

# Clean Energy Access Network (CLEAN)

## State of DRE Sector

### DRE as a Complete Climate Solution



2024

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# abbreviations

<b>AMI</b>	Advanced Metering Infrastructure
<b>ANMs</b>	Auxiliary Nurse Midwives
<b>AREAS</b>	Association of Renewable Energy Agencies of States
<b>BEE</b>	Bureau of Energy Efficiency
<b>BRT</b>	Bus Rapid Transit
<b>CapEx</b>	Capital Expense
<b>CCP</b>	Climate Collective Pune
<b>CCTS</b>	Carbon Credit Trading Scheme
<b>CEA</b>	Central Electrical Authority
<b>CLEAN</b>	Clean Energy Access Network
<b>CSR</b>	Corporate Social Responsibility
<b>DISCOM</b>	(Electricity) Distribution Company
<b>DMS</b>	Demand Management Service
<b>DRE</b>	Decentralized / Distributed Renewable Energy
<b>EMS</b>	Energy Management System
<b>ESMAP</b>	Energy Sector Management Assistance Program
<b>EV</b>	Electric Vehicles
<b>FAME</b>	Faster Adoption and Manufacturing of (Hybrid) & Electric Vehicles
<b>GDP</b>	Gross Domestic Product
<b>GHG</b>	Greenhouse Gas
<b>GPRS</b>	General Packet Radio Service
<b>GW</b>	Gigawatt
<b>ICM</b>	Health and Wellness Centre
<b>ICM</b>	Indian Carbon Market
<b>INR</b>	Indian Rupee
<b>IPCC</b>	Inter-governmental Panel on Climate Change
<b>IPDS</b>	Integrated Power Development Scheme
<b>ITMO</b>	Internationally Transferred Mitigation Outcome
<b>LPG</b>	Liquified Petroleum Gas
<b>LWB</b>	Low Weight Baby
<b>MDB</b>	Multilateral Development Bank
<b>MNRE</b>	Ministry of New and Renewable Energy
<b>MoEFCC</b>	Ministry of Environment Forest and Climate Change Government of India.
<b>MSME</b>	Micro, Small and Medium Enterprises
<b>MW</b>	Megawatt

# abbreviations

<b>NAPCC</b>	National Action Plan on Climate Change
<b>NDC</b>	Nationally Determined Contributions
<b>NGO</b>	Non-Governmental Organisation
<b>NPCCHH</b>	National Program for Climate Change and Human Health
<b>NSGM</b>	National Smart Grid Mission
<b>O&amp;M</b>	Operation and Maintenance
<b>PAT</b>	Perform, Achieve and Trade
<b>PHC</b>	Primary Health Centre
<b>PLC</b>	Power Line Communication
<b>PM-FME</b>	Prime Minister's Micro Food Enterprises Scheme
<b>PM-KUSUM</b>	Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
<b>PMR</b>	Pune Metropolitan Region
<b>PNG</b>	Piped Natural Gas
<b>PV</b>	Photovoltaic
<b>R&amp;D</b>	Research and Development
<b>RBI</b>	Reserve Bank of India
<b>RE</b>	Renewable Energy
<b>RKS</b>	Rogi Kalyan Samiti
<b>RMS</b>	Remote Monitoring System
<b>SAPCC</b>	State Action Plan on Climate Change
<b>SCADA</b>	Supervisory Control and Data Acquisition
<b>SCs</b>	Sub Centres
<b>SDG</b>	Sustainable Development Goal
<b>SGIA</b>	Smart Grid Implementation Agency
<b>SMG</b>	Smart Micro Grid
<b>UNDP</b>	United Nations Development Programme
<b>UNFCCC</b>	United Nations Framework Convention on Climate Change
<b>UNIDO</b>	United Nations Industrial Development Organization
<b>USD</b>	United States Dollars

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# Message from Executive Director, AREAS, MNRE



**Mr. Jeevan Kumar Jethani**

**T**he Decentralised Renewable Energy (DRE) sector has been continuously evolving over the years. From providing quality of life services (e.g. clean cooking and lighting) to remote and marginalised communities in the 1980s, to becoming a driver of economic prosperity in rural areas from 2010s onwards. In the 2020s, DRE is also emerging as an important component of the global response to the climate change, which is presently the largest crisis being faced by humanity. India has made some strides in this context with policy and finance support for several DRE interventions - solar powered water pumping for irrigation and grid connected solar rooftop PV systems being the currently prominent ones. Considering that DRE based livelihood applications can play an important role in rural economy and uplifting the living standards, India has issued Policy

Framework for developing and promoting DRE Livelihood Applications.

The Clean Energy Access Network (CLEAN) has been bringing out the State of DRE Sector Reports annually focusing on various themes. I congratulate CLEAN for the 2024 State of Sector report which focuses on the crucial role that DRE interventions can play in climate action.

This report showcases some successes as well as future opportunities of DRE interventions leading to climate change mitigation and resilience building. It provides a very positive message of how Indian DRE sector is well poised to play its role in the fight against climate change.

I am sure that this report will prove a valuable and inspirational resource for the DRE sector stakeholders as well as policy makers, funders, and investors.

**Mr. Jeevan Kumar Jethani, Executive Director, Association of Renewable Energy Agencies of States  
AREAS,**

**Ministry of New and Renewable Energy Ministry Government of India.**

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## A DECADE OF DEDICATION, A DECADE OF SCALING

Over the past decade, the Clean Energy Access Network (CLEAN) has grown from a pioneering initiative into a key driver of India's decentralized renewable energy (DRE) sector. Through challenges and transformations, our commitment to empowering communities, fostering innovation, and unlocking new opportunities has remained unwavering.

As we move into the next decade, the need for urgent climate action and equitable energy access has never been clearer. DRE has consistently proven its potential - not just as a solution to energy poverty but as a catalyst for economic development, resilience, and sustainability. What began with portable lighting solutions has expanded across sectors, including agriculture, agro-processing, healthcare, education, small enterprises, textiles, and commercial applications, demonstrating its power to uplift communities and drive inclusive growth.



**Mr. Nitin Akhade**

### **Government & Private Sector**

Catalysts for Transformation : Government policies and private sector innovations are accelerating this transformation. Initiatives like PM-KUSUM, PM Surya Ghar, PM-FME, and PM-Suryoday are ensuring millions gain access to clean, reliable energy, helping them climb the energy consumption ladder toward greater prosperity. Similarly, programs such as Powering Livelihoods, SELCO's healthcare electrification, UNDP's DRE for Livelihoods, GIZ's Agro-Photovoltaics, CEEW and Vilgro Aquaculture program and Sustain Plus and National Dairy Development Board's biogas program, and various sub-national government programs on solar irrigation and livelihoods solutions are unlocking scalable, bankable DRE-driven enterprises and livelihoods.

At the same time, private sector players are going beyond infrastructure challenges, addressing bottlenecks across value chains that keep communities in poverty. They are deploying mini grids and off grid solutions in remote regions, designing innovative business models, and creating strong market linkages, taking ecosystem approaches ensuring that clean energy fuels long-term economic and social progress.

### **India's Leadership in the Global South**

The past decade has been one of learning, innovation, successes, and setbacks. These experiences position India as a global leader in DRE solutions that can be replicated across the Global South particularly in Africa, Latin America, and Southeast Asia - where energy poverty, climate vulnerability, and technological barriers remain pressing challenges.

India's expertise in scalable, decentralized energy solutions, financing mechanisms, and policy frameworks can help shape a global just energy transition. By fostering knowledge exchange and implementing cross - border programs, we have an opportunity to uplift billions across the Global South and accelerate the transition toward clean, inclusive, and sustainable development.

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## A Decade of Action: Moving Forward Together

The next ten years will be disruptive and transformative, offering new opportunities to scale DRE-powered development. Advances in technology, artificial intelligence, and innovative financing must be harnessed to drive universal clean energy access and inclusive growth.

This is a call to **industry leaders, policymakers, civil society organizations, researchers, donors, and multilateral agencies** - let's come together, share our successes and failures, and build an enabling ecosystem that supports the scaling of DRE solutions for sustainable impact.

I congratulate CLEAN for publishing the 6th edition of the State of the Sector Report, which highlights the critical role of DRE in achieving India's climate commitments, SDG7, and national development goals. The report reinforces how **DRE is not just about energy access - it is about transforming lives, economies, and the future of our planet.**

As we embrace this next phase, let us work collectively to make **India an energy-efficient, resilient, and equitable economy** while ensuring a sustainable future for all.

**The future is decentralized, clean, and powered by collaboration. Let's make it happen.**

**Nitin Akhade | President, Clean Energy Access Network |  
Executive Director – Energy Access and Livelihoods, - Customized Energy Solutions**

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# EXECUTIVE SUMMARY

The CLEAN State of the DRE Sector 2024 report examines the intersection between climate action and Decentralized/Distributed Renewable Energy (DRE).

The first few articles review the multiple facets of this intersection.

## **DECENTRALIZED Renewable Energy for Climate Action**

Climate change is now demanding the world to move away from fossil fuels towards preferably renewable energy. At the same time the global warming already induced has started creating adverse impacts in different parts of the world. Under these circumstances DRE can play a crucial role in this energy transition by not only mitigating greenhouse gas (GHG) emissions, but also building climate resilience among communities and supporting climate adaptation efforts in various sectors. Government of India has been integrating DRE in India's energy transition through policy and financial support for solar powered water pumps and rooftop solar systems but there is a lot more that needs to be done to accelerate the process. Clean Energy Access Network (CLEAN) is committed to strive in mainstreaming DRE as a complete climate solution.

## **DRE in State Action Plans on Climate Change: Ideas and Opportunities**

While India is committed to its national goals for climate mitigation, climate adaptation requires more localised action. In this context it is important to assess State Action Plans on Climate Change (SAPCC) from the DRE lens. An assessment of 14 SAPCCs reveals how different state governments are looking at the energy transition in their own contexts. Some plans have already acknowledged the importance of some DRE interventions (e.g. use of biogas for cooking in rural households to reduce dependence on firewood). However, several plans have identified specific challenges for which DRE interventions can provide solutions, but the solutions have not been acknowledged (e.g. DRE powering of disaster response shelters). Implementing DRE interventions in the field requires strong cross-cutting institutional mechanisms. Only a few SAPCCs display such DRE-readiness. The overall picture is encouraging but there is scope to do more and this highlights the need for the DRE and climate response communities to interact more.

## **Significance of DRE in Achieving Just Energy Transition**

Transitioning away from fossil fuels will also bring disruptive change for many people and communities whose livelihoods are dependent on the fossil energy sector. The issue of 'just transition' – an energy transition that also provides a fair and just solution to those adversely affected by it – has become an important area of debate in discourses on climate action. DRE-based green businesses can play an important role in providing alternative economic activities to the affected communities. This is a new opportunity for the DRE sector, but requires a massive effort focussed on creating local energy service business models, and re-skilling and mentoring community members to make the economic and social transition.

## **Climate Finance and DRE**

Globally, availability of climate finance has become an acrimonious political issue. While the finance available is considerably short of what is required to combat climate change, most of the available climate finance is going towards climate change mitigation, primarily through large renewable energy projects. Climate adaptation is emerging as a major need for the Global South, but very little climate finance is available for the same. DRE technologies with their multifaceted benefits of climate mitigation as well as adaptation and resilience building, deserve more financial support from the point of view achieving more positive impact with less spend. From this perspective, there are a few

interesting developments that can benefit the DRE sector in India such as the climate finance taxonomy and Indian carbon market. taxonomy and Indian carbon market.

The next few articles examine specific examples of how DRE can play a vital role in responding to climate change in the specific context of India.

### **Enabling Climate Resilient Healthcare using DRE**

Strong last mile public healthcare ecosystem is going to be increasingly crucial for climate resilience as the impacts of climate change escalate. While solar DRE systems are the obvious choice for powering last mile delivery of healthcare in remote areas, operationalising the same is faced with several challenges. Firstly the DRE systems must be customised to the needs of the specific primary health centre and the subcentres in its jurisdiction. Secondly there are operational challenges from maintaining reliability of the system despite variability of available sunlight to getting service and maintenance support within at most 48 hours from registering the complaint. In spite of these challenges, the efforts of SELCO Foundation in North East India are bearing fruit and a template of actions is emerging for providing climate resilient healthcare to vulnerable communities.

### **The Role of SMART Microgrids (SMGs) in Emission Reduction and Grid Resilience**

The forward-looking approach of DRE Powered SMART Microgrids integrated with centralised grids (powered by fossil fuels or large RE) can provide both reliability and flexibility in energy access for communities across India in the face of increasing climate change impacts. The SMG can be operated in grid connected mode or island mode as per requirement. Access to reliable and affordable energy is the key to rural upliftment. This approach can help India achieve its commitments under Paris Agreement as well as achieve its targets under Sustainable Development Goals framework.

### **DRE for Cooking: Sectoral Challenges and Climate Mitigation-Adaptation Potential**

DRE based cooking technologies (biomass, biogas and solar thermal as well as solar PV powered electric) deliver a more reliable access to clean cooking energy than LPG/PNG or grid electricity powered cooking technologies in the face of an increasing risk of climate induced disasters disrupting centralised energy supply chains. Furthermore, DRE based cooking energy technologies are also ahead of fossil energy powered cooking technologies in terms of reduction of GHG emissions as demonstrated in a study conducted by OrjaBox. However hardly any policy or financial support has been available for DRE based cooking. There is a strong case for the government to rethink its policies on this issue.

### **PURE Approach to Climate Readiness in North-East India**

Two case studies of Productive Use of Renewable Energy (PURE) in Assam, empowering two rural women entrepreneurs, highlight that PURE interventions can not only provide economic empowerment but also lead to building resilience to the impacts of climate change in the vulnerable regions of North East India. Both the women (one running a tailoring shop and another running an IT-enabled public service centre) were able to grow their businesses once customised DRE systems provided them with reliable and affordable access to electricity. Their businesses are practically carbon neutral but more importantly the increased family income will help them cope with climate shocks that may adversely impact their family's agricultural business. This underlines the dual role of DRE – in mitigation and adaptation.

Overall the report presents a compelling case for bringing DRE systems to the centre of India's renewable energy transition. This will allow India to stay on track for achieving carbon neutrality in 2070 while also building climate resilience and adaptive capacity among the Indian populace.

# 1. 'DECENTRALIZED' Renewable Energy for Climate Action

Priyadarshini Karve - Clean Energy Access Network ( CLEAN)

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## Introduction

Climate change is the biggest challenge human society is facing today. The political and economic decisions made at the global level during this and the next decade will determine whether we can slow down climate change, or whether climate change will hamper human progress. The deciding factor is our energy consumption.

Energy has always played a crucial role in the history of humanity. Fire, created by burning wood, was the first energy source that humans controlled and utilized. The technological advancements of the past two centuries stemmed from our shift from traditional energy sources to fossil fuels - mineral coal and petroleum initially, followed by natural gas. Today's global economy is driven by fossil fuels with nearly 82% of the total primary energy consumed globally coming from them.<sup>1</sup> While fossil fuel reserves on earth are finite, and there has always been a speculation about when we are likely to run out of this resource. We have been able to find and access new reserves till date, proving wrong various predictions of 'peaking' the curve of accessible fossil fuels. However, the last couple of decades have seen a global agreement on the need to transition away from fossil fuels due to climate change considerations, rather than the possibility of the eventual depletion of fossil fuels. The latest assessment report by Intergovernmental Panel on Climate Change (IPCC)<sup>2</sup> has clearly pointed out that we must start seeing a drop in global use of fossil fuels from 2030 onwards to stay on track with the Paris Agreement target of capping global warming between 1.5 to 2 deg C. However, the global annual consumption of fossil fuels continues to rise every year and with the current status of global geopolitics, it is obvious that we are going to overshoot the Paris Agreement target.

India has strongly committed to increasing the proportion of renewable energy in its overall energy mix from 2008. According to the Ministry of New and Renewable Energy (MNRE), renewable energy in various forms contributed to about 46% of the total installed electricity generation capacity in India in 2024.<sup>3</sup> It must however be noted that none of these new power plants have been able to replace existing, mostly mineral coal fired, power plants. Furthermore, along with the increase in renewable energy-based electricity generation, there has also been a small but steady increase in fossil fuel-based electricity generation year on year (Figure 1.1).

As far as use of fuels for thermal and motive power is concerned, fossil fuels continue to dominate and their consumption continues to rise as the country is still developing.<sup>4</sup> The contribution of renewable fuels continues to be miniscule, however this situation may change over the next decade or so with the advent of 'green' hydrogen.

<sup>1</sup>The 2024 statistical Review of World Energy : <https://tinyurl.com/5xytkkx2>

<sup>2</sup>AR6 Synthesis Report Climate Change 2023 : <https://tinyurl.com/yc23n2fy>

<sup>3</sup>Press Release by MNRE on 13 Nov 2024 : <https://tinyurl.com/45akxjzv>

<sup>4</sup>India Power Capacity Overview, India Climate and Energy Dashboard : <https://tinyurl.com/ycy9dy4x>

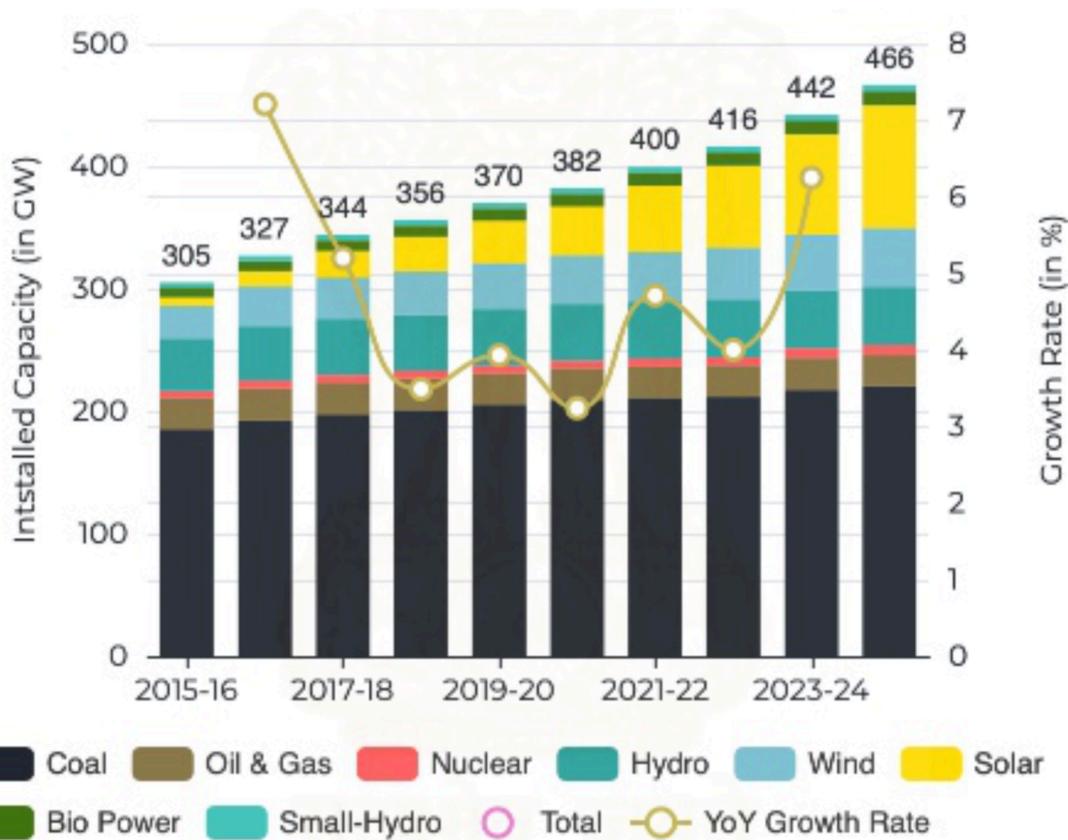


Figure 1.1 Power Sources Trend - Installed Capacity from 2015-16 to 2024-25 (in GW) as on 31 January 2025 (Copyright 2025 India's Climate and Energy Dashboard, Niti Ayog, Government of India)

## The Nuclear Dilemma

Apart from renewable energy sources, nuclear energy is also a potential climate change solution. Until the 1980s, nuclear energy was viewed with great optimism, as a promising alternative to fossil energy. France was leading the way by aiming to generate 100% of its electricity from nuclear power. Researchers also believed that nuclear fusion-based power generation would soon become feasible. However, while some progress is reported from time to time, we are still far away from commercially viable nuclear fusion reactors.

The nuclear fission based power generation technology evolved post the second world war and was still relatively new in the 1960s and 70s. Minor mishaps in nuclear reactors were quite common at the time. Disposal of radioactive waste from the power plants was another challenge. Also, the close relationship between nuclear energy generation and nuclear weapons meant that nuclear technology was not easily accessible to the developing world.

Despite these hurdles, India made some progress in nuclear power generation with mostly indigenous technology. Currently in India, there are 23 nuclear power plants contributing about 3% to the country's total electricity generation. India's installed nuclear power capacity stands at about 8 GW, far short of its initial 2032 target of 63 GW.<sup>5</sup>

<sup>5</sup> Press Release by Department of Atomic Energy : Nuclear Power in Union Budget 2025-26 : <https://tinyurl.com/bdeewvz6>

The Chernobyl disaster of 1986 sharply brought into focus the potential hazards of large-scale nuclear power deployment. The global tide of negative public opinion pushed anti-nuclear policies in many parts of the world. The 2011 Fukushima Daiichi nuclear disaster in Japan, triggered by a tsunami, further dampened progress in this sector.

