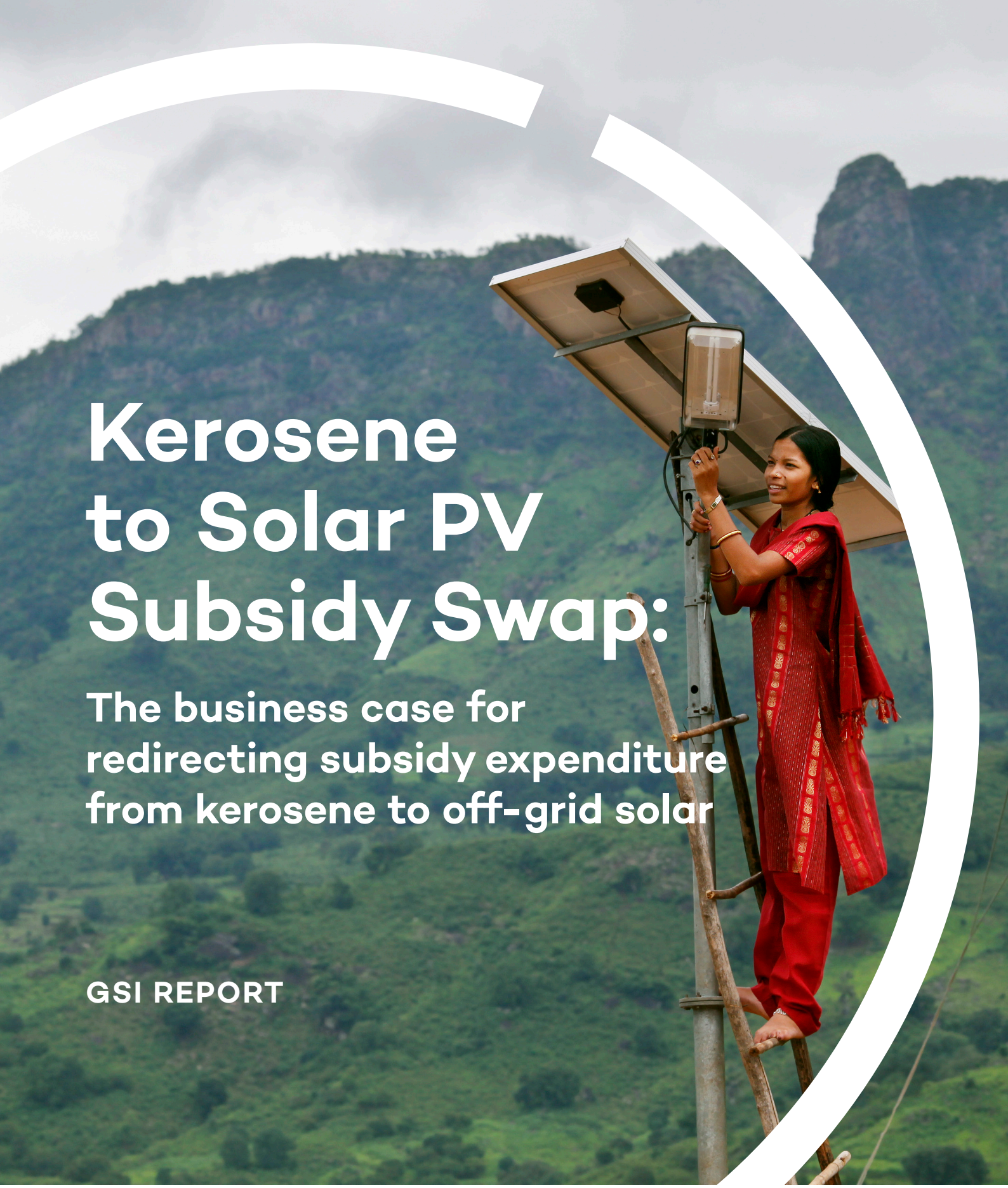

Kerosene to Solar PV Subsidy Swap:

The business case for redirecting subsidy expenditure from kerosene to off-grid solar

GSI REPORT

IISD International Institute for Sustainable Development

Global Subsidies Initiative

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International Institute for Sustainable Development

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Head Office

111 Lombard Avenue, Suite 325
Winnipeg, Manitoba
Canada R3B 0T4

Tel: +1 (204) 958-7700
Website: www.iisd.org
Twitter: @IISD_news

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Global Subsidies Initiative

International Environment House 2,
9 chemin de Balexert
1219 Châtelaine
Geneva, Switzerland
Canada R3B 0T4

Tel: +1 (204) 958-7700
Website: www.iisd.org/gsi
Twitter: @globalsubsidies

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Executive Summary

India is aggressively moving toward its target of universal household electrification by March 2019 (Ministry of Power, 2017). Solar power has a key role to play in this transition. Market trends suggest that this will involve a combination of grid-connected and decentralized energy systems, including standalone solar lighting products and solar home systems (SHSs). India became the third largest grid-scale solar photvoltaic (PV) market in the world in 2017, reaching a total installed capacity of 8.8 GW (Bridge to India, 2017); that year, it also recorded its highest sales volume of off-grid products, with 1 million branded pico PV and SHS products sold in the first half of 2017 (Gada, 2017). Pico PV products under 3 watt peak capacity (Wp)—like solar lanterns, study lamps, task lights and torches—make up a considerable share of the off-grid solar market as affordable backup lighting systems, in both high quality and cheaper, non-quality-assured options. According to the International Energy Agency (IEA), off-grid systems including solar PV and mini-grids are the least-cost solution for three quarters of the additional connections required in India to provide electricity for all by 2030 (IEA, 2017a).

Nonetheless, despite recent progress, and the wide range of on- and off-grid electricity and lighting options, a large number of marginalized households in India continue to remain without power. This is due to a range of factors—their geographical isolation, the upfront cost of such systems, the lack of access to solar distribution supply chains, the lack of consumer awareness of the technology and access to consumer finance.

Surprisingly, a key opportunity to further invest in household clean energy access is not a renewable energy policy, but a policy on fossil fuel subsidy reform—to be precise, kerosene subsidy reform.

For many years, the Government of India has sought to gradually reduce kerosene subsidy expenditures by increasing product prices and restricting the volume of subsidized fuel supply. Kerosene subsidies were originally provided as a way to promote access to affordable fuel for lighting and cooking—but the case for reform is compelling. Kerosene contributes to household indoor air pollution and has negative impacts on health, particularly for women and children. The subsidies are also costly and inefficient because it is easy for fuel to be illegally diverted in the distribution system.

If kerosene subsidies are being gradually removed, can a share of the subsidy savings not be reinvested in helping the most vulnerable households access electric lighting through off-grid solar technologies? This paper explores this idea in detail, referring to it as a "kerosene to solar subsidy swap" or a "subsidy swap."

A kerosene to solar swap could create sufficient funds to provide a pollution-free and cost-effective alternative for lighting some of the most vulnerable homes in India. It is estimated that government expenditures on kerosene subsidies could fund the full capital cost of 350 million entry-level solar lanterns over 1.5 years or 97 million mid-level solar lanterns over two years (Garg, Sharma, Clarke, & Bridle, 2017).

To further explore the feasibility of this concept, this study:

- Reviews the extent to which pico solar PV products (see Box 1) are currently available on the market to provide an affordable, reliable, direct replacement for lighting with kerosene.
- Examines how the current business models and market structure for the suppliers of these products could enable a subsidy swap.
- Presents an analysis of household usage patterns for subsidized kerosene in Uttar Pradesh and Odisha to determine the feasibility of the replacement of kerosene lamps with pico solar systems.
- Reviews the suitability of Uttar Pradesh and Odisha to host a subsidy swap pilot study, assessing the real-world impact of increased adoption of solar energy and a reduction in kerosene consumption.

The study finds that there are in fact a large number of products available that present a practical replacement for kerosene lamps. Nearly 200 pico PV products from various manufacturers were identified and reviewed.

Subsequently, 15 pico PV products were identified as meeting the specified price, quality and performance criteria deemed necessary to reliably replace kerosene at an affordable price.

These shortlisted products are manufactured by d.light, Greenlight Planet, Omnivoltaic Power Co. Ltd (OV Solar), RAL Consumer Products Ltd. and Barefoot Power. All five companies import fully integrated products made at their manufacturing units in China. These companies sell products that have achieved laboratory certification and are manufactured according to international quality standards (Box 1). These companies' products have been used for analysis because third-party certification provides indication of quality; data on sales from these companies was available from IFC-World Bank Lighting Global program and the Global Off-grid Lighting Association; and international certification requires companies to publish data on product specifications and distribution channels.

This shortlist should not be taken as an endorsement of only these specific products. Indeed, many other competing products are likely to be perfectly adequate alternatives—it was simply not possible for this report to assess them in detail. There remains an active debate about the role of certification schemes to ensure that consumers are protected from substandard products. Rather, the key conclusion of the review is that there is a surfeit of available, market-ready options for reinvesting kerosene subsidies into solar lighting, including but not limited to the shortlisted products. A summary of market segmentation and quality standards is shown in Box 1.

Box 1. Pico PV market segmentation and certification

Globally, the market for standalone solar products is essentially divided into two product segments based on their power capacities.

- All systems below 10.999 Wp are classified as pico PV systems and include integrated solar lanterns, study lamps, task lights, solar torches and basic solar home lighting systems (GOGLA, 2017).
- Products with capacities of 11 Wp and above are classified as solar home systems and come in varying configurations.

This study focuses on the pico PV product category, specifically on products priced at or below INR 3,000 to equate it to expenditure on kerosene.

In the Indian market, pico PV products are available in three categories depending on their certification:

1. **Internationally certified products** for pico PV solar products according to laboratory testing standards as defined by IEC/TS 62257-9-5 and manufactured to Lighting Global Solar Home System Kit Quality Assurance Protocols.
2. **Indian-verified products** that follow quality standards defined by the Ministry of New and Renewable Energy (MNRE) and/or other independent testing laboratories.
3. **Unverified products** that have not been certified to any quality or performance standards.

Sales data was only available for the first of these categories.

A second finding is that there is a wide range of business models adapted to different contexts. Some companies provide financing through microfinance institutions, some partner with established retailers, and others have worked with social enterprises for distribution and after-sales service. As different niches develop for pico PV products, business models will continue to develop. In terms of geography, a counter-intuitive finding was that some companies found grid-connected areas to be significant drivers of sales, as consumers who had access to electricity sought lighting during power outages. This indicates that the solar industry may continue to co-exist with the electricity grid to a greater extent than might have been assumed. It was also noted that distribution

networks were weaker in more rural areas, where kerosene use for lighting was most widespread. This may have been due to a lack of access to capital, a lack of awareness of the technology or other factors relating to the attractiveness of these markets.

Analysis of the potential for a kerosene to solar subsidy swap in Uttar Pradesh (UP) and Odisha through a series of consultations with government representatives, solar suppliers and end users in Bijnor district (in western UP) found that kerosene subsidies often incentivized the consumption of the fuel for purposes other than lighting or cooking, particularly as a transport fuel. This indicates that the kerosene subsidy as currently designed is not well targeted. The consultations also found that pico PV products in western UP were largely used as secondary backup devices, as most households had access to grid electricity and used grid or solar charged inverters as primary backup options during power failures. Initial research suggests that eastern UP may have more demand for pico PV as a primary source of lighting, and therefore a subsidy swap pilot in this area may achieve greater impact.

In Odisha, the proportion of unelectrified households (even in grid-connected areas), in combination with their dependence on kerosene for lighting and cooking, presents a good market scenario for pico PV products as well as for other solar-based electricity solutions in the state. There is a strong presence of both internationally verified and Indian-verified solar products in Odisha, which indicates that end users are familiar with the technology and there may be potential to swap subsidies from kerosene to solar to accelerate the uptake of solar lighting products. The existing Public Distribution System (PDS) network may be able to be co-opted to engage consumers to replace kerosene with clean solar lighting alternatives.

However, a complication that needs to be considered here is that end users in Odisha rely on kerosene for both lighting and cooking (in the absence of reliable and affordable liquefied petroleum gas or other clean and efficient resources). While a subsidy swap to solar PV can displace kerosene used for lighting, it cannot replace the cooking side of the equation. The state government's opposition to reductions in kerosene quotas is also a key factor that must be considered and explored further to understand the acceptability and feasibility of a kerosene to solar subsidy swap model in the state.

In summary, this report finds that:

- There are numerous market-ready solar products that can replace traditional kerosene lamps at the same or lower cost than existing kerosene subsidies.
- As supply chains strengthen, solar is already starting to replace kerosene in some places.
- In other parts of India, widespread use of subsidized kerosene for lighting continues and could be replaced by these products.

A consolidated government push for a kerosene to solar subsidy swap policy could enable households to transition away from an unhealthy, costly fossil fuel and toward clean and competitive pico solar systems. Further, pilot studies on existing business models can help to identify the impacts of possible swap policies and to design mitigation options to ensure robust policy design and policy effectiveness. This report encourages policy-makers and energy sector stakeholders to further explore the development and implementation of a subsidy swap to support the kerosene to solar transition.

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Abbreviations

B2B	business to business
B2C	business to customer
B2G	business to government
BPL	below poverty line
CSR	corporate social responsibility
DC	direct current
DDUGJY	Deen Dayal Upadhyaya Gram Jyoti Yojana
DISCOM	distribution company
GOGLA	Global Off-Grid Lighting Association
FY	fiscal year
IEA	International Energy Agency
IEC	International Electrical Committee
IFC	International Finance Corporation
INR	Indian rupee
LPG	liquefied petroleum gas
MFI	micro finance institution
MNRE	Ministry of New and Renewable Energy
NFSA	National Food Security Act
NGO	non-governmental organization
OMC	Oil Marketing Company
OREDA	Odisha Renewable Energy Development Agency
OTELP	Odisha Tribal Empowerment and Livelihood Programme
PAYG	Pay-As-You-Go
PDS	Public Distribution System
PV	photovoltaic
PVVNL	Paschimanchal Vidyut Vitaran Nigam Limited
RAL India	RAL Consumer Products Ltd
SAUBHAGYA	Pradhan Mantri Sahaj Bijli Har Ghar Yojana
SHG	self-help group
SHS	solar home system
UP	Uttar Pradesh
UPNEDA	Uttar Pradesh New and Renewable Energy Development Agency
USD	US dollar
UT	Union Territory
VAT	value-added tax
VLE	village-level entrepreneur
Wp	Watt peak

1.0 Introduction and Context

In 2018, 32 million Indian households, or 18 per cent of the population, are still waiting to receive reliable and affordable electricity (Government of India, 2018), and in 2017, over 64 per cent did not have access to clean cooking alternatives (International Energy Agency [IEA], 2017b). However, significant efforts have been made by the government to enable nearly 500 million people to gain access to electricity in India since 2000 (IEA, 2017b). In 2018, the government continues to maintain an emphasis on household electrification to achieve "power for all," through priority programs like Deen Dayal Upadhyay Gram Jyoti Yojana (DDUGJY), which will cover over 10 million below-poverty-line (BPL) households, and the Pradhan Mantri Sahaj Bijli Har Ghar Yojana (SAUBHAGYA), which aims to provide electricity connections to an estimated 30 million households in rural and urban India by March 2019 (Ministry of Power, 2017).

