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Stand-alone solar systems in India: Emerging lessons

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Electricity access has been a key priority for the Government of India over the past few years. In 2014, the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) scheme was launched to achieve universal electrification at the village-level. The Government also launched the Saubhagya scheme in 2017 to provide last-mile connectivity and service connection to all remaining households in rural and urban areas to achieve universal household electrification by March 2019. All the states in India reported electrification of all willing-households. Rural electricity connections are estimated to have gone up from 83% in 2015 to about 99.9% as of today[1].

The electrification thrust in India since 2014 has been dominantly based on the rapid expansion of the national grid. There has been no official national electrification plan, although grant support has been provided to various States for reaching village- and household-level electrification targets. Between 2017 and 2019 alone, over USD 390 million had been disbursed (PIB, 2019)[2].

Stand-alone systems, such as solar lights, home systems, street lighting and water pumps, have been supported by the government for use in areas where the grid is either unavailable or unreliable. A dedicated off-grid solar PV component was established within the National Solar Mission in 2010. By February 2020, over 700,000 street lighting systems, 1.7 million home lighting systems and 7.4 million solar lanterns had been deployed. In addition, over 254,000 solar pumps had also been installed (MNRE, 2020)[3].

In 2018 alone, over 2.5 million stand-alone solar systems had been adopted[4]. The market for stand-alone solar systems in India can broadly be categorised into three distinct components:

[1] https://qz.com/india/1751712/modis-saubhagya-village-electrification-hits-solar-appliance-cos/

[2] https://pib.nic.in/PressReleseDetail.aspx?PRID=1592833

[3] https://mnre.gov.in/the-ministry/physical-progress

[4] GOGLA (2020), Global Off-Grid Solar Market Report – India, https://www.gogla.org/global-off-grid-solar-market-report#vis

a) **Government-driven:** This involves large-scale government procurement programs for stand-alone solar systems such as solar home systems, street lights and solar pumps.
b) **Private sector-based:** This involves private entities and other non-governmental entities (e.g., foundations, cooperatives) offering stand-alone solar products to consumers through various business models (e.g., pay-as-you-go) and consumer financing models.
c) **Consumer-driven:** This primarily involves cash-sales with consumers purchasing stand-alone solar systems with no consumer financing involved.

This technical note discusses the various models through which stand-alone systems are being deployed in India along with lessons learnt.

Government-driven deployment

Successive government programmes have been launched at the central and state-level to deploy stand-alone solar systems. The objective of bulk procurement of such systems is to benefit from economies of scale and standardise system configurations and quality.

Under the National Solar Mission, the Off-grid and Decentralized Solar PV Applications Programme focuses on providing electricity access solutions in rural and remote areas. Three Phases of the Programme have been implemented since 2013 focusing on different applications such as solar lighting, solar water pumps for irrigation and drinking water, solar study lamps and mini/micro-grids. The third phase of the programme concluded on 31st of March 2020 aiming to deploy about 2.5 million solar lamps and 0.3 million streetlights.

The central government ministry, the Ministry of New and Renewable Energy (MNRE), aggregates demand from various states for stand-alone solar systems. Based on the demand, MNRE defines the allocation of the number of systems to be procured. The constraining factor here is the amount of subsidy available with MNRE. A 30% capital subsidy is provided by the central government on solar streetlight system, and an 85% subsidy on solar lights (MNRE, 2018[5]). The subsidy is provided on the system cost identified through the competitive bulk tendering process.

The bulk procurement is carried out in a centralized manner undertaken by a public entity designated by MNRE. It is the responsibility of the public entity to ensure transparent procurement of systems through e-tender and ensure compliance to

[5] MNRE (2018), Guidelines of Off-grid and Decentralized Solar PV Applications Programme –Phase III, http://164.100.77.194/img/documents/uploads/7d748f6ca04d4d1e81fd5277e9e46f93.pdf

MNRE specifications and standards[6]. Once the vendor has been selected, a tripartite agreement is signed between the public entity, the vendor and the State Nodal Agency (SNAs) responsible for implementation at the state-level. The vendors co-ordinate with SNAs for repair and maintenance of the systems deployed for a period of five years.