Interestingly in the 2020s nuclear energy is again gaining some traction. The reactors are now safer and the radioactive waste generated is miniscule. Furthermore, an approach of small scale distributed nuclear reactors is being recommended to avoid widespread impact even if a mishap occurred in a nuclear power plant.

Recently, Government of India announced plans to achieve 100 GW nuclear power generation by 2047 primarily with the help of small modular nuclear reactors.<sup>6</sup> However, it is highly unlikely that nuclear energy would play a central role in India's energy transition for at least a decade or more.

## The Renewable Energy Pathway

Solid biomass fuels, solar thermal energy, wind mills and water wheels for mechanical energy, and human and animal muscle power were the energy sources of industries across the world in the pre-fossil-fuel era. Solar photovoltaics technology was developed in the 1950s for powering satellites and spacecrafts. The developed countries invested substantially in research in renewable energy sources in 1970s after the OPEC oil embargo made them realise their economic vulnerability due to dependence on imported fossil fuels. In 1980s, the climate change discourse further underlined the need to find alternatives to fossil fuels and pushed investments in renewable energy. Despite this the overall thinking on renewable energy around 2000s can be summed up as follows:

- Biomass has slow growth rates, making it impossible to replace all fossil fuels with biofuels.
- Solar energy is available only during the day, with variable intensity depending on the weather.
- Wind energy has variable speed and direction.
- Hydroenergy is dependent on rainfall.
- Geothermal energy can be used in specific regions, but is not a globally available resource.
- Experiments on electricity generation from tidal waves or ocean currents have not yielded hugely promising results.

The key barriers to renewable energy being able to replace fossil energy were identified as:

- The generation of energy from renewable sources requires much larger land area than an equivalent fossil fuel energy generation system.
- Due to intermittency, energy storage becomes necessary and these technologies are inefficient and polluting (namely lead acid batteries).

In the last couple of decades, technological advancements in wind mills and solar photovoltaics on one hand, and biofuels on the other hand, have gone a long way in making renewable energy systems more efficient and reliable. The rapid expansion of manufacturing capabilities for various components

<sup>6</sup>Press Release by Department of Atomic Energy: Nuclear Power in Union Budget 2025-26 : <https://tinyurl.com/bdeewvz6>

required for renewable energy systems made these systems economically viable. Furthermore, breakthroughs in energy storage technologies like the development of lithium batteries have become a game changer for this sector. As a result, the world has seen a surge in renewable energy deployment post 2010. And yet, as mentioned earlier, as of 2024, fossil fuel consumption continues to rise within India and globally. The rate of deployment of renewable energy systems remains too low to reverse the trend of increasing fossil fuel consumption.

## The Decentralized Renewable Energy (DRE) Pathway

Two main reasons can be cited for the slow rate of deployment of renewable energy worldwide despite the urgency created by climate change:

- There are parts of the world where the fossil fuel industry exerts so much influence on the governments that they are deliberately creating policy barriers to the spread of renewable energy.
- Even in countries where the policies are favourable to renewable energy systems, the large geographical footprint of these systems is becoming a barrier. In densely populated countries of Asia and Africa, with a complicated history and scarce documentation around land ownership and land rights, acquisition of large tracts of land for 'a hundreds-of-megawatt' scale project becomes the most time-consuming and acrimonious exercise. Choosing land tracts away from human settlements is likely to result in adverse ecological impacts.

As far as the first point is concerned, sustained people's movements to negate the political clout of the fossil fuel industry is the only way forward.

Regarding the second point, specifically in the Indian context, it must be noted that an energy transition to renewable energy may result into about 3% of the total land of the country being occupied by the energy generation systems. This is likely to be accompanied by significant social and environmental impacts. There have been several reported instances of village commons or pristine ecosystems being encroached upon by renewable energy projects.<sup>7</sup> Claiming carbon emission reductions or eco-friendliness for a large scale renewable energy project established, for example, on a previously forested land, does not make any logical or ethical sense.

Some solutions such as agrivoltaics with a dual use of the land for agriculture and energy generation are being recommended and may address some of the social impacts. However, the issues of ecological damage are far more complex to deal with.

The concept of centralised power generation (or fuel refineries) worked well for fossil fuel driven energy system as the availability of the mineral resources is not uniform across the planet. In contrast, renewable energy sources are available everywhere in one form or the other. Before the industrial revolution, local energy needs were met using a combination of locally predominant renewable energy sources. Therefore, decentralized power generation (and fuel production too, to some extent), and local consumption to the best extent possible, is the more appropriate pathway for harnessing renewable energy. Decentralized renewable energy (DRE) systems are small scale, have a smaller geographical footprint, and in majority of cases can be installed on top of existing infrastructure like buildings, bridges, roads, water canals, etc. This approach can accelerate deployment of renewable energy generation systems tremendously.

<sup>7</sup>Renewable Energy and Land Use in India by Mid-Century, 2021 Report by Institute for Energy Economics and Financial Analysis : <https://tinyurl.com/ypxjujasm>

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The decentralized approach has another advantage. The centralized energy generation systems have inherent inequalities associated with distribution of the energy. For example, urban areas receive priority in the distribution of electricity, while rural areas face disproportionate power shortages. Consistent supply of petrol, diesel, LPG, etc. to remote areas is challenging and expensive, and therefore local population in such regions face scarcity or intermittent supply. Local generation of both electricity and fuels using renewable energy can eliminate these barriers. This approach promotes equitable energy access for all. If every rooftop becomes an energy generator for that building and every backyard becomes a waste management + biofuel generation system for the neighbourhood, the renewable energy generation potential of a land area can increase without much additional geographical footprint, and therefore very limited adverse environmental or social impacts. Strategies like agrivoltaics too can be more effectively used in the decentralized energy generation systems given the generally small land holdings of individual farmers.

Whether large or decentralized, a shift from fossil fuel to renewable energy leads to a net reduction in greenhouse gas emissions per unit of energy generated over the lifecycle of the energy system. The DRE system has the additional advantage of aiding resilience building and adaptation to impacts of climate change. If uninterrupted and assured energy supply of a standard quality is ensured, the local population can use the energy for livelihood generation. If decentralized renewable energy systems become more prevalent, productive use of renewable energy (PURE) can expand beyond the few pockets of success and become more universal. An assured source of income based on local resources goes a long way in building resilience to a variety of calamities for everyone, but even more so for nature based and marginalised communities, in the face of potentially increasing impacts of climate change.

India being one of the countries most vulnerable to various impacts of climate change, an energy system that helps in mitigation as well as adaptation should be favoured over an energy system that can only provide mitigation benefits (and that too is doubtful given the potential of other adverse environmental impacts of large RE). The fact that building many DRE systems can be achieved much faster and at a much lower cost than a few large scale RE systems, further adds to the attractiveness of the DRE approach.

In India while there has been in general more policy and finance support to large RE systems, there have also been some policies and financial assistance focused on a few specific DRE systems. Biogas systems and rooftop solar thermal water heaters have been promoted for several decades and in recent times there have been policies supporting solar-powered irrigation pumps as well as rooftop solar photovoltaics for industries, commercial complexes, and households. The general rhetoric around the energy transition however shows that the large RE systems are considered to be the centrepiece of the energy transition with the DRE systems visualised as playing a backup role by the energy planners in most countries including India. Particularly DRE is often considered relevant, for only remote areas inaccessible for the centralised energy system.

If renewable energy sources are to achieve mitigation of greenhouse gases, they should be deployed more where the carbon emissions are higher, namely the urban centres. Given the cost of land in urban centres, this approach is totally unrealistic for large RE systems. Cities have high rise buildings and produce large volumes of organic waste and sewage. All the urban rooftops can be utilized for decentralized power generation, and all the urban organic waste can be converted into biofuels. Reducing urban carbon emissions will go a long way in achieving carbon neutrality as a country (Box 1). It must be emphasised that a sustained focus on improving energy access in remote and inaccessible areas is also necessary and can indeed be achieved very effectively and economically through DRE deployment. In this case the usefulness of DRE approach is more relevant for climate change adaptation rather than mitigation.

## POTENTIAL OF DRE FOR URBAN CLIMATE CHANGE MITIGATION

In 2018 Climate Collective Pune [CCP], a voluntary group of experts in various sectors, was formed under the leadership of Pune International Centre to develop a roadmap for making Pune Metropolitan Region (PMR) carbon neutral by 2030.

PMR is spread over 7,256.46 sq. km. and comprises of two Municipal Corporations of Pune and Pimpri Chinchwad, three Cantonment Boards, seven Municipal Councils, 13 census towns and 842 villages. It is one of the fastest-growing urban conglomerates in the Asia-Pacific region with a population of more than 7 million.

The analysis by CCP indicated that a combination of climate-smart development, carbon sequestration through green cover, investment in improving energy use efficiencies across various sectors and deployment of various DRE systems can take PMR towards carbon neutrality by 2030.

The DRE systems recommended for the city include solar rooftop thermal and PV systems, solar micro grids or solar-wind hybrid systems, combination of net-metering and battery storage, decentralised biogas systems operating on organic waste generated in neighbourhoods in urban areas and agricultural and animal husbandry waste in rural areas.

Source | 'Making Pune Metropolitan Region Carbon Neutral by 2030: A Policy Roadmap' by Pro. Amitav Mallik, Team Energy Environment and Climate Change, Pune International Centre, 2020

### An Ideal Energy System for the future

Decentralized renewable energy systems are deployed in urban and rural areas. Meeting local energy demands takes priority. Excess electricity is fed into a centralized grid, and surplus fuels are stored up. The centralised RE system becomes the backup in this scenario. Whenever and wherever there is a shortfall in the local electricity generation, it will be drawn from the central grid (fed by a few large RE systems and the excess electricity from numerous DRE systems) and stored renewable fuels (produced by a few centralised fuel generation systems like green hydrogen and surplus of local biofuel generation systems), as the case may be.

Such an energy system will create numerous green jobs and green entrepreneurial opportunities, evenly distributed across various geographical regions in India. Needless to say, urban and rural youth must be imparted relevant skills and expertise to capitalize on these opportunities.

### Conclusion

As history has shown us, changing the energy system drives technological advancements and also transforms societal structures and economies. Today's economy and social order are built on fossil fuels and are highly unequal and unfair. A DRE centric energy system can usher in an era of social and economic equality and lay the foundation for a sustainable global human society while combating climate change on multiple fronts. India can be at the forefront of this climate-ready energy revolution with the right alignment of priorities in policies and finance. Clean Energy Access Network (CLEAN) is committed to advocating for and being a part of this transformative change.

## 2. DRE in State Action Plans for Climate Change : Ideas and Opportunities

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### What is the Significance of SAPCC in India's Climate Change Policy

When the Government of India released its National Action Plan on Climate Change (NAPCC) in 2008 and set up various National Missions (Table 2.1), it was clear that sub-national planning was necessary to address the imminent adaptation and mitigation challenges. In 2009, at a conference of state environment ministers, the preparation of State Action Plans on Climate Change (SAPCCs) was initiated and a common framework document was prepared for the same. Following this, 33 SAPCCs of States and Union Territories were approved and made operational. Dedicated climate change institutions/cells have coordinated activities related to climate change in the states.

India submitted its 2022 Nationally Determined Contributions (NDC) with three notable quantifiable goals relating to emission reduction, clean energy and forestry (i.e. 45% emissions reduction by 2030 relative to 2005; 50% non-fossil fuel-based electricity generation capacity by 2030 and additional carbon sink through forestry of 2.5-3 billion tons of CO<sub>2</sub> equivalent). With these goals in context, the Government of India noted the need to further strengthen the SAPCCs and laid out a framework for revising the SAPCCs.

Table 2.1 : Eight Missions of the National Action Plan on Climate Change (NAPCC)

Mission Name	Goals and Measures
National Solar Mission	Increase the share of solar energy in the total energy mix
National Mission for Enhanced Energy Efficiency	Enhance energy efficiency through market-based certification mechanisms , cost reduction through R&D, demand-side financing mechanisms and fiscal instruments.
National Mission on Sustainable Habitat	Improvements in energy efficiency in buildings , solid waste management and modal shift to public transport.
National Water Mission	Ensure integrated water resources management helping to conserve water, minimize wastage and ensure equitable distribution both across and within States.
National Mission for Sustaining the Himalayan Ecosystem	Evolve management measures for sustaining and safeguarding the Himalayan glacier and mountain ecosystem.
National Mission for a Green India	Enhance ecosystem services including carbon sinks.
National Mission for Sustainable Agriculture	Devise strategies to make Indian agriculture more resilient to climate change.
National Mission for Strategic Knowledge for Climate Change	Enhance the understanding of challenges of response to climate change.

The SAPCC has now come to be recognized as arguably the single most comprehensive policy document outlining the major initiatives and strategies of a State/ Union Territory that is in line with the NDCs but also aligns with goals such as the Sustainable Development Goals (SDGs) and relevant national policy initiatives like the National Forest Policy, Biodiversity goals, Swachh Bharat Mission, Make in India etc. so that there are developmental co-benefits.

### What does a typical SAPCC contain ?

In its current framework, an SAPCC includes the following:

- **Vulnerability assessment** : The states are expected to assess and prepare composite vulnerability profiles including aspects like exposure, sensitivity, adaptive capacity and systemic preparedness. This assessment is done for the state as a whole and for specific sectors in the state. On this basis, states have identified highly vulnerable districts. Analysis covered in various SAPCCs at the sectoral level have pointed to various types of vulnerabilities such as high disease prevalence, low availability of relief shelters, poorly equipped or distant healthcare facilities, insufficient irrigation coverage, falling groundwater tables or poor water quality.
- **Mitigation – activities, barriers, implementation mechanisms** : The SAPCCs outline a range of mitigation measures and the most commonly seen ones are around expansion in RE (renewable energy) capacity, energy efficiency improvement in various sectors, electric mobility.
- **Adaptation – activities, barriers, implementation mechanisms** : Adaptation measures vary across sectors. Typically, the focal sectors include agriculture, livestock, fisheries, forestry and water resources. Adaptation measures across sectors are expected to build climate resilience, reduce carbon emissions and also enhance income for local communities.
- **Financing, institutional arrangements, monitoring and evaluation arrangements for the plan** : State Plans are expected to indicate how the proposed measures will be financed as well as the roles and responsibilities of various governmental and other agencies.

### Why DRE is well - suited for inclusion in the SAPCC ?

A range of DRE technologies are well-established (Figure 2.1) and offer a great opportunity to

- **Build climate resilience using clean technology** : For example, solar powered irrigation make agriculture less dependent on rainfall, which is rendered irregular by climate change.
- **Meet growing energy needs for activities and infrastructure in a low-carbon manner** : For example, as states seek to expand rural livelihoods or strengthen social infrastructure, energy expansion can be facilitated through DRE to reduce dependence on grid and/ or fossil fuels.
- **Empower individuals, communities or organisations to handle their energy planning** : For Example, solutions like solar rooftop can empower households or organisations to power their needs using RE.

As the comprehensive climate action policy at the state level suggesting adaptation and mitigation efforts across sectors, the SAPCC is a strong policy document for DRE integration. Specifically, various SAPCC elements in which DRE can find place are as follows:

- **Vulnerability assessment and adaptation activities** - that point to climate resilience planning can integrate DRE such as solar pumps as mentioned above :
- **Mitigation activities typically include expansion of RE** - of which DRE can be a part.

- **Disaster relief can also incorporate relevant DRE options** - such as solar powered relief centres and boats
- **DRE related opportunities for carbon sequestration** - e.g. biogas slurry for soil health or biochar to build climate resilience.

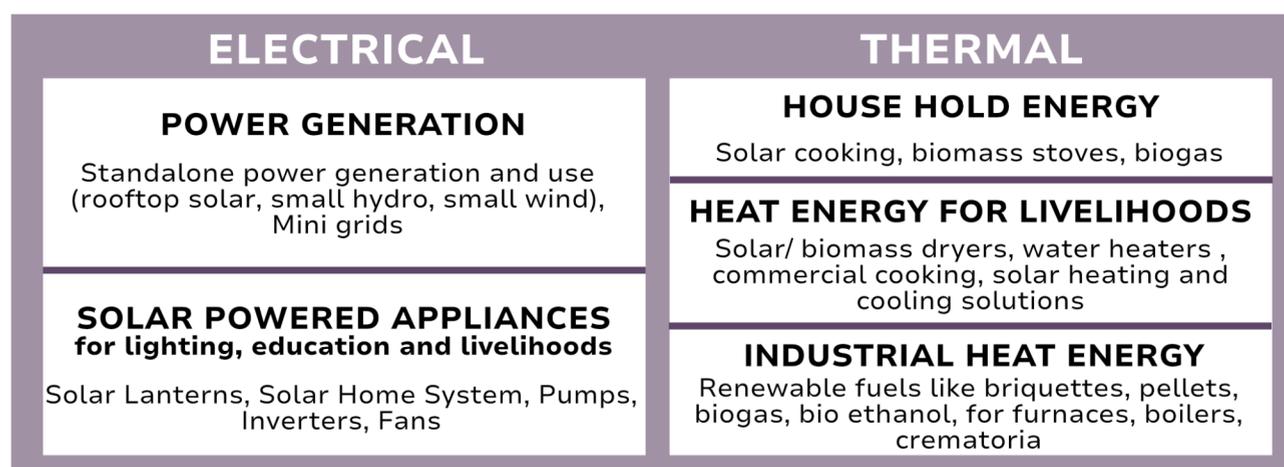


Figure 2.1 : Types of DRE technologies available

### Analysing SAPCCs for DRE Inclusion

A macro level analysis of SAPCCs has been conducted using a three-fold framework around (1) DRE inclusion (2) DRE opportunities or possibilities and (3) DRE readiness. The outcome of the analysis is described below. It is observed that a thorough analysis of each SAPCC through the DRE lens would require several months of in-depth review and consultations as many of them are around 250 pages long with a large amount of rich data and analysis.

#### Framework for DRE - centric analysis of SAPCCs

The WEFT team reviewed 14 SAPCCs through a DRE lens, specifically, focusing on the following questions:

##### 1 ] Does the state’s plan for the future till 2030 include DRE adoption?

- While this can be a rather vast question, the focus of the review is largely around two significant DRE options that have occupied most of the policy space thus far – solar irrigation pumps (PV-KUSUM) and solar rooftop (SuryaGhar Bijli Yojana) while also checking for inclusion of other DRE like biogas, small hydro etc.
- Given the relevance of DRE for disaster relief, this point has also been examined.

##### 2 ] Are there any opportunities for DRE adoption in the state based on the adaptation and/ mitigation activities planned in its strategy ?

- While this is also an open-ended question, the SAPCC review has focused on expected mega trends around farm mechanisation, MSME decarbonisation, e-mobility and creation of charging infrastructure as well as green cooking – all of which can create new opportunities for DRE adoption.

### 3 ] Does the SAPCC point to an institutional readiness for DRE adoption in the state in the dual sense of:

- Is there an established sub-state or local institutional mechanism in climate change planning - as this would allow for ease of DRE integration given its decentralised nature.
- Is there an institutional readiness for DRE adoption in terms of linkages of various relevant departments (like agriculture etc.) to work closely with energy department.

#### Findings of SAPCC analysis through DRE lens

Table 2.2 summarises the findings from a review of the SAPCC under four heads:

1. DRE inclusion in the plan.
2. Possible DRE inclusion due to new energy expansion opportunities.
3. DRE readiness with strong local climate change planning.
4. DRE readiness with strong cross-sectoral linkages with energy.

The table is colour-coded - Red indicating no mention in the plan; green referring to good level of detail in the plan and yellow for mention but with not much detailing.

**Table 2.2 : Summary Analysis of 14 SAPCCs**

State name	Inclusion of DRE	Pointers/ possibilities for DRE inclusion	Recognition of importance of local planning	Recognition of importance of energy department linkages with other sectors
Chhattisgarh	<ul style="list-style-type: none"> <li>• Solar pumping and solar rooftop mentioned in plan.</li> <li>• Other DRE included: Small hydro, Waste-to-energy, solar cold storage etc.</li> <li>• No mention of DRE in disaster relief.</li> </ul>	<ul style="list-style-type: none"> <li>• Animal shelters.</li> <li>• Drinking water provision.</li> <li>• Charging stations for EV.</li> <li>• Processing of forest produce.</li> <li>• Strengthening rural livelihoods esp. post-harvest processing.</li> </ul>	Plan advocates for mainstreaming of strategies at local planning level; Has set up District Climate Change Cell with proposed institutional mechanism detailed.	Energy department to coordinate with apex body (CSCCC) and district cell but no mention of inter-departmental coordination.
Goa	<ul style="list-style-type: none"> <li>• Solar pumping and solar rooftop mentioned in the plan.</li> <li>• Other DRE: Solar powered vessels for inland waterways; Biogas from dung and municipal waste.</li> </ul>	<ul style="list-style-type: none"> <li>• Eco-tourism.</li> <li>• E-Transport especially in mining areas.</li> <li>• Fisheries.</li> </ul>	Creation of a Technical / Green Cell for the Directorate of Panchayats.	Inter-department co-ordination identified as a necessity, issue-specific multi-department working groups proposed. Each department also have a 2-3 member working group .