For those without electricity access, lighting needs are often met through subsidized kerosene, the cheapest and most accessible fuel. In rural areas, kerosene is predominantly used for lighting, compared to urban areas, where it is mainly used for cooking (Rao, 2012). According to the 68th National Sample Survey of 2011–12, almost 88 per cent of rural households were using kerosene. Over a fourth of the households (27 per cent) in rural areas used kerosene for lighting and only 0.8 per cent used it as a primary cooking fuel. On the other hand, in urban areas, 5.7 per cent used it for lighting and 3.2 per cent households used kerosene for cooking (Council on Energy, Environment and Water [CEEW] & IISD, 2016). Thus, even though 97.5 per cent of the villages in India have been declared "electrified," subsidized kerosene continues to remain a key resource for lighting in rural households (CEEW & IISD, 2016).

Access to subsidized kerosene for domestic consumption is provisioned across states and union territories (UTs) in India through the Public Distribution System (PDS) network. This is a nationwide network of third-party-run public distribution shops, commonly known as "ration shops," administered at the state level to sell subsidized food grains (wheat and rice), sugar and kerosene. The central government allocates subsidized kerosene to different states and UTs on a quarterly basis. Further, distribution of this subsidized kerosene through the PDS network is then the responsibility of each state and UT. In 2017/18, the central government allocated a total of 5082.4 million litres of subsidized kerosene, of which Uttar Pradesh (UP) received the maximum allocation of 911.2 million litres (approximately 18 per cent of the total allocation) (Ministry of Petroleum and Natural Gas [MoPNG], 2018).

With rapid acceleration in electrification and a move toward market-oriented reforms in the petroleum sector, the government is also gradually reducing subsidies on kerosene to lessen the overall burden of subsidies (Choudhary, 2017; The Wire, 2017). In fiscal year (FY) 2015/16, kerosene subsidies amounted to 41 per cent of all fuel subsidies (Garg et al., 2017) and put a significant strain on government funds. Allocations to subsidized kerosene have been declining on a year-on-year basis, especially since 2013 (Figure 1), and the government is encouraging states that have achieved 100 per cent electrification to become kerosene-free (Garg et al., 2017).

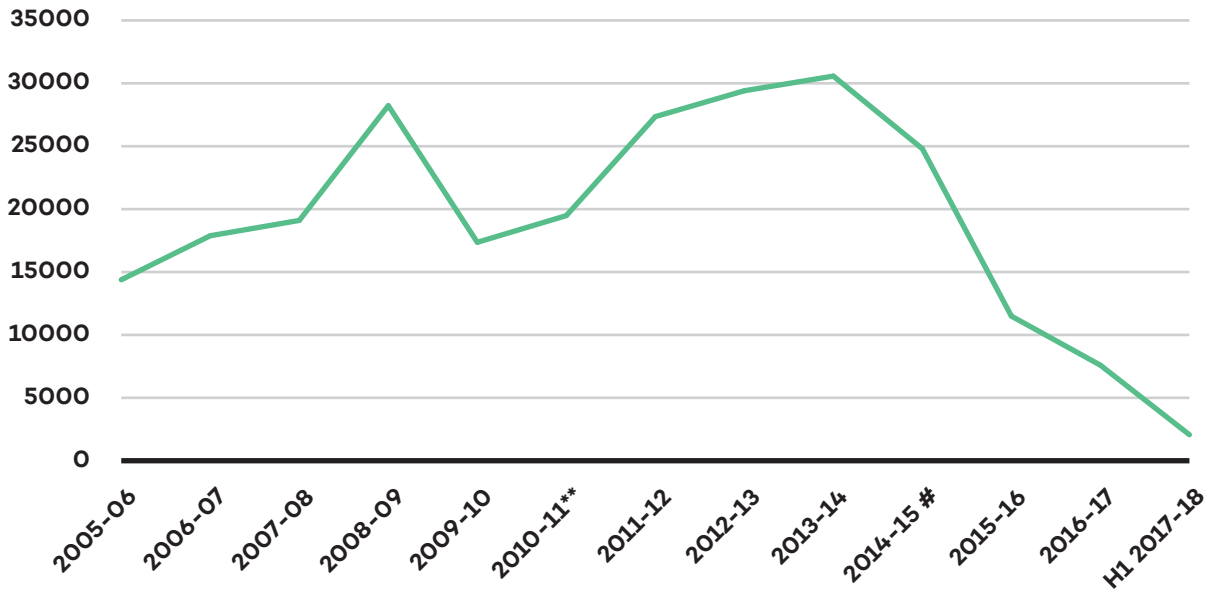


Figure 1. Year-on-year PDS kerosene allocation by Government of India (INR crore)

Source: Petroleum Planning & Analysis Cell, n.d.

Diversion of subsidized kerosene to alternate markets has undermined the ability of the subsidy to reach its intended recipients (Lam et al., 2016). A significant proportion of the subsidized kerosene, 51 per cent by volume, is leaked and illegally diverted away from its intended recipients to alternate markets, particularly to dilute diesel (Kumar & Viswanathan, 2017; CEEW & IISD, 2016). This forces approximately half of the poor households who do not receive their quota to buy it at much higher rates on the black market, rendering the kerosene subsidy inefficient.

Further, the provision of subsidized kerosene to poor households has the negative effect of creating an incentive for these households to continue using this fuel instead of switching to cleaner alternatives. A major consequence of continued kerosene use is indoor air pollution, which is estimated to cause approximately 500,000 deaths every year (Harish, 2013; Jena & Natrajan, 2017; Mahapatra, 2009).

In light of this evidence, there is a strong case for consideration to be given to whether solar off-grid technologies should be promoted as a cleaner and more cost-effective alternative for lighting in rural households. A recent draft of the National Energy Policy 2017 (NITI Aayog, 2017) suggests that solar lanterns are more cost effective than subsidized kerosene to meet the lighting needs of households. For households, the cost of using kerosene lamps is similar to entry or mid-level solar lanterns with superior lighting quality (Garg et al., 2017). It is estimated that if kerosene subsidies were reallocated to solar lighting it could fund the full capital cost of 350 million entry-level solar lanterns in 1.5 years or 97 million mid-level solar lanterns over two years (Garg et al., 2017).

As the cost of lighting from kerosene lamps is comparable to some solar lantern models, this report investigates the business case for a subsidy swap, where kerosene subsidies are reallocated and diverted to subsidize solar lanterns, making a cleaner and more efficient lighting alternative available and affordable for unelectrified households that currently rely on kerosene for their lighting needs.

This concept of reallocating kerosene subsidies to solar is being conceptualized as a clean energy swap (see Box 2). This report is designed to support a clean energy swap by examining the structure of the solar market and by identifying key brands of solar lanterns, their business models in the Indian market and the barriers to the expansion of solar lighting.

Box 2. Defining a clean energy swap

IISD-GSI identifies a "clean energy swap" as the reform of fossil fuel subsidies with a reallocation of some of the revenues to promote a transformation of the energy system toward sustainable energy. The core concept of a clean energy swap aims to accelerate the replacement of fossil-fuelled energy systems with sustainable energy. Therefore, a kerosene to solar swap will reallocate finances away from kerosene, promoting cleaner lighting fuels for unelectrified or underserved consumers.

This report is organized into six main chapters, including this introduction.

Chapter 2 outlines the methodology used in this report for selecting pico PV technologies that can replace kerosene lamps and their business models.

Chapter 3 introduces the reader to the Indian solar market landscape, elaborating on the way the market is segmented on the basis of price, level of service and end use of the product, as well as on the basis of the quality standards that the various manufacturing companies adhere to. The section also details the main business models operating in India to deliver clean energy access through off-grid solutions and elaborates on the pico PV product market, which is the focus of this study.

Chapter 4 delves deeper into the 15 shortlisted pico PV technologies that may be considered as viable replacement options for kerosene lamps and presents stakeholder views on them.

Chapter 5 elaborates on the findings from the review of technology and stakeholder consultations. The cases of Uttar Pradesh and Odisha are examined in more detail with respect to the electrification status, kerosene consumption and presence of solar off-grid solutions in the state.

Chapter 6 details the key issues and challenges for off-grid solar providers in scaling up rural sales and their distribution network.

2.0 Methodology

Kerosene is the primary lighting fuel for poor households without electricity access or with limited hours of electricity supply. Pico PV technologies provide a lighting solution for the same users with significant benefits over kerosene (IEA, 2017b). For many households, annual kerosene expenditures closely match the yearly cost of ownership of pico PV technologies (Garg et al., 2017). However, even though a solar lantern may be a cost-effective alternative over a longer period, the upfront costs may still be a barrier for the poorest households (IEA, 2017b).

This study focuses on understanding the opportunities to use a kerosene solar subsidy swap to enable more households to be able to afford solar lighting technologies. It aims to identify the technologies and business models that can enable the scale-up of solar lighting and the transition from kerosene to solar by mapping the market for pico PV technologies and their distribution models currently available in India. This study focuses geographically on UP and Odisha. These states have been selected due to their low electrification rates and the high rate of illegal PDS kerosene diversions to alternate markets.

Table 1. Types of off-grid solar technologies

Off-Grid Solar Systems
Pico PV: standalone lighting devices with a maximum output power of 10.999 Wp. Further divided into three sub-categories: • Single light only (0–1.499 Wp) • Single light & moblie charging (1.5–2.999 Wp) • Multiple light & mobile charging (3–10.999 Wp)
Solar Home Systems (SHSs): modular standalone power systems with power outputs of 11 Wp and above, for lighting and appliances in off-grid homes. • SHS Entry level (11–20.999 Wp) • SHS Basic Capacity (21–49.999 Wp) • SHS Medium Capacity (50–99.999 Wp) • SHS High Capacity (100+ Wp)

Source: Global Off-grid Lighting Association [GOGLA], 2017

UP had the highest allocation of subsidized kerosene in 2015/16 (MoPNG, 2016c) and 14.6 million households in the state are still waiting to be electrified (Ministry of Power and Central Electricity Authority, 2018). Within UP there are disparities: eastern UP fares worse on nearly all development indicators compared to the more thriving western part of the state (PACS & TATA Trusts, 2017), including indicators relating to quality and reliability of electricity. Part of this difference is because western UP, along with Haryana and Punjab, underwent a significant transformation in the 1960s during the green revolution, whereas the economy of eastern UP remained dependent largely on small holding agriculture or wage labour (Shah, 2000).

In Odisha, despite the government's push toward 100 per cent rural electrification, more than 3.2 million rural homes are still unelectrified (Ministry of Power and Central Electricity Authority, 2018). Even though more than 65 per cent of these unelectrified households lie in areas that are already connected to the grid, they find the upfront connection costs and recurring monthly expenses for on-grid electricity too expensive, relying instead on kerosene as their primary lighting source (CEEW, 2017). This high reliance on kerosene makes Odisha a key state to explore possibilities for a kerosene to solar subsidy swap.

The key elements of the study include:

- **Identification of pico PV solar technologies in India and an overview of the Indian solar market with a deeper understanding of UP and Odisha**

  Pico PV solar technologies were identified and profiled through an intensive review of over 200 product models through secondary literature, as well as online and offline data sources including product catalogues, manufacturer websites, e-commerce portals, third-party sellers and promoter websites. Consultations were conducted with key stakeholders across the value chain like sector experts and solar companies holding a major share in the product market. These consultations helped map technologies across a range of indicators on product features, performance, efficiency, warranty, after-sales services, distribution network and reach.

  Two main criteria were considered to shortlist technologies:

  - Products priced at INR 3,000 or lower—equivalent to half of the consumer expenditure on subsidized kerosene over a period of two years, to recover the cost of the solar product that is swapped in place of subsidized kerosene for lighting.
  - Product's charging compatibility – initially, the shortlisting used criteria for the product's ability to be charged through both grid and solar power sources, to make it sustainable for use even after grid electrification is received by the consumer. However, during the product review process, it was observed that the majority of "integrated" pico PV products, in which all components are incorporated into a single device (specifically the solar panel), were not grid chargeable. And since this segment of "non-grid-chargeable" products constituted a significant proportion of the entry-level lighting solution range and priced well within the pricing threshold, they were included in the overall technology review.

  The range of products that qualified for the above criteria includes integrated solar lanterns, study lamps, solar lanterns with a separate solar panel and entry-level micro solar home systems. The top manufacturers on the list include Barefoot Power, Greenlight Planet, d.light, OvSolar and RAL Consumer Products Ltd (RAL India). Other major manufacturers whose products were also reviewed include Phocos, Gautam Solar, Fosera, Andslite and Thrive, among others.

  The overview of the Indian solar market covers aspects related to market size, structure, range of products, policy/regulations and issues and challenges. Consultations with major pico PV product manufacturers were conducted to supplement information on product details gathered from secondary sources. Key sector experts were consulted to develop a wider perspective on the pico PV market in India and their distribution models. Field visits to UP and Odisha were also conducted to gather state-level contextual information on the market, status and quality of electrification, as well as on kerosene use patterns.

- **Mapping existing business models that support the sale of leading pico PV products in India**

  Business models of key market players in the pico PV category were documented through stakeholder interviews with energy and electricity sector stakeholders, sector experts, manufacturing companies and distribution channel partners. These interviews covered details about products, sales, management and financing.

  Since the cost of a typical solar home system (see Table 1) exceeds the benchmark of INR 3,000 set for this project, business models pertaining to these products have not been covered in this report. Also, as the focus of this project is on solar products, dry cell-based products, which cannot be charged by solar power, have not been discussed in this report.

2.1 Limitations

One of the key challenges of the study was the unavailability of any official or reliable data sources on the size of the solar market in India or on technology features and standards. Consultations with off-grid industry stakeholders GOGLA[1] and IFC Lighting Asia[2] (India) revealed that data on sales volumes of off-grid solar products is only maintained for those companies in India (and in the world) that are associates or members of these organizations. Products that meet Lighting Global Quality Standards undergo stringent quality testing of solar products, and this report refers to products from these companies as "internationally verified" products. Sales of these products constitute approximately 25 per cent of the total market share in India. A detailed description of this segmentation is provided in Section 3.2.

For products constituting the remaining share of the market, there is no clear indication on size or volume, neither from the government (MNRE) nor from any other sources. Even the CLEAN[3] network, which has 104 member companies working in the decentralized renewable energy space, is limited in listing the total volume of sales that their member companies contribute to the market. In its recent state-of-the-sector report on decentrialized renewable energy (CLEAN, 2017), only 32 members shared their overall sales and revenue data. The lack of any standardized data monitoring or data maintenance practices limits this study's assessment of the overall market.

[1] GOGLA is an association for the off-grid solar energy industry. For more information, see https://www.gogla.org/about-us

[2] The IFC Lighting Asia program promotes access to clean, affordable energy by working with the private sector to promote modern off-grid lighting products and systems. For more information, see: http://www.lightingasia.org/

[3] The Clean Energy Access Network (CLEAN) (http://thecleannetwork.org/) is an all-India representative organization that works to support, unify and grow the decentralized clean energy sector in India by bringing together diverse stakeholders across India working to improve energy access. CLEAN has 104 registered members in its network, some of which are also GOGLA members. Members include international manufacturers who have operations in India. Not all members are manufacturers of solar technologies. The network includes all stakeholders in the energy access sector (finance, skill development, consulting and research).

3.0 The Indian Solar Market

In the off-grid market, from 2010 to 2016, approximately 23.5 million off-grid systems (pico PV and SHSs less than 100 W) were sold worldwide, and from 2015 to 2016, a 41 per cent increase in global product sales of off-grid solar was recorded, with over 100 companies focusing on the pico PV and SHS segment (REN21, 2016).