The financial support is the capital subsidy itself. A total of 3% of the eligible subsidy is provided as a service charge to the Implementing Agencies. Of which, 0.5% of the service charge is offered to the public entity responsible for undertaking the centralized procurement. The vendors receive the grant-component of the system costs from the SNAs either as lumpsum or in different milestone-linked stages.

Several state-level programmes have also been implemented. In the state of Uttar Pradesh in India, two flagship schemes promoting off-grid solar in underdeveloped villages were launched in 2012. The Dr Ram Manohar Lohia Samagra Gram Vikas Yojana (RMLSGVY) scheme delivered a total of 42,181 solar home systems in the period 2012 to 2014 across 27 districts with 99,353 solar home systems planned for 2016–17. The Janeshwar Mishra Yojna (JMY) scheme was designed to provide free solar home systems to 10 low-income families per village from 1000 Janeshwar Mishra villages across 72 districts. In 2014–15, 10,000 households benefited from the program and 11,250 solar power packs were planned for 2016–17.

Often, despite a capital grant programme, end-users still require consumer financing to cover the remaining cost of the systems. Rural banks in Uttar Pradesh have supported the adoption of solar home systems by raising awareness of the technology and schemes, offering financing including flexible repayments, and establishing partnerships with solar PV service providers. Public sector banks in rural areas facilitate financing by participating in the capital subsidy cum-refinance scheme. Some rural banks have been instrumental in initiating SHS programs (e.g. Aryavart Gramin Bank, Kashi Gomti Samyut Gramin Bank and Prathama Bank) and have partnered with solar companies to deploy 80,000 solar home lighting systems using consumer finance. These programs have provided a foundation to off-grid solar PV applications in rural areas, familiarising local communities, and setting a stage for the wider diffusion of the technology and creation of markets. However, financing of solar home systems by rural banks has declined after subsidy discontinuation by the central government in India (Yadav et al., 2019[7]).

A number of state-level initiatives have also been implemented to support stand-alone solar development for public institutions. Prominent among them has been the

[6] http://164.100.77.194/img/documents/uploads/a7afa1471d70433bbcf9731a2ff49593.pdf

[7] Yadav, P. et. al., (2019), Distributed solar photovoltaics landscape in Uttar Pradesh, India: Lessons for transition to decentralised rural electrification, https://www.sciencedirect.com/science/article/pii/S2211467X19300859

Chhattisgarh Renewable Energy Development Agency (CREDA)'s programme to deploy stand-alone solar systems for over 900 rural health centres and district hospitals in the state. In partnership with the Department of Health, the installation is preceded by an energy audit of the health facility and ensuring that energy efficient appliances are in place. Based on this, the solar system is designed to meet the daily electricity needs for lighting, operation of health equipment during day and night. The systems are broadly grant-financed implemented by CREDA which is also responsible for its operation and maintenance for a period of 5 years. The impact has been a 50% increase in patients admitted; twice the number of successful childbirths per month in solar powered PHCs; electricity cost savings at 90%; improved day-to-day aspects of providing care; and improved ability to provide services at night[8].

Some key lessons that have emerged from government-driven approach to deploying stand-alone solar systems:

1. ***Financing support*:** The government has traditionally followed a capital subsidy approach to support stand-alone solar systems. In some cases of solar lighting and water pumping systems, the subsidy amount can go up to 90% of an administratively determined benchmark cost. A capital subsidy programme offers limited incentive for system providers to reduce costs and improve cost-efficiency of financing support. To address this, national programmes are transitioning to linking capital subsidy to a competitively determined system costs through bulk procurement.
2. ***Bulk procurement of systems**:* Demand aggregation and procurement of large volumes of systems is now conducted to realise cost-savings for the government as well as consumers. The model has been extremely successful for India's LED programme and emulated for stand-alone solar systems like solar home systems, lighting solutions and water pumps. It further allows for standardization of technology.
3. ***Clear allocation of responsibilities between public and private sector*:** A legally-binding contract between a public entity and the private sector allocates roles and responsibilities. The private sector is responsible for delivery of systems, installation and provision of operation and maintenance services (usually for a five-year period). No metering or collection is involved as part of government-led processes to deploy stand-alone systems.
4. ***Staggered disbursement of payments to guarantee compliance*:** The contract defines stage payments for the system provider ensuring sufficient skin-in-the-game for the private sector for a period of at least 5 years.

