicability

This initiative has trained 1,700 rural women to be solar engineers, and 96 countries have instituted Barefoot solar programmes. Additionally, solar home-lighting systems have been installed in 75,000 households across 1500 villages by the women solar engineers through the support of cooperation partners (The Barefoot College 2022). Thus, the replicability of this initiative has been evidenced by its impact in training women from countries such as Botswana, Cameroon, Mali, Swaziland, Gambia, Colombia, Ecuador, Guatemala, Mexico, Paraguay, Egypt, Syria, Turkey, Indonesia, Malaysia, Thailand, Nepal, and Nauru. Therefore, because it offers training in alternative technologies and equips the most vulnerable rural communities to deal with climate change, this programme has a high potential for replication and scaling in nations with large populations of rural disadvantaged groups.

Guiding principles' performance

Scale	**Highest rung:** 1,700 rural women have been trained as solar engineers; solarised 75000 households across 1500 village
Citizen-centric approach	**Middle rung:** A focus on the inclusion of women and marginalised communities (by training illiterate women from marginalised and low-income communities from LDCs).
Convergence to achieve impact	**Highest rung:** It is not an isolated energy-focused intervention: focuses gender, education, water access and waste water treatment, and improving incomes and livelihood opportunities.
Long-term sustenance	**Highest rung:** The project serves as a model for similar other projects across the region/nation/globe. Women from different nations get training as Barefoot Solar Engineers (BSEs) in Tilonia, Rajasthan, before returning (to their nation) to assist with the establishment of the centres. They reproduce Barefoot's solar programme with the help of local Barefoot partners and experts, teaching other women how to solar power their communities.

Source: Authors' compilation

India

UJALA (Unnat Jyoti by Affordable LEDs for All) Scheme
2015–present

Enabled thriving market ecosystem and eased affordable financing for

ENERGY EFFICIENCY IN HOME AND STREET LIGHTING

Image: EESL India

The LED bulb distribution in rural India under the UJALA scheme.

Objective

To promote energy efficiency by replacing 770 million traditional bulbs and CFLs and 35 million street lights with LEDs to save 8.5 million kWh of power and 15,000 tonnes of CO_2 overall.

Stakeholders

Implementing agencies

Energy Efficiency Services Limited (EESL) under the Ministry of Power, Government of India; discoms

Beneficiaries

Domestic lighting industry, households

Project brief

The Unnat Jyoti by Affordable LEDs for All (UJALA) programme, launched in 2015, aims to provide LED bulbs to domestic customers and replace 770 million incandescent lights with LED bulbs (IBEF n.d.). The programme is implemented by Energy Efficiency Services Limited (EESL), and households can purchase LED lights at low initial costs (USD 0.154), with the remaining amount being deducted from their power bill. The initiative focuses on EE in lighting as LEDs are 88 per cent more energy efficient than incandescent bulbs and 50 per cent more energy efficient than CFLs. Initially, 100 cities had signed up for the programme, and, by 2020, the government had installed 366 million LEDs. However, the domestic market sales of LED bulbs have reached beyond 1.15 billion units, surpassing the programme's goal of 770 million LED bulbs (IBEF n.d.).

Under this scheme, the government also launched, the *Street Lighting National Programme (SLNP)*. SLNP, through the Energy Efficiency Services Limited (EESL), aims to install and retrofit over 30 million LED streetlights in rural India by 2024, through investments of USD 1.09 billion (INR 8,000 crore).The same scheme was also replicated in Malaysia (PIB 2017).

Key takeaways

- Through bulk procurement, the UJALA scheme aided in obtaining economies of scale in producing LED bulbs. As a result, retail prices of LED bulbs fell substantially to USD 0.5 (INR 38) by 2017 (PIB 2022c). (PIB 2022c).
- Transparency in government procurement also boosts competition in the sector. By using electronic procurement for products and services, UJALA upheld transparency and promoted competition under the programme. As a result, transaction costs and order processing times significantly reduced, improving process efficiency.
- Innovative financing and an understanding of the end user's ability for uptake significantly impact the success of such interventions. In UJALA, consumers could opt for the 'pay as you save' programme, wherein the customers were offered the choice of paying an initial cost of USD 0.15 (INR 10) per bulb, with the remaining balance being recovered through a monthly charge of USD 0.15 (INR 10) in their electricity bill. The programme allowed customers an opportunity to buy up to eight LED bulbs on a single electricity bill.

Scale and replicability

Through the UJALA programme, about 366 million LED bulbs were distributed, resulting in an annual energy savings of 47,784 million units of electricity. Furthermore, it contributed in avoiding a peak demand of 9,566 MW and reducing CO_2 emissions by 38.70 million tonnes per year (PIB 2022c). UJALA was a pan-India programme; however, following its success, the idea was also implemented in Malacca, Malaysia, in 2017. The UJALA programme was implemented in Malaysia to improve the welfare of the local population by reducing their energy use and easing the burden on consumers. Here, as part of the UJALA scheme, 10 high-quality 9-watt LED lights were to be given to every family at a cost of RM 10. Thus, given its potential impact, this programme can be duplicated in other countries where demand-side interventions/programmes are required to stimulate EE.

Guiding principles' performance

Scale	**Highest rung:** Distribution of 366 million LED bulbs (as of 2022)
Citizen-centric approach	**Middle rung:** A focus on the inclusion of women and marginalised communities (as part of its inclusive growth strategy to enable growth in lower-income communities, EESL also enrolled self-help groups (SHGs) for the distribution of LED bulbs under the UJALA programme).
Convergence to achieve impact	**Highest rung:** It is not an isolated, energy-focused intervention: helped increase savings, improve quality of life; contributed to economic growth and prosperity, and expanded the domestic LED market.
Long-term sustenance	**Highest rung:** The project serves as a model for similar projects across the nation/globe. GRAM UJALA Scheme was launched as furtherance of this programme in 2021, and another government initiative for LEDs, the Street Lighting National Programme (SNLP) was also launched. The UJALA programme was also replicated in Malaysia in 2017.

Source: Authors' compilation

India

NDDB Manure Management Initiative

2018–present

Enabled thriving market ecosystem and conducive environment for innovations for

BIOGAS

Manure management at an Indian farm.

Objective

To strengthen livelihood opportunities for dairy farmers by optimising the use of cow dung for the production of biogas, compost and other products.

Stakeholders

Implementing agencies

National Dairy Development Board (NDDB); Ministry of Fisheries, Animal Husbandry, and Dairying; dairy cooperative milk unions or federations

Beneficiaries

Dairy farmers

Project brief

NDDB launched a project to create a value chain for manure. **The goal of the manure-management model was to equip small-scale female farmers with the tools necessary to effectively use cow dung as a cooking fuel, minimise the labour intensity of dung management, lessen the health hazards caused by cooking smoke, lessen the negative environmental impact, and provide an additional income through the sale of digested slurry from biogas plant by-products (NDDB 2022).** In 2018, the *New National Biogas and Organic Manure Programme* (NNBOMP) recognised the National Dairy Development Board (NDDB) as a national-level programme-implementing agency (PIA).

In the village of Mujkuva, Anand district of Gujarat, a pilot project for manure management was initiated to set up thirty-eight 2-cubic-meter biogas plants. It focuses on the effective use of dung by developing a value chain for manure management. It will involve establishing the manure value chain, creating CNG from biogas, and creating electricity for dairy plants from biogas (PIB 2022a). To further manure management activities across the nation, the union minister of Fisheries, Animal Husbandry, and Dairying established NDDB MRIDA Ltd., a fully owned subsidiary firm of NDDB (PIB 2022a). The company will conduct R&D on low-cost methods for optimal dung management, and a key area of interest will be developing village-level revenue-generating schemes through the sale of cow-dung-based products. It will set up procedures to accumulate carbon revenue from the projects and give marketing and sales support to organisations producing gobar-gas slurry-based fertilisers to create additional cash streams for dairy producers.