In 2017, approximately 3.52 million off-grid products[4] were sold between January and June worldwide (see Table 2), with sub-Saharan Africa and South Asia accounting for nearly 83 per cent of total sales, followed by 8.5 per cent of total sales from the Middle East and Northern Africa, and the remaining 8.5 per cent from all other regions in the world (GOGLA, 2017). Total revenues from cash sales amounted to USD 95.57 million, with sub-Saharan Africa and South Asia again making up the lion's share at USD 40.67 million and USD 30.20 million respectively (GOGLA, 2017).

Table 2. Global off-grid sales, January to June 2017

Region	**Volumes** (in Millions)	**Revenues** (in Million $)
Sub-Saharan Africa	1.77	40.67
South Asia	1.16	30.20
Middle East & North Africa	0.29	19.29
Rest of the World	0.29	5.41
TOTAL	3.52	95.57

Source: GOGLA, 2017

In terms of the types of products sold, the market is divided into two main product segments based on their power output or watt peak (Wp) value (see Table 1). Products that deliver power up to 10.999 Wp are categorized as **pico PV products** delivering a Tier 1 level (see Box 3) of electricity access.[5] These include portable lighting systems like solar lanterns, study lamps, task lights and torches, and fixed micro solar home systems that offer very basic lighting (two or three lights) and a mobile charging facility. Standalone off-grid products with capacities of 11 Wp and above are categorized as **SHSs** and can have multiple configurations and capacities based on end-use requirements and consumer affordability. These range from basic systems that provide lighting along with mobile charging and small appliance use (11–20.999 Wp) to those that support a larger number of appliances and deliver power for a much longer duration (above 21 Wp).

[4] The *Global Off-Grid Solar Market Report* (GOGLA, 2017) presents sales and revenue data for only GOGLA member companies and IFC Lighting Global Associates—the global market of branded solar devices and integrated solar home systems. Products sold by these companies are IEC certified and adhere to international standards and technical specifications as developed under the GOGLA Quality Assurance framework. https://www.gogla.org/sites/default/files/images/gogla_member_qa_guidance_paper_march_2017.pdf

[5] As per the UN SE4ALL Tier system for electricity access: http://www.se4all.org/sites/default/files/MTFpresentation_SE4ALL_April5.PDF

Box 3. Pico PV Products

Products that deliver power up to 10.999 Wp are categorized as pico PV products. They essentially deliver a Tier 1 level of service—around 4–5 hours of lighting, and in some cases the additional service of mobile charging. They replace kerosene lamps, candles and battery-powered flashlights, and for this reason are considered as entry-level products.

Pico PV products are further divided into three sub-categories according to their power output:

- Single light only: 0–1.499 Wp
- Single light + mobile charging: 1.5–2.999 Wp
- Multiple lights + mobile charging: 3–10.999 Wp (micro solar home systems)

In India, pico PV products tend to cost between INR 250 and INR 3,000. Typical pico PV lighting products include integrated solar lanterns, study lamps, task lights, solar torches and micro solar home systems.

Source: GOGLA, 2017; SE4ALL, 2016

Pico PV products of up to 3 Wp had the largest share of cash sales in 2017, at nearly 78 per cent of the total sales volume of 3.52 million. Within this, the larger share of sales (43 per cent) was from the 1.5 to 3 Wp category of products, which are typically single light devices with a mobile charging facility (see Figure 2), and they are also the highest contributors (63 per cent) to total cash sale revenues (GOGLA, 2017). Nearly 35 per cent were single light products without mobile charging (0–1.5 Wp), which, owing to their low retail pricing, contributed to only 13 per cent of the total revenues.

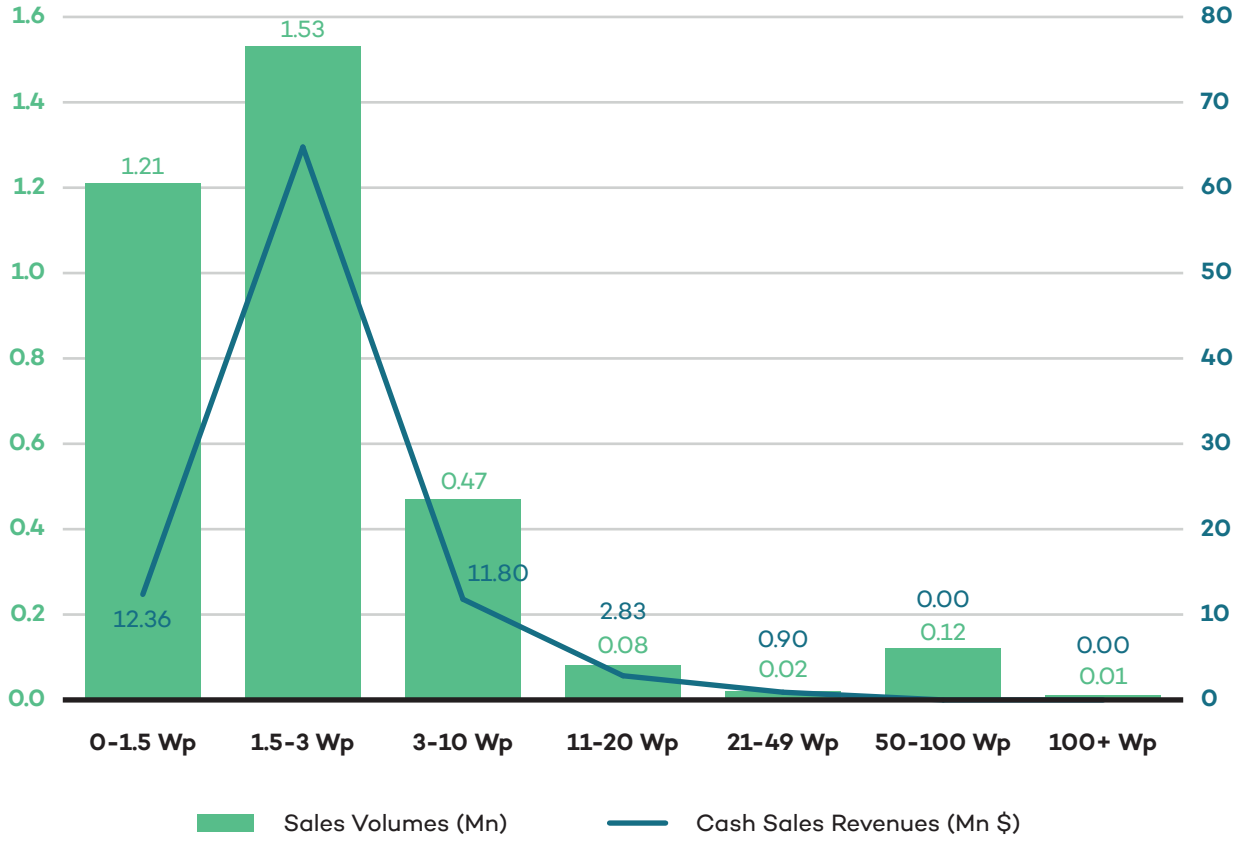


Figure 2. Global sales by product category

Source: GOGLA, 2017

The bulk of the sales, in terms of both volume and revenues, is generated by products with capacities lower than 3 Wp, indicating consumer preference for these lower cost products. However, data from GOGLA indicates that demand for larger systems is slowly growing. Between 2016 and the first half of 2017, the share of sales of larger systems (greater than 3 Wp) increased from 5 per cent to 7 per cent (GOGLA, 2017).

Within South Asia, India has been the single largest market for off-grid product sales and related cash sale revenues in the last few years and continues to be so. In 2017, it constituted nearly 94 per cent of total off-grid sales in South Asia and 88 per cent of the total revenues generated in the region (Figure 3) (GOGLA, 2017). India has been a dominant market for the under 3 Wp category of products (which typically includes solar lanterns, study lamps, solar torches), largely due to their affordability, ease of use and availability. The prices of pico PV products in India typically range between INR 250 and INR 3,000. According to The Climate Group, solar lanterns and entry-level solar home lighting systems have been the two main categories of consumer products in the off-grid sector in India. The growing awareness and falling prices of these solar products has enabled greater access to clean lighting solutions, and India is expected to witness a per-annum growth of 60 per cent for solar home light systems and 35 per cent for solar lanterns by 2018 (The Climate Group, 2015).

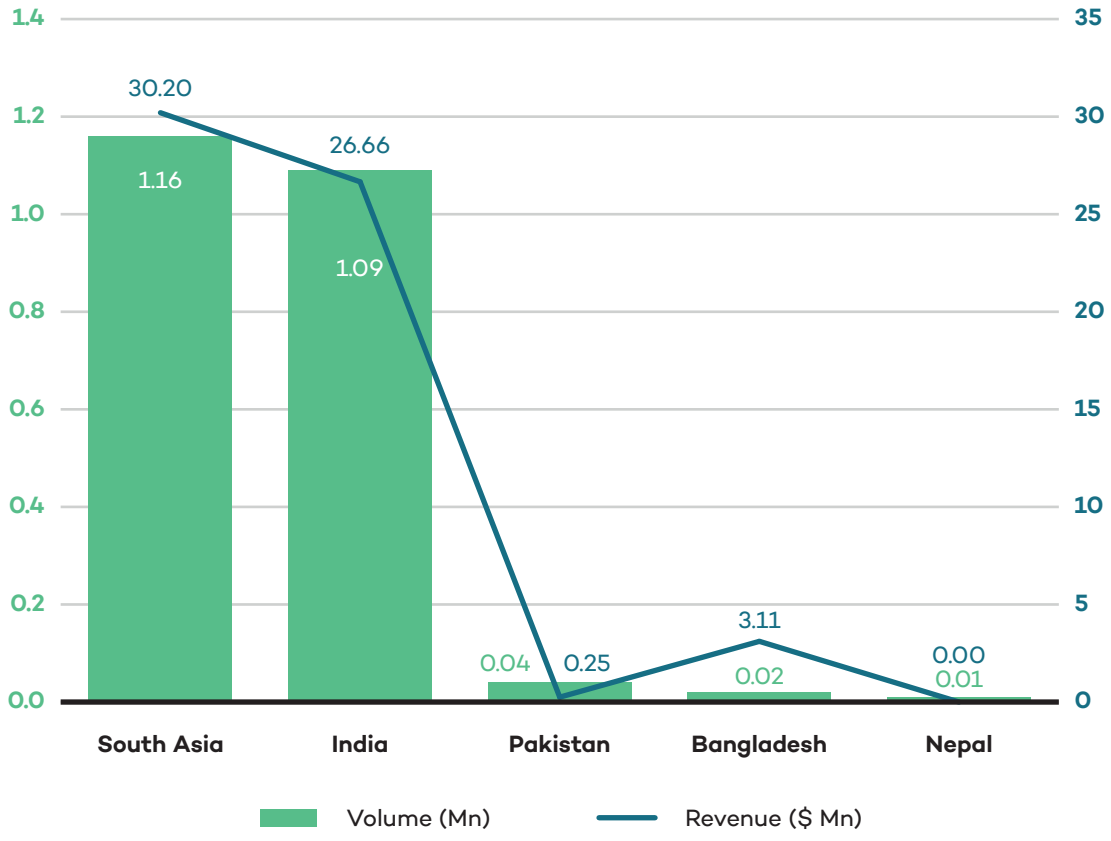


Figure 3. Off-grid sales volume by country – South Asia

Source: GOGLA, 2017

3.1 Market Size and Recent Trends in India

Consultations with key sector experts and stakeholders indicate that the Indian off-grid solar market has transitioned considerably. Between 2010 and 2014, the Government of India's National Solar Mission financed over 1 million solar home systems sold by companies including Orb Energy, SELCO and others (HYSTRA, 2017). Several international companies have also built a strong presence in India, including Greenlight Planet, Barefoot Power and d.light, among others.

As these companies offered accessible financing solutions to rural customers, the demand for solar home systems and solar lanterns increased (Bloomberg New Energy Finance, 2017). From 2014 to 2016, the rate of growth of off-grid solar products, specifically pico PV, has been increasing steadily in the subcontinent, where, historically, India has had the largest share of sales by far. Annual solar lantern and solar home system (less than 10 W) sales grew from 0.7 million in 2013 to 2.3 million in 2016, at a compounded annual growth rate of 47 per cent (Bloomberg New Energy Finance, 2016). Solar home systems have historically benefitted from significant government support and are also now being promoted by profit-driven solar companies (Bloomberg New Energy Finance, 2016). Interviews with Barefoot Power and IFC suggested that, since 2016, demand for larger system-compatible direct current (DC) appliances such as fans, radios and televisions have also been increasing. In a bid to incentivize and promote the domestic production of PV modules and products, the central government exempted companies from custom and excise duties in 2014, which contributed considerably to the market's growth. In addition, some state governments allowed significant reductions in value-added tax (VAT), from 15 per cent to 5 per cent (KPMG, 2015). In UP, the state government announced a complete removal of VAT on solar energy equipment (The Hindu, 2015). Since then, the introduction of the goods and services tax (GST) in 2017 has created a level playing field across states and solar lanterns are subject to a higher taxation (International Finance Corporation [IFC], 2018).

3.2 Product Segment of Focus: Pico PV Products

The off-grid market in India may be segmented into three groups based on price and end-use demand (see Table 3). This study focuses on the first segment of pico PV products due to their pricing and affordability in comparison to consumer expenditure on subsidized kerosene over a period of two years and their potential to replace kerosene as a primary source for basic lighting.

Pico PV products can be lanterns and study lamps or task lights and can have additional features including torches, adjustable stands, mobile charging ports and detachable solar panels. Pico PV products can also include basic micro solar home systems, generally supporting two or three LED bulbs and a mobile charging port.

Table 3. Segmentation of off-grid market in India based on price and end use

Product Type	**Entry-Level Products** (Pico PV products)	**Basic Solar Home Light Systems**	**Advanced Solar Home Systems**
Price	INR 250–3,000	INR 3,500–6,000	INR 8,000–65,000
Level of Service/ End Use	Basic lighting for 4–5 hours to replace kerosene lamp; portability; mobile charging	Room lighting for 4–5 hours; as backup during power cuts; mobile charging	Lighting + cooling (fan); entertainment (TV, radio); convenience (appliances)
Type of Technology	Solar lantern (with/ without mobile charging), solar torch, study lamp, task light	Micro SHS (2–3 luminaries plus mobile charging)	SHS with multiple luminaries plus support for fans and other appliances

Source: Review of solar technologies in India through secondary sources and stakeholder interviews

In the Indian market context, pico PV products can be organized into three categories on the basis of quality certifications: internationally verified products, Indian-verified products and unverified products. The market share distribution of pico PV products in India across these three categories is not very clear, as there is no established system of tracking the sales of products in the latter two categories, and there is no real sense of the actual overall market size. The most reliable source of data currently only exists for the internationally verified products, which

are being tracked jointly by GOGLA and IFC as part of the IFC-World Bank Lighting Global program. Further, it is estimated that the internationally verified products hold at least 25 per cent of the total market share in India (GOGLA, 2018). At the same time, in the absence of any data on the sales volumes of the other two categories, it is expected that an approximately equal sized market of Indian-verified and unverified products also continues to exist and grow in parallel. Each category is further described in Table 4.

