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Decentralized Solar Applications: Lessons Learned from India and Replicability Potential in the Global South



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A connection is only the first step: electricity must also become reliable, affordable and productive

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Connection
Household is wired

→

Reliable supply
Adequate hours, stable voltage

→

Affordable electricity
Tariffs within household

→

Productive use
Supports livelihoods and income

GLOBAL, 2024

655 million
people without electricity; global access about 92%.

INDIA, 2014 → 2025

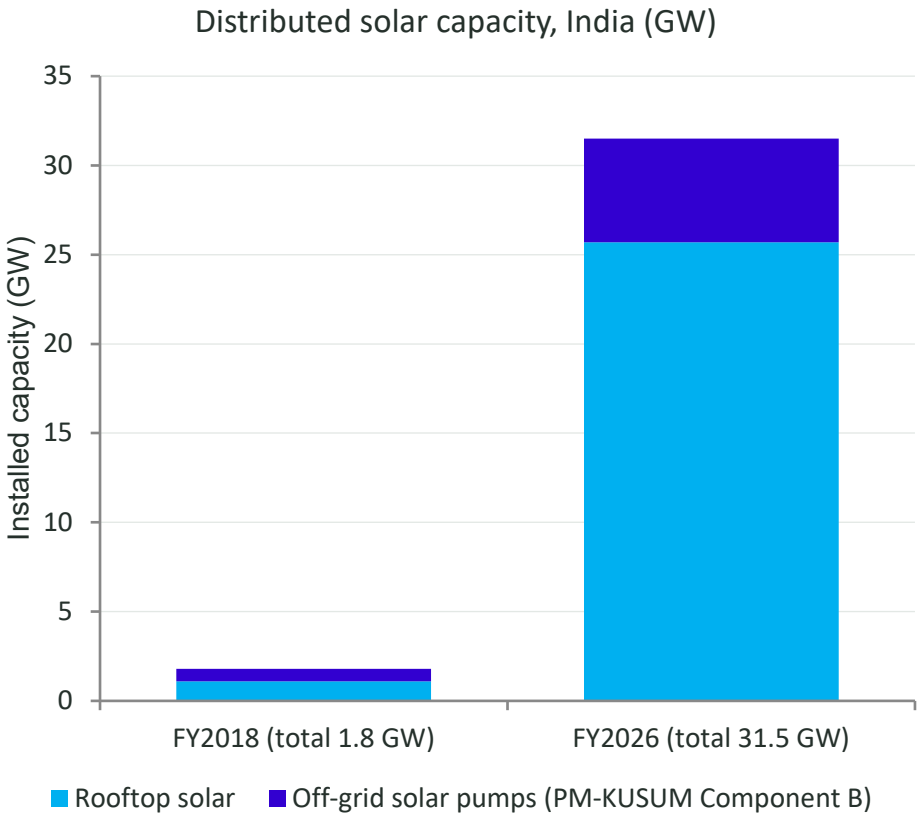
12.5 → 22.6 hours
average daily rural supply; urban average 23.4 hours in 2025. Affordability and reliability remain the next questions.

Where decentralized solar can complement the grid

- Weak or unreliable supply: local generation and storage as an added option
- Dispersed or remote demand: mini-grids and off-grid systems
- Daytime farm and building loads: solar pumps and rooftop systems

Decentralised solar can build on electricity access to deliver more reliable, affordable and productive energy services.

India's distributed solar is a family of applications with different users' needs



Rooftop solar

Who: households, businesses, industry, public buildings.

Relevance: lower bills; commercial and industrial users took about 23% of 2025 new installations.

Mini-grids and off-grid

Who: remote or unreliable-grid villages, small enterprises.

Relevance: adopted where grid supply was unreliable.

Solar irrigation

Who: farmers, via standalone pumps and feeder solarisation.

Relevance: farm energy cost and diesel or grid dependence; over 29 million pumps could be solarised (potential).

Solar-plus-storage

Who: households, utilities, local systems.

Relevance: can shift daytime solar to the evening peak and support reliability.