Key takeaways

- Government initiatives for developing value chains can play a significant role as pioneers in the industry. This allows the setting up of a conducive environment for further innovation. The setting up of NDDB MRIDA Ltd. for manure management is a key example.
- NDDB MRIDA Ltd. will also facilitate the building of a thriving market ecosystem, as it will play a crucial role in the R&D of low-cost methods for optimal dung management and creating additional cash streams for dairy farmers

Scale and replicability

The development of a manure management value chain is an innovative approach to further India's efforts of biogas generation. As part of this intervention, cattle manure will be utilised as a substitute for traditional wood, clay, paint, etc., in a variety of industrial applications and as a component in a variety of other products. These manure management programmes have the potential to generate biogas equivalent to the 14.2 MT of LPG consumed in India. Through this, the program has the potential to impact 305.3 million active domestic LPG customers across India, reduce the nation's reliance on fossil fuel imports, and sustain the clean cooking ambition for its population. Additionally, this programme can also generate the bio-slurry equivalent to 28.03 LMT (lakh metric tonnes) NPK fertiliser. Hence, this programme offers a substantial opportunity to efficient manure management, bridge the gap in domestic bio-slurry requirement, provide additional income opportunity for dairy farmer, and consequently aid in reduction of greenhouse gas emissions.

Guiding principles' performance

Scale	**Lowest rung:** Though in the early stage, the initiative has the potential to impact 305.3 million active domestic LPG customers across India, reduce the nation's reliance on fossil fuel imports, and sustain the clean cooking ambition for its population.
Citizen-centric approach	**Middle rung:** A focus on inclusion of women and marginalised communities. (a major area of focus will be establishing revenue generation models at the village level through the sale of cattle dung-based products).
Convergence to achieve impact	**Highest rung:** It is not an isolated energy-focused intervention: creating new revenue streams for dairy farmers through; saves money for farmers by substituting cooking fuel with biogas, encourages the use of dung-based manure, and reducing India's reliance on imports.
Long-term sustenance	**Highest rung:** The company aims to explore opportunities to efficiently use cattle dung as an ingredient for various applications in different industries and as a replacement for traditional wood, clay, paint, etc.

Source: Authors' compilation

Image: Alamy

Bamboo forest in Indonesia

Indonesia

Rural Electrification Using A Community- And Biomass-Based Power-Generation System

2018–Present

Enabled thriving market ecosystem and active community engagement, and eased affordable financing for

BIOGAS

Objective

To develop climate-smart agroforestry business models to supply sustainable biomass feedstock for energy, catalysing the transformation of land use and energy sectors throughout Indonesia.

Stakeholders

Funding agencies
Millennium Challenge Corporation

Partners
Perusahaan Listrik Negara (PLN)

Implementing agencies
Clean Power Indonesia

Beneficiaries
Rural households and commercial establishments

Project brief

The rural communities in the eastern part of Indonesia, especially island provinces such as Mentawai, do not have access to reliable power. A detailed study was conducted under the leadership of *Clean Power Indonesia* to pilot a biomass-based power plant that is suitable for remote island villages and that can be run with local biomass resources. **A bamboo-based community power plant project was conceptualised and implemented with the support of the Millennium Challenge Corporation. The state-owned utility firm PLN was involved in purchasing the power generated under a 20-year PPA at a regulated price and selling it to village residents and commercial entities at a subsidised retail tariff in accordance with the prevalent regulations (Wahono et al 2022).** The project also includes a 20-year Feedstock Supply Agreement with the communities, under which all bamboo generated by the villages will be purchased (Wahono et al 2022). This initiative directly benefits approximately 1,181 households, and the electricity generated is also used for product-related operations such as cold storage and other agroforestry activities (Wahono et al 2022).

Key takeaways

- Technology selection needs to be suitable for the local environment and community.
- A robust business strategy and finance mechanism are required to make the DRE solution affordable for the local population, such as a PPA with the state utility, a feedstock supply agreement, and financial incentives such as FiT and subsidies.
- Synergy between the local community, off-taker, and developer for long-term sustenance of the programme. The community grew the feedstock and had a 20-year agreement with the power plant operator for the sale of the bamboo produced, with decision-making based on consensus to avoid over-supply.

Scale and replicability

A total capacity of 700 kW was deployed, consisting of six units of 100 kW each and two units of 50 kW; three villages took part in the project – namely, Madobag, Saliguma, and Matotonan on the island of Siberut of Mentawai province (Wahono et al 2022). Community-based biomass power plants based on bamboo have shown to be a viable model that can be replicated in the other 50,000 villages in Indonesia that do not have access to reliable power, as well as other regions with similar characteristics.

Guiding principles' performance

Scale	**Lowest rung:** Power generation for 1,181 HHs and 456 non-residential connections.
Citizen-centric approach	**Highest rung:** Communities' needs were prioritised; and power generation from locally available resources.
Convergence to achieve impact	**Highest rung:** Has an impact on the overall development of the region. Buy-ins by the federal and state government agencies and the community.
Long-term sustenance	**Highest rung:** It is being replicated in the country and scaled.

Source: Authors' compilation

Kazakhstan

Kazakhstan Energy Efficiency Project 2013–2022

Enabled policy environment for

ENERGY EFFICIENCY (EE) – LIGHTING (PUBLIC AND HOUSEHOLD)

A Mosque powered by solar in Kazakhstan

Objective

To enable EE in public and social facilities, and environment for sustainable energy financing.

Stakeholders

Funding agencies

The World Bank

Beneficiaries

Energy Service Companies (ESCOs), households, schools, hospitals, and other public buildings

Implementing agencies

Ministry of Industry and New Technologies, KazEE (Kazakh Energy Expertise, a government EE agency), the Ministry of Finance, the Ministry of Economy and Budget Planning, the Ministry of Regional Development, the Ministry of Environmental Protection

Project brief

In March 2010, Kazakhstan had set the goal of reducing the energy intensity of the national economy by 10 per cent by 2015 and 25 per cent by 2020, making EE a top policy priority (The World Bank 2013a). In January 2012, a new Energy Efficiency Law – Kazakhstan Energy Conservation and Energy Efficiency Law – went into effect. A salient feature of this law is a mandatory energy audit of all business entities consuming 1,500 tons of oil equivalent or more per year. Also, public enterprises are mandated to prepare EE plans to ensure government-specified annual reductions in energy consumption (The World Bank 2013a). To support the implementation of the new law, the Government of Kazakhstan (GoK) approved a CPEE (*Comprehensive Plan on Energy Efficiency*), a time-bound action plan, which contains 47 specific policies whose responsibilities are assigned to various GoK agencies (The World Bank 2013a). The project was implemented under the aegis of KazEE, a dedicated EE agency established under the Ministry of Industry and New Technologies (MINT). The project led to the development and implementation of EE demonstration projects in public and social facilities – schools, kindergartens, clinics/hospitals, and street lighting. In addition, a technical assistance component was included to ensure effective project implementation and encourage dialogue regarding matters of policy and institution/market development. Scaling up EE financing, developing of an EE web platform, and organising an international forum on EE are some of the key features of the component.

Key takeaways

- There are high chances of a policy being successful if it is accompanied by specific time-bound programmes together with an action plan coupled with implementation mechanisms (budget allocation, standards, etc.).
- The project's outreach component was critical to raising widespread knowledge and interest in energy conservation and EE improvements across all 14 oblasts (states) in Kazakhstan. A State Energy Register was created to keep track of, monitor, and report on major consumers' energy consumption. The database also contains information on major consumers' EE improvement action plans and records the energy savings for the relevant EE initiative. There is also documentation of qualified EE product manufacturers and service providers.