Table 4. Shortlisted pico PV product segmentation based on quality certification

Pico PV Products	Internationally Verified Products	Indian-Verified Products	Unverified Products
Production	Fully assembled products imported for distribution (no manufacturing in India)	Manufactured/ assembled in India	Assembled/imported
Quality Certification	Lighting Global Quality Assurance Framework (tested using IEC 12257-9-5 test methods at ISO 17025 accredited laboratories)	Performance testing and certification through autonomous empanelled testing labs	No certification
Key Players	Barefoot Power, d.Light, Greenlight Planet, OV Solar, RAL India All are international brands except RAL India, which also has a manufacturing facility in China. *Note: Not all products made by these companies have the above certification.*	Gautam Solar, Andslite, Andromeda, Vikram Solar, Ritika Systems, Thrive Solar, SPJ Solar, Orb Energy, etc. *Note: Some products made by these companies also have the international certification.*	Information unavailable
Product Offering	12–24 month product warranty.	6–24 month separate warranties on components (luminary, battery, etc.)	No warranty
Market Share	Estimated to be 25 per cent of overall market in India	Information unavailable	Information unavailable
Pricing	INR 500–3000	INR 250–2000 approx.	Information unavailable
Geography	All India Key presence: Bihar, Odisha, Assam, Jharkhand, West Bengal, North Eastern states, Rajasthan, Karnataka, Maharashtra, Tamil Nadu, UP	All India	Highest concentration in UP and Bihar

Source: Stakeholder interviews, secondary research. The key players listed here are based on the shortlisting of product specifications.

3.2.1 Internationally Verified Products

These products adhere to the Lighting Global Quality Standards and are tested according to International Electrical Committee (IEC) test methods[6] at an ISO 17025 accredited test laboratory. Currently, most companies retailing these products in India are international brands with a global presence across Africa and Southeast Asia. Leading internationally verified product companies with a sales presence in India include d.light, Greenlight Planet, OvSolar, RAL India and Barefoot Power. Discussions with GOGLA revealed that these companies contribute to nearly 95 per cent of the total internationally verified pico PV solar product sales in India, which is also our market of focus for this study. However, GOGLA was not in a position to disclose company-level details of market share due to confidentiality requirements, which was also binding on representatives of these companies interviewed during the course of this study, making it difficult to present a breakdown of their individual market share. Individual company data would have provided more detail to compare the prominence of different business models associated with the various companies.

3.2.2 Indian-Verified Products

Indian-verified products are manufactured primarily by companies of Indian origin, based on specifications defined by MNRE. They are officially listed as registered or authorized manufacturers of solar PV products on the MNRE website (MNRE, 2018). In this category, MNRE requires companies to conform to its product specifications and get their products tested for performance and quality at registered testing labs. The MNRE's Lab Policy for Testing, Standardisation and Certification of Renewable Energy Sector (MNRE, 2017) does not necessarily demand products conform to international standards, but the policy's objective is to update Indian standards and adopt international standards. Therefore products based on MNRE guidelines may or may not actually meet internationally accepted quality standards.

Some prominent companies in this category include: Gautam Solar, Vikram Solar, Ritika Systems, Andslite, Thrive and Andromeda, among others. These manufacturers follow MNRE's testing requirements. However, data from these large market players in India is not captured as is done for products in the previous category. The absence of this data presents a significant gap in understanding the actual market share of pico PV products in the country.

3.2.3 Unverified Products

These products include cheap solar- and non-solar-based (electric) rechargeable lighting devices that do not fall into either of the above categories, as they neither conform to international standards for performance or quality evaluations nor to MNRE's product specifications. It appears that most low-cost products in this category may be assembled using low-cost imported parts and components and are perhaps unreliable. Most of these products are cheap imitations of branded products and have unpredictable shelf lives.

Based on stakeholder consultations, it is understood that these products hold a significant share of the market, especially in UP and Bihar. In these states, some manufacturers have found it challenging to compete with unregulated low-cost products that consumers prefer to buy on a use-and-throw-away basis. Consumers in India, being extremely price sensitive—often at the expense of quality (Bridge to India, 2014)—prefer to buy and replace these cheaper products every few months instead of investing in a high-quality product that may have a high upfront cost but will last them much longer and come with warranty benefits. Interviews with companies revealed that the use of these substandard products has also led to growing instances of poor consumer experiences, an opportunity that is being capitalized by international-quality certified brands to pitch the benefits of robust and high-quality products through awareness campaigns.

[6] IEC: international standards and technical specifications for all electrical and electronic technologies as developed under the Lighting Global Quality Assurance framework https://www.gogla.org/sites/default/files/images/gogla_member_qa_guidance_paper_march_2017.pdf

3.3 Business Models for Pico PV Products

A range of public and private stakeholders across India have made efforts to foster access to clean lighting through solar-based technologies, including national and state governments, civil society institutions, multilateral and bilateral institutions, international aid agencies and businesses. Hence, a range of business models is operating in the solar sector in India, which can be classified into three categories: business to consumer, business to business and business to government. This report focuses on the B2C category.

Business to Consumer (B2C): In the B2C model, an enterprise targets individuals and households directly for the sale of its products. To reach consumers, the enterprise either uses the traditional distribution model (comprised of carrying and forwarding agents, distributors and retailers), develops institutional partnerships or operates through a combination of both. Sales in B2C models can occur through multiple channels, such as through manufacturers or distributors, through financing or lease-based arrangements, through service-based fee models and through rent-to-own or pay-as-you-go models (see Table 5).

Business to Business (B2B): In B2B models, enterprises carry out bulk sales through direct transactions with other commercial or non-commercial institutions, and do not interact directly with the end consumer. For example, several CSR projects source solar equipment for dissemination and installation from manufacturers, but the actual implementation of the project is undertaken by a third-party project implementer or by the corporation itself. *B2B models are beyond the scope of this report.*

Business to Government (B2G): In the B2G model, manufacturers provide turnkey project implementation services to national or state governments and their agencies. For example, in India, MNRE-approved solar PV manufacturers and suppliers often bid for tenders released by government agencies to implement large-scale projects that may involve the installation or dissemination of clean lighting products. Such tenders are generally issued to meet specific energy access targets of the government or for disaster relief. *B2G models are beyond the scope of this report.*

3.3.1 B2C Business Models for Pico PV Solar Products

As described above, B2C business models carry out sales through various channels. Table 5 presents a summary of the various business models identified for sales of pico solar products.

Table 5. B2C business models for pico solar PV products

Retail Sales	
Direct Sales	Manufacturers operate through an in-house distribution network and dedicated storage facilities to reach the end user through a direct sales force or commissioned agents.
	Manufacturers/suppliers/bulk product aggregators manage a pool of village-level entrepreneurs (VLEs), microfinance institutions (MFIs) and other grassroots organizations who are part of the overall sales network.
	Independent micro-entrepreneurs operate in village *haats* and at weekly markets (in urban areas) to sell used products that are not covered under any warranty service.
Over-the-Counter sales	Undertaken by independent general or specialty shops and micro-enterprises (like Akshay Urja Shops*) that source products from various manufacturers.

* These shops were established under the MNRE Akshay Urja Shops Programme that was initiated during the 10th Five-Year Plan period. The program was set up to support the establishment of one shop in each district of the country for the creation of a network of retail outlets across districts to sell and service solar energy and other renewable energy products. MNRE supported these shops through soft loans, recurring monthly grants and sales incentives. As of March 31, 2017, this program has been discontinued, though several shops continue to exist.

Consumer-Finance-Based Sales

Institutions, most prominently MFIs, enter into sales partnerships with solar product manufacturers and provide small-ticket loans to households and self-help group (SHG) members to purchase clean lighting products. Due to their extensive reach in rural areas, they function as an extended distribution network for manufacturers with the added benefit of being a ready source of consumer finance.

Regional rural banks and government bodies like the Bihar Rural Livelihoods Promotion Society (BRLPS) also provide loans to households, SHG members and to joint liability group members for the purchase of clean lighting products, as approved by their local branches or head offices.

Fee-for-Service Sales

In this model, the solar lighting product (typically a solar lantern or solar home system) continues to be owned by the retailer, while the consumer pays a fee for using the system. Retailers are often VLEs who rent out the systems on a daily, weekly or monthly basis. The main advantage of this model is that it makes the lighting service affordable for the end user with minimal commitment or risk.

Under its Lighitng a Billion Lives initiative, The Energy and Resource Insitute (TERI) promoted a similar fee-for-service-based solar charging station model wherein solar lanterns were owned and charged centrally by a VLE and rented out to end users on a daily basis for a nominal rental fee.

Rent-to-Own Sales

This model works well where consumers prefer to own their lighting source but cannot afford to pay for it upfront. Under the model, consumers pay fixed monthly installments to pay off the cost of the solar lighting system while continuing to use it. Rural Spark, a social enterprise in India, implements a similar hire-and-purchase model at the village level for its solar energy kits. The only disadvantage of this model is ensuring guaranteed repayments from the end user.

Pay-As-You-Go (PAYG) Sales

The PAYG model has been very successful in East Africa and is slowly picking up in India. In this model, companies rent solar lighting systems to consumers and charge them periodically through a mobile payment system. Being an information-technology-based system, the model allows companies to minimize their transaction costs, automate payments and remotely activate services, while consumers receive immediate access to clean lighting sources without having to take out a loan. Under this model, customers may either opt to take over the ownership of systems or may choose only to purchase electricity as a service.

In India, Greenlight Planet's EasyBuy solution leverages the PAYG model to promote its solar lamp and home lighting systems. Pollinate Energy, a social enterprise, offers a distribution network that also employs the PAYG concept to make quality solar lighting products accessible and affordable to underserved consumers. Simpa Networks offers its entire energy solution range through the traditional PAYG model.

Sources: Gevelt & Holmes, 2015; The Climate Group, 2015; Sanyal, 2017; stakeholder interviews

3.3.1.1 Institutional Structures of B2C Business Model Operators in India

The range of entities operating in the pico PV product segment can be classified based on their profit-making objectives. **Commercial enterprises** are already commercially viable entities, operating primarily or entirely with a profit-making motive. **Quasi-commercial enterprises** operate through a social responsibility lens and purposefully subsidize products and services to address consumer needs. These enterprises tend to operate through grant/corporate social responsibility (CSR) support or a public–private partnership approach. **Non-commercial enterprises** are essentially not-for-profit institutions that are mostly publicly funded by governments or donors and are engaged in similar energy access initiatives, albeit without a profit-making motive (IFC, 2012). Table 6 presents a summary of the institutional structures of these entities within these categories.

Table 6. Examples of institutions retailing solar products in India

Institutional Structure	Entity Type	Description	Examples
Commerical	For-profit company	Manufacturers and sellers of lighting products who are registered tax payers in the government's records and operate in a particular business area.	Eveready, Gautam Solar, RAL India
Commerical	Social enterprise	Manufacturers/sellers/service providers who operate on a for-profit business model. The mission and vision of the organization are directly linked to a particular societal challenge. Unlike other commerical organizations that measure performance only based on the annual revenue generated, social enterprises measure their performance in terms of both revenue generated and the positive impact that their business makes to society.	Greenlight Planet, d.light, OV Solar, ONergy, Frontier Markets
Commerical	Energy-enterprise	Retail shops that operate at the block or district level. These enterprises pay taxes to the government and have a valid Tax Identification Number.	Aditya Urja Shops and Akshay Urja Shops
Commercial	Micro-enterprise	Comprises micro-enterprises that are not solely into the business of solar. For these enterprises, solar and other clean lighting products might be just another product offering. These are part of the organized sector in India.	General shops, electronics repair shops at the village / block level
Quasi-commercial	Think tank/ network	Institutions that support stakeholders in the energy access value chain and facilitate market creation for energy access by mobilizing funding, enabling skill development, project implementation, technology innovation and building partnerships and networks.	TERI, GOGLA, IIT Bombay, CLEAN
Non-commercial	Multilaterial/bilateral institutions/CSR foundations	Multilateral/bilateral institutions and foundations of public and private sector companies provide grants and low-cost financing to the private sector and to not-for-profit institutions to facilitate energy access. These institutions do not themselves directly disseminate or sell products at the last miles. Some of the organizations provide advisory services to social enterprises that are operating in the clean lighting space.	UN Women, International Finance Corporation (IFC), Bijli Clean Energy for All

Institutional Structure	Entity Type	Description	Examples
Non-commercial	Civil society institutions	Not-for-profit institutions that disseminate clean lighting products on a grant basis in partnership with a funding agency.	Grassroots NGOs
Commercial	Individual entrepreneurs	These are informal micro-entrepreneurs who operate at the village level and do not possess any technical or business training. They are part of the unorganized solar sector in India.	VLEs and retailers
Commercial	Used product aggregator and seller	These players operate in weekly markets or in village *haats* and often sell second-hand (possibly refurbished) products that have been discarded by the original owner at reduced prices.	Independent sellers / hawkers

Source: IFC, 2012; Jena & Natarajan, 2017; Singh, 2016; The Climate Group, 2015; Verma & Vohra, 2014

4.0 Deep Diving: Pico PV Products in India

4.1 Shortlisting Internationally Verified Pico PV Products in India

This chapter shortlists internationally verified pico PV technologies that may be considered as viable replacement options for kerosene lamps and presents stakeholder views on them. Observations are limited to the 15 technologies (see Table 7) that were shortlisted based on their price (less than INR 3,000 [USD 45]), international standards verification and the availability of information about the product features. Consultations were held with stakeholders from different groups in the pico PV value chain in India, including product developers, manufacturers, funding, channel partners and sector experts. A total of 27 interviews were held in August–September 2017. This section summarizes the views of stakeholders on several parameters including product details, information on manufacturers, production, warranties, pricing, market share and several others.

Initial screening identified products from nearly 200 manufacturers. After evaluation, 15 of these were considered to meet the criteria applied (see Table 7). Only internationally verified products have been included in this list. The lack of sales, market and other product data of Indian-verified (MNRE-certified) and unverified products makes it difficult to evaluate and include these products. The shortlisted 15 products manufactured and supplied by five brands reportedly account for nearly 95 per cent of the internationally verified product market share in India, namely, d.light, Greenlight Planet, Barefoot Power, RAL India and OvSolar. Four of these five companies (excluding RAL India) are international brands with a strong presence in Africa and other parts of South and Southeast Asia, and all five have manufacturing units based out of China, from where fully assembled products are imported for sale in India. While the entire product portfolios of d.light and Greenlight Planet are internationally quality verified, only a select few products from Barefoot Power are internationally verified as of February 2018, and only one solar lantern model (Mitva MS-16B) manufactured by RAL India qualifies for this list.

All products listed in Table 7 are priced between INR 520 to INR 3,000 to be at least half of the expenditure on subsidised kerosene over 2 years of approximately INR 1248. The information presented here is based on discussions with representatives from each of these companies.

