



Peering into the future

India and the distributed standalone solar products market

At a glance: report highlights

- India is the world's single largest market for portable lanterns, and even though there is a trend towards electrification across the country, there is still potential for a range of other products as well.
- India represented over 30% of the global volume share of sales in the first half of 2018 for distributed standalone solar products sector – as reported in the H1 Global Off-Grid Solar Market Report published by GOGLA and the World Bank Group's Lighting Global program.
- The Indian market is made up of two distinct components: the **private player driven market** (enterprises developing consumer-led business models) and the **government-driven market** (subsidy programs and driving economies of scale).
- The private player driven market has enabled the sector to advance lanterns into the mainstream. The overall private player driven market is estimated to grow by two to three times to reach INR 16,468 million (USD 206 million) to INR 26,178 million (USD 327 million) by 2023. Most of the future sales are estimated to come from lanterns with additional services (like mobile charging, radio, etc.) and solar home systems. Increasing incomes and greater energy demand are amongst key drivers.
- Solar home systems, particularly with higher wattages (ranging from 100 Wp to 400 Wp) are expected to increase. The growth will come mainly in the states of Jammu and Kashmir, Chhattisgarh, Jharkhand, Arunachal Pradesh, Uttar Pradesh, Bihar and Mizoram where there is increased electrification but outages are likely to remain for the next few years.
- The Indian government has shifted its focus towards the solar pumping segment. This segment received a fillip in March 2018 with the announcement of the KUSUM scheme wherein a key component is to set-up 1.75 million off-grid solar pumps by 2022: nearly ten times the number of current installed pumps.
- A few levers will be key in realizing the potential. Among them are **strengthening distribution for an expanded product range and specialized segment-specific financing**, where some specialized players are emerging.
- There are a number of factors that could change the dynamics within the sector, including 24/7 electrification programs reaching all parts of India, DC-AC hybrid infrastructure getting traction and blockchains.

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Methodology of the study

Segments that constitute the distributed standalone solar products sector

This report examines the following segments that constitute the distributed standalone solar products sector. The products have been mapped to the consumer needs they meet in under-electrified and un-electrified regions of India.

Products	Power consumption	Needs met	Price range (INR)	Price range (USD)
Developed markets/ segments				
Basic lanterns	0-1.49 Wp	<ul style="list-style-type: none"> • Basic lighting • Back-up source of light 	300-700	5-10
Lanterns with additional services (like mobile charging, radio, etc.)	1.5-2.99 Wp	<ul style="list-style-type: none"> • Connectivity* • Back-up light • Entertainment*** 	900-2,500	13-37
Multi-light systems with charger (MLS)	3- 10.99 Wp	<ul style="list-style-type: none"> • Connectivity* • Basic lighting • Back-up source of light 	5,000-6,000	75-90
Solar Home Systems (SHS) and devices (e.g. TVs, Fans)	11- 100 Wp	<ul style="list-style-type: none"> • Basic lighting • Back-up source of light • Personal cooling** • Entertainment*** 	10,000-30,000	150-450
Solar Home Systems (SHS) provided in government schemes	100-300 Wp	<ul style="list-style-type: none"> • Main source of lighting • Connectivity* • Personal cooling** • Entertainment*** 	20,000+	300
Solar pumps	2k Wp	<ul style="list-style-type: none"> • Drinking water and irrigation 	230,000-500,000	3,400-7,460
Emerging segments				
DC Fans	11-20.99 Wp	<ul style="list-style-type: none"> • Personal cooling 	1,500-4,000	23-60
DC Televisions	11-20.99 Wp	<ul style="list-style-type: none"> • Entertainment 	15,000-20,000	224-300
DC Refrigerators	50- 99.99 Wp	<ul style="list-style-type: none"> • Food cooling 	6,000-12,000	90-180
Solar DC deep freezers	100 Wp+	<ul style="list-style-type: none"> • Medicines and food storage 	40,000	600

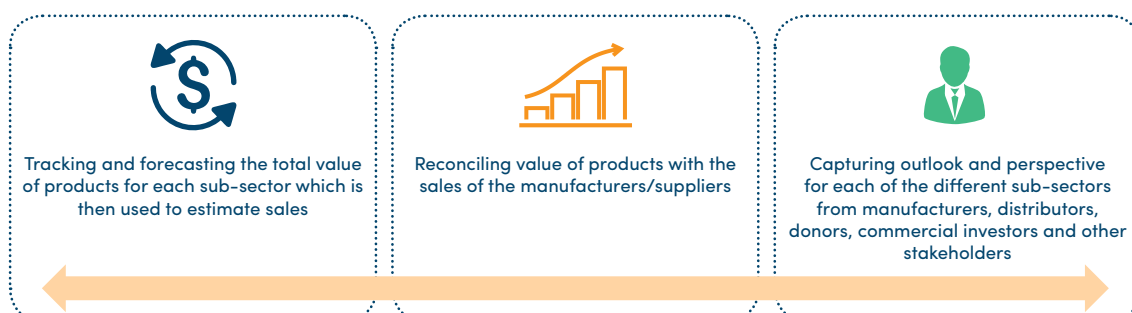
* Charger is used mainly for mobile phones, which connects different people

** Fans used for cooling

*** Television or radio

Approach taken: creating a cash flow model of the sector

Figure 1: Methodology overview



cKinetics constructed a bottom-up cash-flow model of the distributed standalone solar product sector that captures the present sales. This was combined with the outlook of the different players, and the cash-flow forecasts. That in-turn helped create a bottom-up view of the market for 2023.