**Table 2.2 : Summary Analysis of 14 SAPCCs [ Continued ]**

State name	Inclusion of DRE	Pointers/ possibilities for DRE inclusion	Recognition of importance of local planning	Recognition of importance of energy department linkages with other sectors
Gujarat	<ul style="list-style-type: none"> <li>• Solar pumping and solar rooftop mentioned in plan.</li> <li>• Other DRE included: Solar cold storage, Solar tractor, solar-wind hybrid, small hydro, waste to energy plants.</li> <li>• Plan recommends RE for electricity provision during disaster relief.</li> </ul>	<ul style="list-style-type: none"> <li>• Charging stations for EV.</li> <li>• Micro irrigation practices (drip &amp; sprinkler).</li> <li>• Bamboo processing units.</li> <li>• Post harvest management of agriculture/ horticulture products.</li> </ul>	Plan is silent on role of local or district level planning.	Energy department to coordinate with apex body and vice versa but no mention of inter-departmental coordination.
Haryana	<ul style="list-style-type: none"> <li>• Solar pumping and solar rooftop mentioned in plan.</li> <li>• Other DRE included: Biomass Cogen unit, waste to energy.</li> <li>• No mention of DRE in disaster relief.</li> </ul>	<ul style="list-style-type: none"> <li>• Waste management.</li> <li>• Charging stations for EV.</li> <li>• Farm mechanisation/In-situ management of crop residue.</li> <li>• Ice plants /Cold storage for fish</li> <li>• Rural water supply.</li> </ul>	Plan is silent on role of local or district level govt institution in implementing SAPCC.	Recognises the importance of inter-departmental coordination but does not mention clear mechanism of coordination or linkages of other sectors with energy department.
Himachal Pradesh	<ul style="list-style-type: none"> <li>• Solar pumping and solar rooftop mentioned in the plan.</li> <li>• No mention of DRE in disaster relief.</li> </ul>	<ul style="list-style-type: none"> <li>• Fodder station.</li> <li>• Clean Cooking.</li> <li>• Fencing</li> </ul>	No clear mention	No clear mention
Karnataka	<ul style="list-style-type: none"> <li>• Solar pumping and solar rooftop mentioned in plan.</li> <li>• Other DRE not mentioned in plan.</li> <li>• No mention of DRE in disaster relief.</li> </ul>	<ul style="list-style-type: none"> <li>• Charging stations for EV.</li> <li>• Aquaculture, cold storage for fish.</li> <li>• Livelihood of Fishing Community.</li> <li>• Micro-irrigation techniques.</li> <li>• Vaccine stations For animals.</li> </ul>	Plan includes a detailed mechanism for district level planning and implementation and has set up coordination committee at district level.	Plan highlights the importance of inter departmental coordination and has set up Coordination and Management Committee to bring alignment and coordination in the working of different agencies of the State.

Table 2.2 : Summary Analysis of 14 SAPCCs continued

State name	Inclusion of DRE	Pointers/ possibilities for DRE inclusion	Recognition of importance of local planning	Recognition of importance of energy department linkages with other sectors
Kerala	<ul style="list-style-type: none"> <li>• Solar pumping and solar rooftop mentioned in the plan.</li> <li>• Other DRE: Floating solar, Solar powered charging stations, Solar passenger ferry, Dedicated solar agri-feeder, Solar Street lights, and Small hydro.</li> </ul>	<ul style="list-style-type: none"> <li>• Fisheries.</li> <li>• Agri-processing.</li> <li>• Disaster relief.</li> <li>• Eco-tourism.</li> </ul>	Sectoral Climate Change cells and District Climate Change cells that will work closely with Panchayats and prepare local climate change action plans.	DCCs working closely with SeCCs – good example of decentralised cross-sectoral working.
Madhya Pradesh	<ul style="list-style-type: none"> <li>• Solar pumping and solar rooftop mentioned in plan.</li> <li>• Other DRE included: solar streetlights, biogas plant, small scale wind, methane for energy in industries, use of bio-char.</li> <li>• No mention of DRE in disaster relief.</li> </ul>	<ul style="list-style-type: none"> <li>• Charging stations for EV.</li> <li>• Post harvest infrastructure for Horti &amp; fish.</li> <li>• Drinking water supply in rural area.</li> <li>• Fodder development, semen storage</li> <li>• Strengthening livelihood of forest people.</li> </ul>	Although clear and detailed institutional mechanism is not mentioned, plan recognises the importance of local planning. Plan has proposed preparation of district Climate Change action Plan.	Plan recognises the role of interdepartmental coordination to effectively implementing the climate relevant strategies. However, a clear and detailed mechanism is missing.
Mizoram	<ul style="list-style-type: none"> <li>• Solar pumping and solar rooftop mentioned in plan with budget outlay.</li> <li>• Other DRE included: biogas plant, micro/small hydro, biomass cookstove, solar-wind hybrid,</li> <li>• No mention of DRE in disaster relief.</li> </ul>	<ul style="list-style-type: none"> <li>• Post harvest mgmt. system, Farm machinery.</li> <li>• Animal Shelters, Incubators.</li> <li>• Processing of forest produce.</li> <li>• Drinking water provision.</li> </ul>	ULBs, Village level institutions mentioned in plan but no clear role has been mentioned.	Department and their agencies mentioned in the institutional framework but clear and linkages for inter-departmental coordination not mentioned.
Odisha	<ul style="list-style-type: none"> <li>• Solar pumping and solar rooftop mentioned in the plan.</li> <li>• Other DRE included: Solar dryers for fish drying, solar water heating integrated in public infrastructure, solar thermal integration in industry .</li> <li>• No mention of DRE in disaster relief.</li> </ul>	<ul style="list-style-type: none"> <li>• Micro irrigation.</li> <li>• Bamboo.</li> <li>• Disaster relief.</li> <li>• E-vehicles</li> </ul>	Panchayati Raj recognised as a key stakeholder – as the schemes of this department have critical climate relevance.	No specific mention but there is a recognition that various interventions must be integrated. Climate change cell set up but its role in inter-department linking is not clear.

**Table 2.2 : Summary Analysis of 14 SAPCCs continued**

State name	Inclusion of DRE	Pointers/ possibilities for DRE inclusion	Recognition of importance of local planning	Recognition of importance of energy department linkages with other sectors
<b>Punjab</b>	<ul style="list-style-type: none"> <li>• Solar pumping and solar rooftop mentioned in the plan.</li> <li>• Other DRE: Solar in farms, Solar Street lighting, Canal top solar, Solar water heaters.</li> </ul>	<ul style="list-style-type: none"> <li>• Fish culture.</li> <li>• Solarisation of pumps.</li> <li>• Biogas – focus on dairy.</li> <li>• Biomass to energy – palletisation of agri residue.</li> <li>• Electric charging stations.</li> <li>• Fencing for man-animal conflict.</li> </ul>	No specification.	No specification.
<b>Rajasthan</b>	<ul style="list-style-type: none"> <li>• Solar pumping and solar rooftop mentioned in plan .</li> <li>• Other DRE included: biogas plant, waste to energy plant, solar charging stations in tourist spots, solar PV and SWH for hotels.</li> <li>• No mention of DRE in disaster relief.</li> </ul>	<p>DRE can be integrated in</p> <ul style="list-style-type: none"> <li>• Charging stations for EV.</li> <li>• Micro irrigation practices (drip &amp; sprinkler).</li> <li>• Animal shelters, Incubators.</li> <li>• Processing of forest produce.</li> <li>• Drinking water provision.</li> <li>• Monitoring for climate-sensitive diseases.</li> </ul>	Plan advocates for decentralization of action plan and includes strategy for developing city-level climate action plan. But does not mention about the role of district institutions.	Plan mentions that apex body will coordinate with line departments but no mention of inter departmental coordination or any energy department linkages with other sectors.
<b>Tamil Nadu</b>	<ul style="list-style-type: none"> <li>• Solar pumping mentioned in plan, solar rooftop not clearly mentioned but central scheme part of proposed activity</li> <li>• Other DRE included: Solar dryers, solar streetlights, solar in aquaculture</li> <li>• No mention of DRE in disaster relief</li> </ul>	<p>DRE can be integrated in</p> <ul style="list-style-type: none"> <li>• Micro irrigation practices</li> <li>• Animal housing, fodder development</li> <li>• Value-addition of horticulture products</li> <li>• Enrichment of non-timber forest product</li> <li>• Strengthening livelihood of fishermen</li> </ul>	Plan does not mention anything about local planning	Recognises the importance of inter-departmental coordination. Plan has identified proposed activities that are cross-departmental in each sector and also mentioned the name of departments involved
<b>Uttar Pradesh</b>	<ul style="list-style-type: none"> <li>• Solar pumping and solar rooftop mentioned in plan</li> <li>• Other DRE included: Solar cooker, off-grid solar plant on waste land, solarizing public and private pumps, solar based EV charging, waste to energy plant</li> <li>• No mention of DRE in disaster relief</li> </ul>	<p>DRE can be integrated in</p> <ul style="list-style-type: none"> <li>• Post harvest management and value chain</li> <li>• Micro irrigation practices (drip &amp; sprinkler)</li> <li>• Recycling of wastewater in residential area</li> <li>• Space cooling system, refrigeration</li> <li>• Skill development centres</li> </ul>	Plan does not mention anything about local planning	Plan mentions that apex body will coordinate with line departments but no mention of inter departmental coordination or any energy department linkages with other sectors

Among the 14 SAPCCs that were reviewed, the SAPCC of Gujarat state was found to be more progressive in terms of inclusion of DRE technologies or opportunities for DRE integration but the state is silent on recognition of importance of local planning and inter-departmental coordination. In contrast, SAPCC of both Karnataka and Kerala have recognised the importance of local planning and inter-departmental coordination and have set up detailed mechanism for district level planning and department level coordination. A few states have unique measures that can be replicated by other states as well. Kerala has set up Service centres for RE devices, and state-specific business models for rooftop solar PV adoption by domestic consumers. Madhya Pradesh plan refers to setting up of dedicated R&D and technology demonstration centre for low carbon technologies. The MP plan also recognises an opportunity in capturing and utilizing methane for energy generation in all industrial units with organic effluent. Another useful example is that of Himachal Pradesh where a Renewable Energy Centre leads the effort on solar rooftop. Such a centre is best-suited to take on the technical advisory role for DRE Integration.

### **Sectoral observations from the SAPCCs**

The key sectors included in the SAPCCs vary from state to state based on the local conditions and priorities, though several of them are common across SAPCCs. the following sectors have been studied to showcase some stand-out ideas, marked (and missed) opportunities as well as some interesting local insights from the DRE perspective.

- **Agriculture (including horticulture) and allied activities (livestock, fisheries, dairy)**
- **Cooking energy**
- **Urban/ sustainable habitat**
- **Forestry**

#### *Agriculture and allied activities*

Agriculture is an important sector from the point of climate change for a number of reasons. All the SAPCCs recognize the importance of making agriculture resilient to variations in temperature and rainfall. This is succinctly summarised in the Kerala SAPCC document:

“ Improving climate resilience in agriculture and profitability along the entire value chain in the least productive farmlands within the most vulnerable districts. Focus on climate-proof production practices, minimize post-production losses and build the capacities of supporting institutions and service providers.”

Value added post-harvest processing and cold storage can improve adaptive capacity. But use of DRE for this could also lay down a low-carbon option for such interventions.

Solar irrigation pumps and DRE-powered cold storage and processing infrastructure represent a strong way to climate-proof agriculture and to minimise post-harvest losses. It is heartening to note that all the SAPCCs reviewed recognise the role of solar irrigation.

Income diversification in the form of allied activities like livestock-rearing, poultry, fishery and dairy can contribute to resilience building for farming communities. DRE technologies can also help in these allied activities. The following are observations around DRE technologies that can be integrated within the SAPCCs in the context of farm income diversification for climate resilience:

- In livestock rearing and poultry, there is concern voiced around vaccine storage in some of the SAPCCs. Solar-powered vaccine storage may be considered. Fodder availability is also a concern particularly in states with high population density (i.e. Punjab, Kerala). Vertical fully RE-integrated fodder stations are worth exploring to address this gap. Further, SAPCCs (of Chhattisgarh, Mizoram,

Rajasthan, Tamil Nadu) have proposed development of shelters for animals along with lighting and ventilation for reducing heat stress. Solar powered sheds can be explored to meet these energy needs.

- Some states (Odisha, Tamil Nadu) have integrated DRE-powered cold storage, dryers etc. in their plan for fisheries. This is encouraging.
- In some states, animal dung-to-energy generation is positioned as a tool to both manage methane from dung and to also generate clean energy.

### **Cooking energy**

Biomass-based cooking in traditional stoves is a leading source of carbon emissions. Yet, very few of the SAPCCs focus on the linkage between black carbon from traditional cooking and climate change. This is surprising given that it is estimated that 41% of Indian households continue to depend on traditional biomass for cooking,<sup>1</sup> with dependence at over 90% in some states like Chhatisgarh. There is, nevertheless, a recognition of the possible detrimental impact of fuelwood dependence for cooking on the forest cover, as in the case of state plans like Himachal Pradesh and Odisha. References to expansion of biogas for cooking are encouraging. Uttar Pradesh has proposed measure to ensure access to biogas, solar cooker, and electric convection stoves to fuelwood dependent households.

Some disconnects should be pointed out here:

- Some state plans have proposed inclusion of UJALA scheme for cooking energy needs (the LPG expansion programme), however, it is not justified given that LPG is a fossil fuel.
- There appears to be a presumption that electricity for cooking can improve adaptive capacity in Odisha. Such an approach presents some concerns. Firstly, this may result in a missed opportunity for building clean cooking based on bio-energy including biogas. Secondly, it appears that there is a need to assess electricity loads carefully to be able to manage cooking loads that occur at specific times of the day.<sup>2</sup> Thirdly, the suitability of electricity to all forms of cooking applications – like roasting or roti making etc. – continue to be under scrutiny.

### **Urban/ sustainable habitat**

In terms of sustainable habitats, rooftop solar and solar cities find mention in several of the SAPCCs. Waste management is covered in most of the plans; however, waste-to-energy is not commonly seen. While some of the SAPCCs focus on urban households, others focus equally on rural. E-mobility finds mention in most of the SAPCCs in the context of mitigation action in urban transport. Very few SAPCCs, however, refer to powering of charging stations with DRE.

A few SAPCCs clearly spell out the importance of solar rooftop integration in public buildings, schools, eco-tourism sites and forest beat houses. There is mention of compressed biogas from municipal waste in some of the states' plans.

### **Forestry**

On a positive note, most SAPCCs recognise the role of forests in mitigation. Some reports mention the potential adverse effects on forests of biomass dependence on cooking. But the importance of provision of alternative clean energy to forest-fringe communities is not seen. The role of DRE in processing minor forest produce is also immense and is not seen.

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<sup>1</sup>According to the National Family Health Survey conducted in 2019-2021

<sup>2</sup>Role of DISCOMs in Scaling up of eCooking in India | Finovista : <https://tinyurl.com/3yvf7pms>

## AGRICULTURE AND HORTICULTURE



**Solar water pump**  
[Source - Wemaga ]



**Hydro powered pump**  
[Source-aQsta]



**Solar cold storage**  
[Source - Ecozen]



**Solar dryer**  
[Source- Back2Farm]



**Biomass dryer**  
[Source-CLEAN]



**Solar sprayer**  
[Source-RSR agro]



**Solar milling machine**  
[Source-Indiamart]



**Solar rice huller**  
[Source-SEMA]

## LIVESTOCK



**Animal shed powered by solar** [ Source - Alamy]



**Fodder station**  
[ Source-Hydrogreens ]



**Solar egg incubator**

## HANDLOOMS AND SERICULTURE



**Solar powered power loom**



**Solar powered silk reeling and twisting**



**Solar water heaters for washing / bleaching of yarn** [ Source - Sunbank]

## FISHERIES



**Solar powered boats**



**Solar dryer**  
[ Source - Back2Farm]



**Biomass Dryer**  
[ Source -Clean ]

## TOURISM



**Solar water-heater**  
[ Source - Sunbank]



**Solar street light**  
[ Source -Dabholkar]



**Battery operated vehicle**  
[ Source - India mart ]

Figure 2.2 : Mapping of DRE Technologies for various sectors  
(Photographs : Courtesy various members of CLEAN)

## Optimising DRE impacts: possible ideas for effective SAPCC integration

DRE options that find mention in the SAPCCs are largely confined to solar rooftop, solar irrigation pumps and solar street lights. There are some concerns that are mentioned in the SAPCCs which can be reliably addressed through DRE technologies/ products. Examples include solar-powered vertical fodder stations to surmount gaps in livestock grazing; solar-powered fences and repellents to address human-animal conflicts. Agricultural waste reduction through processing and effective storage as well as management of agri-waste through waste-to-energy technologies find mention in some of the SAPCCs, but the role of DRE is not recognised. Several SAPCCs mention eco-tourism but the importance of low-carbon technologies like DRE is not mentioned in most of them. Where DRE technologies like solar drying or solar water heating are mentioned, there is no clear implementation or financing plan.

For an optimal role for DRE in the resilience and mitigation planning of a state, mapping of DRE possibilities in various sectors is useful. The above Figure 2.2 provides an overview of DRE technologies applicable to various sectors:

A number of various aspects need to be taken note of and woven into the SAPCCs when the states plan for DRE integration.

- **Energy Efficiency** : The DRE technologies considered must be energy-efficient and reliable.
- **Local involvement in maintenance** : It is essential to ensure that end-users are involved in the design of DRE systems so that their needs are met. Arrangements for installation and service of the systems need to be in place. DRE vendors may be involved in the servicing of systems through O&M commitments woven into purchase contracts. Nevertheless, a local network of youth (including women, e.g. Urja Sathi or Saur Sakhis, in several states) needs to be groomed to address day-to-day operation issues and frequent simple glitches that may arise.
- **Factor in climate change impacts** : Seasonal and diurnal variations in RE availability (e.g. solar available only during the day or hydro not reliably available in the summer) should be factored into the design of systems by matching with energy needs. Battery storage or hybridisation with other RE may be considered for full-day or year-round operation.
- **Disaster-proofing of RE** : In order to make DRE relevant, it is essential to disaster-proof DRE installations. This may raise cost and should be part of climate resilience financing.
- **Designing with local and sustainable materials** : Use of sustainable materials like bamboo and locally available resources can help create an ecosystem around DRE product development while also ensuring minimal ecological footprint. Bamboo solar torches, use of bamboo poles for installation of solar panels in fields are, examples.
- **Pressure on land** : Large RE systems are constrained by the availability of land and by elaborate land procurement process. DRE options can help by-pass this issue – examples include solar rooftop, agri PV (installation of solar panels on land used for agriculture, animal-rearing, or on polyhouses in farms etc), floating PV (installation of solar panels on water bodies). This may call for addressing issues around ownership and control which need to be resolved at the regulatory level.

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- **Recognise the complementarity rather than competition of DRE with large RE :** DRE does not and cannot compete with large RE. Nevertheless, it must be pointed out that the latter are not only capital-intensive but are also not as employment-intensive as DRE. The Odisha SAPCC observes that “mega solar projects especially in areas like Manmunda (Boudh District,) a backward district, will spur growth and reduce disparity”. But, large RE projects have sometimes caused loss of livelihoods<sup>3</sup> while DRE installations that are people-centric can have significant socio-economic benefits for the state.
  - **Tapping existing multi-sectoral local level institutional setups :** An example is in the Kerala SAPCC with its sectoral climate change cells and district-level climate change cells. The district cells, work on multiple sectors at the very local level with panchayats. Such institutional set-ups are well-placed to take on the role of DRE integration.

In summary, DRE is best planned at the local level of a district or a block or even panchayat / hamlet. As the SAPCC is drafted and owned by the state or UT government and is expected to have local and cross-departmental institutional arrangements, planned DRE integration in the SAPCC can be an opportunity to simultaneously build climate resilience, to replace fossil fuels, and to leapfrog to green-tech.

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<sup>3</sup>Poojary V, Hingne A, Kelkar U, 'In India, New Solar Parks can either Uproot or Uplift Landless Workers', World Resources Institute (2023) :<https://tinyurl.com/48pdsc8j>

# 3. Significance of DRE in achieving just energy transition.

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## Introduction

**W**hen we talk about "transition" in the context of climate change, we are referring to the shift from a high-carbon economy powered by fossil fuels to one that is low-carbon, sustainable, and resilient. This shift is essential for reducing the harmful effects of climate change. It also opens new opportunities in green industries, which can create millions of jobs and support long-term sustainable economic growth. Beyond that, the transition helps protect biodiversity and natural resources that are threatened by climate change.<sup>1,2</sup>

**The transition from high carbon to low carbon economy spans multiple sectors, including:**

- **Energy Transition** : Moving away from fossil fuels like coal, oil, and natural gas, and embracing renewable energy sources like solar, wind, geothermal, etc.
- **Industrial Transition** : Overhauling industries, particularly heavy ones like steel and cement, to adopt cleaner technologies and more sustainable practices.
- **Transportation Transition** : Encouraging cleaner transportation options, such as electric vehicles and better public transport, to reduce GHG emissions.
- **Agricultural Transition** : Shifting to more sustainable farming methods, cutting emissions from livestock, and ensuring food security for a growing population.