Rooftop solar alone has potential of 960 gigawatts (GW)

India's Policy Trajectory for Decentralised Solar

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2010 onwards: Energy access

National Solar Mission and Off-grid Solar PV Programme

- Set targets for off-grid and decentralised solar PV.
- Supported solar lighting, lanterns, solar pumps and small off-grid plants.
- The 2014–17 phase emphasised rural applications.

Policy mechanism: targeted programme support and application-specific deployment.



2019 onwards: Agriculture

PM-KUSUM

- **Component A:** Decentralised, grid-connected renewable power plants (500 kW–2 MW under original guidelines).
- **Component B:** Standalone solar agricultural pumps.
- **Component C:** Solarisation of grid-connected pumps and agricultural feeders.
- Support includes central assistance, state participation and DISCOM power-purchase arrangements.

Policy mechanism: combine decentralised generation with agricultural energy use and, where applicable, sale of surplus electricity.

India's Policy Trajectory for Decentralized Solar


Image Credit: Smart Power India

2022

Productive use

Framework for Promotion of Decentralised Renewable Energy Livelihood Applications

- Promotes decentralised renewable energy technologies for livelihoods and rural enterprises.

Policy mechanism: explicitly recognise the role of decentralised energy in livelihoods, beyond household electricity access.



2024 onwards

PM Surya Ghar: Muft Bijli Yojana

- ₹75,021 crore outlay; target of rooftop solar for one crore households.
- Central financial assistance for eligible households.
- DISCOM and local-body incentives, capacity building, model solar villages and RESCO/aggregation models.

Policy mechanism: household support combined with delivery-system and institutional measures to expand residential rooftop solar.

OVERALL POLICY SHIFT

Targeted off-grid applications → decentralised agricultural generation → livelihood applications → large-scale residential rooftop deployment.

PM Surya Ghar combines household support with delivery-system reform

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60 lakh+ households reported are benefiting from the programme

17.8 GW rooftop solar capacity commissioned under the scheme

≈20 lakh households reported to have received zero electricity bills

How does the Model Work?

Household support

Central financial assistance helps eligible households meet upfront costs.

Utility + vendor delivery

DISCOM responsibilities, simplified processes and vendor networks support implementation.

Flexible ownership models

Consumer-funded systems, RESCO and aggregation models can suit different household circumstances.

Deployment at scale depends on the combination of household affordability, utility participation and workable delivery arrangements.

Deployment models differ in who invests, who owns the asset and who carries the risk

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Model or instrument	Application	Financing and ownership
PM Surya Ghar: CAPEX route	Residential rooftop	Household pays upfront and owns; capital subsidy up to 60%, concessional loans, net metering
PM Surya Ghar: utility-led aggregation	Residential, incl. lower-income households	DISCOM pools demand, empanels vendors; earns performance-linked incentives
RESCO / OPEX	Commercial and industrial; growing in residential	Third party finances, owns and operates; consumer buys the service on a long-term contract
PM-KUSUM: farmer-owned pumps	Standalone solar irrigation pumps	Scheme target 30.8 GW. Farmers own and operate standalone solar pumps, with central and state subsidies supporting the initial investment. The remaining cost is borne by the farmer, with bank loans available to reduce the upfront burden.
PM-KUSUM: feeder solarisation	Agricultural feeders	Solar plants are developed through CAPEX or RESCO models. Investment may be undertaken by the implementing agency or a private developer, with power purchased by DISCOMs under agreed tariffs and power-purchase arrangements.

Uptake depends on financing, consumer affordability, institutional capacity and implementation processes, as well as on technology and subsidy design.

Lessons from India:

Scale depends on finance, utility incentives and implementation, not technology alone

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1. Financing and affordability

Access to affordable finance remains limited for lower-income households and small firms, despite subsidy.

Lesson: Pair capital subsidy with blended finance, credit guarantees and aggregation.

2. Distribution utility incentives

Utility revenue considerations and implementation arrangements can affect residential uptake.

Lesson**: Design incentives so utilities can participate in and benefit from distributed solar.**

3. Grid integration and readiness

Smart-metering progress and the integration of storage vary across implementation contexts.