The study has used both primary and secondary research to capture opinions of various stakeholders and estimate the future of the distributed standalone solar product market in India. A total of 53 stakeholders have been interviewed. These includes manufacturers, suppliers and distributors, market catalysts, MFIs, CSR departments, NGOs and investors. Of these, 22 are manufacturers/ assemblers, eight are investors/ lenders, and a remaining share formed of other stakeholders.

Validation with the top-down estimates of demand potential

In addition to the above, a top-down demand potential was estimated based on:

1. Expected trend of electrification (based on peak deficit and hours of supply) over the next few years
2. State-wise income of households in rural areas on electricity across different income deciles (10%, 20% and so on) and estimating affordability

3. Replacement demand

The forecast assumes that (a) outages from the grid will reduce over the next five years and (b) incomes will rise. Correspondingly the following will happen:

1. Some consumers will move up the energy ladder and graduate to higher-capacity devices
2. Some consumers will move out of the market

Based on these factors the demand potential was estimated for the different states and for different product types. These top-down demand potential estimates were compared with the bottom-up cash-flow forecasts.

Currency across periods

This study captures the value of the market in Indian Rupees (INR) and US Dollars (USD). For the present sales, the conversion between USD and INR has been taken as 1 USD = 67 INR (average across 2018). For the forecast in 2023, the conversion between USD and INR has been assumed at 1 USD = 80 INR.

Abbreviations

Term	Definition
AC	Alternating Current
BLDC	Brushless Direct Current
BPL	Below Poverty Line
CSR	Corporate Social Responsibility
DC	Direct Current
EESL	Energy Efficiency Services Limited
GoI	Government of India
HP	Horse Power
IFC	International Finance Corporation
IIT	Indian Institute of Technology
ISA	International Solar Alliance
JREDA	Jharkhand Renewable Energy Development Agency
kWh	Kilowatt hour
LED	Light emitting diode
MLS	Multi-light systems
MFI	Micro-finance Institution
MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
MPCE	Monthly per-capita expenditure
NGO	Non-government organisation
NSSO	National Sample Survey Office
SHS	Solar home system
SNA	State Nodal Agency
UPNEDA	Uttar Pradesh Non-conventional energy development agency
Wp	Watt (peak)



Outlook for the distributed standalone solar products market in India

India represented over 30% of the global volume share, and revenue share, for the distributed standalone solar products sector in the first half of 2018 (as reported in the H1 2018 Global Off-Grid Solar Market Report¹). It remains the world's single largest market for portable lanterns, while continuing to hold potential for a range of other products too despite there being a thrust towards electrification.

Figure 2: Comparative revenue of the standalone solar products by country



Source: GOGLA H1 Global off-grid solar market report²

The market in India consists of two distinct components: (a) **the private player driven market** and (b) **the government driven market**. The private player-driven market consists of an ecosystem of enterprises that have developed consumer-led business models for their products. The government-driven market consists of (a) subsidy programs and (b) programs where the government is a customer.

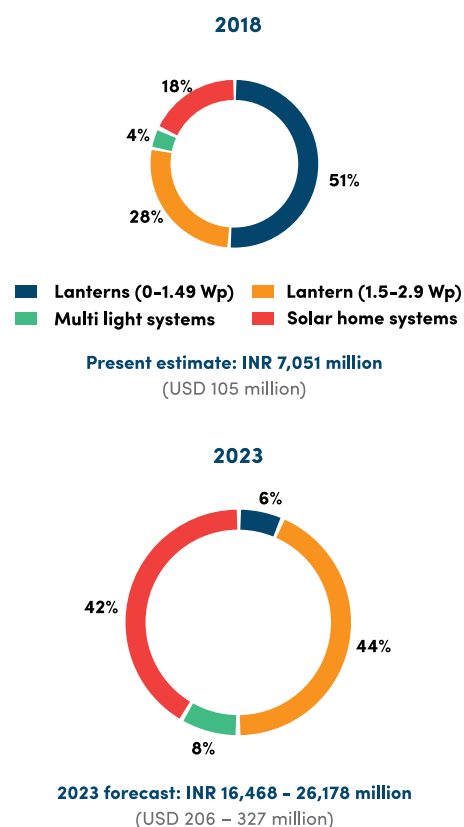
Private player driven market

Over the last 10 years, the private player driven market has successfully grown its user base. In the lanterns segment, the sector has been able to move beyond the early adopters of the product to the mainstream.

It has been able to establish customer relationships and develop distribution channels. Even in the midst of decreasing prices (due to reduced component costs and economies of scale), revenues have grown i.e. sales increases have outpaced price reductions.