Table 7. **Qualifying quality verified pico PV products in India**

Brand	Model	Type	Product Image	Price (INR)	Dual Charging	Mobile Charging	No. of LEDs	Solar Panel	Run time (hours)*
d.light	S 3	Solar Light		785	Yes (with Nokia charger)	No	1	Integrated	4 to 13
d.light	S 30	Solar Lantern		NA	Yes (with Nokia charger)	No	2	Integrated	3
d.light	S 100	Solar Lamp		1300	No	Yes	3	Separate	4 to 8
d.light	S 300B	Solar Light		1900	Yes (with Nokia charger)	Yes	1	Separate	4 to 16
Greenlight Planet	Sun King Pico - SK121	Study Lamp and Task Light		520	No	No	1	Integrated	6 to 65

Brand	Model	Type	Product Image	Price (INR)	Dual Charging	Mobile Charging	No. of LEDs	Solar Panel	Run time (hours)*
Greenlight Planet	Sun King Pro All Night - SK302	Solar Lamp		2900	No	Yes	4	Separate	8 to 56
Greenlight Planet	Sun King Pro 2 - SK303	Solar Lamp		2500	No	Yes	5	Separate	5 to 11
Greenlight Planet	Sun King Pro 300	Study Lamp		2299	No	Yes	9	Separate	8 to 20
Greenlight Planet	Sun King Pro 400	Study Lamp		2699	No	Yes	12	Separate	5 to 14
Barefoot	Go 150	Solar Light		2000	Yes (with USB charger)	No	10	Separate	5 to 8.5

Brand	Model	Type	Product Image	Price (INR)	Dual Charging	Mobile Charging	No. of LEDs	Solar Panel	Run time (hours)*
Barefoot	Go 250/255	Solar Light		3000 / 2400	Yes (with USB charger)	Yes	20	Separate	5.5 to 11
RAL India	Mitva MS-16B	Solar Lantern		700	Yes (with USB charger)	No	1	Integrated	2 to 10
OV Solar	ON OV Pilot X	Study Lamp		1300	No	Yes	2	Separate	9 to 35
OV Solar	ON OV Beacon MB2-160	Lamp + Torch		2400	No	Yes	2	Separate	5.4 - 84 / 5
OV Solar	ON OV Beacon MB2-200	Lamp + Torch		2900	No	Yes	2	Separate	4.4 / 3.4

Source: Secondary literature, stakeholder interviews

4.2 Observations from Stakeholder Consultations

This section presents stakeholder views on the shortlisted pico PV technologies. Observations are limited to the 15 technologies that were shortlisted in the previous section (see Table 7). The section summarizes product details on several parameters, including information on manufacturers, production, warranties, pricing, market share and several others.

4.2.1 Documentation of Product Details

There is a stark contrast in the nature of product-level information that is available for internationally verified products, compared to those that are Indian verified or those that fall in the unverified product segment. Internationally verified products have detailed and standardized information available on the features and performance of their products. In the case of MNRE-approved and unregulated products, information is less consistent, with no standardized documentation available on technical specifications of the product or its performance and quality standards, except generic product highlights.

4.2.2 Information on Manufacturers

There is no clear information available on the registered Indian-verified manufacturers of entry-level pico PV products from MNRE or any other source, even though there are several large manufacturers operating in this space. The list that MNRE shares on its website is for all registered solar PV manufacturers, who may or may not be producing pico PV technologies. Of the 200 products identified during the technology review, manufacturers of most of these products do not have a company website or adequate information on the company's profile, portfolio, regional presence, etc. In the absence of such information, it is not possible to make a judgment on operations of these manufacturers.

4.2.3 Production

Internationally verified products are mostly multinational brands that import fully assembled products for sale in India. Many other brands supply products or components imported from China that are assembled in India with additional domestically produced components. There was no data available on the certification of these domestically manufactured or assembled products.

4.2.4 Warranties

All 15 shortlisted internationally verified products come with a 24-month replacement warranty. While repair services are made available by the manufacturers, repair of defective products often tends to be more expensive than replacement. Due to the quality assurance standards applied to such products, the defect rate for these products is very low, typically below 1 per cent of their total sales. The product design and development is done keeping in mind the nature of end use, handling and probable tampering of the device. Intuitive features have been incorporated into the product design to protect it from typical misuse. For example, end users generally tend to overuse a product beyond its recommended duration, draining the battery completely and sending it into a deep discharge state that affects the overall performance and longevity of the product.

Complaints from end users are not frequent, though when they do occur, stand-by devices are provided to the consumer while their device undergoes repair or evaluation for replacement. Though most channel partners provide basic replacement and minor repair services, some manufacturers maintain company-owned-and-operated regional service centres as well.

MNRE-approved, Indian-verified companies offer warranties ranging from six to 24 months, and in several cases these warranties vary for components within the product. For example, Thrive Solar offers a 12-month warranty on the luminary in its lantern but only a six-month warranty on the battery.

4.2.5 Pricing[7]

For most internationally verified products, information on product price is not ambiguous and is readily available on their official websites. However, for Indian-verified products there is no centralized information on pricing on the MNRE website and only fragmented information is available on some of the manufacturer websites. The information that is available indicates that MNRE-certified products tend to cost in the range of INR 320 to INR 1,600.

4.2.6 Market Share

Discussions with GOGLA revealed that d.light, Green Light Planet, OV Solar, RAL India and Barefoot Power together constitute nearly 95 per cent[8] of the total sales volume in the internationally verified product segment in India—approximately 1.03 million products in H1[9] 2017 (GOGLA, 2017). Due to confidentiality requirements, information on the market share of sales volume or the profit margins of the individual company was not shared. There is no documented information available on the market share of Indian-verified products or for those falling in the unverified products category.

4.2.7 Consumer Awareness, Preferences and End Use

It was reported that pico PV solar products are generally used as backup lighting devices, for emergency use during power cuts at home and as portable lighting devices to commute in the evenings or work in the fields. The level of consumer awareness of product standards was reported to be low. Negative experiences of unreliable, cheap and substandard products, especially in states like UP and Bihar where the market has been inundated by these alternatives, has affected consumer perceptions of pico PV products as a whole. The Lighting Asia/India program, working in partnership with member companies, implements public awareness drives to highlight the differences between quality and substandard products and the value of investing in better quality devices.

Even among quality-assured products, product failures do occur. Common faults resulting from user damage or manufacturing faults include damage to switches, mobile charging jacks and battery indicators, as well as deep discharge of batteries due to overuse. On the positive side, it is reported that, due to the growing diffusion of quality-assured products, consumers have started trusting pico PV technology and have even begun to identify quality with the brand name.

4.2.8 Distribution Network and Business Models

The five companies with internationally verified products identified above operate similar business models with a primary focus on tapping existing networks across India to achieve reach and scale. For example, in rural India, MFIs currently possess the strongest and most widespread networks and are a ready source of consumer finance, making them an effective and compelling distribution partner for these companies. The companies recognize that access to consumer finance is an enabling factor for sales of quality entry-level products and larger systems, as it helps to overcome high upfront costs (see Figure 4). MFIs are particularly key as distribution networks for entry-level products, as no other channel partner offers such small loans to consumers to buy these products. Discussions with sector experts revealed that an estimated 75 per cent of the total sales portfolio of these companies relies on the MFI channel alone.

Other prevalent and emerging distribution partners include regional rural banks (who are more supportive toward consumer loans upward of INR 25,000 and therefore well suited for larger home lighting systems), post offices, insurance companies and non-governmental organizations (NGOs). All stakeholders agreed that consumer finance is key to achieving scale and keeping business viable, which explains the reliance on microfinance and regional rural banking channels.

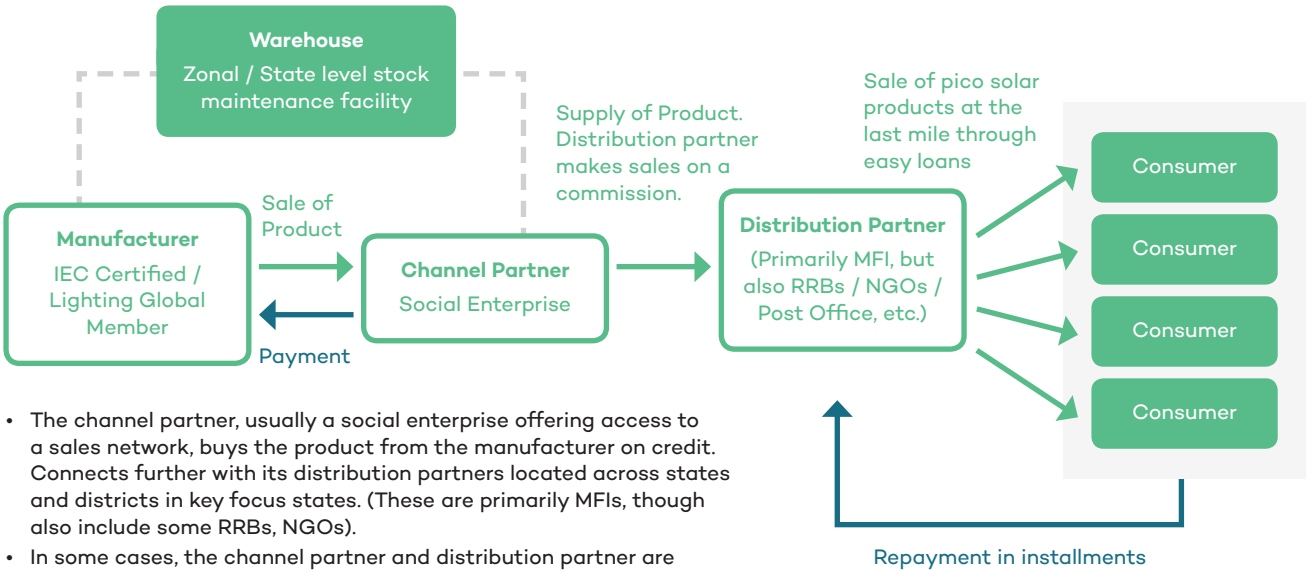
[7] As per secondary data available on product websites, e-commerce listings, product catalogues

[8] Calculated as 95 per cent of total sales reported for India by GOGLA in H1 2017

[9] H1 indicates the first half of the fiscal year, starting in April.

Several manufacturers, being 100 per cent internationally owned, cannot directly sell their products in India and have partnered with social enterprises to enter the Indian market and connect with other distribution networks through them. In some cases, these social enterprises are also engaged as exclusive distribution partners for sales in India. Dharma Life and Frontier Markets are two notable social enterprises that offer distribution services to manufacturers through their networks.

In addition to these networks and partnerships, these five companies are also setting up dedicated company-owned retail channels and making bulk sales through CSR projects whenever possible. Online retail through third-party e-commerce websites is also an option, though it currently constitutes a very small proportion of the overall sales.



- The channel partner, usually a social enterprise offering access to a sales network, buys the product from the manufacturer on credit. Connects further with its distribution partners located across states and districts in key focus states. (These are primarily MFIs, though also include some RRBs, NGOs).
- In some cases, the channel partner and distribution partner are the same entity. In such cases, the manufacturer directly manages relationships with multiple distribution partners.
- The responsibility of making the sale lies with the channel or distribution partner. The manufacturer aids with marketing activities and awareness campaigns.

Figure 4. Typical consumer-finance-based distribution model

Source: Stakeholder interviews

4.2.9 Pay-As-You-Go

PAYG technologies, where consumers make regular payments in exchange for continued operation, is still in its infancy in India (see Table 5), though interest around this mobile-based payment and service delivery system has been developing over the past few years. Currently, Simpa Networks is the only service provider that offers its entire energy solution range through the PAYG model, operating in the Vridavan belt near Mathura, UP. It is estimated that around 180,000 customers currently use this system (Simpa Networks, 2017).

Other market players, including d.light, Greenlight Planet and OV Solar have also tried to operationalize this model in the past with mobile operators like Vodafone, M-Pesa and Airtel, though they have not met with a lot of success. D.light is currently working on a pilot project to test the feasibility of the solution. Greenlight Planet has already floated its EasyBuy mobile payment platform, which enables consumers to buy its energy systems in small amounts over time through 10- or 20-week recharge plans. It also helps distributors and agents to reliably collect payments, review credit and manage customer relationships.

The PAYG model continues to hold significant interest in the market; however, the main barriers limiting its progress in India so far have been:

- Lack of confidence in the mobile technology, as there are still network reliability (connectivity) and data management gaps.
- Lack of complete clarity on the regulatory aspect for the model (in terms of balance sheet management, leasing company requirements, etc.).
- The biggest factor affecting the model's success is the appetite of the rural consumer to transition to a fully digital payment and energy use platform. Discussions with stakeholders trying to operationalize this model revealed that consumer demand for PAYG-based solutions is not high, even though developments like demonetization emphasized its relevance; now that things are back to normal and consumers are not cash strapped anymore, it has lost interest value again.

The main driver of the PAYG model in India is that the model is popular with investors hoping to replicate the success of the telecommunications industry, where low-cost handsets and regular purchases of mobile credit funded a technological revolution.

4.2.10 Presence

The five identified companies with internationally verified products have a strong presence in West Bengal, Jharkhand, Karnataka, Odisha, Assam, Rajasthan, Maharashtra, Gujarat, Tamil Nadu, Kerala, Madhya Pradesh, UP, Bihar and Manipur.

4.2.11 Market Outlook and Geographic Focus

None of the manufacturers or distribution partners interviewed had a negative outlook of the changing market in view of the government's focus on achieving 100 per cent electrification by the end of 2018. On the contrary, they welcomed the development. This is due to the fact that their primary target market is end users who have been exposed to electricity and habitual minimum service delivery. The companies have positioned themselves to fill the service gap that occurs when grid supply fails.

It is important to note that these players tend to target or operate in few remote rural areas, because reaching consumers there is often a challenge. The conventional wisdom is that it makes better business sense to target peri-urban and adjoining rural areas where electricity is available but not reliable. Owing to this market dynamic, some of these companies have diversified their product solutions beyond lighting to include other household appliances like DC fans, televisions, inverters, refrigerators and laptop chargers.

> "The more the grid expands, the more people will want reliable power, and it is going to take some time for electricity supply to become 100 per cent reliable."
> – A solar company

4.2.12 Competition

Stakeholders do not perceive direct competition between companies that sell internationally verified products and those that sell Indian-verified products, as both groups serve different markets through different supply approaches.

While internationally verified product companies focus on the private retail market, the Indian-verified product companies, such as Gautam Solar, Vikram Solar, Andslite and Ritika Systems, operate in project mode, relying on government-funded projects acquired through tendering procedures or on CSR-funded projects that require large-scale procurements and deployment of equipment.

Competition is reported to be an issue for internationally verified products when they compete against unverified products that are far cheaper and often provide poor consumer experiences. These products are reported to be especially prevalent in UP and Bihar, making these markets especially challenging.

5.0 State Scenarios: Uttar Pradesh and Odisha

This chapter studies practical issues from solar distribution projects, household kerosene consumption patterns, grid electrification status and solar off-grid market conditions in two states: UP and Odisha. The resulting analysis presented here is based on field visits to regions in both states. The visits were also undertaken to identify the feasibility of conducting a possible pilot under the kerosene to solar subsidy swap project and to evaluate the presence of other actors in the states who could collaborate with IISD on this project. Information was gathered from stakeholders operating in the off-grid, grid and public administration spheres. The visits also allowed conversations with consumers at the town and village levels. These discussions followed a snowballing technique, and hence any findings from these field visits should only be interpreted as indicative.

5.1 Uttar Pradesh

In UP, a field visit was made to the district[10] of Bijnor. The district has a few unelectrified villages located near the banks of the Ganga River where a kerosene to solar swap pilot could possibly be conducted. However, before commencing pilot activities, a visit to Bijnor and surrounding areas was organized to understand the situation on the ground in more detail and the scope for a subsidy swap initiative to work.