[8] http://poweringhc.org/in-conversation-with-chhattisgarh-state-renewable-energy-development-agency-creda/

5. ***Technical standards*:** MNRE has stimulated detailed technical specifications for various types of stand-alone solar systems including solar lights and AC/DC home systems, as well as water pumping systems. For each system, various capacity sizes are covered which guides various central and state-specific procurement programmes. Non-compliance makes products ineligible for any central grants.
6. ***Coupling with consumer finance*:** While capital subsidies are offered for stand-alone solar systems, adoption may still be challenging for rural households unable to afford the downpayment for the remainder amount. Depending on the local communities' ability to pay, partnerships with financing institutions may be required to cover remainder of the cost. To overcome consumer financing gaps, PAYG models have not been widely followed due to substantial transaction costs associated with metering, billing and collection.
7. ***Cross-sector partnerships*:** For stand-alone solar applications for public infrastructure and livelihoods, cross-sector partnerships have been crucial. The largest state-level solar pumping programme in India was implemented by the Rajasthan Horticulture Department. Similarly, in the state of Chattisgarh, over 900 rural health centres installed stand-alone solar-based systems through a partnership between the state Renewable Energy Development Agency (CREDA) and the Health Department.

Private sector-based approaches

India has also seen a large number of private sector-based approaches that involve private entities and other non-governmental entities (e.g., foundations, cooperatives) delivering stand-alone solar products and services to consumers through various delivery channels and consumer financing approaches.

Pay-as-you-go (PAYG) enterprises have been operational in India, most prominent among those has been Simpa Networks (Yadav et al., 2019[9]). PAYG offers important advantages over other models. By tailoring service charges to the cash-flows of end-user households or enterprises, the need for consumer financing is reduced if not eliminated. However, this shifts a large portion of the investment risks to the PAYG operators themselves requiring large capital to scale-up deployment as systems gradually amortize over time. In Simpa's case, even as they were able to gain traction

[9] Yadav, P. et. al., (2019), Distributed solar photovoltaics landscape in Uttar Pradesh, India: Lessons for transition to decentralised rural electrification, https://www.sciencedirect.com/science/article/pii/S2211467X19300859

from international lenders, receiving support from domestic lenders has been a significant challenge with a crippling effect across the sector as a whole[10].

Further, a key reason why PAYG penetration rates in India have been lower compared to East Africa is that the mobile money ecosystem is still in its infancy[11]. With a strong focus on digital payments across the economy in the recent years, PAYG solutions are seen to have a strong focus not just for solar applications but also for productive end-use appliances[12].

The PAYG model is being considered for productive end-use appliances such as solar water pumps, solar cold storage and agro-processing equipment. While the grid has expanded, in a number of cases the electricity supplied remains unreliable and a large number of micro-enterprises still are unconnected to the grid. However, productive end-use asset utilisation is often low to justify full ownership by a household or farm or rural enterprise. In such cases, service-based/PAYG models are being considered.

In the state of Bihar, for instance, under the Bihar Saur Pump Yojana, a PAYG model has been adopted. A system provider (land donor of the tube well) would bear the capital costs and charge farmers a government-fixed irrigation service fee based on serviced water. The Bihar Water Users' Association (WUA) (farmers' cooperative) manages irrigation, collects fees, and maintains the system, with support from a private company, Claro Ventures, for operation and maintenance of the solar pumps for the initial five years. Through this model, farmers don't have to pay up-front costs and avoid system performance risks, while system providers can enjoy greater benefits through optimal management of the solar pump as per water demand that can help to reduce costs (GGGI, 2017[13]).