**At the core of this transformation are key aspects like:**

- **Decarbonization** : Cutting carbon dioxide and other GHG emissions across industries, transportation, and energy systems by adopting cleaner technologies.
- **Sustainable and Resilient Infrastructure** : Building infrastructure that can withstand the impacts of climate change, such as extreme weather events and rising sea levels.
- **Circular Economy** : Creating systems where materials are reused, recycled, and kept in use for as long as possible, minimizing waste and reducing the need for new resources.
- **Adaptation** : Making sure that societies and ecosystems can adapt to unavoidable climate impacts, such as stronger floods or rising temperatures.
- **Social and Economic Transformation** : Ensuring that the transition is just and fair for everyone, especially for those in vulnerable communities and workers who depend on industries like coal mining.

<sup>1</sup>International Labour Organization, 2015. Guidelines for a just transition towards environmentally sustainable economies and societies for all. International Labour Organization.

<sup>2</sup>United Nations Framework Convention on Climate Change, n.d. Just Transition of the Workforce, and the Creation of Decent Work and Quality Jobs (Technical Paper). United Nations Framework Convention on Climate Change.

While the transition holds great promise in addressing the climate crisis, it is not without its challenges:

- **Cost and Investment** : Moving away from fossil fuels demands large investments in new technologies, infrastructure, and retraining workers.
- **Social and Political Resistance** : Fossil fuel industries and communities dependent on them may resist the shift, making it difficult to implement necessary policies.
- **Inequality** : It is critical to ensure that no one is left behind in the transition - especially vulnerable communities that could face hardships due to the changes.

### What is 'Just Energy Transition'

Recognizing the impacts of climate change, several countries have adopted proactive strategies by setting ambitious renewable energy targets. India, for instance, has set a goal of achieving 500 GW of renewable energy capacity by 2030 (having recently reached 200 GW) and aims to achieve carbon neutrality by 2070.<sup>3</sup>

**The key principles of a just transition include:**

- **Equity and Fairness** : Ensuring that all people, particularly those who have been historically marginalized, benefit from the shift to a green economy.
- **Worker Support** : Offering retraining, job creation, and new work opportunities for those whose jobs may be displaced by the move to renewable energy.
- **Inclusive Decision-Making** : Making sure that everyone, especially those most impacted by the changes, has a say in how the transition happens.
- **Social Protection** : Providing financial support to those who may be negatively affected, like unemployment benefits or retraining programs.
- **Community Empowerment** : Helping communities, particularly those dependent on fossil fuels, to diversify their economies and build sustainable, clean industries.

**Some examples of a just transition in action include:**

- **Renewable Energy Jobs** : As coal plants shut down, retraining programs can help workers shift to new jobs in the renewable energy sector that will be simultaneously growing to fill the gap in electricity generation.
- **Climate-Resilient Infrastructure** : Investing in green infrastructure, like energy-efficient buildings and sustainable public transport, that creates jobs and helps local communities thrive while reducing the overall energy demand.
- **International Support** : Wealthier nations supporting developing countries in making the transition to low-carbon economies by sharing technology and providing financial assistance.

<sup>3</sup>Press Information Bureau, 2024. India's Renewable Energy Capacity Hits New Milestone Renewable energy now constitutes more than 46.3% of total capacity.

## How DRE Can Support 'Just Energy Transition'?

Decentralized Renewable Energy (DRE) is an important part of a just energy transition. Compared to large RE, DRE systems—like rooftop solar panels, small wind turbines, and microgrids are smaller in scale, locally controlled, and designed to meet the specific energy service needs of **communities**.<sup>4,5,6,7</sup>

Here is how DRE contributes to a fairer, more inclusive transition:

### Economic Empowerment and Job Creation

- 1. Local Job Creation through Training and Retraining :** DRE systems can create new jobs in communities where opportunities were once limited. These jobs range from designing and installing renewable energy systems to maintaining them long-term. The availability of green jobs through solar power depends on both the location and the size of installations. Utility-scale (large-sized) solar photovoltaic plants create nearly three times as many jobs as wind energy-based plants. In contrast, rooftop solar installations generate seven times the number of jobs compared to utility-scale solar plants and these job opportunities are scattered over a larger geographical area. It is important to train/retrain the candidates to access these new jobs. Green jobs play a crucial role in achieving a just transition, not only for individuals who will be impacted by the phasing out of fossil fuels in industries such as mining, transport, and coal-based electricity generation, but also for providing employment opportunities to the youth entering the labour market today.<sup>8</sup>
- 2. Entrepreneurship :** DRE opens entrepreneurial opportunities, allowing local businesses to get involved in managing locally available renewable energy resources or setting up energy service cooperatives. These are entirely new type of green business opportunities with a huge scope for innovation.

### Energy Access and Equity

- 1. Improved Energy Access :** DRE systems are a lifeline for remote or underserved areas that do not have reliable access to a central grid irrespective of whether the grid is powered by fossil fuels or large RE. For rural communities or developing countries, locally operating DRE based energy service providers means a chance to access electricity where it was previously either unavailable or highly unreliable. For this reason, DRE must be at the centre of just and inclusive global energy transition.<sup>9</sup>
- 2. Affordable and Reliable Energy :** DRE, especially solar or wind systems, can lower energy costs in the long run, giving low-income households a chance to save on expensive (often diesel powered solutions) and unreliable grid power. DRE can lift people out of energy poverty, improving their living standards and enabling small businesses to thrive, while also supporting education and healthcare in underserved areas.

<sup>4</sup>Das, B., Batra, A., Bhatti, J., 2022b. Vol. 2: Mini Grids: A Just and Clean Energy Transition. Centre for Science and Environment.

<sup>5</sup>IRENA and SELCO Foundation, 2022. Fostering Livelihoods with Decentralised Renewable Energy: An Ecosystems Approach. International Renewable Energy Agency, Abu Dhabi, Abu Dhabi.

<sup>6</sup>IRENA, 2023. IRENA Coalition for Action (2023), Finding common ground for a just energy transition: Labour and employer perspectives. International Renewable Energy Agency, Abu Dhabi.

<sup>7</sup>Kwatra, S., 2019. Distributed Renewables and India's Energy Transition : <https://tinyurl.com/4ee3c76u>

<sup>8</sup>Kumar, A., 2023. OPINION: Distributed solar for just energy transition. ETEnergyWorld.

<sup>9</sup>PSU Watch Bureau, 2023. Decentralised Renewable Energy must be at centre of just energy transition: MNRE Secretary. PSU Watch.

## Community Empowerment and Control

1. **Local Ownership and Control** : DRE systems are often community-driven (e.g. operated by a co-operative formed by members of the community), giving local populations the power to manage their own energy resources and decide how they are used. This promotes energy sovereignty and Ensures communities have a direct stake in their future. This also helps shape climate action around the real needs and values of those directly impacted.

## Environmental and Social Benefits

1. **Reduced Environmental Impact** : DRE not only helps reduce GHG emissions by switching energy production from fossil fuels to renewable sources but also in many instances result into reducing local air and water pollution. This helps improve the health of the local ecosystems creating positive health benefits for the local community too.
2. **Resilience to Climate Change** : DRE systems can help communities stay resilient to extreme weather events, ensuring they still have power even when traditional infrastructure is knocked out. DRE powered shelters in the neighbourhood can help local communities cope better with climate change induced natural disasters.

## Social Inclusion

1. **Support for Vulnerable Populations** : DRE ensures that marginalized groups, such as women, indigenous peoples, and low-income communities, are not left behind in access to energy.
2. **Transition** : Access to energy can improve quality of life by providing better living conditions, healthcare, education, and economic opportunities.
3. **Equitable Distribution of Benefits**: Because DRE systems are decentralized, they provide an opportunity to spread the benefits of renewable energy more evenly, ensuring that rural or lower-income communities become equal partners with their better off counterparts in the country's journey towards climate aligned sustainability.

## Support for Energy Transition in Fossil Fuel Regions

1. **Fossil Fuel Communities** : DRE can help communities that rely on fossil fuel industries transition to cleaner energy and alternative employment opportunities. It offers a way for these areas to move away from harmful environmental practices without sacrificing their economic stability.
2. **Economic Diversification**: DRE projects help regions that depend on fossil fuels diversify their economies, reducing their reliance on extractive industries and making them more resilient to market shifts or the decline of fossil fuel industries.

Thus, DRE is key to making the shift to a sustainable, low-carbon future more equitable and inclusive. By empowering communities, creating jobs, and ensuring energy access for everyone, DRE can be a powerful tool in achieving a just energy transition that leaves no one behind.

## Way Forward

To fully realize the potential of 'DRE' in a Just Energy Transition, the following key challenges must be addressed as a priority going forward:

**A] Strong policy support for 'DRE' is crucial in a Just Transition :** The envisioned Just Energy Transition involves establishing renewable energy projects aimed at reducing carbon emissions, providing energy access, and generating employment. This is primarily achieved through large-scale grid-connected renewable energy projects and small-scale decentralized projects. While large-scale projects are essential for mitigating carbon emissions by replacing fossil fuel-based energy generation, they often dominate policy frameworks, overlooking the advantages of small-scale DRE projects. Moreover, large-scale projects often face socio-environmental challenges<sup>10</sup>, such as land and water requirements, impacts on local livelihoods, and the destruction of local flora and fauna. Therefore, it is necessary to develop Just Energy Transition policy frameworks that place DRE at the forefront, alongside large-scale utility projects, to ensure a more inclusive and balanced approach.

**B] Financial mechanisms for just energy transition :** Given the substantial financial requirements for a comprehensive energy transition, it has been suggested that countries should develop innovative financing mechanisms. For example, India can kickstart its Just Transition investments by utilizing local resources such as the District Mineral Foundation (DMF) and Corporate Social Responsibility (CSR) funds. To date, over ₹29,707 crore (approximately \$3.7 billion) has been accumulated in the DMF through contributions from coal and lignite mining companies. These funds can be directed towards economic diversification, green energy investments (especially DRE to improve access), workforce development, and enhancing community resilience by strengthening social infrastructure. These investments align well with the objectives and scope of both DMF and CSR funds.<sup>11,12</sup>

**C] A well-thought-out plan is essential for ensuring a Just Transition :** The low-carbon energy transition could have a significant negative impact on countries rich in natural resources, such as coal and other fossil fuels, across the globe. For example, in India, states like Jharkhand, which are rich in coal reserves, could be significantly adversely impacted by this transition. Several policy and financing interventions will be necessary to mitigate the adverse effects of the transition. Investment will be needed in alternative industries and livelihoods, including large-scale workforce re-skilling, job creation, and targeted social spending. Substantial planning is required to create a suitable roadmap that ensures that the transition benefits everyone. This roadmap should estimate the incremental investment needed each year in emerging technologies, alongside the decline in stakeholders' revenue or income from conventional resources. Additionally, it will be crucial to identify appropriate sources of finance and develop frameworks that facilitate the flow of funding to the necessary areas.<sup>13</sup> Care must be taken to ensure that DRE systems are given appropriate attention in developing the transition plans.

**D] Anticipating and developing comprehensive skilling program leading to Just Transition :** Discussions on skills development in Just Transitions often focus on reskilling coal miners for alternative employment. However, a broader Just Transition requires significant decarbonization across the entire economy, creating a wide range of new employment opportunities while wiping out a number of livelihoods. There is a need for upskilling investment analysts, policymakers, utility officers, developers, installers, and maintenance staff, to name a few among a wide variety of stakeholders. As new sectors like energy-efficient buildings, industrial decarbonization, and coal sector rehabilitation develop, new skills will be needed. Thus, anticipating skill requirements and establishing institutions and curricula to support these needs will be key to a successful Just Transition.<sup>14</sup>

<sup>10</sup>Schiffer, A., 2023. Renewable Energy & Land Use - Barriers to Just Transition in The Global South. Friends of the Earth International.

<sup>11</sup>Bhushan, C., n.d. Just Transition, Just Finance. iFOREST.

<sup>12</sup>Mitra, J., Singh, A., Victor, A., 2023. Just Transition Framework For a Sustainable Future In India's Coal Mining Regions. The Energy and Resources Institute.

<sup>13</sup>United Nations Global Compact, 2023. Just Transition and Renewable Energy: A Business Brief.

<sup>14</sup>Climate Investment Funds, n.d. Just Transitions in India: A study by the Climate Investment Funds.

# 4. Climate Finance and DRE [ based on ‘The State of Climate Finance in India 2024’]

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## Need and Current Status of Climate Finance in India

**P**rojections suggest that climate change could reduce India's Gross Domestic Product (GDP) by 3% to 10% annually by the end of the century.<sup>1</sup> Climate change is set to impact various regions and sectors, including agriculture, health, infrastructure, and labour productivity. If temperature exceeds certain thresholds, climate impacts may become irreversible, posing a threat to ecological, social, and economic systems, which makes limiting warming to 1.5°C crucial for a low-carbon future. A transition to a low-carbon economy will demand significant shifts in India's economic investment priorities and development goals.

As per India's original commitment under Paris Agreement (Nationally Determined Contribution or NDC) submitted in 2015, meeting the 1.5°C target required annual investments of USD 167 billion from 2016 to 2030 - equivalent to around 8% of 2015 GDP.<sup>2</sup> According to India's updated NDC submitted in 2022, the country requires climate finance to the tune of trillions of dollars by 2050. More specifically, from 2026 to 2030, India will need between \$253-\$263 billion annually in clean energy investments, which will further rise to \$325-\$355 billion per year between 2031 and 2035, to align with its climate and development goals.<sup>3</sup> Other studies suggest that to reach carbon neutrality by 2070, the total required investment amounts to \$10.1 trillion. However, current climate finance availability in India is only about \$44 billion per year, highlighting a significant investment gap that must be addressed.<sup>4</sup>

As per Paris Agreement, developed countries were supposed to provide funding for developing countries. However, this monetary assistance has not materialised to the extent that is required. In any case, the least developed and most vulnerable countries have priority in such international assistance. India being one of the developed among developing countries finds itself unable to access the meagre international climate finance that is available through Paris Agreement and related global agreements. Therefore, attracting private sector investments into India's climate mitigation and adaptation goals is crucial. This requires creating an investment ecosystem with regulatory stability, bankable projects, and financial innovations.

Between 2017 and 2019, India's climate finance increased by 150%, reaching USD 44 billion in 2020. However, funding remains insufficient and heavily skewed toward mitigation efforts (90%) rather than adaptation (10%).<sup>4</sup> Most climate finance stemmed from domestic commercial sources, followed by public funds, with private investments largely focused on large scale renewable energy. Multilateral Development Banks (MDBs) provided \$60.9 billion in climate finance to low- and middle-income economies in 2022, a significant increase from previous years, and yet this was highly inadequate compared to the requirement.<sup>5</sup>

<sup>1</sup>Picciariello, A., Colenbrander, S., Bazaz, A. and Roy, R. (2021) The costs of climate change in India : <https://tinyurl.com/yc6x7xva>

<sup>2</sup>India's Intended Nationally Determined Contribution – Towards Climate Justice, MoEFCC (2015) : <https://tinyurl.com/swftfkr>

<sup>3</sup>Scaling Up Private Finance for Clean Energy in Developing and Emerging Economies, IEA-IFC (2023): <https://tinyurl.com/3mzkprer>

<sup>4</sup>Global Landscape of Climate Finance: A Decade of Data : <https://tinyurl.com/379mp2zh>

<sup>5</sup>2022 Joint Report on Multilateral Development Bank's Climate Finance, European Investment Bank, 2023 : <https://tinyurl.com/3487jakt>

Transitioning away from coal will incur short-term economic costs but may offer long-term benefits with the right policies. India's coal-dependent workforce - numbering over 7 million - faces job losses, and state revenues reliant on coal royalties will decline. A 'just transition' is essential to address social risks like job displacement, and workers will need to be compensated and reskilled for new employment opportunities. Communities may require alternative livelihoods and possible resettlement.

Effective policy coordination between central and state governments is critical to managing the energy transition while maintaining financial stability. Financial institutions must incorporate climate risks into decision-making processes to limit further investment in carbon-intensive assets. India's financial stakeholders, including banks and regulators, can facilitate this shift through green bonds and targeted subsidies.

In terms of adaptation, India's 2020 costs were INR 29 trillion, which will be rising to INR 86 trillion by 2030. However, the available green finance for adaptation in 2020 was only INR 370 billion per year, a small fraction of what was needed.<sup>6</sup>

### Recent efforts to Increase Climate Finance in India

In February 2024, the Reserve Bank of India (RBI) introduced a Disclosure Framework on Climate-Related Financial Risks. This framework mandates that banks and regulated financial entities disclose how they are managing and mitigating climate risks.<sup>7</sup> The framework focuses on four main pillars: governance, strategy, risk management, and metrics and targets, encouraging financial institutions to integrate climate-related risks into their operations and decision-making. While the RBI's draft framework is a proactive stance on climate risk, it also brings in implementation challenges for renewable energy systems. Data-related limitations (granularity, history, reliability), lack of standardised methodologies and resource constraints are few of the hurdles that entities may face in complying with the disclosure requirements. There are ongoing discussions on how to provide these entities with the necessary guidance and tools to comply with the framework's requirements. However, most of this discussion is currently focused on large RE systems and their investment needs. The versatile and multi-fold role played by DRE in addressing climate change and the need for relatively smaller investment and funding support for DRE is mostly missing from these discourses.

India is actively developing a Climate Finance Taxonomy to streamline and increase the flow of investments into climate-related activities. Finance Minister Nirmala Sitharaman, while presenting the Union Budget for 2024-25 in July 2024, announced that the government would develop a 'climate finance taxonomy' to enhance the availability of capital for climate adaptation and mitigation on four major cases i.e. 'Garib' (poor), 'Mahilayen' (women), 'Yuva' (youth) and 'Annadata' (farmer).<sup>8</sup> This taxonomy will serve as a standardized framework to classify economic activities that align with the country's climate goals, including both adaptation and mitigation efforts. The primary goal is to improve transparency in climate investments and reduce the risk of greenwashing - where projects falsely claim to be environmentally sustainable. The taxonomy will make it easier for both domestic and international capital to flow into projects that support India's green transition. This framework is crucial for mobilizing the estimated \$10.1 trillion required to achieve India's net-zero targets by 2070. So, climate finance taxonomy could, in theory, guide the new investments coming into the country towards more climate-friendly sectors like renewable energy, electric vehicles, and climate-resilient infrastructure. It would help investors, both domestic and international, identify which projects are truly green and deserve funding. There is a scope to include DRE considerations into this process so that the financing community will also see the attractiveness of the DRE sector.

<sup>6</sup>Global Landscape of Climate Finance: A Decade of Data : <https://tinyurl.com/379mp2zh>

<sup>7</sup>Draft Disclosure framework on Climate-related Financial Risks, Reserve Bank of India, 2024 : <https://tinyurl.com/533k5cvr>

<sup>8</sup>Making sense of the 2024-25 Union Budget : <https://tinyurl.com/mpc8kxt3>

## Energy Security for Vulnerable States and Communities

Clean energy initiatives, including the promotion of renewable energy (large and decentralized) and electric vehicles (EVs), are central to India's climate mitigation strategy. These efforts aim to reduce greenhouse gas emissions, transition to a low-carbon economy, and address energy poverty, particularly in vulnerable states and communities. Rural and underdeveloped regions in India are disproportionately impacted by climate change, and integrating DRE solutions such as rooftop solar power and EV charging infrastructure not only mitigates these impacts but also promotes economic development and resilience.

### Bihar and Jharkhand

These states face significant energy poverty, with many rural populations lacking access to reliable electricity. Small scale solar energy projects and microgrid solutions are being implemented to provide sustainable and affordable energy access to isolated and impoverished areas. Additionally, the introduction of electric two-wheelers and e-rickshaws, which are more affordable and accessible to low-income groups, reduces dependence on fossil fuels and provides clean transportation options.

### Odisha

Odisha, frequently affected by cyclones and flooding, focuses on renewable energy to build resilience. The state has implemented programs to install solar-powered water pumps and off-grid solar systems in remote coastal communities, providing essential services while reducing emissions. Furthermore, Odisha is investing in solar-powered charging stations for electric vehicles, ensuring that rural and coastal areas have access to clean transportation even during power outages caused by extreme weather. These initiatives also create green jobs, improving local economic conditions and supporting small businesses.

### Rajasthan

As a drought-prone state with significant solar potential, Rajasthan is expanding its solar capacity to provide affordable clean energy. Many of these projects target smallholder farmers and rural households, enabling them to access solar-powered irrigation systems and other decentralized energy solutions, thereby supporting sustainable agricultural practices. Additionally, the state is integrating EV infrastructure, targeting electric tractors and two-wheelers for farmers and rural residents, providing them with low-emission and cost-effective alternatives.