Meetings with various stakeholders were conducted during the visit, including with the district's administrative officers (Chief Development Officer and Regional Supply Officer), the local electricity distribution company (discom) Paschimanchal Vidyut Vitaran Nigam Limited (PVVNL), Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA), an Akshay Urjashop, a local solar product retailer/system installer, and end users from the nearby villages of Bukhara and Chowkpuri.

5.1.1 Electricity

The GARV Dashboard,[11] a tool for visualizing electrification status, shows that the concentration of electrified villages in western UP is far higher than in eastern UP (Figure 5). From a further exploration of the GARV GIS dashboard, it appeared that perhaps there are significant data gaps in the electrification status information from eastern UP, as no status was indicated there at all. In contrast, for western UP and other key states (Bihar, Jharkhand, Odisha), data was available on village electrification status (classified as 100 per cent electrified, 100 per cent distribution transformer capacity enabled and to be electrified).

[10] A district (*zila*) is an administrative division of an Indian state or territory and may have both urban and rural areas under its administrative boundaries.

[11] See the Garv Dashboard at http://garv.gov.in/dashboard (accessed on October 8, 2017).

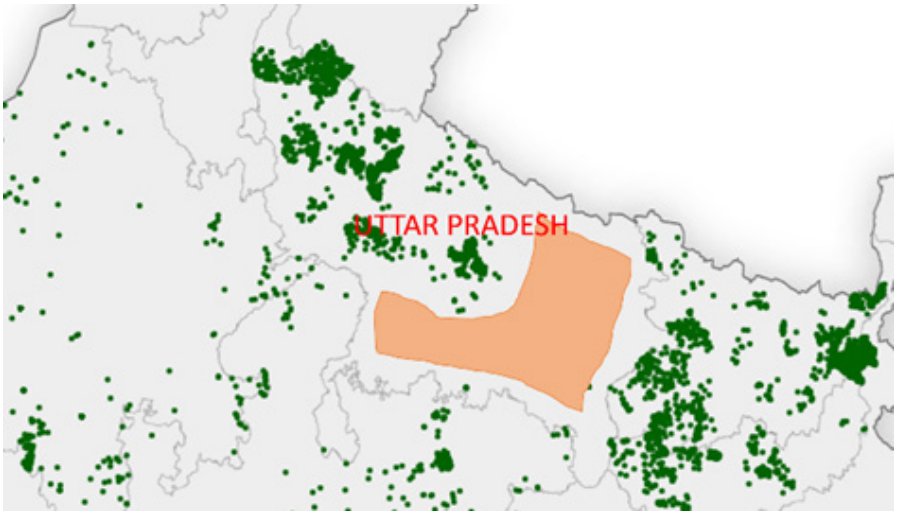


Figure 5. Electrification status in UP: Screenshot from GARV GIS Dashboard

Source: GARV Dashboard

The field visit to Bijnor revealed that the grid electrification situation in Bijnor district has improved considerably over the past year, with rapid expansions in electricity infrastructure. In 2017, at the time of the field visit, interviews with PVVNL suggested that Bijnor town was receiving an average of 20–22 hours of quality electricity supply and its peripheral villages 18 hours, while villages located farther away from the district centre received around 15 hours. A number of new substations are planned or under construction to further improve the grid. The local distribution company had been mandated to expand the supply to all the district's villages in time to meet the government's target. Since electricity supply has improved only recently, people are used to frequent power failures and most homes have inverters for backup. Lighting in all rooms and fans have now become a necessity for all electricity consumers in the district, even during power cuts.

A key concern that continues to put a strain on the discom is electricity theft. Illegal hooking[12] is rampant in Bijnor. The discom representative explained that many households that do not subscribe to legal connections and are officially unelectrified have electric lighting in their homes. Measures like metering and armoured cabling are being taken to curtail this practice. Efforts are also being made to strengthen and streamline billing and collection processes. Currently, bills are generated bi-monthly, but payment rates are quite poor as most rural consumers prefer to clear their bills annually, based on their harvest cycles, even though this attracts a late payment interest penalty.

Though the discom has been mandated to provide electricity connections to all households in the district, the visit to Chowkpuri[13] village revealed that, even in an "electrified" village, there can be households that do not subscribe to the service as they cannot afford to pay for the connection. Villagers in Chowkpuri shared that, even when the connection was offered for free, these households chose not to subscribe as they could not then afford to pay the monthly consumption bills. Hooking therefore became their only option to have lighting at least for a few hours every day, a fact the villagers said they often turned a blind eye to as these households did not have any other recourse.

[12] Hooking is an illegal practice of electricity theft where the consumer taps into a power line from a point ahead of the energy meter. This energy consumption is unmeasured and procured with or without switches.

[13] Chowkpuri Village is located approximately 10 kilometres from Bijnor town, the district headquarters of Bijnor district. The village is well connected by road, and agriculture is the primary occupation. We interacted with a group of men who appeared to be prosperous and well informed. A walk through the village showed that most homes were brick and mortar houses. The group informed us that Chowkpuri had been electrified nearly 50 years ago, though the quality of electricity supply was extremely poor until recently, when new transmission infrastructures had been set up near the village.

5.1.2 Kerosene

Subsidized kerosene is supplied through the PDS, which is a statewide network of "ration shops" that provide food and non-food essential items at a subsidized rate to BPL families. In Bijnor interviews with beneficiaries suggested they received an average of 2 litres of kerosene per family through the PDS system at a rate of INR 22/litre. All eligible beneficiaries claim their kerosene quota irrespective of the end use and requirement of kerosene in the household. The main uses of kerosene observed are: as a backup fuel for cooking when liquefied natural gas (LPG) runs out, to ignite traditional wood stoves, as fuel in small pumps that draw out underground water (tullu pumps) or as fuel for small motors that mechanize fodder-cutting equipment. Substituting kerosene for diesel to run motors does not appear to affect the performance or life of the motor. Villagers in Chowkpuri expressed that, if kerosene subsidies were to be removed, making it effectively as expensive as diesel, they would stop buying it at the market rate and choose diesel instead; the absence of kerosene is not likely to have a large impact on their lives. However, as long as the government provides subsidized kerosene, they will continue to purchase it, as they consider it their rightful entitlement.

The use of kerosene for lighting is minimal in the region, and it is used only if other backup options such as emergency lights, torches, solar lanterns/home systems or inverters are not available during an unscheduled blackout. Users are also known to prefer cheap LED strips for lighting instead of kerosene, in the absence of other lighting sources.

5.1.3 Solar

Bijnor is well endowed with both substandard and good-quality solar products. However, it was observed that people tend to purchase cheaper unregulated pico PV products instead of investing in good-quality products that last longer and provide a better lighting experience. Local energy providers and retailers stated that most consumers prefer to buy a product for INR 200–300 that might last them 6 to 12 months or less, as compared to a branded, quality product that may last them a minimum of 2 years, because it has a high upfront cost. Many assemble their own mini lighting systems, which include a 3–5 watt panel costing INR 200–300, small battery packs of INR 300–500, and small LED bulbs and mobile chargers. Overall, this mini system costs them around INR 600–800 and lasts for up to a year. Users who have even lower affordability levels reuse mobile phone batteries by locally charging them and using them to power small LED bulbs, which costs them approximately INR 100–200.

Local dealers further revealed that the demand for solar lanterns and similar entry-level solar products has shrunk drastically, both because their level of service does not fulfill lighting requirements adequately (as compared to larger solar home systems and/or grid electricity) and because most consumers in the district are grid electricity users and require backup solutions that serve greater energy needs and match the service level of grid electricity. Being portable, solar lanterns are generally used at night in fields to fend off stray grazing animals. In comparison, cheaper, dry cell-based or grid-chargeable products appear to have a higher demand.

The biggest market is currently for solar panels as most consumers buy these to charge their batteries during extended power cuts. TATA Power Solar was seen to be the leading brand in the market for solar panels. The most visible brand of standalone pico PV products in Bijnor was Andslite, an MNRE-certified solar module manufacturing company and a leading manufacturer of a range of solar products including solar lamps, lanterns, torches, batteries for uninterruptible power supply, fans, solar panels, LED bulbs and solar cells.

Based on consultations with manufacturers and distributors of internationally verified products, UP appears to be a contentious state for some for three main reasons:

- First, due to the presence of numerous large and small players, the market is crowded and the scope to establish product differentiation is low.

- Second, with consumers being extremely price sensitive, the ready availability of poor quality products in the state makes it very difficult for quality-assured brands to compete on pricing.
- Third, companies do not find the market "credit-safe," and there is apprehension about relying on consumer-finance-based distribution channels due to a poor repayment record in the state. However, there are still some players who do continue to operate in UP and focus on the eastern UP market, as this region has much poorer quality electricity access than the other half of the state.

The solar market in Bijnor district runs nearly entirely on institutional and commercial installation projects (large rooftop solar systems). UPNEDA is responsible for grid-connected, solar thermal and off-grid solar programs in UP and commissions several projects to implement schemes for rural home lighting, street lighting, solar pumps, reverse osmosis water purification systems, etc. (UPNEDA, 2018). As of December 2017, UPNEDA had installed 220 MW of utility scale solar power projects and 30 MW of rooftop power plants, as well as electrified 20 of the 29 target villages under DDUGJY through solar power packs (UPNEDA, 2017).

According to local dealers, solar street lights are in high demand and assembled locally at the dealer level by sourcing material from nearby suppliers and manufacturers who can be relied upon for spares and warranty services. DC television and fan sales are also picking up and are used in both rural and urban households. A typical DC fan was priced at approximately INR 1,500. Over-the-counter retail sales comprise a very small proportion of total sales and are not a primary revenue stream. Dealers provide dedicated after-sales, repair and replacement services which is key for customer retention. The size of the market remains unclear, as neither of the solar dealers interviewed was willing to share any information on sales volumes, margins or revenues.

5.1.4 Conclusion

The visit to Bijnor gave a fair sense of the scale of electrification in western UP and the pattern of kerosene use as a source of lighting at the household level. Even though consumers claimed their full quota of subsidized kerosene through the PDS every month, this was more to exercise their entitlement to the subsidy and also due to a fear of being removed from the list of beneficiaries due to non-collection. Kerosene was used primarily as a fuel and cheaper alternative to diesel or in kerosene stoves as a backup cooking option when LPG runs out. In very few cases, it is used for lighting in emergencies when no other alternative is available.

Based on these observations, the scope for pico PV solar in western UP appears to be quite limited, remaining confined to the backup lighting solution category of devices. In eastern UP, there is more promise for pico PV solar products to be used as primary lighting devices by replacing kerosene lamps. However, the presence of several decentralized mini-grids (government and private), the increasing expansion of grid infrastructures as well as government-mandated off-grid deployments through UPNEDA must also be taken into consideration, as they move to cover a larger number of consumers over time, eventually reducing the scope for pico PV lighting products.

5.2 Odisha

A field visit to Odisha was also made to gather information on the electrification situation, use of kerosene and the overall market for solar energy products in the state. Stakeholder consultations were conducted with local NGOs and MFIs headquartered in Bhubaneswar with operations in various districts; product manufacturers and retailers in Bhubaneswar and Cuttack; the Odisha Tribal Empowerment and Livelihood Programme (OTELP); the Odisha Renewable Energy Development Agency (OREDA); and the District Supply Officer.

5.2.1 Electricity

According to the DDUGJY, as of November 2017, of a total of 8.6 million rural households nearly 3.2 million (over 40 per cent) are still not yet electrified (DDUGJY, 2017). Being a forest-rich state, with over 37 per cent of its total land area recorded as forest (Odisha Forest Development Corporation, 2018), Odisha has a large

tribal population that resides near or within forest boundaries. Earlier regulations disallowed forest villages from being electrified, and later their remote locations and lack of transport infrastructure made it difficult for the government to extend electricity to these regions. Other factors that have kept electrification from progressing in these areas are the consumers' inability to pay for services, the distance of hamlets from the main road or villages, and other infrastructure maintenance and transmission issues.

Many households find the upfront grid connection costs and recurring monthly expenses of grid electricity unattractive and prefer to rely on kerosene as their primary lighting source (CLEAN, 2017). Reluctance to sign up for grid connections reduces the potential consumer base for discoms and increases the cost per consumer of installing new connections. The government is resolving the grid connection costs for households through a new policy called Saubhagya, which absorbs the costs of last-mile grid connectivity and makes it free for rural poor households (Choudhary, 2017).

Stakeholders reported that, while most villages have been electrified, scheduled and unscheduled power cuts prevail everywhere, and reliability and duration of supply are key issues. In villages without grid connections, kerosene and biomass are the primary sources of lighting, and the main backup source during unscheduled blackouts, along with chargeable lights.

5.2.2 Kerosene

Distribution of subsidized kerosene in the state is generally done through the *gram panchayat* or village council and in a few cases through women's group networks and private retailers. Consumers who were registered as beneficiaries under the National Food Security Act (NFSA) during the census survey of 2011 are eligible to receive subsidized kerosene. Since the central government's decision to reduce kerosene allocation under the PDS, there has been a strong opposition from the state government in Odisha, as most beneficiaries under the NFSA use kerosene for both cooking and lighting purposes. The state government has been opposing the reduction of its kerosene quota by the central government since 2015, when the MoPNG decided to reduce the kerosene quota after removing the new LPG connection beneficiaries under Pradhan Mantri Ujjwala Yojana. A reduction of nearly 40 per cent in the quota since 2015 has resulted in each beneficiary now receiving only 640 millilitres (ml) per month compared to one litre at the rate of INR 22 per litre (Indian Express, 2017).

Ganjam is the highest kerosene-consuming district, followed by Mayurbhanj (Government of Odisha, 2018). As detailed by the District Supply Officer in Mayurbhanj, there are a total of 5,73,281 families and approximately 21,48,690 registered beneficiaries in the tribal-dominated district, with a total per-month kerosene distribution of 13,75,163 litres. People tend to spend INR 60–70 per month on kerosene (which implies that they have to buy from the open market to meet their cooking and lighting needs). There are also instances of some beneficiaries selling their quota of subsidized kerosene to diesel pump owners at a higher rate. While each registered beneficiary receives 640 ml of subsidized kerosene per month, since there are generally multiple beneficiaries in a single household, overall 2 to 3 litres is the average subsidized kerosene consumed by a household. Any additional kerosene required is sourced at double the price from the black market. It is estimated that 50–80 per cent of households in rural Odisha use kerosene for cooking and lighting, as most of this population still does not have access to reliable electricity.

5.2.3 Solar

Odisha is a focus state for several internationally verified product companies as well as for other MNRE-approved manufacturers. As a state with nearly 40 per cent (or more) of its total rural households without grid connections, it is a prime market for decentralized solutions. The large number of industries in the state (cement, steel, electricity) have also generated a number of CSR-funded opportunities for implementation. Odisha's microfinance and women SHG networks are also considered to be stronger and more credit worthy than those in UP. Manufacturers state that another reason for Odisha being an attractive market for off-grid

players is because its markets have not yet been flooded with poor quality and cheap products, making it very conducive to creating space for high-quality products in the market.

Consultations with NGOs and MFIs show that leading manufacturers are approaching them to become channel partners for their products. In MFIs, an entry-level quality-assured product is sold on a 6-month EMI loan at a 22–23 per cent interest rate. People generally used these portable pico PV solar products for lighting, mobile charging, as back up, and to support livelihood activities like tailoring or on their boats when they go fishing. As some products have the flexibility of being used in different ways (as a lamp, hanging light, torch or a power bank), it allows people to use them for different activities. The durability and sturdiness of the product has developed trust in the users toward the technology and most consumers are satisfied with the service received.