Scale and replicability

The project funded EE projects at 96 public and social facilities, resulting in 719.47 GWh of EE savings as against zero at baseline and a reduction of 306105 MT CO_2 (The World Bank 2023). The project is a first-of-its-kind EE project in the region, with the potential for replication in other fossil-fuel-dominated nations in the region.

Guiding principles' performance

Scale	**Highest rung:** 96 sub-projects completed as against a baseline of zero; and 53,625 total beneficiaries, of whom 26,813 were female.
Citizen-centric approach	**Middle rung:** A focus on the inclusion of women and marginalised communities (26813 female beneficiaries).
Convergence to achieve impact	**Highest rung:** This is not an isolated energy-focused intervention; it also affects outcomes related to health, education, income generation, and so on.
Long-term sustenance	**Middle rung:** The project has led to the addition of or furtherance of 'end-use activities/applications' across the region/nation/globe.

Source: Authors' compilation

Kenya

Solar-Powered Irrigation
2000–Present

Enabled active community engagement and eased affordable financing for

SOLAR IRRIGATION

Image: Alamy

A demonstration of solar-powered irrigation in Kenya

Objective

To scale solar-powered irrigation system for small farmers.

Stakeholders

Funding agencies

OPEC Fund for International Development; Ministry of Sustainability and Tourism, Austria

Implementing agencies

SunCulture, Future pump

Beneficiaries

Small farmers

Project brief

The adoption of solar water pumps in Kenya is an example of a market-driven DRE technology scale-up (REEEP n.d., Michaelowa et al 2016). Although the scheme received grant and subsidy support, farmers still had to bear the high initial cost of the pump. Furthermore, via iteration, private companies (manufacturers) designed products that met the genuine needs of farmers and launched payment systems such as pay-as-you-go, making the solution affordable for farmers. SunCulture and Future Pump, two significant private companies dealing in solar water pumps, have been functioning in the country since the early 2010s and have played a vital role in scaling up the adoption of solar water pumps in the country. Both companies provide financing options, which are critical for increasing adoption of solar water pumps (REEEP n.d., Michaelowa et al 2016). SunCulture has created an innovative pay-as-you-grow approach in which farmers pay the capital only after harvesting (ARE 2022). Future pump offers remote monitoring of the pumps and tie-ups with PAYGO services. This user-centric approach has led to faster adoption of solar water pumps, and the companies have expanded to larger areas in Kenya and neighbouring countries (REEEP n.d., Michaelowa et al 2016).

Key takeaways

- Solutions catering to the actual needs (of farmers), such as a pumping solution with a battery that powers lights and other home loads with a pay-as-you-grow payment scheme and supply chain support, have higher chances of adoption and scale.
- Demand-side financial interventions are needed to scale up end-user DRE applications, and flexible payment methods such as PAYGO have been critical in generating new demand among farmers who cannot afford to pay the entire sum upfront, as in Kenya, where such payment methods have been important in increasing demand among farmers who cannot afford the full upfront cost of solar water pumps.

Scale and replicability

Per solar water pump deployment, about two jobs are created and 192 kg of CO_2 is saved annually (REEEP n.d.). Because it delivers an affordable customised product that suits the needs and financial capacity of the beneficiaries, the Kenyan solar-powered irrigation project has significant potential to be replicated and scaled to regions with similar characteristics, such as India.

Guiding principles' performance

Scale	**Lowest rung:** <1000 solar water pump deployment (exact estimate could not be determined through literature; and ~2 jobs created per deployment
Citizen-centric approach	**Highest rung:** Community engagement was the key part of the project.
Convergence to achieve impact	**Highest rung:** The project has multiple outcomes, including impact on household incomes, essential healthcare access, and wealth savings.
Long-term sustenance	**Highest rung:** The project has been a huge success, based on impact-based modelling studies.

Source: Authors' compilation

Kenya

Pay-As-You-Go Model By M-Kopa For Solar Home Systems
2011–Present

Enabled active community engagement and eased affordable financing for

SOLAR HOME SYSTEMS (SHS)

A school powered through solar in Kenya

Objective

To build an advanced PAYGO platform to provide low-income homes with affordable asset financing for connected solar technology and other life-changing products and services.

Stakeholders

Funding agencies

Bill and Melinda Gates Foundation; Shell Foundation.

Implementing agencies

M-KOPA, Safaricom

Beneficiaries

Rural households

Project brief

M-KOPA is a connected asset-financing platform that gives millions of unbanked customers access to goods and services that improve their quality of life. Beginning in 2011, it focused on the poor and BOP consumers with M-KOPA Solar, an off-grid energy solution that makes use of cutting-edge innovative technologies and a distinctive financing and operational model. A total of 820,000 customers in M-KOPA's customer base have incomes of less than USD 2 per day (M-KOPA 2022). The organisation has expanded and gone ahead to distribute hospital cash and life insurance products in 2020 by adding a payment of USD 15–40 cents per day to asset payments. It is also offering this model to switch its target population to smartphones and has provided 1 million smartphones between 2020 and 2021. A 1,000-person sales force for M-KOPA is hired from the community it serves, and 98 per cent of its customers purchase SHS on finance. These agents from the community demonstrate the effectiveness of their model and garner community trust with the help of local members such as church leaders, community chiefs, and teachers (Adwek et al. 2019).

Key takeaways

- Innovative financial mechanisms such as PAYGO by M-KOPA bridge the gap in affordability among all income groups, especially BOP groups.
- Additionally, providing product warranties has enabled better uptake of SHS and has increased demand for this financing model.
- Providing end users with options to pay in daily, weekly, or monthly instalments according to their payment capabilities or income capacity increases participation in such new mechanisms. Here, initial down payments can act as a default risk-mitigation approach.
- The participation of community members furthered acceptance of this innovative financing mechanism by creating awareness and fostering learning among the end users.
- Small daily repayments that are less expensive than the daily cost of kerosene have also contributed to the success of M-KOPA Solar.

Scale and replicability

The project began as a SHS initiative but has since grown to include monetary loans and health insurance in addition to solar lights, TVs, and refrigerators. As of December 31, 2021, it had touched over 1,100,000 Kenyan citizens (M-KOPA 2022); SHS, in particular, had been delivered to over 350,000 customers via PAYGO. Following the success of this concept, it was replicated in other countries such as Uganda, Nigeria, and Ghana. Following the success of M-KOPA, two similar companies that offer PAYGO emerged — Mobisol and BBOX Rwanda. PAYGO's scalability and replicability depend on demographic characteristics such as financial literacy and digital penetration, and it would benefit from energy policy planning and incentives for adoption in rural areas.

Guiding principles' performance

Scale	**Highest rung:** Cumulative Kenyan customers was >1,000,000, as of 31 December 2021 and, in particular, there were more than 350,000 customers for SHS PAYGO.
Citizen-centric approach	**Highest rung:** Financial product was tailored to citizen's need. 820,000 financed customers have incomes below USD 2 per day.
Convergence to achieve impact	**Highest rung:** It is not an isolated energy-focused initiative: impacted indoor household health by replacing open-flame kerosene lanterns with SHS, distributed a hospital-cash and life-insurance product, increased children's study time at home, and promoted digital and smartphone penetration initiatives.
Long-term sustenance	**Highest rung:** Similar PAYGO mechanisms were implemented in other countries (Uganda, Nigeria, Ghana) and by other entities such as BBOX Rwanda, Mobisol, and Azuri technologies.

Source: Authors' compilation

Maldives

Hybrid microgrids in Shaviyani atoll and Noonu atoll
2017–2021

Enabled policy environment and eased affordable financing for

SOLAR PV–DIESEL HYBRID MINI-GRIDS

Image: iStock

Solar panels at a resort in Maldives

Objective

To design, supply, install, and maintain grid-tied solar PV–diesel hybrid power generation plant, and generator and grid infrastructure.