### Focus on Marginalized Communities

Investing in DRE systems and EV infrastructure for vulnerable communities in these states not only mitigates climate change but also enhances livelihoods and living standards. Special funding mechanisms, such as subsidies for solar installations, green microfinance, and incentives for purchasing EVs, are necessary to make these solutions accessible to economically disadvantaged groups. By targeting marginalized communities, these initiatives aim to achieve equitable climate mitigation that supports sustainable development across India.

## Clean Transportation

Clean transportation is a critical component of India's climate mitigation strategy, aiming to reduce greenhouse gas emissions from one of the country's largest polluting sectors. The transportation sector accounts for a significant share of India's total carbon emissions, driven by a rapid increase in vehicle ownership and urbanization. To address these challenges, India is focusing on promoting sustainable transportation options, including electric vehicles (EVs), public transit systems, and alternative fuels.

The Indian government has implemented policies such as the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, which provides financial incentives for EV purchases. This initiative encourages the adoption of electric two-wheelers, three-wheelers, and buses, making clean transportation more accessible to the masses. States like Delhi and Maharashtra are leading in EV deployment, with aggressive targets for increasing the number of electric buses and establishing extensive charging infrastructure to support the transition to electric mobility. Ownership of EVs has also resulted into a shift towards rooftop solar PV installations due to the charging requirement in urban residential areas as the electricity consumption of households has gone up.

Expanding and improving public transit systems is essential for reducing the reliance on personal vehicles and lowering emissions. Initiatives include investing in metro rail projects, BRT (Bus Rapid Transit) systems, and clean buses, particularly in densely populated urban areas. For instance, cities like Mumbai and Bengaluru are expanding their metro networks to provide efficient and low-emission public transport options. The integration of electric buses into public transit fleets is a key strategy for reducing urban air pollution and greenhouse gas emissions. Several states are piloting electric bus services, aiming to replace older diesel fleets with cleaner alternatives.

Promoting the use of alternative fuels such as compressed natural gas (CNG) and biofuels is also part of India's clean transportation strategy. CNG is increasingly being adopted for public transportation vehicles, while biofuels derived from agricultural waste are being explored as a sustainable option for the transport sector. The government is investing in research and development of biofuel technologies to ensure a stable supply and to create market opportunities for rural farmers, thus supporting both climate goals and local economies. Distributed biofuels production can emerge as a promising strategy in this context.

Interesting future possibilities are likely with the ongoing R&D on using rural and urban organic waste as a feedstock for production of green hydrogen.

A robust charging infrastructure for electric vehicles is crucial for promoting their adoption. The government is working to expand the network of charging stations across urban and rural areas, making it easier for users to transition to EVs. Solar powered fast charging stations is another DRE applications that is an offshoot of the promotion of EVs for private ownership and public transport. Additionally, policies encouraging the development of dedicated lanes for bicycles and electric scooters in urban areas aim to promote non-motorized transport, reducing congestion and emissions in cities.

Clean transportation is essential for India to achieve its climate mitigation goals. By promoting electric vehicles, investing in public transit, and developing alternative energy options, India can significantly reduce emissions in the transportation sector. These initiatives not only contribute to environmental sustainability but also enhance the quality of life for millions, particularly in vulnerable communities, by providing cleaner, more efficient, and accessible transportation solutions. There are several ways in which the DRE sector can benefit from the thrust on clean transportation as described above.

## Energy Efficiency

Energy efficiency is a critical component of India's climate mitigation strategy, aimed at reducing energy consumption while maintaining productivity and economic growth. This focus is essential for lowering greenhouse gas emissions, minimizing energy costs, and enhancing energy security, particularly as India transitions to a more sustainable energy landscape.

In 2024, India took a significant step by joining the International Energy Efficiency Hub, a global platform that fosters collaboration and shares best practices in energy efficiency among member countries. This membership will provide India access to a vast network of experts and innovative solutions, enhancing its domestic energy efficiency initiatives. The Bureau of Energy Efficiency (BEE) has been designated as

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the implementing agency to align India's participation with its national energy efficiency goals.

Key initiatives in energy efficiency include the Perform, Achieve and Trade (PAT) scheme, which targets specific industries to reduce energy consumption through market-based mechanisms. This program incentivizes companies to adopt energy-saving technologies and practices, thus fostering a culture of efficiency .

Moreover, the government's focus on energy-efficient appliances, backed by the BEE's star labeling program, promotes the adoption of technologies that consume less power, further reducing overall energy demand. A lowered energy demand also makes a shift to a DRE based energy system more viable for many industries and commercial establishments.

As India continues to emphasize energy efficiency, it is crucial to recognize its potential benefits for vulnerable communities, particularly in rural areas where energy access is limited. By promoting energy-efficient solutions, India can enhance the resilience of these communities, enabling them to thrive despite the challenges posed by climate change. In this case too, a reduced energy requirement makes it relatively easier to shift to a DRE based energy system to ensure energy security.

## Carbon Market

India has become a key player in the voluntary carbon market (VCM), issuing 278 million carbon credits between 2010 and 2022, representing 17% of the global carbon credit supply. Despite the decline of the Clean Development Mechanism (CDM) market in 2012 due to reduced demand for CERs and a price collapse, the VCM in India has flourished. The Indian carbon market is expected to avoid 295 million tonnes of CO<sub>2</sub> emissions by 2030 across several sectors under a well-regulated carbon market system.<sup>9</sup>

India's carbon market was valued at over \$1.2 billion in 2021, with Indian firms issuing a significant portion of carbon credits, which account for around 10% of the country's annual greenhouse gas emissions. In May 2023, India hosted nearly 1,450 projects listed under the world's top voluntary carbon credit registries, Verra and Gold Standard, with many projects focusing on transitioning from fossil fuels to renewable energy.

In May 2023, the Ministry of Environment, Forest, and Climate Change (MoEFCC) issued a notification on developing the Indian Carbon Market (ICM), with the Bureau of Energy Efficiency (BEE) and the Ministry of Power overseeing the initiative. The Ministry of Power also introduced the Carbon Credit Trading Scheme (CCTS), 2023, to facilitate a robust cap-and-trade mechanism, which aims to incentivize decarbonization while fostering sustainable development. In Sept 2024, BEE has released a list of approved sectors in offset mechanism under CCTS.<sup>10</sup>

With a well-designed carbon market, India has the potential to address the dual challenges of decarbonization and development, offering significant contributions toward global climate mitigation goals. By the very nature of the carbon market mechanism it is better suited for large scale RE rather than DRE. However over the years several DRE projects worldwide have managed to sell carbon credits in the voluntary market. It remains to be seen how the carbon market option may play out for DRE systems as new mechanisms and frameworks for climate finance are emerging within India and globally.

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<sup>9</sup>Keshari N., Voluntary Carbon Markets in India and How They Have Evolved Over the Years, Outlook Business, 26 Dec 2024.

<sup>10</sup>BEE Office Memorandum 20 Sept 2024 : <https://tinyurl.com/58bsku6t>

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## Conclusion

The analysis shows that while the headlines in climate action news are all about climate finance gap on one hand and large investments going into large RE systems, and on the other hand, there is a tremendous scope for DRE systems to access the available climate finance and financial instruments to deliver mitigation and adaptation benefits to rural and urban communities.

Under these circumstances, it is important to document and showcase success stories of carbon emission reductions and economic inclusion achieved simultaneously through DRE interventions. While building case studies it is important to quantify the climate change benefits to the best extent possible. This will help in both policy advocacy at the level of MoEFCC and accessing various climate finance mechanisms emerging internationally and within India.

It must however be emphasized that there is a big gap between climate finance needed and climate finance available globally. It will therefore be an uphill battle to ensure that the DRE sector attracts sufficient climate finance/incentives to start with, to be able to create a **noticeably large collective impact as a sector.**

# 5. Enabling Climate Resilient Healthcare using Decentralized Renewable Energy

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## Introduction

In 2022, the staff at Narang subcenter delivered a baby in the facility for the first time since its inception. The subcenter is the primary healthcare facility serving 3000 people from seven villages in the forested area of Umling in Ri Bhoi district, Meghalaya. It was equipped with a delivery room with critical medical equipment and reliable, clean energy source in 2021.

It is estimated that close to 1 billion people in low - and lower-middle-income countries are served by health-care facilities without reliable electricity access or with no electricity access at all.<sup>1</sup> In low- and lower-middle-income countries of South Asia and Sub-Saharan Africa, approximately 12% and 15% of health-care facilities, respectively, have no access to electricity whatsoever.<sup>2</sup>

These influence the health of populations, the trust that people place in healthcare systems and motivation levels of healthcare workers themselves.

“Performing deliveries in the dark is dangerous, the situation becomes even worse if the infant is born with hypothermia or jaundice or is a Low weight baby (LWB) and we have no light or access to neonatal, radiant warmers. We had no option but to refer such cases to the sub-divisional hospital. Some also had to use private hospitals” **Mr Abhilash Nandan, Block Program Manager, National Health Mission.**

## The Health - Climate - Energy Nexus

In 2019, Healthcare Without Harm reported that if healthcare was a country, it would be the fifth largest emitter of greenhouse gases in the world. The healthcare sector’s carbon footprint is equivalent to 4.4% of global net emissions.<sup>3</sup>



Figure 5.1 : Active working hours being affected by energy poverty. ( Source : SELCO Foundation)

Health sector facilities are the operational heart of service delivery, protecting health, treating patients, and saving lives. Yet health sector facilities are also a source of carbon emissions, contributing to climate change. The world’s health sector facilities churn out CO<sub>2</sub> through the use of significant resources and energy-hungry equipment. This is perhaps ironic - as medical professionals our commitment is to ‘first, do no harm.’ Places of healing should be leading the way, not contributing to the burden of disease.” **Dr. Tedros Adhanom Ghebreyesus, Director General, World Health Organization.**

<sup>1</sup><https://tinyurl.com/455n6me4>

<sup>2</sup><https://tinyurl.com/yac394ax>

<sup>3</sup><https://tinyurl.com/5c7pf2tr>

Climate change is one of the most pressing global challenges of our time, affecting numerous facets of human life. Extreme weather events have led to an increased number of vector-borne diseases, respiratory issues from poor air quality, illnesses due to heat stress particularly affecting vulnerable populations such as people in poverty, women, elderly and those with pre-existing health conditions. In case of an adversity, provision of healthcare becomes more crucial for these communities.

**Pathways from hazards, exposure and vulnerabilities to climate change impacts on health outcomes & health systems.**

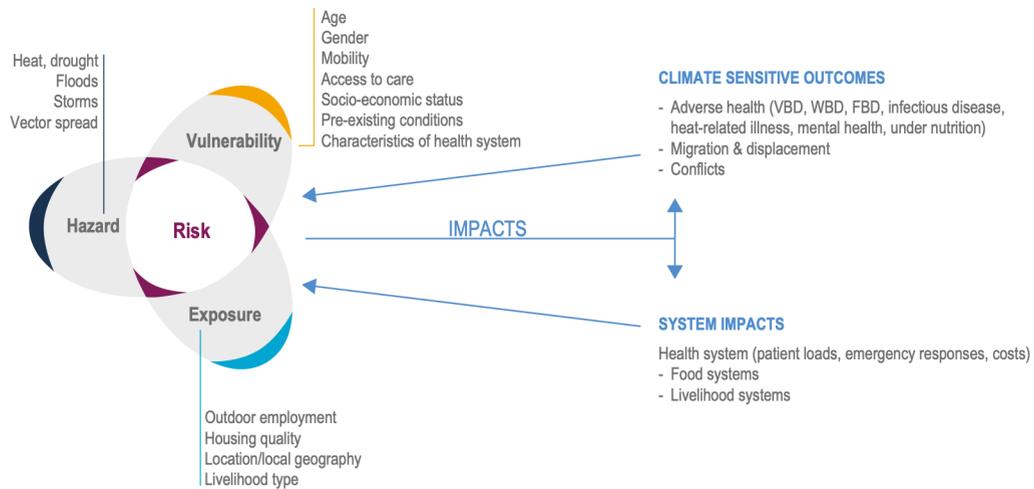


Figure 5.2 : The impacts of climate hazard on highly vulnerable people and the health system. ( Source ; IPCC 6th Assessment Report, Chapter 7 Health, Wellbeing and the Changing Structure of Communities)

**Strengthening Last Mile Public Healthcare Ecosystem**

The Indian public health system consists of a hierarchy of health facilities (Table 5.1). The first tier includes smaller outposts called Sub-Centers (SCs) which are critical first points of care, followed by Primary Health Centers (PHCs) catering to a jurisdiction of 20,000-30,000 population and the referral unit for 6 sub-centers. The second tier includes Community Health Centers and District hospitals administering more surgical services and care, while the third tier includes medical colleges and Specialized hospitals.

65% of India's population live in rural areas and are dependent on the country's public health facilities for care. In particular there is a high dependence on primary healthcare facilities (Sub Centers and PHCs) for maternal and childcare, immunization and diagnostics amongst last mile communities. Over 45,000 primary health centers and sub-centers in the country are in areas without electricity, due in part to the surrounding terrain. An additional 42,000 health facilities are yet to be built, mostly in remote places.<sup>4</sup> Hence, strengthening primary healthcare and equipping them to deal with future climate risks is crucial for breaking the cycle of poverty and building community resilience in India.

**Table 5.1 : Hierarchy in Indian Public System**

Sub Centers	Primary Health Centers	Community Health Centers
The most peripheral point of contact between health care system & the local community. It serves 5,000 people in general and 3,000 in hilly/tribal areas.	A referral unit for 6 Sub Centers. It serves 30,000 people in general and 20,000 in hilly/tribal areas.	A Hospital/Referral Unit for 4 PHCs. It serves 120,000 people in general 80,000 in hilly/tribal areas.
Have female health worker/ ANM and a male health worker	Have a medical officer, 1 doctor and 12-13 paramedical & administrative staff.	
Services		
<ul style="list-style-type: none"> <li>• Antenatal, natal, postnatal care with some sub centers also performing institutional deliveries</li> <li>• First aid, minor and common ailment treatment</li> <li>• Immunization</li> <li>• Weekly outpatient services</li> </ul>	<ul style="list-style-type: none"> <li>• Inpatient services with 4-6 beds for patients</li> <li>• Maternal and child health services including institutional deliveries</li> <li>• 24x7 services</li> </ul>	<ul style="list-style-type: none"> <li>• Specialist services in medicine, surgery, obstetrics &amp; gynecology, pediatrics</li> <li>• Inpatient services with 30 beds</li> <li>• 24x7 services</li> <li>• Regular outpatient services</li> </ul>

Nearly 86% of all medical visits in India are made by rural inhabitants, with a majority traveling more than 100 km to access healthcare facilities, of which 70-80% cost is paid out-of-pocket.<sup>5</sup> While the



Figure 5.3 : Enroute a sub - centre in East Garo Hills, Meghalaya. ( Source : SELCO Foundation)

medical fees and charges of getting healthcare might be nominal, there is a cost to reach the facility itself. In many Nearly 86% of all medical visits in India are made by rural inhabitants, with a majority traveling more than 100 km to access healthcare facilities, of which 70-80% is paid out-of-pocket. While the medical fees and charges of getting healthcare might be nominal, there is a cost to reach the facility itself. In many remote areas or difficult terrains, there is little to no public transport and people use their private vehicles, increasing travel costs exponentially, contributing to the higher transaction costs of accessing healthcare. When people cannot

afford to reach the hospital, they do not come till the treatment is unavoidable, which increases the severity of the disease and makes it more expensive.

*“Electricity access in health-care facilities can make the difference between life and death,”* **Dr Maria Neira, Assistant Director-General, for Healthier Populations at WHO.**<sup>6</sup>

All of this warrants a re-think of how infrastructure itself can be decentralized to reduce the burden of accessibility. This is an opportunity to chart alternative pathways to healthcare delivery.

<sup>4</sup><https://tinyurl.com/2jbuvb5j>

<sup>5</sup><https://tinyurl.com/4szwzexz>

## DRE for Resilient Healthcare Delivery

Decentralized Renewable Energy (DRE), particularly solar given its versatility, can power equipment to enable timely delivery of services.

Solar PV modules mounted on the rooftop offer a great deal of decentralization of energy generation. Integrated with a battery backup, it is also resilient to climate events or cloudy days. Even in the event of landslides, excessive rainfalls, storms etc. that usually result in breakage of grid-electricity wires and poles, decentralized energy systems can operate, customized to the needs of the local area, people and disease burden. In remote areas, it is much more cost-effective to install modular and portable systems than other conventional energy sources.

DRE solutions catalyse the creation of a local supply chain of panels, servicing and maintenance where local communities can begin to operate and maintain systems themselves.

Typically, health facilities are forced to have diesel generators and fuel as back-up since they cannot afford the risk of power failures that hinder regular functions and use of critical care equipment. DRE solutions enable facilities to completely do away with diesel and significantly reduce their operational energy expenditure.

*Energy expenditure forms a significant part of the total recurring expenses for a health facility, especially those dependent on traditional back-up fuels. The civil hospital in Nongpoh in Meghalaya estimated spending a staggering amount of over INR. 2,00,000 (USD 2,400+) per month on the electricity bill and the cost of diesel-back up to power the blood bank, Maternity block, Intensive Care Unit (ICU), wards and Operation Theatre.*

### Innovating for appropriate and efficient technologies

Usage of energy can be optimized by efficient technologies and low power consuming appliances that meet performance standards. This reduces the overall costs of the DRE system as well. The differences in appliance efficiency significantly change the sizing of the decentralized solar energy system- both PV panel and battery capacities- which in turn change the cost of powering the system and the future cost of maintenance.

*For example, experiences from Mizoram, suggest that a Sub Center that performs institutional deliveries, saves up to 33.2% of power consumption if all appliances - fans, lights, labor room equipment (suction apparatus, baby warmer, oxygen concentrator) - are modern and energy efficient. These lead to reducing emissions by 33.2% and 1.76 Kg carbon dioxide equivalent per sub center.*

<sup>6</sup><https://tinyurl.com/2vncm87r>

In addition to appliance efficiency, innovations in technology that transform health delivery models can play a role in reducing the costs to end-users and healthcare providers. Options like telemedicine, where solar-powered digital tablets and diagnostic kits are used with the assistance of a non-medical personnel to communicate with medical professionals in the nearest town or hospital, can help with doctors diagnosing issues and recommending further actions to rural patients without requiring them to undertake multiple trips to the hospital.

### **Challenges in Maternal and Infant Care**

*Maternal and infant health was a high priority for the National Health Mission in Meghalaya for which they were targeting at improving institutional delivery facilities. Even for routine pregnancy checkups, apparatus must be sterilized for which gas burners are used due to limited access to electricity. For performing delivery at any given time, the medical health practitioners also needed access to a spotlight, baby warmers and lights and fans.*

### **Efficient built environment ensuring wellbeing for patients and staff at the time of health service delivery**

- Design a health center keeping in mind – local climate and terrain, resilient building materials and capacity of patient inflow based on the projected population growth of the community or village. Providing a comfortable and stable indoor environment is essential for safeguarding the well-being of both patients and staff during health service delivery. This proactive approach ensures that the facility can effectively meet the healthcare demands of the area, preventing overcrowding and maintaining quality care.

*Successive meetings with the communities in Meghalaya while planning for setting up of new Health and Wellness centers (HWCs) highlighted a need for a dedicated waiting area with the clinic as the region receives high rainfall. Through discussions the need for a pre- and post-delivery room emerged as young mothers travelled large distances to deliver and could not travel back on the same day.*

- Prioritize spatial planning that adheres to stringent hygiene, sanitation standards and infection control measures like appropriate distancing to create a safe and clean healthcare environment. This not only enhances patient well-being but also reduces the risk/complications due to lack of space.
- Buildings must be energy - optimized and utilize the energy supplied to them in the most optimized and economic way. They are less expensive to operate during the life cycle of a building and more comfortable to reside in, as well as to be more environmentally friendly.

### **Cooling solutions for patient and healthcare staff comfort**



*With heat stress affecting the world at an unpredictable rate, health outposts are facing increased burden but also need to be able to provide safe space for staff and incoming patients. Passive cooling measures like innovative building and roofing material, facility height and active cooling solutions like energy efficient air conditioners or fans should be basic in regions that experience severe heat and humidity consistently.*

**Scan QR code for video.**

## **Learning From The Field**

The 'Energy for Health' initiative launched by SELCO Foundation in partnership with National and State Health Departments, IKEA Foundation and other Philanthropies, CSRs, Health NGOs, Clean energy and technology enterprises, seeks to bring solar energy solutions with efficient medical and electrical

equipment to 25,000 healthcare facilities across resource-constrained, climate vulnerable regions in 12 Indian states by 2026. This represents roughly 11% of India's total public health facilities.

So far, over 4000 such public health facilities, 90% of which are primary health facilities, have been solarized with efficient equipment, resulting in learnings on aspects across the ecosystem, including technology and innovation, training and capacity building, service and delivery, financing and policy.

Given below are some of the crucial learnings from the on-ground efforts so far.