The main areas of distribution revealed during consultations with NGO and MFI channel partners include the districts of Khordha, Bhadrak, Dhenkanal, Ganjam, Koraput, Bolangir, Baleshwar, Jajpur, Cuttack, Kendrapada, Sambalpur, Bargarh, Sundargarh, Sonpur, Bhawanipatna and Jharsuguda. The channel partners undertake various activities including product demonstrations, sensitization games on adverse impacts of kerosene and advantages of solar light, and demand generation for women's group members who have good repayment track records of previous loans. Smaller products are generally paid for over six equal monthly installments (or even on direct cash sales); for larger solar home lighting systems, payment is often made through a deposit followed by 12 equal monthly installments. Typical interest rates are around 22 per cent. Products are delivered within seven days of receiving an order from the customer. Some leading brands support after-sales services through a dedicated sales person at every branch (of the MFI) to take care of repairs and maintenance. Depending on the size and reach of the channel partner, sales may range from 1,000 units to 2,500 units per month. There is a combination of MFIs/NGOs that sell multiple brands, as well as those that operate as exclusive partners for some brands.

The other prominent channel for decentralized electricity provision in the state is government agencies. OREDA is the primary agency for promoting and implementing renewable energy interventions across all districts in the state. As of August 2015, more than 41,000 solar lanterns have been disseminated to rural households, weavers, handicraft artisans, etc. The agency has electrified over 1,600 villages through solar power systems (mini-grids) and more than 9,000 households have been provided with solar home systems for lighting and mobile charging (OREDA, 2016). OREDA commissions solar manufacturers and integrators to implement projects and ensures warranty services for five years are contracted for every solar power system solution. The systems are provided to communities at a subsidy from the government, though they need to arrange funding for maintenance and services after the five-year warranty period is over. However, these interventions are not actively monitored and some of them are non-functional now. The systems provide an average of 4–5 hours of supply.

In OREDA's experience, one of the main challenges in providing decentralized supply is that the tariffs for solar power are still high compared to the tariff and service levels of grid power. For example, a smart power system installed in Chutkei village in Angul district charges users a rate of INR 7 per unit. However, even at this rate, the solar power plant is only able to support a very limited load. Another major challenge is extension of after-sale services after implementation. Despite the contracted five-year warranty period, visits from the supplier to rectify problems are not regular. Despite OREDA's efforts and the growing proliferation of entry-level solar products through the retail market, people continue to collect and use kerosene as a major lighting source.

5.2.4 Conclusion

While there is a strong presence and penetration of internationally as well as Indian-verified solar products in Odisha, there remains a large proportion of households without access to either grid electricity or solar lighting. Since manufacturers of internationally verified products are not aiming to reach remotely located consumers at the moment, the 65 per cent of the population without grid connections living in grid-

connected areas present a ready market. There is also a strong case for reaching remotely located consumers through PDS networks to replace kerosene with clean solar lighting alternatives.

However, since the reliance on kerosene is not only for lighting but also for cooking, in the absence of reliable and affordable LPG (or other cleaner and efficient sources), the consumer's demand for kerosene for cooking will also have to be taken into account. The state government's opposition to reductions in kerosene quotas is also a key factor that must be considered and explored further to understand the acceptability and feasibility of the kerosene to solar subsidy swap model in the state.

5.3 Business Models in UP and Odisha

The market dynamics for standalone solar lighting products in the states of UP and Odisha are determined by a range of factors including electrification levels, access to consumer finance and preferences of consumers. In rural areas, consumers, particularly household consumers, are often reluctant to try out new innovations and have very low levels of disposable incomes. In addition, the dispersed and remote nature of villages and households makes product distribution a daunting task.

The market conditions are quite different in both states, highlighting the need to adapt business models to local conditions. The differences in each state have led to the adoption of different partnership models, with a greater reliance on partnerships with MFIs in Odisha than UP. Based on stakeholder consultations and secondary data research, a summary of pico PV business models in these states has been outlined in Table 8.

Table 8. Business models in UP and Odisha

B2C	
Direct Sales	UP: **Dharma Life**, a social enterprise and aggregator of products, has developed a pool of rural entrepreneurs who undertake direct-to-home sales in rural areas. **Pollinate Energy** uses a "franchise model within a franchise model"—the Pollinators themselves operate their own micro-franchise network of "Worker Bees." Franchisees ("Pollinators"), trained and financed by Pollinate Energy, distribute products vetted and branded by Pollinate Energy in their local communities. Odisha: Interviews suggested that **Dharma Life** has recently begun operations in this state as a channel partner for Green Light Planet, OV Solar and RAL India **Greenlight Planet** has an exclusive network of village-level entrepreneurs who are part of its direct channel, which is operational in Odisha and other states such as UP (Green Light Planet, 2015).

B2C

Over-the-Counter Sales	**RAL India** has been working with a network of distributors that are connected to its state offices, warehouses and stockists (RAL India, 2018). **Akshay Urja Shops**, micro-enterprises operating at the block and district level, undertake over-the-counter sales and services of clean lighting products. **d.light** has worked with domestic LPG distributors to promote sales of their products (Shah, 2013). **Greenlight Planet** has partnered with the postal department in India for sales of its products through post offices. UP: There is widespread availability of branded and unbranded solar and battery products through electronics retailers. For over-the-counter sales, retailers do not generally facilitate any consumer financing. Odisha: A 2014 report by IFC (Lighting Asia, 2014), based on a primary survey in the district of Kalahandi, outlined that mostly electronics shops and general stores sold solar lighting products, and very few exclusive solar product shops existed. Sales of battery products that can be charged from the grid are reported to be larger than solar products. While retailers may avail credit and financing through wholesale distributors and manufacturers of solar products, credit facilities for end users are largely absent, as most products are not covered under any kind of warranty service and are low-priced products, generally less than INR 400. Since the prices of most solar lanterns are very low, commercial banks in general do not provide any loan schemes to end users.

B2C

Pay-As-You-Go Model	UP: **Simpa Networks** is operating on a PAYG model in Vrindavan in UP. However, most of Simpa's products are solar home lighting systems that are priced above INR 3,000. **Greenlight Planet** is conducting some PAYG pilots using its EasyBuy platform, which enables consumers to buy its products in small amounts over time through 20- to 32-week payment plans and helps distributors and agents to reliably collect payments, review credit and manage customer relationships. Odisha: No information is available on manufacturers using the PAYG model in Odisha.
Consumer-Finance-Linked Models	Most solar lighting product sellers partner with MFIs to expand reach and facilitate access to consumer finance for their end users. UP: Several MFIs and SHGs include solar lighting products in their lending portfolio. Odisha: There is a strong presence of MFIs, SHGs and other similar networks that provide consumer financing facilities to end users in the state. CSR funds and/or development assistance from multilateral/bilateral institutions have been leveraged to bring down the upfront consumer costs.

Source: Stakeholder interviews, secondary literature

6.0 Issues and Challenges

This section elaborates on key issues and challenges experienced by pico PV manufacturers and channel partners for deployment of solar PV products in the Indian market.

- **Demonetization:** The demonetization that took place in India on November 8, 2016, where the vast majority of the country's cash was made invalid, had a severe impact on the largely cash-based Indian economy. The phenomenon negatively affected sales, especially in the first quarter of 2017. MFIs, which are major distributors of off-grid solar products in India, had to focus efforts on collecting repayments from existing customers, reducing the resources available for new customer acquisition. This is likely to have contributed to reduced sales in India (GOGLA, 2017). The impact of demonetization was felt for a long period of time and, while the market is still recovering, it is also looking for alternative mechanisms to reduce dependence on cash and explore alternative payment mechanisms like PAYG, etc.
- **Overdependence on the MFI-linked distribution channel:** For all companies supplying internationally verified products in India, MFIs are the primary distribution network to deliver their products to consumers. Nearly 75 per cent of their overall sales are made through MFIs. While these networks offer help to overcome upfront costs, relying on a single network type for the majority of sales poses a business risk, especially since the MFI market is reaching its saturation point and the scope for further expansion is low.

  MFIs have a specific customer base that is not going to expand at the rate solar companies desire. Sector experts report that the annual incremental increase in MFI customers is approximately 10,000. The limits of MFI expansion could also limit the expansion of solar lighting. Over the last four years, many MFIs across India have developed solar portfolios, bundling solar with other financial products. The Microfinance Institutions Network, the sector's self-regulator, has recently expressed that it may bar its members from selling third-party products to avoid the "forced selling" of products—and developments like these could eventually affect solar businesses if they continue to rely so heavily on just this sector for distribution.

- **Lack of Financing:** A lack of financing at the enterprise and consumer levels continues to be a big challenge.
  - Experts stated that the only opportunity available for enterprise finance currently is the Responsibility Energy Access Fund, an impact-focused fund manager. Many companies that get bulk orders from government-funded projects are sometimes not able to meet the targets due to lack of sufficient working capital. Banks are still not willing to take the risk and lend to these companies—as they don't understand the model or trust the market enough to feel confident in recovering their money.
  - On the consumer financing side, MFIs are popular, but they are also limited by the amount of financing they can offer to the consumer to buy these products, as they are only allowed to have 10–15 per cent of their total lending portfolio for non-productive consumer loans. Regional rural banks are not open to lending to consumers either, as systemic issues have delayed their payments from the central bank (National Bank for Agriculture and Rural Development) on previous consumer finance schemes. Financing needs to move away from impact investment and toward commercial investing.

- **Market spoilage due to the import of substandard products:** The lack of regulations on products and components being imported from other countries has led to significant market spoilage in the states of UP and Bihar and is an impending threat for other states where electricity reliability and consumer affordability are low and where markets for decentralized energy solutions are growing. Due to the lack of awareness of standards and specifications, consumers unwittingly purchase low-quality products, leading to poor performance and mistrust in the technology, in addition to the financial loss. This adversely affects the market for quality-assured brands that need to put in extra efforts toward consumer awareness and information dissemination to undo the misperceptions created by poor quality products.

- **Changing markets for pico PV with electrification and kerosene use for non-lighting purposes:** As witnessed during visits to UP, pico PV products such as solar lanterns and torches are either used as backup lighting devices or generally outside the home when there is no other lighting source available. While pico PV products are a viable substitute for kerosene lamps both financially and in terms of the improved lighting service they offer, the increasing rate of grid electrification will affect the already shrinking market for these entry-level lighting products. Apart from backup lighting, manufacturers are also focusing on fulfilling energy needs during power cuts. This requires systems to be much larger than what pico PV products can offer. Remote rural villages that do not have any grid infrastructure available for electricity supply also remain viable markets for manufacturers. However, many of these villages are being electrified through state-sponsored mini-grids and solar home systems. But in some of these remote villages, households that are eligible for subsidized kerosene do not use it strictly for lighting (as in the case of Odisha where households use subsidized kerosene for cooking), weakening the case for pico PV products as complete substitutes/replacements of kerosene.

7.0 Conclusion

This study reveals that pico PV products are an affordable and efficient backup lighting system for consumers in rural and urban Indian markets. However, in the absence of grid electricity, a significant number of marginalized households continue to rely on subsidized kerosene for their lighting needs. Subsidized kerosene has serious health implications and is a significant financial burden on the government that is augmented by inefficiencies in the distribution system, defeating the overall targeted benefit that was envisioned for end users.

In April 2018, the Government of India's ambitious program of providing grid electricity reached all villages in India. The next target of universal household electrification is also not far away. In spite of these ambitious targets, households may not receive reliable 24x7 grid electricity and may continue to experience unscheduled blackout hours, limiting their productivity. At such times, kerosene-based lighting is a poor substitute, while off-grid lighting is superior, economically on par and without adverse health impacts. In this dynamic scenario of achieving universal electrification, the government needs to consider a role for off-grid lighting through a policy that enables vulnerable households to transition away from kerosene subsidies toward renewable energy. A kerosene to solar subsidy swap suggests the reallocation of kerosene subsidies toward funding the capital cost of pico PV lighting devices, addressing affordability and clean energy access gaps at the household level and the burden of fossil fuel subsidies on the government.

While the government appears to be aligned with this transition, a formal policy pushing a swap is missing. This report and other IISD publications (Bridle & Clark, 2017; Garg et al., 2017; Jena & Natrajan, 2017) have observed that government policies are aligned with a kerosene to solar swap, as the government has been reducing subsidized kerosene allocation since 2013 and the 2017 draft of the national energy policy also suggests that solar lanterns are more cost effective than subsidized kerosene to meet household lighting needs.

Previous IISD publications have examined the economic impact of a swap on households and found that they have no added expenditure burden when transitioning away from kerosene toward entry-level solar products. Similarly, government budgets will also save money if a swap is implemented.

This report examines the situation of the entry-level solar market in India to understand if the market and its operations are ready for the government to push for a swap policy. The report understands the types of products available and the business models of the companies and their geographic focus. This report will use these findings to design and test the swap through a pilot in a suitable location in Odisha or UP.

The report has benefitted from the easily accessible information on market data of manufacturers having internationally verified products operating in India. Similar information about MNRE-certified manufacturers has been unavailable. On account of the unavailability of sales data of the latter, the report has studied internationally verified products and their companies' business models in greater depth. The report acknowledges this limitation and, in the next steps of designing the pilot, will attempt to overcome this through detailed field studies.

The key findings and conclusions from this study are:

- The market for pico PV products is segmented on the basis of quality verification standards in internationally verified products and Indian-verified products, each of which serve two different market segments through different supply approaches. The third category of unverified products, particularly prevalent in UP and Bihar, includes products made from substandard components assembled locally and often presented as cheap imitations of branded products.
- Findings from UP (specifically western UP) show that, while households regularly claim their kerosene subsidy benefit, they rarely use it for lighting purposes (only when no other backup alternative is available). Here, kerosene serves a wider purpose as a motor fuel or as a substitute for diesel. The research

conducted here suggests that many beneficiaries do not view the kerosene subsidy as essential to meeting their lighting needs but, while it remains available, continue to purchase subsidized kerosene as an exercise of their rights. Eastern UP is not likely to have a similar outlook, as electricity infrastructures and household affordability levels are known to be much lower there. However, to consider eastern UP viable for a subsidy swap pilot, a more detailed study of the region would be required.

- In Odisha, the use of kerosene for lighting is more prevalent than in UP. Even in grid-connected areas, a large proportion of households remain unelectrified because they find grid connection charges very expensive. Odisha also has a robust microfinance presence in the state, which is already well tapped by manufacturers of pico PV products, to reach new markets through a consumer-finance-based distribution channel.
- While Odisha presents a suitable opportunity to test the subsidy swap, one of the main complications facing the swap mechanism is the mixed use of kerosene in households. Most households in Odisha use kerosene for both lighting and cooking, and preliminary consultations with households suggests that kerosene consumption for cooking further varies with seasons. While the subsidy swap will address the need for lighting by replacing kerosene lamps with a cleaner and more efficient solar lighting device, it will not provide a solution to replace the cooking fuel. This will entail an important implication for marginalized households that use kerosene for lighting and cooking. Any swap design will have to make provisions for the use of kerosene for cooking.
- In most households, pico PV products are primarily used as backup lighting devices and can therefore only limit the expenditure on kerosene. This has implications in pilot design. A pilot in a geographic location where consumers spend significantly more on open market kerosene will show more contrasting results once consumers use pico PV instead of kerosene.
- The five companies with internationally verified products identified in this report—d.light, Greenlight Planet, OvSolar, RAL India and Barefoot Power—operate using a range of business models. Together these companies also have 95 per cent of the internationally verified product market share in India. This implies that a swap pilot focused on internationally verified pico PV products will have broad replicability since the business model of the companies remains the same across geographies.
- Since 75 per cent of the total sales portfolio of these companies is estimated to involve the MFI channel, any pilot should consider a role for MFIs in the final design.
- Since most companies are operating in electrified areas, where there is consumer demand for such products, a pilot should consider the same areas since the use of kerosene is less justified in electrified areas.