Besides PAYG, India has also seen a large number of private initiatives that focus on deploying stand-alone solar systems through asset-based consumer financing. SELCO India has been a pioneer in the large-scale deployment of stand-alone solar systems for households as well as for various livelihood applications. Having emerged from the state of Karnataka, SELCO's guiding principle has been to deploy stand-alone solar systems as assets for the under-served populations. This entails working closely with various financing institutions from commercial banks to cooperatives to

[10] http://awsassets.wwfindia.org/downloads/strides_to_success.pdf

[11] https://www.gogla.org/about-us/blogs/developing-a-payg-market-in-india

[12] https://www.sciencedirect.com/science/article/pii/S0973082618309839

[13] GGGI (2017), Solar-Powered Irrigation Pumps in India — Capital Subsidy Policies and the Water-Energy Efficiency Nexus, https://www.greengrowthknowledge.org/sites/default/files/downloads/best-practices/GGGI%20Case%20Study_Solar-Powered%20Irrigation%20Pumps%20in%20India_June%202017.pdf

national agriculture banks, to design tailored financing products for stand-alone solar home systems.

The lack of creditworthiness of households is overcome through guarantee mechanisms which is gradually withdrawn as earlier-bankable households develop a credit history by paying back for solar systems. This advances financial inclusion and unlocks greater asset-building opportunities for rural households. In the state of Karnataka, which has a strong financial ecosystem with a network of commercial and cooperative banks, the SELCO model has been successful in delivering stand-alone solar systems to the poorest of the households. The same ecosystem has been utilised for expanding stand-alone solar system use for livelihood applications.

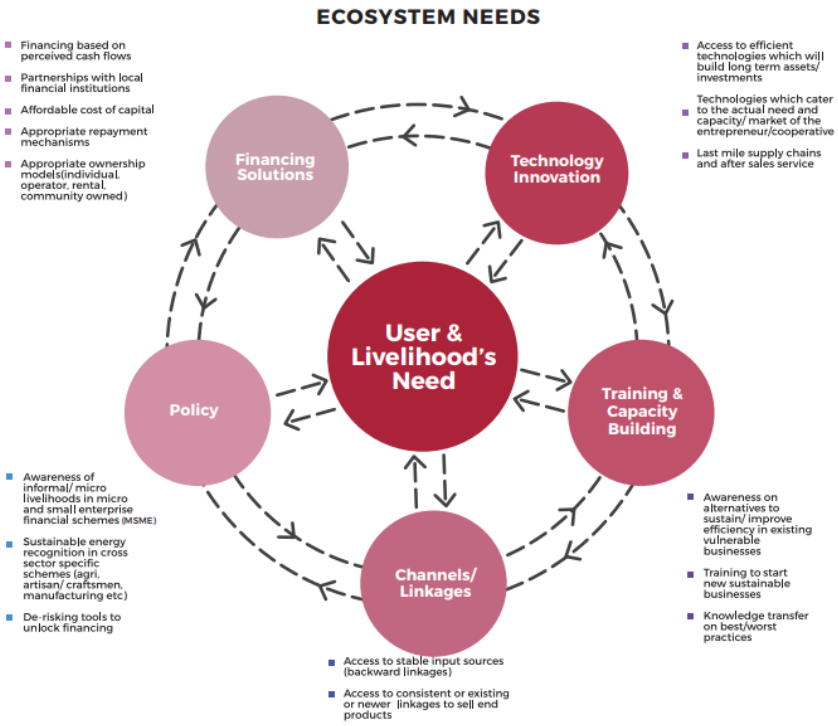
SELCO Foundation has worked across a wide range of sectors, such as textile, agriculture, animal husbandry, carpentry, pottery and cottage industry, to develop various livelihood applications based on stand-alone solar. In 2019, it published a selection of 65 livelihood applications linked to sustainable energy.[14] For linking stand-alone systems with livelihood applications (productive end-use), SELCO argues that a broader ecosystem is needed beyond those simply for deploying the energy technology. Illustrated in the figure below, the main feature of the ecosystem is that the end-user/livelihood needs are at the center.