Stakeholders

Funding agencies

Climate Investment Fund; Asian Development Bank (ADB); Islamic Development Bank; European Investment Bank

Implementing agencies

Sinomach-Sungrow JV; Ministry of Finance; Ministry of Environment; DHYBRID; Sino Soar Hybrid (Beijing) Technology

Beneficiaries

Rural population and commercial establishments

Project brief

This intervention is a part of several projects being supported under the ADB initiative – '*Preparing Outer Islands for Sustainable Energy Development (POISED)*'. **The overall objective of the programme is to increase the dissemination of rooftop and ground-mounted solar-power appliances across the different islands in the Maldives archipelago and reduce reliance on imported diesel oil.** The project was implemented across 26 islands of the Shaviyani and Noonu atolls (islands) that previously relied on diesel-based microgrids (Djunisic, Sladjana 2021). China Machinery Industry International Cooperation Co. Ltd., part of China's Sinomach Group, was the general contractor selected for the design, supply, installation, and maintenance of the systems (Djunisic, Sladjana 2021, Bordini, G 2021). A joint venture between Sinomach International and Sungrow Power Supply Co. Ltd. (a solar-inverter manufacturer) designed the hybrid generating systems.

In the Maldives, the cost of diesel power is USD 30–70 cents/kWh and requires government subsidies in excess of USD 50 million annually. The project is expected to reduce diesel consumption to 0.1–0.3 litres per kWh from the baseline of 0.45–0.70 litres per kWh (ADB 2021). This will yield significant foreign-exchange savings, and the country can develop its own expertise in solar technology. In addition, the decentralised nature of the technology makes it self-sufficient and a near-perfect option for the island nation

Key takeaways

- A clear vision emphasising RE targets and penetration (by year) coupled with phase down of fossil fuels (targets by year) is key for a country to address mitigation of GHGs.
- A net-metering regulation (with technical and financial guidelines) is important for the RE target to be realised with individual capacity/tariff guidelines for residential, commercial, and industrial sectors.
- Exemptions in duties (import duty waiver on RE equipment) and taxes (GST waiver on products and services) are some of the financial incentives to reduce the technology/energy service costs.

Scale and replicability

The solar battery–diesel hybrid systems installed across the islands comprise 2.86 MWp of PV capacity, 3.23 MWh of energy storage, and a new hybrid diesel genset of 6.72 MW. Furthermore, PV installation with a power output of 100 kW on the island of Fohdoo supplies around 30 per cent of the island's electricity, saving around 35,000 litres of diesel a year. (ADB 2022). This is a special case of a low-lying island that is highly vulnerable to rising sea levels. Such nations are at the forefront of climate change. The example serves as a model for small island states, and there are 38 such UN and 20 such non-UN member states across the globe (United Nations 2022), with an aggregate population in the range of 65 million.

Guiding principles' performance

Scale	**Lowest rung:** The beneficiaries are approximately 2,500 HHs, along with business enterprises
Citizen-centric approach	**Middle rung:** There is focus on the inclusion of women and marginalised communities across the two atolls.
Convergence to achieve impact	**Highest rung:** This is not an isolated energy-focused intervention; it also has an effect on other outcomes, including health, education, income generation, and so on.
Long-term sustenance	**Highest rung:** The project serves as a model for other similar projects across the region/nation, especially among small island developing states.

Source: Authors' compilation

Mali

Green Business Areas
2000–present

Enabled active community engagement and thriving market ecosystem for

SOLAR PV | BIOFUEL

A solar panel storage facility in Mali

Objective

To facilitate energy access for very small enterprises (VSEs) and rural micro-businesses established in villages with little or no access to electricity.

Stakeholders

Funding agencies

Swedish International Development Agency (SIDA), the French Fund for the Global Environment, the Prince Albert II Foundation and the Nexans Foundation

Partners

JAD, SAER GROUP

Implementing agencies

Geres (NGO)

Beneficiaries

VSEs

Project brief

The Green Business Areas (GBAs) are established in rural areas with very low or no energy access. These GBA buildings are bioclimatic commercial buildings with 24/7 electricity access and run on RE (GERES 2022a). They house small businesses, especially micro-enterprises and community entities, and provide additional support in the form of access to finance, business management, and capacity building, very much like any incubator. Several of the GBAs developed in Mali use solar power along with a power generator running on Jatropha oil, which is a local biofuel (GERES 2022a, GERES 2022b).

Key takeaways

- Designing an intervention with the local economy and comprehensive economic development of the region in mind, instead of standalone DRE interventions, can lead to multi-pronged benefits to the community and ensure long-term sustenance. Rural renewable-powered business 'incubators' with 24/7 power supply are one such intervention that can lead to significant economic development in communities with no energy access.
- It is important to consider the local environment and available resources while designing a programme. Utilising RE technologies that are already well known in the region while designing a DRE-based intervention for the rural economy and integrating them into the design is necessary for cost-effective and replicable models. An earlier intervention (the ALTERRE project) led to the creation of short biofuel supply chains in certain regions of Mali, which was then leveraged by the GBAs and integrated with its design.

Scale and replicability

The concept of a GBA, if scaled, can have a huge positive impact on the rural economies of remote regions. Designing the concept as a comprehensive intervention – with reliable power, physical space to conduct business, access to finance, business management, and administrative support and guidance – ensures that the small enterprises in the region are set to succeed and scale on their own. The concept can be scaled using local government funds for economic support or through other international support. It can also be made scalable by creating a revenue model where the enterprises contribute to the cost of setting up the GBA in a way that is affordable and beneficial to them.

Guiding principles' performance

Scale	**Lowest rung:** 37 VSEs set up.
Citizen-centric approach	**Middle rung:** It focuses on providing the necessary support to VSEs in rural areas without energy access. There is no element of imposition.
Convergence to achieve impact	**Highest rung:** Focuses not only on energy access, but also on support in setting up and scaling businesses, access to financing, and skill development.
Long-term sustenance	**Highest rung:** The pilot projects were set up in 2015 and 2019; after seeing the success, the concept is being scaled across the country.

Source: Authors' compilation

Mexico

Provision of solar power for rural households through Iluméxico
2009–present

Enabled thriving market ecosystem and conducive environment for innovations and ease affordable financing for

SOLAR HOME-LIGHTING SYSTEMS | SOLAR FOR PRODUCTIVE-USE

Image: iStock

Rooftop solar in Mexico

Objective

To scale the adoption of DRE solutions such as SHS, water pumps, refrigerators, public lighting, and electric fences, among others.

Stakeholders

Funding agencies

ENGIE and Iberdrola, Acumen, Promotora Social (impact investors)

Beneficiaries

Rural low-income households

Implementing agencies

Ministry of Energy (SENER): Federal Electricity Commission (CFE), an Electric Utility; Oaxaca State Department of Social Development (SEDESOH); National Council of Science and Technology (CONACYT); Iluméxico (social enterprise)

Project brief

Iluméxico was launched in 2009 with the aim of improving the lives of Mexico's rural poor by increasing access to affordable solar products. They present an innovative social-enterprise model to simultaneously address the electrification challenge and to reduce energy poverty while engaging sustainable market outcomes (Walters, Terri 2015). The model encompasses all the elements of the energy-access value chain, including technology, installation, service, and financing.

Iluméxico has established ILUCentros to provide customer service and troubleshooting in rural areas. The individuals serving in these centres are part of the community. In addition to providing technical assistance, spare parts, and other services such as battery replacement, the ILUCentros serve as hubs for community development. Iluméxico also works closely with local and federal governments to identify the needs of rural communities. Two key federal government policies were key to the success of the operation as well as organisation sustainability (Walters, Terri 2015). The first was the Law for the *Development of Renewable Energy and Energy Transition Financing (LAERFTE)*, which was established in 2008 and mandated that a certain portion of the total energy supply should come from renewable resources. The second is the *National Energy Strategy* (2013–2027), which evolved from the LAERFTE; its objective is twofold: to drive development and economic growth and to increase energy access and consumption. Furthermore, the *National Energy Strategy* explicitly promotes community RE schemes supported by public institutions and private-sector companies such as Iluméxico.