This report finds that the Indian off-grid market has operations that can match rural and urban households' aspirations for affordable but higher-quality energy consumption. The report finds that national energy plans support a transition toward off-grid alternatives. The report also identifies that the Indian solar pico PV market has several international and domestic companies offering products with international certifications at competitive prices. These companies have a range of business models that are growing strong solar distribution chains. This combined with consumer finance delivered through either their own sales channels or local partners, like MFIs, banks or other NGOs, is increasing access for households. Several of these companies are operating in rural areas where a large percentage of households unconnected to the grid is located. Overall, the report identifies that the Indian solar market is becoming more accessible and economical for poor households—yet support for the off-grid market in India is in isolated pockets. A consolidated government push for a swap policy can enable households to organically transition toward renewable systems.

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Annex 1: Subsidized Kerosene Allocation and Expenditure

In India, kerosene[14] is primarily used as a household fuel for lighting and cooking, with additional uses in industrial processes and as a fuel for generators, pumpsets, freight and passenger vehicles, and agricultural machinery. Subsidized kerosene—also known as Public Distribution System (PDS) kerosene—constitutes the large majority of total kerosene consumed and is provided to households through a nationwide system of Fair Price Shops.[15] It is through these PDS shops that the central and state governments distribute subsidized food, kerosene and other commodities on the basis of ration card allocations.[16]

The current system of kerosene subsidies dates from the formal dismantling of the Administered Price Mechanism in 2002 and the institution of the PDS Kerosene and Domestic LPG Subsidy Scheme (2002), which was intended to provide a fixed per-unit budgetary subsidy that would be gradually reduced as part of a transition to a fully market-determined pricing system (Ministry of Petroleum and Natural Gas [MoPNG], 2003). However, despite some initial steps to reduce the on-budget unit subsidy,[17] the government continued to prevent the state-owned Oil Marketing Companies (OMCs)[18]—which have an effective monopoly on the supply of PDS kerosene—from revising PDS kerosene prices to reflect the cost of supply, leading to rising under-recoveries (defined as the difference between the desired market price and the price realized upon sale to the final consumer). These under-recoveries were then financed on an ad hoc basis through several mechanisms, including direct budgetary transfers to the companies, the issue of government-backed oil bonds, and as losses carried on the balance sheets of the OMCs and other state-owned energy companies.[19]

Unlike the other major "sensitive" fuel products in India (petrol, diesel and liquefied petroleum gas [LPG]) that have been subject to administrative price determination,[20] the central government controls both the price and the volume of PDS kerosene. From June 2011 to June 2016, both the current and previous governments pursued a policy of progressively reducing the total allocation of PDS kerosene provided to states, while leaving the nominal retail price unchanged. These reductions, combined with a rapid fall in international prices (and therefore the government's increased ability to finance a greater percentage of total under-recoveries), led to the effective cessation of the previous burden-sharing arrangement and the exemption of public sector energy companies from sharing the cost of under-recoveries from the third quarter of fiscal year (FY) 2015/16 onward (Rajya Sabha, 2017).

[14] Also referred to as superior kerosene oil.

[15] Commonly known as "ration shops."

[16] Note that PDS entitlement criteria and allocations differ by state.

[17] The fixed subsidy, initially set at INR 2.45 per litre in FY 2012/13, was reduced by one third in FY 2003/04 and FY 2004/05 (to INR 1.65 per litre and INR 0.82 per litre respectively), and retained at INR 0.82 per litre until its formal discontinuation in FY 2014/15.

[18] Oil Corporation Limited (OCL), Bharat Petroleum Corporation Limited (BPCL) and Hindustan Petroleum Corporation Limited (HPCL)

[19] Primarily Oil and Natural Gas Company Limited (ONGC), and to a lesser extent Oil India Limited (OIL) and Gas Authority of India Limited (GAIL).

[20] Petrol prices were formally decontrolled in 2011, and diesel prices were formally decontrolled in 2014. The price of household LPG continues to be administratively determined for all eligible households.

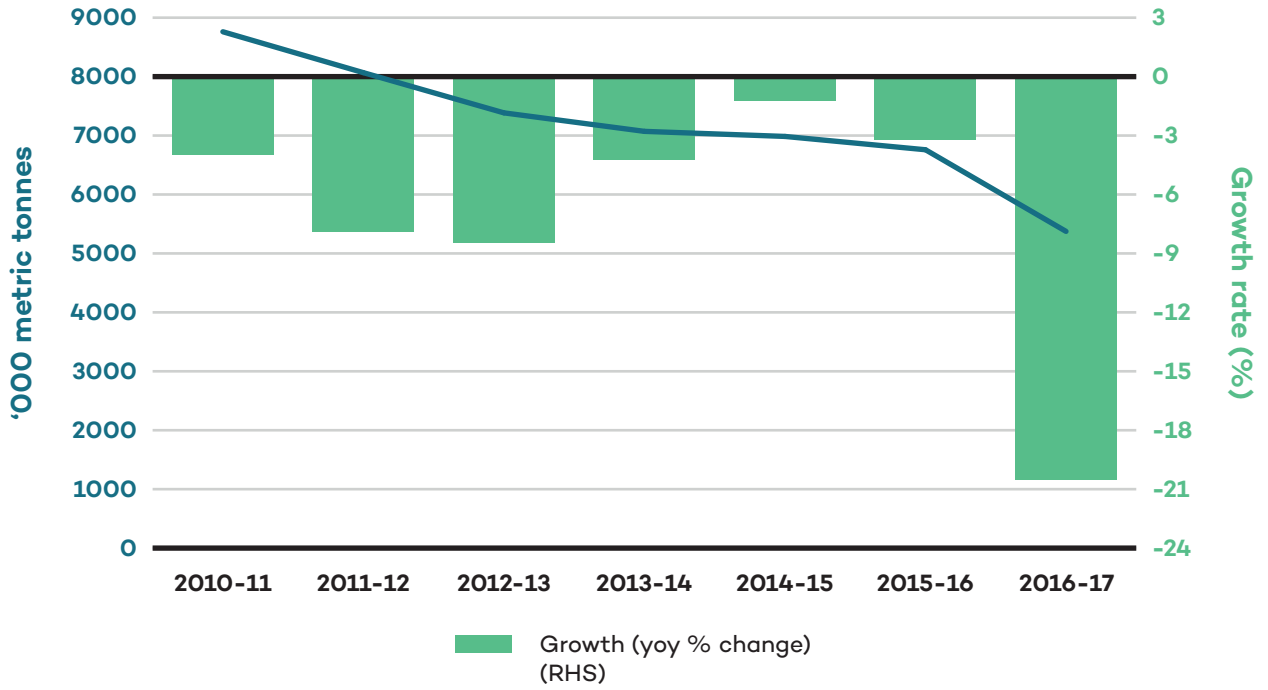

Figure A1. Total PDS kerosene allocation between FY 2010/11 and FT 2016/17

Source: MoPNG, 2016a; Rajya Sabha, 2015; Government of India, 2013

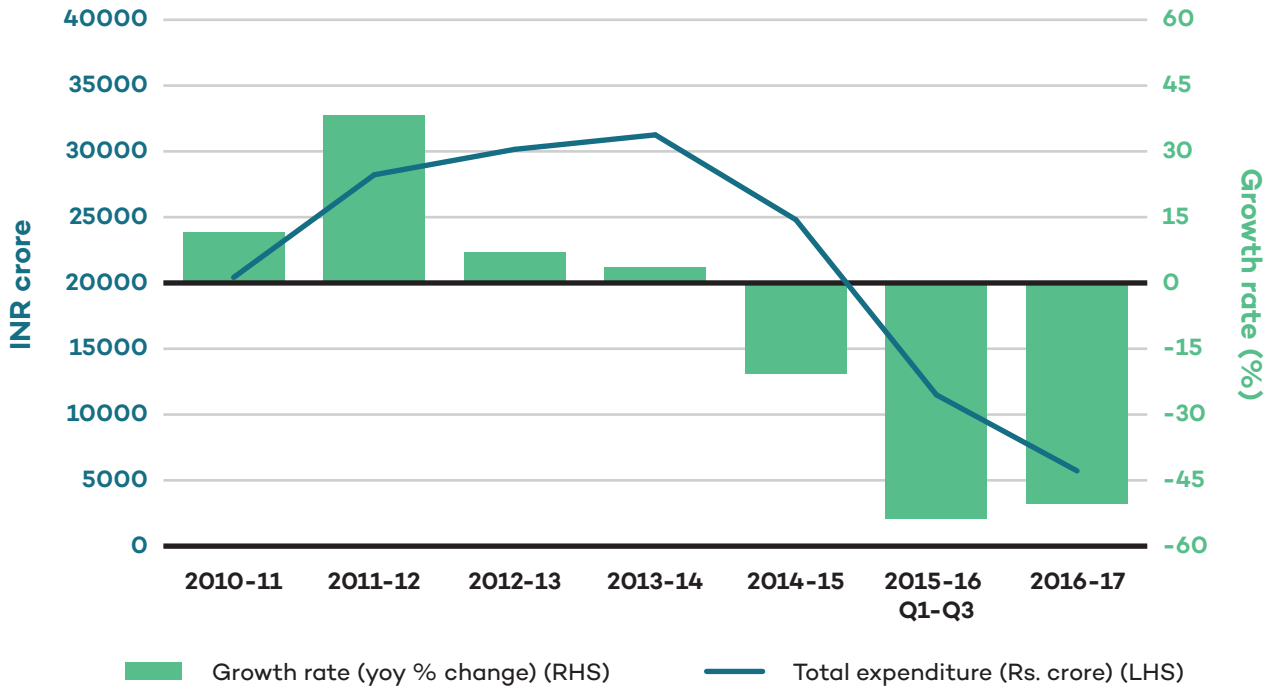

Figure A2. Total PDS kerosene subsidy expenditure between FY 2010/11 and FY 2016/17

Source: MoPNG, 2016b, 2016d, 2017a

In addition to reductions in the volume of PDS kerosene supplied, in June 2016 the government began the first of a series of price reforms, directing the OMCs (without any formal public announcement) to increase the retail price of subsidized kerosene by INR 0.25 per litre (less than USD 0.01) from July 1, 2016 (equivalent

to approximately 1.9 per cent of the per-litre subsidy for July 2016). In August 2016 the MoPNG formally confirmed (in response to a parliamentary question) that it intended to allow the OMCs to raise the price of subsidized kerosene by INR 0.25 per litre every month for a period of 10 months from July 1, 2016 (Rajya Sabha. 2016a). The government stated that these price increases represented the delayed implementation of a decision taken in 2010 (under the previous United Progressive Alliance administration) to increase kerosene prices periodically "in line with the growth in per capita agricultural GDP at nominal price [sic]," and that the pending price increase (calculated at INR 3.23 [USD 0.05] per litre) would be implemented in a staged manner in order to reduce the impact on consumers. In September 2016 the government increased the rate of INR 0.25 per litre price increases to once every fortnight. In November 2016, in response to a parliamentary question, the MoPNG confirmed the revised schedule of kerosene price increases, stating that the retail price would increase by INR 0.25 per litre per fortnight from September 1, 2016 until January 1, 2017, with a further increase of INR 0.23 per litre on February 1, 2017 (Rajya Sabha, 2016b).

Figure A3 shows the phased increases to kerosene prices implemented from June 2016 onwards, and the cumulative reduction in total PDS kerosene expenditure. It also shows actual retail prices against total avoided expenditure (with the latter calculated using announced, rather than actual, price increase schedules, and provided on a fortnightly basis).[21]

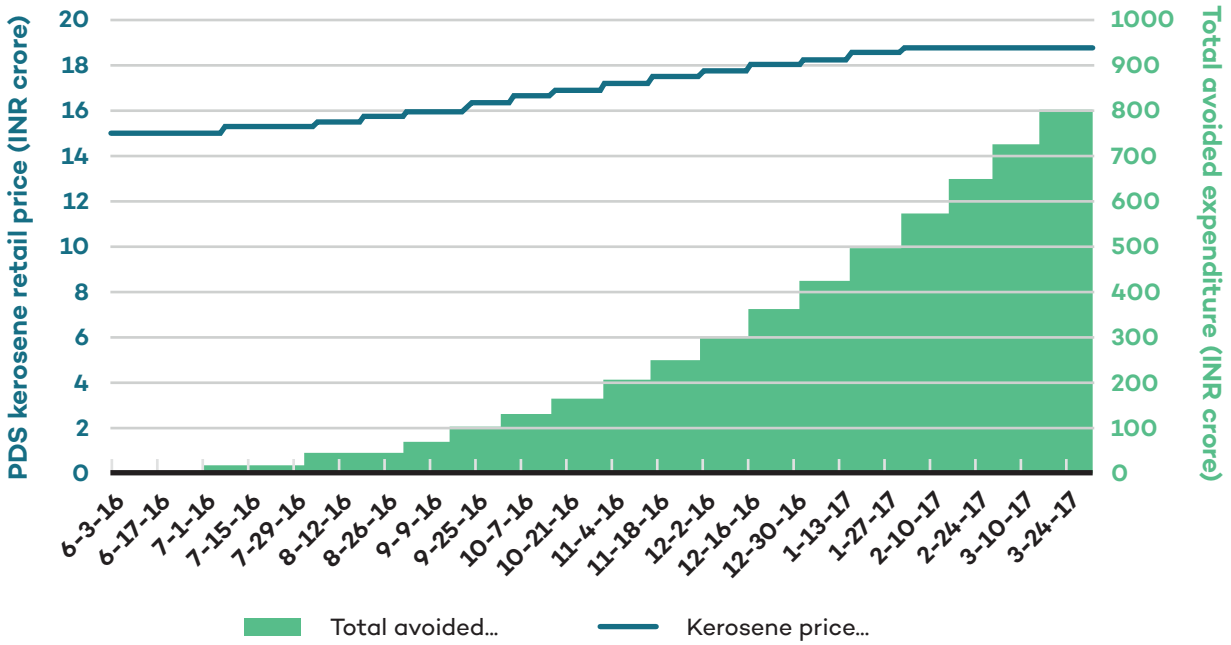

Figure A3. Kerosene price increases and total avoided expenditure (June 2016–March 2017)

Source: MoPNG, 2017d

[21] Total avoided expenditure figures do not therefore correspond exactly with recorded retail price increases (as provided for the benchmark Mumbai rate) with regard to either value or timing.

IISD Head Office

111 Lombard Avenue, Suite 325
Winnipeg, Manitoba
Canada R3B 0T4

Tel: +1 (204) 958-7700
Website: www.iisd.org
Twitter: @IISD_news

Global Subsidies Initiative

International Environment House 2
9 chemin de Balexert, 1219 Châtelaine
Geneva, Switzerland

Tel: +41 22 917-8683
Website: www.iisd.org/gsi
Twitter: @globalsubsidies

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