#### **[A] Need for designs and delivery models that consider climate risks, terrain and local health contexts**

India's diverse landscapes, demography, climate events and disease burden warrant a customized and innovative approach to solving the problem of universal health coverage. The same state has districts undergoing heat stress or riverine flooding – there is no one solution. Primary health-energy needs assessment must inform facility level services, equipment and subsequent energy system design. While using solar PV, peak sunshine hours and rainfall conditions throughout different seasons also provide estimation for battery storage, and days of autonomy required.

Medical technology and delivery model innovations must be geared at making healthcare accessible for all. DRE offers hyper-decentralization of services at the doorstep. Portable and modular delivery models can ensure that no matter what, people in the most remote regions have access to quality healthcare. If doctors are unable to travel to remote places, the communities can be connected to them via tele-medicine, where tablets, laptops and mobile phones are charged on solar energy systems. Boat clinics powered on solar to run healthcare equipment catering to riverine islands or portable vaccine carriers charged on solar energy at the nearest health facility can ensure the efficacy of healthcare delivery, in difficult terrains.

#### **Boat Clinics in Majuli**

*On the mighty Brahmaputra River, the Mising and Bodo tribes have been residing on 2500 small islands in Assam. River islands lack access to basic infrastructure and services such as healthcare, education, power, drinking water and sanitation. The only medical institution is 50 kms away which takes at least 5 hours via boat to reach. In 2004, Centre for North Eastern Studies started three boat clinics which eventually scaled up to 15 that set up health camps for the communities residing on these islands. They were run by diesel powered motors. They were loud and could only store limited diesel on the boats-stopping services abruptly. One of these boats was solar powered by SELCO Foundation which allowed for uninterrupted flow of services, reduction of fuel consumption and ease in the living and working conditions of the boat staff. This boat (in Jorhat) has treated approximately 11,000 people, provided care to 600 pregnant women and immunized 580 children of the islands.*



Scan QR code for video.

#### **Health ATMs**

*These last mile Health ATMs allow for detailed clinical profiles (including 45 parameters) instantly and are very easy to use. It has multiple languages making it versatile for different geographies. Integrating it with tele-consultation, specialized doctors can also be roped in for specific patients. Specialized doctors might not be everywhere, but their expertise can be.*

Scan QR code for Video

### Portable vaccine carriers for Auxiliary-Nurse Midwives (ANMs)

Portable active vaccine carriers were developed as an alternative to the traditional iceboxes previously used for transporting vaccines during community immunization campaigns. The icebox can only ensure vaccine efficacy for 4-6 hours, requiring ANMs and health workers to travel back and forth between the primary health center (where vaccines are stored) and the village where they are administered. With portable vaccine carriers charged at solar-powered primary health facilities, vaccines are effective for 12 hours now, allowing health workers to cover more ground in a day and reduce wastage.



Figure 5.4 : (Left) ANM carrying the vaccine carrier. ( Right) Last - mile healthcare workers using the portable Maternal and Child Healthcare kit.  
(Source : SELCO Foundation)

### [B] Supply chain, installation and servicing need to be robust for sustained adoption

To be able to support all the above-mentioned activities, there needs to be a strong supply chain in place. Current transaction costs are very high for vendors - either clean energy enterprises or medical tech enterprises - due to remoteness. There are limited skilled personnel on-ground to install, operate and offer servicing in case of breakdown.

Not accounting for maintenance logistics and costs while designing the system can hamper utilization of the entire system and eventually interrupt medical services. The transaction costs of installation in more remote areas needs to take note of the geography and terrain where often transportation becomes challenging, and components need to be transported on foot or in four-wheel drives that are more expensive. Post installation, planning for spare part inventory locally can alleviate the challenges with the most commonly occurring issues.

There needs to be dedicated people from the health staff or local capacities that understand the continuous tasks, activities, and procedures involved in running and managing DRE systems, and operating medical appliances to ensure their optimal functionality, efficiency, and longevity. They must be aware of basic troubleshooting and escalation procedures for issues requiring more technical know-how and skills. Operations & maintenance requires people, technology and tools, which includes coming together on technical and financial aspects to serve a DRE system for a longer time.

#### Insights on Operations and maintenance structures:

- **Annual Maintenance Contracts** : a comprehensive service agreement for a 5 year period designed to ensure planned maintenance, troubleshooting and performance monitoring at every facility. This also serves as a guarantee for the vendor to provide better quality systems as they are bound to provide services for it for a fixed price.

- **Remote Monitoring Systems and data logging :** To improve understanding of system performance and enabling more optimized system design and predictive maintenance, RMS and data loggers at facility level have been a strong value add. Through a comprehensive dashboard, these systems provide an understanding of the most common issues and faults, which can improve system design, spare part inventory, field service scheduling and so on.

- **Training and capacity building :** This happens at two levels- At the first level, there is basic training



Figure 5.5 : Installation in remote areas is a challenge.  
(Source : SELCO Foundation)

of health facility staff and personnel on the basics of electricity, DRE systems and troubleshooting. They are also made aware of the escalation procedures for more complex issues. At the second level, technicians, clean energy enterprises and local NGO personnel are trained on diagnosis of issues, servicing and maintenance which require technical capacity but can be cost effective when done locally. These individuals are then integrated into the Annual Maintenance Contract requirements or one-off servicing needs.

- **Customer support and redressal mechanisms :** Regular phone calls to the health facility covering a checklist of system performance and usage in combination with the mechanisms above have helped to ensure that at the facility level, staff can record their complaints, challenges or queries, and these are registered as tickets for the relevant clean energy enterprise/ vendor in case of issues requiring more technical capacity. There is also a toll-free number established through the State National Health Mission in states like Meghalaya, that allows facility staff to directly raise a complaint or issue, which is recorded and goes through a chain for further action.
- **Procurement guidelines for Government and Health providers :** In due course of time, there are certain parts that are more prone for repair due to handling, local weather conditions – these parts need to be identified and be made locally available. Having a manual for governments on energy system components, electrical appliances and medical technologies that are benchmarked based on performance, quality and efficiency, can support healthcare providers particularly Government health departments in procuring spare parts, components and replacements for different types of health facilities with respect to scale, locally recurring issues.

### **C] Ensuring ownership through partnerships with local institutions (Local/district level health departments, National Health Mission, Civil Society organisations)**

- Tailored procurement guidelines of efficient appliances and energy enterprise vendors with proper tendering process is crucial to establish expectations for vendors. Clauses like being able to provide servicing within 48 hours of query, presence in the local district prioritizes the role of local clean energy enterprises.
- Operational expenses could take note of resources from existing budgets for energy expenditure (eg: diesel and generator costs) to be reallocated for operations and maintenance costs of DRE systems. Dedicated funds have been allocated to states under the National Program for Climate Change and Human Health (NPCCHH) which also cover Green and Climate Resilient health facilities and health systems strengthening. These could be tapped into for maintenance. In addition, working with the Rogi Kalyan Samiti (RKS) or health facility management committees for the use of their annual untied funds could unlock resources for post-installation servicing needs.

- Asset handover and capacity building of District administration, State health departments: Involving state health officials and department representatives is critical during the entire process- pre, during and post installation. They support the process of identifying suitable facilities, garnering the requisite permissions to undertake assessments and site surveys, and to enable institutionalization where the DRE assets are formally accounted for within the Government health department registry. This formal asset handover ensures greater ownership from the health sector stakeholders. The state of Mizoram saw a formal asset handover of 400+ solar powered health facilities this year.

#### **[D] Innovating for challenges ahead : from energy generation to med tech and service delivery**

- Improving the energy efficiency of technology and making it more robust for harsher environmental conditions – dust, heat, extreme temperatures- is an important step forward. Innovation needs to be spurred in high-power consuming appliances such as Autoclaves, X-Ray machines, CT scans and other diagnostic measures. Medical technologies for inclusive healthcare must also consider new and emerging diseases induced by climate change or COVID-19-type pandemics. This will need innovations in both medical technologies and delivery mechanisms to ensure the last mile is not left vulnerable.
- With the increasing risk of disasters, cyclones and strong winds, solar panels and energy system components exposed to the elements are highly susceptible to damage. This requires rethinking the design of energy systems and components to make them disaster-ready and modular for storage or portability. Insurance and other derisking mechanisms may also need to be explored.

## Conclusion

Historically, energy and healthcare have been approached in siloes, with energy only being considered for lighting at health facilities. Since the pandemic, there has been an increased interest and commitment from Governments and other stakeholders to address the energy-health-climate challenge comprehensively.

However, simply integrating DRE systems in health facilities will not address health outcomes. Energy is one infrastructure component amongst others - water, transportation, sanitation - that need to be in place to ensure smooth functioning of any health facility. In addition, health facilities need to be equipped with medicines, supplies and human resources to ensure seamless service for last mile communities. Alongside strengthening healthcare delivery systems, it is essential to undertake measures that improve health-seeking behavior amongst the population and build awareness about the availability of services in functional DRE-powered facilities. Here, the role of local institutions, health workers, healthcare awareness camps with ASHA workers. Complemented by improved health facility structures, this can build communities' trust in public healthcare infrastructure, which is what will contribute to improving health outcomes – the primary goal of any DRE intervention.

The models, processes and best practices discussed above are relevant within India and beyond- across regions of the Global South. As we design solutions for marginalized and last mile communities, bringing together energy-efficient technologies powered by renewable energy coupled with green building design, we are not only designing for the Health of our People but also for the Health of our Planet.

# 6.The Role of Smart Microgrids in Emission Reduction and Grid Resilience

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## Introduction

The traditional, centralized power grid is under increasing pressure. Demand for electricity is steadily climbing, driven by factors like population growth, urban sprawls and technological advancements. At the same time, the need to transition towards cleaner energy sources to combat climate change has become more urgent than ever. While renewable energy sources like solar and wind power offer a promising solution, their intermittent nature presents challenges for maintaining grid stability. Furthermore, aging infrastructure and the increasing frequency and intensity of extreme weather events can disrupt power delivery, causing economic losses and inconveniences for homes and businesses alike. In addition to this intermittent generation, there is also a significant growth in variable demand due to electrification of Transport.



Figure 6.1 : Components of a SMART Microgrid

Turning the present energy use more efficient, is a precondition in the path of renewable energy. The Smart microgrids (SMGs) offer a compelling solution. These localized electricity networks are essentially self-contained mini/micro grids that boast the unique capability to disconnect from the traditional grid and operate autonomously. This online (Connected to traditional grid) and island mode functionality ensures uninterrupted power during outages on the main traditional grid, enhancing the reliability and resilience of local power supplies. This self-sufficiency is achieved through a combination of cutting-edge technologies.

## What is a Smart Grid (SMG)

SMG is not one technology solution. Rather it's a collection of multiple technologies and solutions working in unison as explained on the following page :

- **Distributed Renewable Energy (DRE) resources** : form the backbone of power generation within an SMG. These are small-scale, on-site generation units located near the point of consumption, such as solar panels on rooftops or wind turbines in suitable locations. By generating electricity closer to where it's used, DREs reduce reliance on long-distance transmission lines, minimizing energy losses and improving overall grid efficiency.
- **Energy storage technologies** : play a vital role in addressing the intermittency of renewable energy sources. These technologies, such as batteries can store excess energy generated during periods of high solar or wind production. This stored energy can then be released back into the main grid when demand is high or renewable energy generation is low, ensuring a consistent flow of electricity within the microgrid.
- **Advanced metering infrastructure (AMI)** : plays a crucial role in SMG by collecting detailed energy usage data from customers. This data empowers both DISCOMs and consumers to make informed decisions. DISCOMs can use this information to optimize grid operations, identify peak demand periods, and tailor incentive programs for customers. Consumers, on the other hand, gain valuable insights into their own energy consumption patterns, allowing them to identify areas for potential savings and participate in demand response programs.
- **Demand Management Services (DMS)** : is another key technology within an SMG. This system helps DISCOMs by creating flexibility in electricity demand by incentivizing customers to reduce their usage during peak periods. These incentives can take various forms, such as discounts on electricity bills or credits towards future purchases. The key function DMS achieves in today's grids with increasing intermittent RE generation is to make sure "Demand follow generation" rather than the other way round. A new role of Aggregator can also be introduced who acts as an intermediary between DISCOMs and end Customers. By encouraging a shift in consumption patterns, DMS helps to balance supply and demand within the smart microgrid, reducing strain on the system and potentially lowering overall energy costs.
- **Robust cyber security** : is paramount for protecting SMG from cyberattacks. As these systems become increasingly interconnected and reliant on digital controls, they become more vulnerable to malicious actors. Implementing robust cyber security measures is essential to safeguard the SMG from disruptions and ensure its reliable operation.
- **Supervisory control and data acquisition (SCADA) systems** : work in tandem with energy management systems (EMS) to optimize grid operation in real-time.<sup>1</sup> SCADA systems continuously monitor the smart microgrid, collecting data on factors such as power generation, demand, and equipment status. This data is then fed into the EMS, which uses advanced algorithms to analyze and optimize the smart microgrid's operation. The EMS can automatically adjust generation, storage, and demand response programs to ensure a stable and efficient flow of electricity within the SMG.

By integrating these advanced technologies, SMGs offer a multitude of benefits. They enhance the reliability and resilience of local power supplies by providing a continuous source of power during outages on the main grid. Smart controls within the microgrids, optimize energy use, reducing losses and lowering overall costs. The integration of decentralised renewable energy sources, promotes sustainability by reducing reliance on fossil fuels and greenhouse gas emissions. Additionally, demand response programs empower customers to actively participate in managing energy use and potentially benefit from cost savings. In essence, SMGs offer a pathway towards a more secure, sustainable, and efficient energy future, fostering a more robust and adaptable power grid for communities across the globe. Building Smart Microgrids (SMGs) involves significant complexity due to the integration of diverse and sophisticated technologies, such as renewable energy sources, energy storage systems, and advanced control mechanisms like SCADA.

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<sup>1</sup>SCADA: Built In : <https://tinyurl.com/2s3tkn5p>

These systems must operate harmoniously to ensure reliability, efficiency, and resilience. The complexity is further amplified by the need to manage dynamic loads, accommodate fluctuations in renewable energy production, and maintain seamless communication across the network.

SMGs are better suited for certain locations, such as remote areas, industrial zones, or communities with specific energy needs, where the centralized grid is either unreliable or too costly to extend. For instance, in remote or rural areas, the decentralized nature of SMGs can provide reliable power without the need for extensive infrastructure investments. In densely populated urban settings, SMG allow to leverage DRE potential and meeting the variable demand profile while at the same time, creating an economic value by providing flexibility and ancillary services to the traditional centralized grid.

## Why Smart Microgrids ?

In addition to these benefits, SMGs also play a crucial role in employment generation. The development and implementation of SMGs create jobs in various sectors, including construction, operation, maintenance, and management. Local communities can benefit from job opportunities that arise from installing renewable energy technologies and managing SMG operations. This not only stimulates local economies but also fosters skill development within the community.

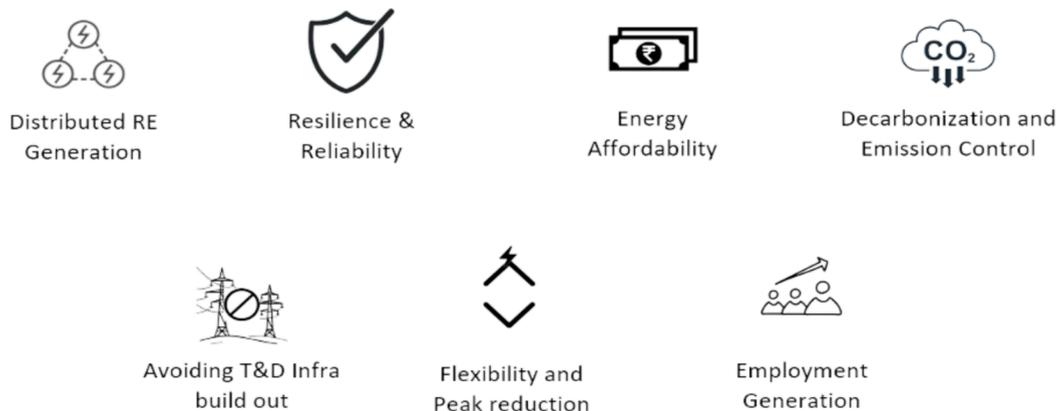


Figure 6.2 : Advantages of a SMART Microgrid (SMG)

SMGs present a viable alternative to traditional distributed renewable energy systems by offering numerous benefits for users and the environment (Figure 6.2). Their adaptability and cost-effectiveness make them an attractive option for modern energy management while contributing positively to local employment opportunities.

### Government Policies

In 2015, India's Ministry of Power took a decisive step towards modernizing its energy infrastructure with the National Smart Grid Mission (NSGM).<sup>2</sup> This central body oversees nationwide smart grid initiatives, streamlining efforts previously undertaken by the India Smart Grid Task Force. The NSGM envisions a smart grid ecosystem that drives efficiency and sustainability in the power sector. Key areas of focus include Advanced Metering Infrastructure (AMI), Substation Modernization, Distributed Generation, Real-time Monitoring and Control, Electric Vehicle (EV) Charging Infrastructure, Microgrid Development, and Power Quality Improvement. These initiatives aim to empower consumers, enhance reliability, promote renewable energy adoption, and improve overall power quality.

<sup>2</sup>Department of Science & Technology. India Country Report on Smart Grids. Ministry of Power, Government of India, 2017

The Government of India provides crucial financial backing through the NSGM, offering a 30% subsidy on capital expenditure for smart grid projects. Further propelling innovation, the Department of Science & Technology (DST) has significantly contributed by funding smart grid research and development (R&D) efforts to the tune of approximately US\$46.5 million. Leading the charge in innovation are India's esteemed academic institutions, including the Indian Institutes of Technology (IITs) and the Indian Institute of Science (IISc). These institutes actively collaborate with private industries on R&D projects funded by the DST, both nationally and internationally with countries like the US, UK, and Netherlands. Several of these projects are nearing completion.

By establishing a robust framework for smart grid development, fostering R&D, and promoting smart microgrid solutions, India is well on its way to a future powered by clean, reliable, and efficient energy.

### **Current implementation progress**

As explained earlier, with maturing digital technologies, SMGs are providing several benefits – From integrating Distributed Renewable Energy resources to providing flexibility and cost-effective ancillary services to traditional grid. However for developing countries like India, the key purpose for the deployment of SMGs is to provide clean energy access to communities in remote locations or in low-income areas. Exorbitant transmission and distribution investments have prevented such areas from being serviced by traditional electricity grids and SMGs are proving a viable and effective solutions to alleviate Energy poverty at such locations.

As per ESMAP, globally there are 19,000 mini-grids installed in 134 countries.<sup>3</sup> These mini-grids are basic implementations with distributed renewable energy generation, minimal energy storage equipment and local distribution to nearby households.

India has made significant progress in installing such mini-grids in rural areas. Although such projects have helped in achieving basic energy access and reliability and also in improvement in power quality to remote rural communities, more work needs to be done in the integration of Productive Use of Renewable Energy (PURE) applications for enhanced mini-grid utilization. PURE applications include provision of electricity for irrigation, water management, waste management and in general in providing better livelihoods opportunities for such disadvantaged communities. Uptake of PURE applications need to be integrated with the rural community environment and ecosystem including the local resources of land, water, forest produce and small local industries.<sup>4</sup>

With the advent of Digital technologies, the mini-grids can also be made “smart” to provide various additional services.

In India, NSGM (National Smart Microgrid Mission) completed 4 Smart microgrid projects in 2016. Several more Pilot Smart microgrid projects were also implemented under IPDS (Integrated Power Development Scheme).<sup>5</sup> Most of these pilots were implemented in collaboration with various SGIAs (Smart Grid Implementation Agency).

While a couple of these pilots were implemented for 2,000 to 5,000 consumers, most of them were targeted for 15,000 to 25,000 consumers. Various technology solutions like AMI, remote monitoring, demand response etc were effectively tested during these pilots.

Different communication technologies like Radio and GPRS communication were implemented. PLC (Power Line communication) was also successfully implemented in several pilot projects.

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<sup>3</sup>ESMAP. Mini Grids for Half a Billion People. World Bank, 2019. : <https://tinyurl.com/66zc5sxp>

<sup>4</sup>WRI India. Status of Mini-Grids in Rural India. World Resources Institute, 2022. <https://tinyurl.com/yc2ek9xj>

<sup>5</sup>National Smart Grid Mission (NSGM): <https://tinyurl.com/2s3barpj>

There were several learnings that were derived from these pilots. All the pilots were implemented in close collaboration with respective DISCOMs and it was realized that Technical training and capacity building needs to be given a special attention. DISCOMs also need to set processes and guidelines to streamline the actual Smart Grid implementation. Financial planning, governance and monitoring practices also need to be strengthened to be able to execute such projects within planned schedule and budgets.

Overall while there are several Mini/Microgrid projects being implemented in India, “Smart” microgrid projects are still not being taken up due to lack of technology maturity, lack of clarity in policy, rules and regulations of various DISCOMs, high CapEX requirements and lack of credit support for such projects. Lack of availability of technical and commercial expertise at scale is also holding back the rapid expansion of such Smart Microgrid projects.