Key takeaways

- A dedicated goal such as universal electrification or energy access by a certain year followed by specific RE targets (in this case, providing RE for indigenous communities) are the basic building blocks for DRE promotion.
- The provision of service delivery models and market mechanisms designed to promote synergies between external and internal service providers are key for project sustainability and the spill over innovations resulting from it.
- Service and maintenance plans are necessary to ensure long-term system sustainability and successful energy-access business models.
- Collaboration with development agencies and sub-national governments can provide an opportunity for diversified funding while also leveraging successes and experience gained from work funded by traditional energy entities.
- In regions where, financial institutions are not present or capable, institutional strengthening and capacity building of the energy service provider (as a microfinance/lending agency) is a prospective/favourable option.

Scale and replicability

Iluméxico has grown significantly, currently operating in 13 Mexican states and serving more than 110,000 customers with approximately 25,000 solar power services installed (Iluméxico, n.d.). Their model presents a unique approach in the dissemination of solar power systems, that encompasses all the elements of the value chain – namely, technology, installation, service, and financing – under one roof. A social enterprise model is an ideal approach to cater to the energy access needs of remote and far-flung communities, the caveat being that it takes time and resources to nurture and establish such organisations.

Guiding principles' performance

Scale	**Highest rung:** Approximately 25,000 HHs; 2,010 communities; 14 indigenous cultures
Citizen-centric approach	**Highest rung:** People's needs and cultures are prioritised (indigenous people have been specifically included and their culture encompassed in design/ installation).
Convergence to achieve impact	**Highest rung:** Designed for homes and businesses in rural areas; productive activities have been emphasised.
Long-term sustenance	**Highest rung:** The project serves as a model for similar projects across the region/nation – an engagement of social enterprise to offer energy services across rural areas.

Source: Authors' compilation

Kingdom of Morocco

Renewable energy and Global Rural Electrification Programme (PERG)

1996–present (the fifth stage is ongoing)

Enabled policy environment and eased affordable financing for

SOLAR PV | SMALL HYDRO | SOLAR FOR LIGHTING AND IRRIGATION

Solar water heater on a rooftop in Marrakech city, Morocco

Objective

To develop local RE sources (hydro, wind, solar PV) and, in turn, diversify the energy mix, reduce external dependence, become producers of energy resources, and meet the growing demands of electricity and attain rural electrification targets.

Stakeholders

Funding agencies

African Development Bank, OPEC Fund for International Development, JBIC, KfW, EU, Islamic Development Bank, Arab Development Fund

Implementing agencies

Office Nationale de l'Electricité – National Electricity Board (ONE)

Beneficiaries

Rural households

Project brief

Morocco, as a non-producer of energy resources, relied heavily on imports (ONEC 2011). Hence, diversifying the energy mix has been a top priority intervention area to reducing this reliance, primarily through fostering the expansion of regional DRE sources. As a result, in 1996, PERG (Programme d'Electrification Rurale Globale) was established to provide rural electrification using DRE sources (ONEC 2011). To facilitate the different phases of PERG, the government has undertaken a series of national-level development efforts for rural electrification. The programme has served as a platform for various organisations to launch innovative and collaborative financial strategies for a variety of interventions related to the extension of existing grids, commissioning of solar and hydropower plants, and adoption of solar PV (for lighting, irrigation, and so on) (ONEC 2011).

Key takeaways

- The project showcased some of the crucial facets of a successful electrification programme using solar technologies. The interventions received significant political support, which translated into ambitious agendas and sufficient public resources to further the electrification goals of the government
- Policy push from the government coupled with leveraging necessary financing mechanisms was crucial to accelerate the adoption of the technology.

Scale and replicability

The electrification rate in Morocco has increased from 18 per cent in the 1995 to almost 100 per cent by 2017, with 10 per cent of the population obtaining electricity through SHS (Usman et al. 2019). The case study serves as an inspiration for other countries that are non-producer of energy resources. The project provides a sustainable and replicable model for scaling the implementation of DRE projects targeted at rural electrification due to its unique policy-centric approach. The model strengthens and leverages both policies as well as innovative financial mechanisms to build inter-institutional collaborations to undertake planning and implementation responsibilities.

Guiding principles' performance

Scale	**Highest rung:** The project has impacted around 2.1 million HHs in more than 42,000 villages as of 2017.
Citizen-centric approach	**Highest rung:** Community and stakeholder engagement is key to developing the projects and sub-projects.
Convergence to achieve impact	**Highest rung:** It is not an isolated intervention and has impacts on employment generation and health.
Long-term sustenance	**Highest rung:** The fifth stage of the project is ongoing

Source: Authors' compilation

Nigeria

Solar Hybrid Mini-Grid Programme {part of the Nigerian Electrification Programme (NEP)}
2018–present

Enabled policy environment and thriving market ecosystem, and eased affordable financing for

SOLAR PV | SOLAR HYBRID MINI-GRIDS

Image: Husk Power Systems

Community mini-grid in Nigeria

Objective

To improve electricity access in rural Nigeria by setting up mini-grids.

Stakeholders

Funding agencies

The World Bank; African Development Bank; GIZ

Beneficiaries

Rural households and commercial enterprises

Implementing agencies

Rural Electrification Agency (REA); Federal Ministry of Finance, Power, Works and Housing, Nigeria; Nigeria Electricity Regulatory Commission; EU; numerous private-sector companies

Project brief

The solar hybrid mini-grid programme is one of the components of the Federal Government of Nigeria's flagship NEP that aims to create private sector–driven infrastructure development in the energy sector, specifically in the unserved and underserved regions of the country (NEP 2023). The programme is implemented by the REA and has secured financing from the World Bank (USD 300 million) and the African Development Bank (USD 150 million) (NEP 2023). The project expects a private investment of around USD 660 million.

Under the programme, partial grants are given to private developers to set up solar and solar hybrid mini-grids in unserved areas to electrify households, local enterprises, and public institutions. The grants are given through two instruments: minimum subsidy tender to electrify selected communities that have high economic growth potential and performance-based grant programmes where developers can set mini-grids in communities of their choice. Technical assistance is also provided as part of the programme for potential developers for the implementation of the project and covers activities such as geospatial assessments, feasibility studies, market-scoping reports, and other studies. The assistance is offered by the German Society for International Cooperation (GIZ). Overall, by 2023, the programme (NEP) aims to provide access to power to 1 million households and 250,000 micro, small and medium enterprises (MSMEs) (Wearne et al. 2021).

Key takeaways

- The two financial instruments designed for the programme, along with the favourable policy environment that was created for microgrid implementation before the programme launch, led to the success and rapid scaling of the programme.
- Fostering environment that supports unlocking private investments is also crucial for a DRE programme to succeed. While external financial support of USD 550 million is allocated, a private investment of USD 660 million will be deployed under the programme.
- Technical assistance to ensure technical and human capacity building is also crucial for effective implementation.

Scale and replicability

From the launch of the programme in 2018 up to November 2022, 29,981 electricity connections have been provided via mini-grids with a cumulative solar-PV capacity of 7,059 kW (NEP 2023). Of these, about 2,968 households connected are households headed by women. A conducive policy environment followed by an innovative programme design led to the rapid scaling up of mini-grids in Nigeria under NEP. The programme design – the financial instrument, the focus on unserved regions with high economic growth potential, and the strategy to catalyse private investment – ensured affordability and accessibility for communities that did not have energy access as well as a scalable model. However, the affordability and economic viability of the programme may suffer if the subsidies are phased out. Hence, the availability of subsidies in the form of government or international grants would also be a crucial factor in replicating this model in other regions.