Lesson**: Plan metering, monitoring and storage alongside solar deployment.**

4. Local institutions and productive use

Reported delivery challenges include finance, land and utility coordination; mini-grid use has often centred on basic loads.

Lesson**: Build around productive demand and local operation and maintenance capacity.**

Case Studies from India



CASE 01 · ECONOMICS
Hiware Bazar, Maharashtra

~₹3/kWh
Modelled solar electricity cost

Compared with Maharashtra's average power procurement cost of nearly ₹6/kWh.

Lesson: Local demand and system planning can influence the cost competitiveness of decentralised solar.



CASE 02 · LOCAL CONTEXT
Bamun Sualkuchi, Assam

~₹4/kWh

Modelled solar electricity cost
Compared with regional average power procurement costs exceeding ₹8.5/kWh.

Lesson: The economic case needs to be assessed against local procurement costs and project assumptions.



CASE 03 · PRODUCTIVE USE
Livelihood applications, Odisha

~11,000
DRE technologies reported
Including 10,729 solar water pumps.

Lesson: Decentralised renewable energy can support agricultural activities and livelihoods; impacts should be assessed separately from deployment numbers.

IMPLICATION FOR THE GLOBAL SOUTH
Replicability depends on local energy demand, project economics and the intended use of electricity - not on technology choice alone.

Bangladesh and Australia: the same technology, shaped by different drivers and constraints

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Similar technologies respond to different market conditions and energy needs

BANGLADESH

418.1 MW

Officially reported rooftop solar capacity, SREDA, June 2026

667 MW across 239 establishments (different coverage; excludes units below 0.15 MW)

- Solar Home Systems: partner-based delivery and financing for rural households (4.13 million to Jan 2019, IDCOL)
- Solar irrigation: potential to cut diesel use; the 4,000 MW and ~US$244 million estimates are IEEFA potential, not outcomes

AUSTRALIA

~30.62 GW

Registered small-scale solar PV capacity, Clean Energy Regulator (CER), August 2026

Rooftop solar supplied over 13% of National Electricity Market generation in 2025

- Early incentives, falling costs and an established installer industry supported deployment
- Residential batteries are expanding (9.4 GWh in 10 months from July 2025); export limits and unequal access remain issues

What can travel: adapting the design features of India's experience to each country's conditions

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STAGE 1: LOCAL ENERGY NEED
A. Match applications to local needs

- Rooftop solar: households, public institutions, commercial buildings, industry
- Solar irrigation: where water and farming conditions support it
- Mini-grids and off-grid solar plus storage: remote or underserved communities
- Distributed solar with storage: where're liability or flexibility justify it

STAGE 2: TECHNOLOGY AND FINANCING MODEL
B. Adapt the enabling arrangements

- Assess finance availability and consumer affordability
- Choose CAPEX, RESCO/OPEX, subsidy or blended models to fit the consumer
- Check regulatory clarity and workable approval processes
- Align utility incentives; plan grid integration and metering

STAGE 3: ENABLING INSTITUTIONS AND IMPLEMENTATION
C. Build in context-specific safeguards

- Affordability and equitable access
- Long-term operation and maintenance
- Compatibility with existing infrastructure and market rules
- Local capacity, consumer engagement, community and productive-user needs

Replicate principles, not templates

The aim is to adapt relevant design features to each country's regulatory, financial, technical and institutional context. Not every application suits every country.

Key Takeaways

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01 **Match the solution to the energy need**
Rooftop solar, solar irrigation, mini-grids and storage address different users and energy requirements.

02 **Align finance, ownership and incentives**
Deployment models must account for consumer affordability, investment responsibilities and distribution utility participation.

03 **Build the enabling ecosystem alongside capacity**
Regulatory clarity, grid integration and implementation capacity are integral to scaling decentralised solar.

04 **Adapt lessons to local contexts**
Experiences from India, Bangladesh and Australia offer approaches to learn from—not programmes to replicate unchanged.

Scale depends not only on the technology, but on how it is financed, integrated and implemented.

THANK YOU

TERI's Energy Programme

TERI's recent work in Electricity and Renewables

Website: https://www.teriin.org/