There are several private companies that have developed mature SMG technologies. While traditional energy and power solution providers like Schneider Electric, Siemens, ABB are active in providing core Smart grid solutions, certain automation technology companies like Honeywell and Eaton are also providing controllers and other automation solutions in this space. Modern information communication and Digital technologies play a key role in smooth and effective functioning of any SMG. Hence several modern digital tech companies like IBM and Cisco are also active in SMG deployment projects.

## Key Challenges

As discussed earlier, SMG is not a monolithic solution; It’s rather a collection of different solution blocks. Hence system design becomes extremely important as all these components need to work with each other seamlessly. This also means that there cannot be a cookie-cutter approach for SMG Design. SMGs need to be designed considering various energy demand and generation attributes at the respective sites.

SMGs are also high CapEX projects with a payback period of 4-7 years. Due to novel nature of interdependent technologies in SMG operations, overall risk profile of SMGs is also not well understood by various Finance companies and impact investors thus limiting finance availability.

A high investment triggers the question of cost-benefit analysis. Often such investments do not offer an immediate financial benefit, and thus these investments are not prioritized.

Finally, although there are multiple instances of SMGs working perfectly fine in islanded mode, when it comes to integrating them to the traditional centralized national grid, the rules and regulations are not yet fully clear. DISCOMs also need to be fully prepared to integrate such SMGs and leverage their flexibility services.

## Impact of Smart Microgrid on GHG Emissions Mitigation

The transition from traditional electrical grids to Smart Microgrids (SMGs) represents a significant shift in energy management, particularly in reducing greenhouse gas (GHG) emissions. Smart Microgrids (SMGs) present a transformative approach to reducing emissions, even when energy is sourced from both renewable and non-renewable sources. By decentralizing energy production and optimizing energy use through localized, efficient systems, SMGs can reduce the reliance on high-emission energy from centralized, fossil fuel-based grids.

Non-renewable energy sources are among the largest contributors to GHG emissions, primarily due to their high carbon content and energy-intensive combustion processes. For example, coal-fired power plants have a Life cycle emission factor of around 860 kg CO<sub>2</sub> per MWh, reflecting the significant emissions from coal combustion. Natural gas, while cleaner than coal, still produces approximately 460 kg CO<sub>2</sub> per MWh in combined-cycle plants. Diesel generators, often used for backup power, can emit as much as 900 kg CO<sub>2</sub> per MWh due to the inefficiencies and high carbon content of diesel fuel. These emission factors highlight the environmental impact of conventional energy sources, particularly as reliance on such fuels continues in various regions.

In contrast, renewable energy sources offer substantial emissions reductions, even when accounting for the entire lifecycle of manufacturing and installation. Solar photovoltaic (PV) systems, for instance, can achieve a net GHG mitigation potential, reducing emissions to around 50 kg CO<sub>2</sub> per MWh depending on the specifics of production and site. Wind energy, which has minimal operational emissions, achieves even lower emissions at less than 20 kg CO<sub>2</sub> per MWh over its entire lifecycle. These lower emission factors underscore the advantage of renewables in providing cleaner energy, making them a pivotal component in strategies to curb overall carbon emissions and combat climate change.

Apart from the above emission mitigation, SMGs also contribute to emission mitigation by deferring or even obviating the need for building large transmission and Distribution networks.

## Conclusion

Smart Microgrids (SMGs) represent a forward-looking solution to the longstanding issues plaguing traditional grid systems, such as high emissions, inefficiency, and vulnerability to disruptions. Traditional grids are inherently centralized, relying heavily on fossil fuel-based generation and extensive transmission networks that lead to significant energy losses and increased greenhouse gas emissions. These centralized systems also face challenges in managing the growing demand for electricity driven by population growth, the electrification of transport, and the variability introduced by renewable energy sources. In contrast, SMGs offer a decentralized, flexible model capable of reducing carbon footprints and improving grid reliability.

The qualitative advantages of SMGs over traditional grids are evident in their design and functionality. Unlike the single-source dependency of traditional grids, SMGs incorporate a diversified energy mix, typically integrating Distributed Renewable Energy (DRE) sources such as solar, wind, and energy storage systems. This allows SMGs to operate independently during outages, enhancing energy resilience and reliability, particularly for critical services and remote locations where traditional grid infrastructure is costly or impractical. Additionally, SMGs utilize advanced technologies such as demand management systems (DMS), Advanced Metering Infrastructure (AMI), and Supervisory Control and Data Acquisition (SCADA) systems. These tools enable real-time monitoring, efficient energy distribution, and demand response capabilities, optimizing energy usage and reducing the reliance on fossil fuels even when non-renewable sources are part of the energy mix.

One of the most important arguments for SMG is that employing SMGs addresses several national climate commitments such as Nationally Determined Commitments (NDC) and touches multiple Sustainable Development Goals (SDGs 7, 8, 11 and 13).

Through their localized, efficient, and resilient structure, SMGs significantly reduce emissions compared to traditional grids, supporting a shift toward cleaner energy without compromising reliability. By addressing the limitations of traditional grids and promoting the adoption of renewables, SMGs pave the way for a more sustainable and adaptable energy future, aligned with global climate goals.

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Better grid reliability brought in by SMG deployment also leads to higher energy security – particularly for vulnerable communities. Energy security is critical for improvement in living standards of disadvantaged communities. Adequate energy availability also creates opportunities for better livelihoods. Ultimately all of this feeds into higher resilience and better climate adaptability. Thus, SMG is not just a climate mitigation solution but also an adaptation solution.

Understandably, operationalizing SMGs across India will require interventions, policy changes, and political will. However, the significant benefits accrued over time, we believe, will justify making these changes. Decentralized renewable energy pathway will be significantly facilitated with SMGs.

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Study on Urban Microgrid : <https://tinyurl.com/4d8jsnx4>

Renewable Energy Resources With Smart Microgrid Model In India : <https://tinyurl.com/rtj9n9n6>

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# 7. DRE for Cooking Energy : Sectoral Challenges and Climate Mitigation - Adaptation Potential

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## Introduction

The latest trends in the clean cooking sector globally are towards promoting cooking with electricity. The World Health Organisation<sup>1</sup> has provided the following guidance to identify clean and polluting cooking technologies.

Clean fuels/technologies	Transitional fuels/technologies	Polluting fuels/technologies
 Solar  Electric  Biogas  Liquefied petroleum gas (LPG)  Alcohol (i.e. ethanol)  Biomass stoves classified as tier 4 or 5 for PM <sub>2.5</sub> emissions and tier 5 for CO emissions	 Biomass stoves classified as tier 3 for PM <sub>2.5</sub> emissions and tier 3 or 4 for CO emissions	 Kerosene  Unprocessed coal  Biomass stoves meeting tier 0, 1, or 2 standards for PM <sub>2.5</sub> and CO emissions

Figure 7.1 : WHO classification of cooking energy technology

Clean fuels and technologies are those that attain the fine particulate matter (PM<sub>2.5</sub>) and carbon monoxide (CO) levels recommended in the WHO global air quality guidelines (2021)<sup>2</sup> for indoor air to be safe for human health.

Fuel and technology combinations will be classified as clean if they achieve:

- Either the annual average air quality guideline level (AQG, 5 µg/m<sup>3</sup>) or the Interim Target- 1 level (IT1, 35 µg/m<sup>3</sup>) for PM<sub>2.5</sub>; and
- Either the 24-hour average air quality guideline level (AQG, 4 mg/m<sup>3</sup>) or the Interim Target-1 level (IT-1, 7 mg/m<sup>3</sup>) for CO.

In the meanwhile, the urgency of addressing climate change has made it imperative that we start moving away from fossil fuels in all energy sectors. The definition of 'clean' in the context of cooking energy sector should therefore also include additional criteria in terms of greenhouse gas emissions over the lifetime of the cooking energy device and its energy source. However, no such norms have been defined or recommended to date.

The RE powered technologies in the WHO list can fit this expanded definition of clean cooking. Most of these happen to use locally available renewable energy sources (e.g. solar thermal, biogas, standardised solid biomass fuels like pellets, etc.) and are therefore DRE powered cooking energy technologies.

<sup>1</sup>Clean Household Energy Solutions Toolkit (CHEST) (2023) : <https://tinyurl.com/ykewpzb4>

<sup>2</sup>WHO global air quality guidelines: particulate : <https://tinyurl.com/3pvmk72y>

## The Government of India Initiatives for Clean Cooking

- **LPG** : The Ujjawla Scheme implemented by the Government of India has been moderately successful in India. LPG fits into the WHO definition of 'clean' but being a fossil fuel it is contributing to greenhouse gas emissions. In urban areas piped natural gas (PNG) is being promoted in a big way to replace LPG cylinders which too is WHO 'clean' fossil fuel.
- **Electric Cooking** : The Government has launched a couple of pilot programs to test the electric cooking technologies for rural areas. The Bureau of Energy Efficiency (BEE) has initiated the "Go Electric" campaign to create awareness about clean cooking through information, communication and education activities.
- **Improved Biomass Cookstoves** : The Unnat Chulha Abhiyan was launched in June 2014 by Ministry of New & Renewable Energy for promotion of improved biomass Cook stoves in all the State/UTs for providing clean cooking energy solutions. This scheme is continued with no promotional activities and no financial incentives.
- **Biogas** : Central Financial assistance is available for small and medium sized biogas plants for clean cooking and power generation from biogas plants. However, the government does not have any promotional activity programs to increase the awareness and adoption of biogas plants in rural areas.
- **Solar Cooking** : Traditional solar thermal cookers such as 4 pot cookers or parabolic cookers are not eligible for central financial assistance. The government does not have any promotional activity programs to increase the awareness and adoption of solar thermal cookers in rural areas. However, Indian Oil has developed a hybrid solar cooker model "Surya Nutan".<sup>3</sup> The government of India has supported the promotion of this cooker on large scale. MoEFCC (Ministry of Environment, Forest and Climate Change) through its office memorandum dated 07.06.2024 finalized Solar cooker as a GHG mitigation activities (#12) under ITMO article 6.2 & 6.4 for trading of Carbon credits under Bilateral/cooperative approaches.

In urban India more than 80% of population has access to LPG (and increasingly PNG) and Electric cooking devices. In rural areas the access to clean cooking is nearly 64% with LPG and Electric cooking.<sup>4</sup> However, the supply chains of both the energy sources are weak. Improved biomass cookstoves are being used marginally and are mainly promoted and distributed using a few CSR schemes. Awareness about solar cooking and biogas cooking remains extremely low. Cooking with pellets and other standardised solid biomass fuels is minimal.

## Private Initiatives to Promote Clean Cooking

A few organisations have been promoting clean cooking other than LPG based cooking with limited impact. These initiatives are innovative, yet mostly limited to urban and peri-urban areas near a few big cities. Some of these initiatives are listed below :

<sup>3</sup>Indian solar cooking system by Indian Oil : <https://tinyurl.com/bdfsjmkf>

<sup>4</sup>State of Clean Cooking Energy Access in India: <https://tinyurl.com/y6esa7yu>

- **Ecosense Appliances** : This company located in Sambhaji Nagar (Aurangabad) in Maharashtra manufactures and promotes improved biomass cookstove using biomass pellets as fuel in rural and peri urban areas. Ecosense appliances have collaborated with e-commerce platforms like Agrivijay to conduct demonstrations of clean cookstoves for increased adoption.
- **Smokeless Cookstove Foundation** : This organisation works in rural areas of Himachal Pradesh and Aarey peri urban forest in Mumbai to empower members of local communities in building of simple rocket stove cookstoves that improve the indoor air quality in these rural/peri urban households.
- **Samuchit Enviro Tech** : This is a knowledge consultancy firm that promotes improved biomass cookstoves mainly for community kitchens like ashram school canteens and rural households. It uses a preference mapping tool to ascertain attributes of a cooking energy device favoured by the target community and either custom design cookstove solutions or find an existing appropriate cooking energy solution for the community. This technology-agnostic DRE based approach has led to high adoption rate of DRE based cooking technologies in several small communities.
- **Solar Cooking Club** : This is a facebook page which promotes cooking with solar energy and has more than 10,000 subscribers from India and other countries.
- **OrjaBox LLP** : This organisation conducts awareness sessions and demonstrations for clean cooking. OrjaBox demonstrates cooking with solar energy, biogas, and smokeless solid biomass fueled cookstove to both rural and urban households.
- **Finovista** : This organisation promotes cooking with electricity and conducts demonstrations for promotion of electric cooking. This program is run with Loughborough University, UK under the Modern Energy Cooking Services program.<sup>5</sup>
- **Biogas** : There are several biogas companies promoting and advocating use of biogas for cooking in innovative ways. One such company is Sistema Bio which has advanced the use of biogas for dairy industry and small farmers associated with dairy industry. Chakrakar Lifestyle Solutions is promoting a biogas plant 'Vaayu' for urban households, mainly as a means of managing household organic waste.

## Challenges in DRE Based Cooking

### Lack of Support

Lack of promotion and awareness about the benefits of using DRE based cooking is one of the major challenges that this sector faces. Most rural households are unaware about alternative clean sources of cooking. They have rarely had the opportunity to experience solar cooking or biogas-based cooking. As a result there is no demand from rural sector for DRE based cooking. There is low or no government initiatives to support promotion and advocacy for the same.

Lack of proper eco-system to enable quick and sustained adoption of DRE based cooking technologies is another challenge. The required ecosystem will include financing support to manufacturers and end users both, standardisation and testing protocols with certification, efficient repair and maintenance support, etc.

The overall lack of support by government agencies has resulted into ignorance of this sector by renewable energy researchers. As a result, many of the products in the market are based on research and development by hobbyists and freelancers who have themselves turned into entrepreneurs.

<sup>5</sup>Modern Energy Cooking Services Program : <https://tinyurl.com/f7f6pvnj>

Investors in renewable energy too have largely bypassed the sector. The lack of economy of scale results into challenges of affordability, quality of production, etc., for the cooking energy devices. The criticism levelled at DRE based cooking energy devices for not being sufficiently efficient or pollution free or not meeting all user needs etc., often ignores these hurdles.

### Fuel Stacking

In urban and rural households fuel stacking is common. Nearly 95% households have a fuel stacking<sup>6</sup> model for cooking fuels. The following diagram represents an example of the fuel stacking patterns for meeting thermal energy needs (mainly cooking and bath water heating) in households in different strata of the society.

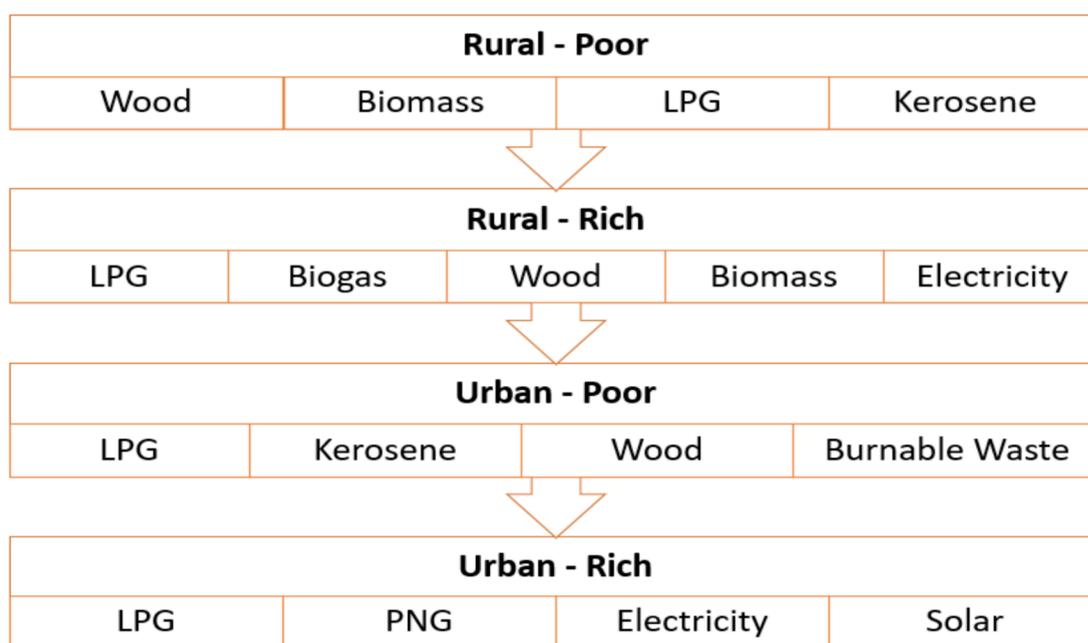


Figure 7.2 : Typically observed stacking of thermal energy devices in Indian households. ( Image : Samuchit Envior Tech)

Under such circumstances, rather than prescribing just one cooking fuel it is more opportune to promote a cleaner stack of cooking fuels. See figure 7.3 for example.

The approach of replacing an existing fuel stack in the household with a 'cleaner' than earlier if not 'clean' fuel stack needs to be explored in the context of DRE cooking energy devices. Rather than struggling to develop a single cookstove that can perform all required thermal energy tasks (something that neither LPG/PNG nor electricity based cooking devices have been able to achieve), stakeholders working in the DRE cooking sector need to collaborate and offer stacks of different devices that can collectively perform all the required thermal energy tasks in a household.

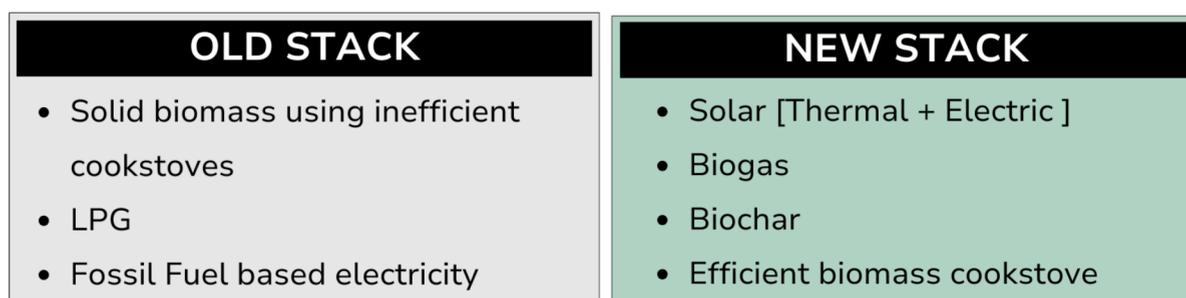


Figure 7.3 : Fuel Stacking - Existing and potentially new

<sup>6</sup>Fuel Stacking : <https://tinyurl.com/k3hkby68>

## Climate Change Mitigation with DRE Based Cooking

The Table 7.1 and Graph in Figure 7.4 indicate the carbon emissions from various cooking energy technologies. This study was commissioned by OrjaBox LLP to present a comparative assessment of climate change mitigation potential of all types of clean cooking technologies on a common footing. It can be derived that through investment in innovation of solar cookers, biogas and solid biomass-based cooking models it is possible to achieve substantial carbon emission reduction. Electric cooking on the other hand seems to be a farfetched solution for achieving actual reduction in carbon emissions until there is further greening of the electric grid. DRE based electric cooking as a stand-alone system is not cost effective. However, with the recent promotion of rooftop solar systems, electric cooking may become cost-effective and climate-mitigative for many households. It must be noted that this approach assumes the presence of a well-constructed rooftop space with secure access for the family investing in the rooftop solar PV system. This implies that this transition to solar electricity powered cooking is more likely to happen in households currently using LPG and/or PNG rather than in households living in makeshift dwellings and cooking on a polluting and deforesting three stone fire. Thus, climate change mitigation will be achieved, but this transition will not address the fundamental challenge of improving indoor air pollution in those households that currently use the most polluting cookstoves.

**Table 7.1 Carbon emissions estimation for various cooking fuel-stove combinations**  
[Credit: OrjaBox LLP and Neo Climate Solutions]

Name of Cooking Appliance	Scope of Energy / Fuel Used	Number of Appliances	Energy / Fuel consumption per hour	GHG emissions (kg CO <sub>2</sub> e)					
				In 1 hour	In 1 month	6 months	1 year	5 years	10 years
Microwave oven	Electricity	1	1.5 kWh [ 1500 Watt hour ]	1.70	51.05	280.75	561.51	2,807.54	5,615.07
Induction	Electricity	1	1.5 kWh [ 1500 Watt hour ]	1.70	51.05	280.75	561.71	2,807.50	5,615.07
	Electricity	1	2.1 kWh [ 2100 Watt hour ]	2.38	71.46	393.06	786.11	3,930.55	7,861.10
LPG Stove	LPG	1	0.18 kg	0.61	18.38	101.07	202.13	1,010.67	2,021.33
Biogas Stove	Biogas		0.45 m3	-0.54	-16.22	-89.20	-178.39	-891.97	-1,783.95
Biochar Stove	Biochar [ Kitchen Waste ]	1	0.06 [ 60 g ]	-0.06	-1.93	-10.64	-21.28	-106.38	-212.75
	Biochar [ Coconut Husk ]	1	0.06 [ 60 g ]	-0.18	-5.46	-30.04	-60.09	-300.44	-600.87
	Biochar [ Coconut Shelf ]	1	0.06 [ 60 g ]	-0.12	-3.50	-19.24	-38.47	-192.37	-384.74
Solar Cooker	Solar	1	0	0	0	0	0	0	0



Figure 7.4 : Comparative study of carbon footprints of different cooking energy technologies

Can climate change mitigation through DRE based cooking be translated into carbon credits? To meet the cost of developing and implementing such a project and to create some financial incentive for stakeholders involved in the project, the emission reductions of at least a few thousand households have

to be aggregated. There have been several attempts to streamline the carbon credits system to aid the adoption of DRE based cooking. However, due to lack of standards and improper monitoring and evaluation protocols most cooking energy carbon projects fail to generate a substantial return on investment for the project proponents in India. There are a handful of successful projects, but these are far outnumbered by failed attempts. Ease of monitoring is one of the reasons to promote electric mode of cooking for carbon credits.