Guiding principles' performance

Scale	**Highest rung:** 29,981 electricity connections with mini-grids
Citizen-centric approach	**Middle rung:** A focus on households headed by women and developed for communities with no energy access.
Convergence to achieve impact	**Middle rung:** Multiple federal agencies are involved, along with numerous international and private partnerships.
Long-term sustenance	**Highest rung:** With access to electricity, HHs are able to improve their quality of life; it has also led to end-use activities. The rapid scaling of MGs serves as a model for other regions.

Source: Authors' compilation

Republic of South Africa

Kuyasa Low Income Energy Efficiency Housing Project 1999–2003

Enabled policy environment and active community engagement, and eased affordable financing for

SOLAR WATER HEATING | ENERGY EFFICIENCY

Solar water heaters in low-cost South African residences

Objective

To improve water-heating efficiency through solar water heaters (SWHs).

Stakeholders

Funding agencies
South African Export Development Fund; government agencies

Partners
Department of Environmental Affairs and Tourism; City of Cape Town (municipality)

Implementing agencies
South South North (SSN)

Beneficiaries
Low-income households

Project brief

The Kuyasa project began in 1999 with the goal of improving the energy efficiency (EE) of 2,309 low-income homes on the outskirts of Cape Town, South Africa, by installing solar water heaters (SWHs), ceiling insulation, and compact fluorescent lighting (CFLs). The project was planned during a three-year period (1999-2002). The initiative was a collaboration between the City of Cape Town (municipality), the Dutch humanitarian organisation SSN, and the Kuyasa residents (ESMAP 2012). The project partners actively engaged local community in the implementation, and as a result, the community reaped enormous benefits from technical training and capacity building for citizens, job creation, and an expanded sense of ownership and responsibility (ESMAP 2012). The majority of the project's funding came from grants from various government bodies. The sale of CER credits under CDM was the project's principal source of revenue, and was expected to bring in a total of USD 3.08 million throughout the duration of the project's 21-year crediting term (ESMAP 2012).

The Kuyasa EE project has received widespread acclaim and attention on a global scale. The ICLEI - Local Governments for Sustainability also submitted the initiative to the World Clean Energy Awards, which recognised excellence and innovation in the use of EE and RE. Furthermore, it was the first gold-standard CDM project (ESMAP 2012).

Key takeaways

- Involvement of the Kuyasa locals during the implementation of the project – through technical training, capacity building, and job opportunities – enhanced a sense of ownership and responsibility within the community.
- The project also shows how an international mechanism such as CDM may be used to promote sustainable development and poverty alleviation.

Scale and replicability

Through the installation of SWHs, ceiling insulation, and the use of CFLs, the project was able to save 7.40 million kWh (34%) and 6,437 tonnes of CO_2 emissions (33%) on a yearly basis (ESMAP 2012). As of 2012, this amounted to a total savings of 155 million kWh and 135,187 tonnes of CO_2 emissions (ESMAP 2012). The Kuyasa project exemplifies how EE projects may be successfully implemented in low-income communities and have a significant influence on complex issues such as poverty, economic growth, unemployment, increased access to and supply of energy, and environmental sustainability. It has also been recognised as a model effort for national replication by the Renewable Energy and Efficiency Partnerships (REEEP).

Guiding principles' performance

Scale	**Lowest rung:** The intervention has directly impacted 2,309 HHs as evaluated in 2010 by the CDM monitoring and evaluation team.
Citizen-centric approach	**Highest rung:** Community engagement was the key part of the project; their needs were taken into consideration while designing, implementing, and monitoring the project.
Convergence to achieve impact	**Highest rung:** The project has multiple outcomes in terms of improved indoor air quality, increase in HH income, local job creation, and community building.
Long-term sustenance	**Middle rung:** The project was a huge success and can potentially act as a model for the execution of other projects, as suggested by international bodies.

Source: Authors' compilation

A solar-paneled residential home in Sweden

Sweden

Environmental Programme for the city of Malmö
2009–2020

Enabled policy environment and active community engagement, and eased affordable financing for

SOLAR PV | WIND | BIOGAS

Objective

To achieve carbon neutrality for the city of Malmö by 2020, and, by 2030, all municipal operations must run on 100 per cent RE.

Stakeholders

Implementing agencies
Malmö Municipal Parliament

Beneficiaries
Urban population of the city

Supporters and others
Energy Oresund (strategic partnership among Danish and Swedish Municipalities)

Project brief

The city of Malmö is a part of the European Green Capital Network, which is a list compiled by the European Commission that rates Europe's most innovative cities in terms of how they are fighting climate change. The city set goals that were substantially more ambitious than the national plan (50 per cent by 2020) and the EU objective for Sweden (49 per cent by 2020), with the expectation that Malmö will be carbon neutral by 2020 and run 100 per cent of its municipal activities on RE by 2030 (Smith, Emily Dowding 2013). This led to the city's decision to shut down its two 1,000-MW nuclear power plants in 2002 and 2005 and initiate the construction of wind and solar farms (CESPA 2022). The city also houses the largest biogas plant in Europe, recycling waste and converting it into fuel for transportation (CESPA 2022). The municipality is also looking to integrate other initiatives, such as the creation of a local climate fund for increasing investment in RE and private partnerships (CESPA 2022).

The city's programme benefited greatly from local leaders' commitment, continued business investment in RE, and close coordination with regional players. The city received immense support from local politicians for creating an enabling policy environment, setting ambitious targets, leveraging local resources, and promoting private-sector investment in all the projects.

Key takeaways

- The role and commitment of local leadership and public institutions for DRE ambitions and targets can prove crucial for enabling policy support.
- Leveraging support from the private sector and other stakeholders (universities, NGO communities) is important – in the form of public–private partnerships – to strengthen institutional and organisational platforms to achieve the city's targets.

Scale and replicability

The case study provides a framework for its replicability and serves as an inspiration for similar interventions at the municipal level in countries such as Denmark, Canada, and so on. The crucial aspects of this case study that are pertinent to scaling and replication are strong political backing, local collaborations, and leveraging private partnerships for financial sources.

Guiding principles' performance

Scale	**Lowest rung:** More than 5,000 people residing in the urban district; approximately 2,200 HHs, HH size is 2.2.
Citizen-centric approach	**Highest rung:** People's needs were prioritised in terms of utility, as in the transport sector.
Convergence to achieve impact	**Middle rung:** Multiple buy-ins from federal agencies as well as the municipality.
Long-term sustenance	**Highest rung:** Serving as a model for the future energy transition in urban areas.

Source: Authors' compilation

Sri Lanka

Energy Service Delivery Programme (ESD)
1997–2003

Enabled policy environment and active community engagement, and eased affordable financing for

SHS | HYDROPOWER PLANTS | WIND MINI-GRIDS

Wind generators among palm trees in rural Sri Lanka

Objective

To promote sustainable technologies for grid-connected power generation such as wind and mini-grids, and to enable rural electrification.

Stakeholders

Funding agencies

The World Bank; Global Environment Facility (GEF); DFCC (bank)

Beneficiaries

Rural households

Implementing agencies

Government agencies, private developers (of energy); NGOs; microfinancing institutions (MFIs); community co-operatives

Project brief

The ESD programme was implemented in 1997 with the support of the World Bank and Global Environment Facility. **It had multiple components to promote sustainable technologies for grid-connected power generation such as wind and mini-grids and rural electrification with SHS and village hydropower plants (The World Bank 2003). The major component of the ESD programme was to provide medium- and long-term credit to private developers, NGOs, microfinancing institutions (MFIs), and community co-operatives deploying DRE interventions (The World Bank 2003).**

At the onset of the ESD programme, the government of Sri Lanka rationalised the steep import duty on solar-PV modules, which was instrumental in making the technology more affordable and encouraging new players (component manufacturers) to enter the market (The World Bank 2003).