A holistic assessment of various value chains in a given community is needed to identify potential energy interventions that have the potential for reducing drudgery, increasing productivity and incomes, enhance value addition and add to resilience of people's livelihoods. Once the need has been identified, another ecosystem components become activated – designing tailored efficient technology solutions (appliance and energy solution); making accessible customised asset-based financing; delivering training and capacity building; building forward market linkages for products and services; and implementing enabling policies to support deployment.

Delivering the above ecosystem requires tailored partnerships between different institutions across sectors. Importantly, it requires public financial resources to not just be deployed in subsidizing the energy assets, but rather into building the ecosystem, for instance by placing as guarantees for financing institutions to lend to poor households and as high-risk innovation funds for technology providers. This ensures permanence of socio-economic development impact by allowing communities to unlock a wider set of financing, technology and market services through energy access. Such ecosystems are developed over a long-term requiring, for instance, a 10-year economic development plan linked to stand-alone solar solutions in remote

[14] SELCO Foundation (2019), http://www.selcofoundation.org/wp-content/uploads/2019/05/SELCO-Foundation-Sustainable-Energy-Livelihoods-65-Appliances.pdf

areas and conduct of pilots to identify "champion" entities (either private sector, or NGOs) to support with the ecosystem development.



Source: SELCO Foundation, 2019

Some key lessons that have emerged from private sector-driven approaches to deploying stand-alone solar systems:

1. ***PAYG model requires a strong digital ecosystem for rapid scale-up***: Adoption of PAYG in India has been relatively slow given the lack of a digital ecosystem as compared to East Africa. Prominent PAYG players in India, such as Simpa, have utilized the prepaid model wherein consumers buy a top-up of energy service days from a local agent. When contract is complete, the system unlocks permanently providing free energy akin to a rent-to-own model[15].
2. ***Appropriate mix of ownership and PAYG model***: A diversity of approaches to stand-alone solar may be required to service different kinds of consumers in a given area. For residential consumers, an ownership-based model has been more commonly adopted in India. Such a model is backed by substantial public financing support or access to asset-based financing. PAYG has also been tested, although with eventual ownership in-built into the business model. PAYG models have substantial potential for productive end-use appliances given that a number of equipment are not utilized throughout the year and are linked to production/harvest cycles.

[15] https://media-openideo-rwd.oiengine.com/attachments/9e932f39-9338-4fb0-8191-e8eb89e77e8f.pdf

3. ***Design asset-based financing*:** Unlocking long-term asset-based financing for rural households to adopt stand-alone systems can advance financial inclusion and unlock capital for other household needs. Rather than (or in addition to) subsidizing the asset, it is important to subsidize the ecosystem through, for instance, guarantees for local financing institutions (e.g., cooperatives, banks) to de-risk lending to off-grid households.
4. ***An ecosystem approach for livelihood applications*:** To support livelihoods with stand-alone solutions, a broader ecosystem is needed that is based on tailored technology solutions (energy and efficient appliances), asset-based financing, market linkages and capacity and skills. End-user/livelihood energy needs need to be at the centre.
5. ***Pilots (e.g., for 1000 people over two years)*** can help identify cross-sector nexus focus areas, champion civil society/private sector/NGO institutions and create a template for the rest of the population.
6. ***Institutionalize energy within cross-sector entities:*** To have broader impact through stand-alone systems on livelihoods, energy has to be integrated into a long-term strategy for economic development with a strong role on nexus opportunities and partnerships with civil society.