The need to monitor so many cookstoves, wherein each household is following its own cooking practices and there is possible stacking of cookstoves, makes DRE based cooking energy carbon credit project extremely challenging. There are a few projects where carbon credits have been assigned with units of cookstoves being sold and the project proponent is required to just provide proof of sale of a certain number of cookstoves annually. However, with fuel stacking and variations in cooking practices it is highly questionable whether such projects actually accrue the claimed carbon credits or not. Recently several questions have been raised on the authenticity of cookstove based carbon projects due to these uncertainties and other uncertainties involved in the calculation of carbon credits based on assumptions of reduction in fuelwood consumption.<sup>7</sup> While a lot of the criticism in these recent studies has been unfair and biased, some valid concerns have been raised, which the sector must seriously take on board.

### Climate Change Adaptation Potential of DRE Based Cooking Technologies

The impacts of climate change are affecting local weather patterns and increasing the risk of several natural disasters from forest fires to floods. LPG supply chains are fragile in many parts of rural India and the cost of an LPG cylinder is prohibitive for many low-income rural households. Weak electric grids with intermittent supply and voltage fluctuations also make it impractical to rely on electricity as a cooking fuel in rural areas. Frequent and intense natural disasters can further amplify these challenges. Access to localised and free or low-cost sources of thermal energy for cooking help reduce at least one aspect of climate vulnerability for many nature-dependent rural and remote communities. Furthermore, a reliable source of thermal energy can also create more profitable livelihoods in rural areas such as operating commercial eateries, processing food items for value addition, etc. Having a decent source of income allows a family to invest in strategies to reduce its vulnerability to climate change. DRE based cooking technologies can also be fitted into cyclone shelters or flood rescue centres, etc., to help provide healthy and hygienic cooked meals to the victims and volunteers in the face of increasingly frequent and intense disasters.

### Way Forward

Various government and private initiatives are designed to improve the adoption of petroleum fuels and electricity for cooking. DRE based cooking is currently not receiving much support despite its climate mitigative and adaptive potential. It is also important to acknowledge the phenomenon of stove stacking in both rural and urban households rather than the unrealistic expectation that all cooking operations in any kitchen must be possible with a single cooking technology intervention. The focus should be on identifying the cleanest stack for cooking in both rural and urban sectors in a way that prioritises meeting user needs and is agnostic to the thermal energy technologies to be added to the new stack. In this case the term 'clean' refers to minimising both indoor air pollution and greenhouse gas emission simultaneously. Investment in innovation and automation is required to ensure that the cooking energy sector too moves in the direction of becoming fossil fuel free and contributing to combating climate change.

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<sup>7</sup>Cooking the books : cookstove offsets produce millions of fake emission cuts (2023) : <https://tinyurl.com/mt2p53fz>

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# 8. PURE Approach to Climate Readiness in North East India

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### Introduction

**T**he term Productive Use of Renewable Energy (PURE) is applied to those interventions where renewable energy is being used for income generation. In particular, distributed/decentralized solar-powered appliances support a wide variety of livelihoods in rural to peri-urban areas across the developing world. These interventions range from enhancing incomes in traditional occupations (e.g. agriculture and agri-processing, artisanal industries such as pottery making, etc.) to creating new livelihood opportunities (e.g. internet cafés, EV charging stations, etc.) based on the use of mostly solar and sometimes other renewable energy sources. These are majorly off-grid appliances.

PURE technologies have the potential to significantly enhance agricultural productivity and rural livelihoods, benefiting nearly 35 million farmers and increasing their incomes by 20-40%. The PURE market in India is valued at approximately \$46 billion, with states like Uttar Pradesh, West Bengal, Gujarat, Madhya Pradesh, and Maharashtra showing high adoption potential. While the Indian government has introduced PURE by drafting a framework to catalyse PURE adoption, challenges such as high initial costs, limited awareness, dependency on subsidies, and a lack of distribution networks continue to hinder large-scale deployment.

Efforts to address these challenges include alternative financing models such as pay-per-use services, anchor-based financing, and carbon credits, which make PURE technologies more affordable. However, additional capacity-building initiatives, improved market linkages, and increased awareness by DRE associations/ trainers/ deployers are necessary to maximize PURE adoption. Government schemes like PM SAMPADA Yojana and the Fodder and Feed Development Program offer subsidies for solar processing and hydroponic fodder units, but knowledge gaps and underutilization remain barriers. A multi-stakeholder approach involving policymakers, financial institutions, private sector players, and farmer organizations is essential to establish a robust and scalable PURE ecosystem. Strengthening policy frameworks, implementing quality standards, and fostering cross-sector collaboration will be crucial in accelerating PURE adoption and driving long-term economic and environmental benefits in India's rural sector.

There are several long-term benefits of PURE as follows.

- 1. Energy Access in Remote Areas :** PURE technologies extend clean and reliable energy to off-grid or weak-grid areas, ensuring that even the most remote regions can benefit from modern energy services, fostering inclusion and reducing energy poverty. For example: Solar-powered cold storage can be operated by a local SHG or FPO for providing a useful service of agri produce preservation to farmers in an off-grid or weak-grid location.
- 2. Economic Empowerment :** PURE applications enable businesses, especially in rural and semi-urban areas, to generate income through improved productivity and reduced downtime, and help expand their markets. For example: Solar-powered water pumping for ensuring optimal irrigation for farming.
- 3. Job Creation and Skill Development :** PURE initiatives often drive job creation, as new businesses emerge and existing enterprises expand. Moreover, they provide opportunities for skill development in maintaining and operating solar-powered appliances, creating a local workforce adept in renewable energy solutions. Rooftop solar PV system allows operating an internet café in an off-grid village.
- 4. Support for Local Economies :** By promoting the use of locally available renewable resources and enhancing local industries like agriculture, crafts, and retail, PURE applications stimulate economic growth within communities, reducing migration and strengthening regional economies.
- 5. Resilience and Adaptability :** PURE technologies help communities become more resilient by providing reliable energy during power outages or periods of low grid reliability. This uninterrupted energy supply helps maintain not just business continuity and agricultural activities, but also essential services like vaccination and emergency medical assistance.
- 6. Scalability and Replicability :** PURE solutions can be scaled and adapted to different regions and industries, making them versatile for various productive uses. Their successful implementation in one region can be replicated in others, supporting widespread adoption of renewable energy for livelihoods.
- 7. Environmental Sustainability :** PURE applications rely on renewable energy, primarily solar, reducing dependency on fossil fuels. This contributes to lower greenhouse gas emissions, and often local air pollution. For example: Businesses operating with a weak electric grid typically use diesel-powered back up generators, but this can be avoided by going for a solar rooftop system.

However, these benefits are often under - recognized or overlooked by many, and those who seek more information frequently encounter difficulties due to a lack of proper documentation, resulting in a knowledge gap. This article tries to address this gap by looking at a couple of specific examples from Assam state in the North East India. Sharing success stories and best practices is crucial for addressing region-specific challenges. By learning from implementations in similar geographical or social conditions, other states in the region can adapt proven solutions, pool resources, and avoid duplication of efforts.

### Why North East India ?

Northeast India, despite its natural wealth and cultural diversity, remains economically underdeveloped compared to the rest of the country. The region faces specific challenges due to its unique geography, limited infrastructure, and socio-economic constraints. Most of the population is involved in agriculture, artisanal crafts, and small-scale industries, which are highly labour-intensive and vulnerable to market fluctuations.

All these livelihood activities are linked to and are affected by either lack of grid connectivity or intermittent and/or low quality electricity supply (either lower or higher voltage compared to the accepted standard).

The north-eastern region of India, rich in water resources, has significant hydropower potential estimated at 58,971 MW, according to the Central Electricity Authority (CEA). However, only 5% of this potential has been developed so far, with solar development also remaining minimal despite an estimated potential of 57,360 MW, primarily in Assam, Manipur, and Mizoram.<sup>1</sup>

The region faces peak power shortages ranging from 3.1% to 5.4%, with Assam having the lowest electrification rate at 37%, while Mizoram and Nagaland exceed 80%. Yet, rural areas still struggle with access.<sup>1</sup> As stated in the “State-wise installed capacity of Renewable Power as on 31.07.2024”, the Northeast had 4980.72 MW of installed renewable energy capacity, with hydropower accounting for approximately 86%, Solar for 5.45%, bio power for 3% and wind for 0%.<sup>2</sup>

In 2023 and 2024, the renewable energy capacity in India's northeastern states has seen significant growth, particularly in solar power. For instance, Assam, Tripura, and Manipur experienced around 25% growth in their installed renewable energy capacity during 2019-2020. This upward trend continued into 2023 and 2024, driven by both solar and hydropower initiatives. In the first half of 2024 alone, India saw a massive surge in solar installations, with about 15 GW added, marking a 282% increase from the same period in 2023, a sign of robust activity in solar projects across the country.

As India targets 500 GW of renewable energy capacity by 2030, the seven North eastern states have also committed to the renewable energy push: Assam (4.94 GW), Arunachal Pradesh (3.36 GW), Tripura (0.84 GW), Mizoram (0.51 GW), Nagaland (0.16 GW), Manipur (0.12 GW), and Meghalaya (0.8 GW).<sup>3</sup>

Table 8.1 : Solar electricity generation potential in different states in North - East  
( Source - MNRE Annual Report 2022-23<sup>4</sup>)

STATES	SOLAR POTENTIAL [ MW]
Arunachal Pradesh	8650
Assam	13760
Manipur	10630
Meghalaya	5860
Mizoram	9090
Nagaland	7290
Sikkim	4940
Tripura	2080
<b>TOTAL</b>	<b>62300</b>

### Case Studies from North East India

- Case Study 1 :** Solar Powered Tailoring Shop
- Case Study 2 :** Common Service Centre

<sup>1</sup><https://tinyurl.com/ycxywe6d>

<sup>2</sup><https://tinyurl.com/3ncvydby>

<sup>3</sup><https://tinyurl.com/3mkszyrn>

<sup>4</sup><https://tinyurl.com/r79ys2um>

## 1: Case Study 1 : Solar Powered Tailoring Shop

Manasha Rabha, a 29-year-old tailor, has spent her entire life in the lush village of Ouguri in Kamrup Rural, Assam. Four years ago, she set up a small tailoring shop, determined to create a better life for herself and her family, but it was not easy. Without electricity, Manasha operated her sewing machine manually with her feet, which was exhausting and slow. “I used to suffer from constant leg pain,” she remembers. “Because the work was so slow, I couldn’t take on many orders, and my income was limited.”

Things took a turn for the better when Manasha decided to install a solar-powered sewing machine with support from the Diya Foundation and SELCO Foundation. The impact was immediate. “I am very happy with the DRE intervention,” she says. “Now, the machine runs on solar power, and I don’t have to worry about leg pain anymore. My work is automated, and I can complete tasks much faster.”

With this new efficiency, Manasha began receiving more orders, and her income grew significantly. Now, Manasha keeps her shop open for 6 to 7 hours daily, running three solar-powered motors for her sewing machines, three LED lights, and two fans. The difficulties she once faced are a distant memory. “The biggest benefit is that I can do more work in a day, without the physical strain,” she explains. Her earnings have nearly doubled, moving from Rs 5,000-7,000 (USD 60-80) per month to Rs 12,000-15,000 (USD 140-175), with profits rising from Rs 2,000-3,000 (USD 25-35) to Rs 5,000-6,000 (USD 60-70) each month. During festive seasons or local marriages, her profits climb even higher.



Figure 8.1 : Manasha Rabha and her solar powered tailoring shop

Manasha’s newfound financial freedom has sparked bigger dreams. She is currently using her profits to build a new shop and stock more fabrics to meet the rising demand. She is also helping her brother set up a Lok Sewa Kendra, or Common Service Centre, powered by decentralized renewable energy (DRE). “I’m reinvesting all I earn into expanding my business and supporting my brother’s venture,” she shares. Though she has saved much yet, her investments are laying the groundwork for future growth.

Her experience with renewable energy has been overwhelmingly positive. “I had no idea about renewable energy before,” she admits, “but now I see how beneficial it is. The solar-powered machine has exceeded my expectations, and I am very happy with it.” Her success has caught the attention of her neighbors and someone installed a solar egg incubator in the vicinity.

Still, the initial cost is a hurdle for many in her village. “People are reluctant because of the upfront costs, but as electricity bills keep rising, I believe they will eventually turn to solar energy,” Manasha predicts. She envisions a future where more people embrace renewable energy, not just for tailoring, but for restaurant appliances and more.

Looking ahead, Manasha is filled with hope. She dreams of expanding her use of DRE technologies, possibly adding a solar-powered ironing solution to her shop. For now, her main focus is helping her brother establish the Lok Sewa Kendra. “I’ll need both financial and technical help for that,” she says, optimistic about the future.

Reflecting on her journey, Manasha has become a strong advocate for solar technology. “I would definitely recommend it to others,” she says with conviction. Her story shows how decentralized renewable energy can empower individuals, reduce physical labor, and open new opportunities for growth, even in the remotest parts of India. With every stitch she sews under the gentle hum of her solar machine, Manasha is creating a brighter, more sustainable future for herself and her community.

## Case Study 2: Common Service Centre

Suman Sharma's story is a heartfelt journey of growth, resilience, and empowerment. At 33, she manages a lively Lok Sewa Kendra, or Common Service Centre, in Hahim village, nestled near the Assam-Meghalaya border. Her adventure into the realm of decentralized renewable energy (DRE) began in 2016, soon after moving to this area following her marriage. Like her neighbours, Suman's days were filled with the uncertainty of an erratic electricity supply from the local Panchayat office, which charged her around Rs 500 (USD 6) monthly. With just a laptop and a printer, she set up shop, but power outages were a constant challenge. "I was always worrying about when the power would go off," she recalls. "It was hard to keep the business going with such unreliable electricity."

Then, an unexpected opportunity knocked on her door, forever altering her business path. Thanks to support from the Digital Empowerment Foundation and SELCO Foundation, a solar energy system, provided by Soltech Solar OPC Pvt Ltd, was installed in her shop. This change was a breath of fresh air for Suman's venture. "I am very happy with the DRE system," she beams. "Now, I do not have to worry about electricity at all."

With a stable power supply, Suman expanded her services. She became a certified Soochnapreneur, registered as a Common Service Centre (CSC), and even started offering banking services as a Customer Service Point (CSP). "Earlier, I could barely manage with just a laptop and printer," she shares. "But now, even if the grid is down, I can provide all the services my customers need. They know they can rely on me, and that has made all the difference."

Suman's daily routine now thrives on a consistent energy supply. She runs her laptop, printer, two fans, and LED lights for up to 10 hours every day, longer on market days. This ability to offer uninterrupted services has significantly boosted her income, which now ranges from Rs 10,000 to 15,000 (USD 120-175) a month, a substantial increase from her previous earnings of Rs 5,000 to 6,000 (USD 60-70). "I have been able to save a little and even started a PPF fund. I have also reinvested in the business by adding a stationery section and buying a new printer," she proudly says. But it is not just about the money. Suman has become a source of inspiration for her community. Many villagers, curious about her DRE setup, still hesitate to adopt it themselves. "They think I was just lucky to get it," she laughs. "But I always tell them about the benefits and offer to connect them with SELCO. Maybe in time, they will see how well it works."

Suman is not stopping here. She dreams of opening a computer training centre for local youth and setting up a solar-powered rice mill. "I also think about packaging local products like pickles and spices," she adds with excitement. However, these ambitions require both technical know-how and financial backing. "If I get more help, I can expand further," she explains. Reflecting on her journey, Suman appreciates how much she has learned about renewable energy. "I didn't know much about it before," she admits. "But now, I see its value every day. It is not just about saving costs; it is about empowerment and independence." Her experience with DRE has given her confidence in the future. "I believe more people will accept solar energy when they see how it benefits them over time," she concludes. "For me, it has already opened so many new doors."

Suman's journey is a powerful example of how decentralized renewable energy can transform lives, not just by lighting up a shop, but by illuminating a path to growth, sustainability, and hope for an entire community.



Figure 8.2 : Suman and her Lok Seva Kendra

## Climate Change Considerations

Based on the data shared by Manasha and Suman, they are both using about 2 units of electricity daily to run their businesses. Conservatively assuming about 200 reasonably sunny days of full-fledged solar-driven operation in a year, their electricity usage is approximately 400 units of electricity per year. According to the Central Electrical Authority<sup>5</sup>, every unit of grid electricity consumed results in about 0.8 kg of carbon dioxide emission into the atmosphere. If Manasha and Suman had got uninterrupted electric supply they would have each been responsible for about 150 kg of carbon dioxide emission per year. In reality, they would have ended up using a combination of grid power and diesel generators, leading to higher carbon dioxide emission. This emission has been avoided because their businesses are powered by solar PV systems.

However, one must acknowledge that this is a notional emission reduction. In reality, Manasha would have continued using a manually operated sewing machine and Sumana may not have been able to run a business at all, given the unreliability of grid electricity. From that perspective, the solar PV systems have provided both women with an affordable energy security to engage in economic activities. Financial independence plays a major role in gender empowerment. In other words, the solar PV system has also elevated both women's status in their families and neighbourhoods. Both of them have now become role models and mentors for others. The boost received by their businesses has also resulted in financial security for both their families. This will help them face whatever climate change-related hardships (e.g. fluctuations in grid electricity prices, fluctuations and supply and pricing of essential goods, etc.) or calamities (e.g. erratic rainfall leading to drought/floods impacting other sources of family income) arise in their neighbourhoods. The PURE interventions have indirectly and unintendedly created climate resilience for the two families.

## Role of the local social ecosystem

The role of the local social organisations also must be underlined in these two case studies. The women struggling with financial and logistical challenges may not have been able to figure out the solutions on their own. Local non-governmental organisations and community-based organisations can play a very crucial role in bringing about a climate-aligned and economically empowering energy transition at the grassroots level across India. Special schemes or programs should be undertaken to impart knowledge about DRE systems to members of grassroots level not-for-profit organisation. Their inputs may also provide valuable insights on further improvements in the technologies/applications. A well-informed ecosystem of grassroots level social organisations can help rapidly spread the PURE approach in rural areas contributing to climate-readiness of vulnerable communities across the country.

## Conclusion

PURE is not only transformative in terms of ushering in economic inclusion and prosperity in rural areas, but it can also help improve climate resilience in the most climate-vulnerable communities across India. A bottom-up approach, with the help of local NGOs and CBOs, may help create many more success stories like Manasha and Suman.

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<sup>5</sup>CO<sub>2</sub> baseline database India: <https://tinyurl.com/ywuvuahk>

# CLEAN at UNFCCC COP 29 at Baku, Azerbaijan



**'Designing for quality and equity in clean cooking carbon projects'** organized by SNV, Cleaner Cooking Coalition and INECC.

**'Scaling Just Energy Transition Innovations Through Global Collaboration'** organized by UNIDO.



## CLEAN was involved as co-organiser in several side events.



**Side Event on 'Empowering the Future: Green Skill and Green Talent Development for Young People in the Global South'**. Panelists (From L to R) were Dr. Priyadarshini Karve (CLEAN), Ms. Aditi Ghosh (Child Fund International), Dr. Saifur Rahman (Institute of Electrical and Electronics Engineers - IEEE), Mr. Nalin Agarwal (Climate Collective Foundation), Mr. Teerthankar Mandal (World Resources Institute India - WRI India), Dr. Gurudas Nulkar (Centre for Sustainable Development, Gokhale Institute of Politics and Economics), and ) (standing on right) Mr. Myron Mendes (CLEAN and INECC) was the moderator.

**Side event on 'Energy for All: Scaling Decentralized Renewables for Equity and Resilience'**. Panelists (From L to R) were Mr. Prabhu Kunwar Singh (Haqdarshak Empowerment Solutions), Ms. Judit Szoleczky (International Network for Sustainable Energy - INFORSE), Utpal Bhattacharjee (Institute for Global Environmental Studies - IGES), and (on extreme Right) Dr. Priyadarshini Karve (CLEAN) was the moderator.



**UNFCCC Side event on 'Beyond Big Banks: Financing Decentralised Climate Solutions for the Global South'**. Panelists were (starting from third on Left) Ms. Sneha Shinde (BAIF), Ms. Hongyu Guo (Greenovation Hub), Mr. Jannsen Martinez (Institute for Climate and Sustainable Cities), MS. Lena Mechenkova (Vlinder), Dr. Priyadarshini Karve (CLEAN), Dr. Abinash Mohanty (IPE Global), Hon. Charan Jeath Singh (Republic of Fiji), and the session was moderated by Mr. Myron Mendes (CLEAN and INECC).



# CLEAN

Create. Connect. Collaborate.



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