Further, initially, MFIs could only participate in the scheme via other participating credit organisations, however, by the mid-term, MFIs were allowed to participate directly to avail of the World Bank line of credit. This also led to the emergence of a new business model where there was a tripartite agreement between the rural consumer, the MFI, and the solar company that identified the responsibilities of each party and included a buy-back scheme (The World Bank 2003).

Key takeaways

- Policy support – such as relaxation in import tariffs, laws aimed at supporting RE markets – had helped in attracting more private sector investments and engagements
- Private sector investments, active community engagement, and use of innovative financial incentives (people contributed their time in exchange for money) proved crucial for large scale adoption RE solutions.

Scale and replicability

At the time of project completion in 2002, installed renewable energy capacity reached about 35.3 MW. This includes 31MW of mini-hydro, 3MW of wind, 0.94MW of solar, and 0.35MW of village hydro) (World Bank 2003). The ESD programme is replicable in other regions with similar issues. During the course of the programme, the government took many steps to ensure an enabling policy environment for DRE-based interventions, which contributed to the program's success. Furthermore, integrating MFIs in end-user finance, particularly in rural regions, was critical in boosting SHS uptake in Sri Lanka. MFIs are effective at enabling affordable financing for rural energy projects and can play an important role in scaling DRE technologies in rural areas.

Guiding principles' performance

Scale	**Highest rung:** The programme served around 20,953 customers with off-grid solar power and 1,732 with village hydropower.
Citizen-centric approach	**Middle rung:** There was focus on capacity building as part of the programme design; there was a component for technical assistance and capacity building.
Convergence to achieve impact	**Highest rung:** Multi-sectoral impact with the development of self-sustaining private DRE sector and improved economic conditions across rural households.
Long-term sustenance	**Highest rung:** The ESD programme is considered to be one of the earliest successful DRE programmes and is replicated in other national programmes across the globe.

Source: Authors' compilation

Tanzania

Micro-Hydropower Plant Project
2015–Present

Enabled policy environment and active community engagement, and eased affordable financing for

MICRO-HYDROPOWER PLANTS

Image: Alamy

River Hagafilo in Njombe Southern Highland Tanzania

Objective

To commission various micro-hydropower plants in the remote regions of Tanzania.

Stakeholders

Funding agencies

Italian Ministry of Foreign Affairs, Belgian Ministry of Foreign Affairs, the EU, European Committee for Training and Agriculture (CEFA)

Implementing agencies

TANESCO; respective village companies

Beneficiaries

Rural households

Project brief

Providing access to energy in rural areas through renewable energy has been a national priority for Tanzania. However, building renewable energy infrastructure for rural populations is a challenging task due to the huge investment requirements. To address this, CEFA collaborated with private companies to install micro-hydropower plants in Tanzania's remote villages (Pendezza, J 2014). CEFA was also instrumental in developing the intergovernmental collaboration required to operationalise the micro-hydropower plants. With the participation of the local village company and Tanzania Electric Supply Company Limited (TANESCO), the distribution company, one of the first plants was commissioned in Matembwe, district of Njombe. Matembwe Village Company manages the plant entirely. Following that, Bomalang'ombe and Ikondo villages implemented similar initiatives, impacting around ten communities (Pendezza, J 2014). CEFA and the EU provided most of the funding, with minor assistance from the Italian Ministry of Foreign Affairs.

Key takeaways

- Appropriate technical capacity, good institutional arrangement and collaboration, and multi-stakeholder involvement contributed to the success of the micro-hydropower projects.
- Unlocking robust financing mechanisms, promotion of local collaboration – by forming a village company responsible for managing the operation of the plant, and skills training–based programmes for the local youth that enabled handing over the operation of the plant to the village company¬ – supported successful implementation of the project.

Scale and replicability

The micro-hydropower plants have been commissioned in a phased manner– one of two villages at one time – that helped in improving on the implantation while replication to other villages. The recent commissioning of a project for the Ninga micro-hydropower plant that will serve the electricity needs of around 1,680 HHs distributed across seven villages is making use of an innovative financial mechanism to include multiple sources such as developer equity, credit lines, commercial loans, and, of course, grants (Pendezza, J 2014).

Guiding principles' performance

Scale	**Lowest rung:** It impacts around 1,013 HHs by providing direct supply of electricity.
Citizen-centric approach	**Highest rung:** Community engagement was the key part of the project.
Convergence to achieve impact	**Highest rung:** The project has multiple outcomes apart from 24-hour electricity supply, largely to power local enterprises and households.
Long-term sustenance	**Highest rung:** The project was a huge success and acted as a model for other micro-hydropower projects. It has successfully connected around 1,013 rural HHs to 24-hour electricity supply.

Source: Authors' compilation

Image: iStock

In Vietnam, a shepherd and a herd of cows

Vietnam

Biogas Programme in Vietnam
2003–2020

Enabled thriving market ecosystem and conducive environment for innovations for

BIOGAS

Objective

To develop a commercially viable biogas market with sustainable lighting and heating services as primary outputs and to provide fuel for household cooking in rural areas.

Stakeholders

Funding agencies

Netherlands Ministry of Foreign Affairs (major funder); Energising Development (EnDev; energy access partnership of 6 countries); GIZ

Implementing agencies

Vietnam's Ministry of Agricultural and Rural Development, SNV (not-for-profit agency, provides technical assistance)

Beneficiaries

Rural households

Project brief

Vietnam has significant potential for biogas production due to its large rural population and livestock population. The Dutch-funded biogas programme, operated by SNV Vietnam, constructed more than 150,000 biogas digesters in 12 provinces between 2003 and 2010, with funding from the Dutch government and farmers (Zafar 2022). Since 2013, EnDev has been the key donor, and the programme also receives funds from carbon certificate sales. A flat-rate subsidy of USD 50 per digester was offered to households, but this has been phased out and replaced by a results-based financing incentive for suppliers. The programme has led to many benefits, such as job creation, wherein approximately 16,800 full-time jobs were established in the construction process (IRENA 2018). Other benefits include household savings and the development of national energy policies. The National Strategy of Integrated Solid Waste Management for the period up to 2025, including the vision for the period up to 2050, was approved by the prime minister in 2009. A National Energy Development Strategy for Vietnam up to 2020, with outlook to 2050, was ratified in 2007. This strategy envisaged 50% of households using RE in cooking by 2010 and 80% by 2020 (SNV 2012).

Key takeaways

- Cooperation between multi-donor agencies (international development agencies) and the government could be critical to the success of a project because there would be knowledge of what has worked, an understanding of country and mission characteristics, and so on.
- Knowledge transfer and capacity building of the local stakeholders) during the first few years of a project are key for its survival and future growth.
- A programme becomes commercially sustainable when there is engagement of the right set of stakeholders, a financial grant component to kick-start the initiative, and realisation of income generation or savings in expenditure from the project.
- A results-based financing framework, which engages the principle of a performance-based incentive (quality, quantity, etc.), stimulates the growth of the market.
- It is critical to foster relationships between research institutes, universities, and the upstream and downstream stakeholders of the programme for R&D to happen, which could yield technological innovation.