Consumer-driven model

India has been the largest cash market for off-grid solar products globally – accounting for about 33% of total volume cash-sales (GOGLA, 2019)[16]. Over the years, cash-sales of stand-alone solar systems has been falling as a result of a rapid expansion of grid electricity. The largest drop has been seen in the solar lantern category which has further been affected by uncertainty in the regulatory landscape i.e., tariffs and standards related to importation of solar lanterns. Further, sales of larger solar home systems has been growing – almost doubling in volume sales between 2018 and 2019 – indicating a shift in consumer preference (GOGLA, 2019).

On the appliance side, India is expected to be a leading market. Even as the grid has expanded, unreliable supply and adoption of stand-alone solar solutions mean that preference for appliances that can work on both solar and grid-based electricity will be especially high. Fans remain India's most demanded appliances due to the hot and humid climate, while televisions are the next most popular product (Efficiency for Access, 2019)[17]. While several PAYGO actors, such as Simpa Networks, are involved in off-grid TV distribution, most off-grid TVs are bought as part of a package from

[16] https://www.gogla.org/sites/default/files/resource_docs/global_off-grid_solar_market_report_h1_2019.pdf

[17] https://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/Clasp-SOGAM-Report-final.pdf

conventional (non-PAYGO) distributors or are bought by households directly from retailers of generic off-grid appliances. In some cases, branded manufacturers also work with MFIs to drive market growth. India has also lowered its goods and services tax for off-grid television and fan components by 5% to encourage business to-business imports and local assembly and manufacturing.

Some key lessons that have emerged from consumer-driven approaches to deploying stand-alone solar systems:

1. ***Sensitivity to macro-economic conditions and policy incentives:*** Consumer cash-sales driven models are highly sensitive to free cash-flows available with end-consumers. With increased electricity access through the grid (and uncertainties around fiscal incentives), the volume of cash-sales for solar lighting products has been reported to be falling. At the same time, demand for multi-light and larger solar home systems has been growing.
2. ***Transition towards appliances****:* Market for energy efficient appliances continues to grow as electrification rates rise with a primary focus on fans, televisions, refrigeration units and solar water pumps. While a large proportion of consumptive appliances (e.g., fans, televisions) are cash-sales; some solar water pumps and refrigeration units are likely to be consumer financed depending on end-use and accessibility to finance.
3. ***Policy incentives for energy-efficient appliances:*** Policy incentives play an important role in the development of a local market for energy-efficient appliances comprising both of manufacturers and retailers. An increase in demand, coupled with fiscal incentives, can raise affordability of both consumptive and productive appliances for adoption by end-consumers with stand-alone solar systems.
4. ***Accounting for demand growth in stand-alone solar system deployment:*** Where stand-alone solar systems are deployed through a government programme, it is crucial to account for demand growth and increasing appliance use in system design. Alternatively, provisions for system capacity upgradation should be available for consumers to move up the energy ladder.

Conclusions

India's stand-alone solar systems market has evolved over several decades and has broadly been driven through three distinct modes: government, private and consumer cash-sales. In the absence of a national-level electrification strategy, the states have been tasked with identifying demand for stand-alone solar solutions and have traditionally supported deployment through capital subsidy. Over the years, innovations, such as bulk procurement of systems and price-discovery through competition, have been introduced to increase cost-efficiency of programmes and

devise clear roles and responsibilities for the private sector. Government-led programmes have focused on direct ownership of assets by end-users given high transaction costs associated with metering, billing and collection. Although, increasingly with productive end-use applications, service-based models (PAYG) are being tried and tested especially in the case of solar water pumps.

The evolution of private initiatives in India's solar home system market offer important insights and lessons. Entities, such as SELCO, have successfully linked stand-alone solar solutions with a wide range of livelihood applications across sectors. The focus on asset-based financing through a network of local financing institutions and tailored efficient technology solutions has been illustrated to be a successful template that is being replicated across multiple states in India. Adoption of such an approach requires public investments not just in the energy assets, but also in the ecosystem – guarantees for financing institutions, innovation grants for technology suppliers, establishing market linkages and incubation of enterprises. These are important aspects to consider if the objective is to go from deploying a defined number of stand-alone systems to supporting various income-generating activities and maximizing the socio-economic benefits from energy access in rural areas.