Scale and replicability

The project resulted in the construction of more than 158,500 biodigesters, which benefits 790,000 rural HHs. This yielded reductions of approximately 890,000 tons of CO_2 equivalent per year, leading to reduced indoor air pollution and improved indoor air quality (IRENA 2018). The savings in fuel and reduced need for chemical fertilisers (and in some cases pesticides) yielded annual savings of around USD 167 per HH. Over its 15-year lifetime, the programme has resulted in around 16,800 full-time equivalent jobs. Approximately 1,000 government technicians have been trained in biogas technologies, and more than 1,700 masons have been trained in the construction of various types of biogas digesters (SNV 2012). With the success of the first phase, a second phase (2007–2010) was established with a target of 150,000 biogas digesters, although the actual number constructed stood at 158,500 (Zafar 2022). This programme was further extended to the year 2020. The success of the intervention could be replicated in other countries of South East Asia where animal husbandry is the staple source of income.

Guiding principles' performance

Scale	**Highest rung:** 790,000 rural HHs
Citizen-centric approach	**Middle rung:** There was a focus on the inclusion of women and marginalised communities as the programme involved the entire extent of rural Vietnam.
Convergence to achieve impact	**Highest rung:** The project had manifold benefits – reduced fuel expenditure, improvement in indoor air quality, reduced indoor air pollution, waste management, and use of residue as fertilisers.
Long-term sustenance	**Highest rung:** The project serves as a model for similar projects across South East Asia, especially in areas where the main occupation is cattle rearing.

Source: Authors' compilation

Yemen

Enhanced Rural Resilience (ERRY) Programme 2016–2018

Enabled active community engagement for

SOLAR PV | SOLAR FOR PRODUCTIVE-USE, COMMUNITY AND INSTITUTIONS

Image: iStock

Small solar panel in a remote desert location

Objective

To enhances the resilience and self-reliance of crisis-affected rural communities by supporting livelihoods stabilisation and improving access to sustainable energy.

Stakeholders

Funding agencies

The European Union (EU)

Beneficiaries

Communities in four governorates of Yemen

Implementing agencies

The UNDP, the International Labour Organization (ILO), the World Food Programme (WFP), and the Food and Agriculture Organization (FAO)

Project brief

The ERRY programme was organised to address the aftermath of the 2015 crisis in Yemen. The efforts were led by the four UN agencies – UNDP, ILO, WFP, FAO – across four governorates. **The programme targeted five sectors: health, education, water, agriculture and productive assets, and market and employment. In all the sectors, solar-PV technology was utilised to meet the energy requirements, chiefly replacing diesel – the primary fuel used in electricity generation (UNDP 2018, UNDP 2019).**

Solar-PV was used to reopen local health centres, pump water through solar pumps, and support livelihood activities. It helped in improving access to health facilities and drinking water – improved access to vaccinations, protection against cholera and other deadly water-borne diseases due to availability of clean water (UNDP 2018, UNDP 2019). Further, farmers saved, on average, more than USD 1,358 per month, which was previously spent on diesel, thus realising higher margins on the crops harvested (UNDP 2019). The initiative has made way for the second programme, ERRY II, which primarily focuses on improved food and nutrition security. A sub-programme of the new initiative encompasses solar panels for households, water pumps, and local manufacturing (UNDP 2019, UNDP 2019).

Key takeaways

- In multi-stakeholder engagements, setting operational guideline in the early stages of the programmes can support agencies, the government, the private sector, and communities to overcome bottlenecks.
- Capacity building on maintenance and sales of solar systems should be emphasised early on.
- Recruitment, retention, and reallocation of staff with project-management experience in conflict and post-conflict societies are a challenge.

Scale and replicability

The study is a special case of approaches/interventions to engage DREs in regions affected by conflicts. Approximately 300 million individuals currently reside in such regions. Here, resilience-based interventions (i.e., energising by solar-PV technology or other DRE technologies) should complement humanitarian relief aid, which could protect livelihood assets and create new opportunities for individuals affected by the crisis. The project directly led to the installation of 3,200 solar home-lighting systems. In addition, more than 52 health centres were energised by solar energy, which resulted in the operation of refrigerators that could store medicines and vaccines (UNDP 2018). The solar-operated schools, on average, showed higher enrolments, with an increase of 33 per cent post-intervention (UNDP 2019). Furthermore, solar pumps have contributed to savings of approximately USD 615 a month on average due to reduced diesel consumption (UNDP 2019). For countries in conflict, similar programmes should yield quick, visible results to satisfy community (public) and political requirements.

Guiding principles' performance

Scale	**Middle rung:** Solar system installed in >3,200 HHs in 20 rural communities; 52 health centres and 52 schools have access to solar energy; 24 solar refrigerators in 24 health centres; solar water pump benefited 80 HHs; and livelihood benefits for 2,226 HHs.
Citizen-centric approach	**Highest rung:** Focused on addressing the needs of low-income families and women in conflict-affected regions.
Convergence to achieve impact	**Highest rung:** Multi-sectoral impacts were seen in terms of improvements in health, education, and agricultural productivity.
Long-term sustenance	**Highest rung:** DRE technologies can serve as livelihood assets and create new opportunities for individuals in regions affected by conflicts.

Source: Authors' compilation

Annexures

Annexure I: Overview of the research steps

Table A1 Research steps undertaken for identifying emerging good practices on DRE

Objective	Method
Finalisation of the core framework	• Literature review
Finalisation of inclusion/exclusion criteria for DRE case studies	• Literature review
Identification and sourcing of DRE case studies	• Literature review
Selection of case studies from the identified long list based on the inclusion/exclusion criteria (limiting it to a maximum of 3 per core element)	• Sourcing additional information for case studies to enable filtering • Filtering out case studies as per the inclusion/exclusion criteria
Feedback on the finalised set of DRE case studies (if required)	• A potential virtual consultation
Inductive analysis of case studies	• Information sourcing (public documents) • Case-study stakeholder interviews (as required)
Collation of emerging good practices across core elements	• Illustrating good practices through real-life examples of relevant case studies

Annexure II: Rating calculation for case studies

Each case was analysed across the guiding principles. We assigned distinct weights to each guiding principle. Thus, the weightage assigned to the guiding principles of impact at scale, citizen-centric approach, convergence to achieve impact, and long-term sustenance was 30 per cent, 25 per cent, 25 per cent, and 20 per cent, respectively.

Further, each case was evaluated based on the intensity bands of the specific guiding principle as applicable. The intensity bands consisted of three grades: lowest, middle, and highest, with defined values for each rung. We also assigned distinct values to each rung, as shown in Table 1. Ultimately, all cases were allotted a rung as per the case's particulars, and values were assigned for each principle to be further calculated.

The calculation process is detailed as follows.

Step 1: Assigning rungs to each case based on the guiding principles

For 'impact at scale', each case was assessed across different grades of intensity bands as per their applicability. The cases were analysed based on the number of beneficiaries impacted, the number of livelihoods and jobs created, and the impact on microenterprises and businesses. For 'a citizen-centric approach', the applicable rung was allotted as per the level of community involvement in the interventions, with a special focus on the involvement of women and marginalised communities. In 'convergence to achieve impact', the applicable rung was determined by the number of stakeholders involved and the focus of the intervention. In 'examining long-term sustenance', the length of the intervention and its subsequent furtherance and replicability were the focal determinants for assigning values.

Step 2: Multiplying the estimated rung values with the assigned weight of each guiding principle:

Once the intensity bands for each principle were determined, the overall case study rating was calculated. For this, the weightage of each guiding principle was multiplied by the intensity band grade, and the final values for all guiding principles were added together. This accounted for the distinct weightage of each principle in the final calculation. This value was represented as the case study's per cent rating.

Step 3: Selection of case studies based on their ratings:

Once the case's ratings were obtained, they were shortlisted based on a case study selection criterion. The shortlisting was based on a hurdle rate of 70 per cent, meaning that the selected cases needed to score higher in a minimum of two guiding principles. Cases that scored lower in all criteria were not eligible. Furthermore, we also made exceptions to include a few case studies with a lower overall score than the cut-off, particularly for the cases from Small Island Developing States (SIDCs), whose scores were skewed due to low rating on the 'impact at scale'.

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