The private player driven market, which is presently estimated to be worth INR 7,051 million (USD 105 million), is expected to continue growing and reach between INR 16,468 million and INR 26,178 million by 2023, that is USD 206 million and USD 327 million respectively.

Figure 3: Present and forecasted private player driven market



¹ https://www.gogla.org/sites/default/files/resource_docs/global_off-grid_solar_market_report_h1_2018-opt.pdf

² ibid

Basic lanterns reaching saturation and new segments growing

Most of the future sales are estimated to come from lanterns with additional services (like mobile charging, radio, etc.) and solar home systems. Consumers in the lower income brackets in rural areas with intermittent electricity are expected to transition from basic lanterns to larger lanterns (1.5–2.9 Wp) and multi-light systems (MLS) as incomes and energy consumption rise. Increasing penetration of smart phones with data plans is leading to greater charging needs (and need for devices with higher charging capacity) and is accelerating this transition.

Table 1: Private sector driven market (annual sales) based on the model developed for the study

	2018	2023
	Units estimated	Range of units estimated
Lanterns (0-1.49 Wp)	6.2 million	2 - 2.7 million
Lanterns (1.5-2.9 Wp)	1 million	3.1 - 3.8 million
MLS	53,000	200,452 - 312,692
SHS (100 Wp) including DC fans	39,903	100,803 - 112,901
SHS (200-300 Wp) including DC fans and DC TVs	8,042	55,226 - 154, 634
SHS (400 Wp) including DC fans, DC TVs and DC refrigerators	3,889	26,708 - 53,416
DC Fans	16,209	87,417 - 130,400

Source: cKinetics model developed for the study

Solar home systems, particularly with higher wattages (ranging from 100 Wp to 400 Wp) will emerge as back-up systems in rural areas with intermittent supply of electricity. The systems will do well in areas where electricity availability is likely to be less than 18-19 hours a day³, particularly during evening hours. SHS is also likely to be seen as an alternative to grid in several areas, assuming the DC-AC hybrid architecture emerges.

The growth will come mainly in the states of Jammu and Kashmir, Chhattisgarh, Jharkhand, Arunachal Pradesh, Uttar Pradesh, Bihar and Mizoram where there is increased electrification but outages are likely to remain for the next few years.

In addition, the companies in the private driven market are now beginning to provide a range of energy efficient DC appliances which are compatible with the design of solar home systems. These appliances include DC fans, DC televisions and DC refrigerators, which are likely to witness an increase in demand as the base of solar home systems expands (driven both by the private sector market and the government driven SHS programs).

Factors driving demand

Mid-income populations in grid-connected areas but with unreliable electricity

In 2017, the government of India launched Saubhagya (Sahaj Bijli Har Ghar Yojana)⁴: a scheme with an aim to provide 100% household electrification by December 2018. However, even as the scheme is being implemented, the pathway for 24x7 electricity remains unclear. Based on data reported by power distribution companies, the aggregate technical and commercial (AT&C) losses continue to be high, leading to unpredictability on when the goal (of 24x7 power) might be met⁵. In essence, while the electricity connections are being provided to the households, there continues to be losses in the distribution infrastructure during supply of power, which may in turn result in fluctuation at the household level.

At the same time, with enhanced household level electrification, several areas in states such as Uttar Pradesh have actually reported deterioration in quality of power supply (in voltage terms) as also hours of supply remain between 14 to 18, depending on the area⁶. These areas continue to present opportunities for distributed standalone solar solutions including solar appliances (television, fans, refrigerator, etc.), lighting devices and solar home systems. The Prayas ESMI data also indicates that only 11% of rural areas across 66 locations in 23 states receive five hours of evening supply from 5 pm to 11 pm.⁷

³ In rural areas where electricity is available for more than 18 hours a day, inverter solutions will come in as they will be competitive vis-à-vis solar home systems

⁴ <http://saubhagya.gov.in/>

⁵ AT&C losses is an important indicator outlining the health of the distribution company. These losses remain high and much below the goal mandated by UDAY scheme of the government. The UDAY portal (<https://www.uday.gov.in>) accessed in Nov 2018 data shows that the average AT&C losses, that should be 15% for all the participating states is at 25%

⁶ Reported from cKinetics data and field surveys from Q3 and Q4 2018

⁷ https://www.watchyourpower.org/location_map.php

Electrification is leading to increased demand

Nine interviewees (assemblers and sector experts) engaged as a part of this study⁸ thought that increased electrification is actually generating demand for distributed standalone solar products. As rural consumers get introduced to some of the benefits of electricity, they are willing to invest in alternative appliances that function when there are power outages.

Consumers in remote and unelectrified areas

When distributed standalone solar products were introduced, they initially targeted regions where there was no electricity. Over the last 10 years, the government has increased its thrust towards electrification under the DDUGJY⁹ and Saubhagya schemes. Within these schemes, there are 2,590 villages in India that have been identified as remote and are planned to be addressed only through distributed standalone solar products and solutions.

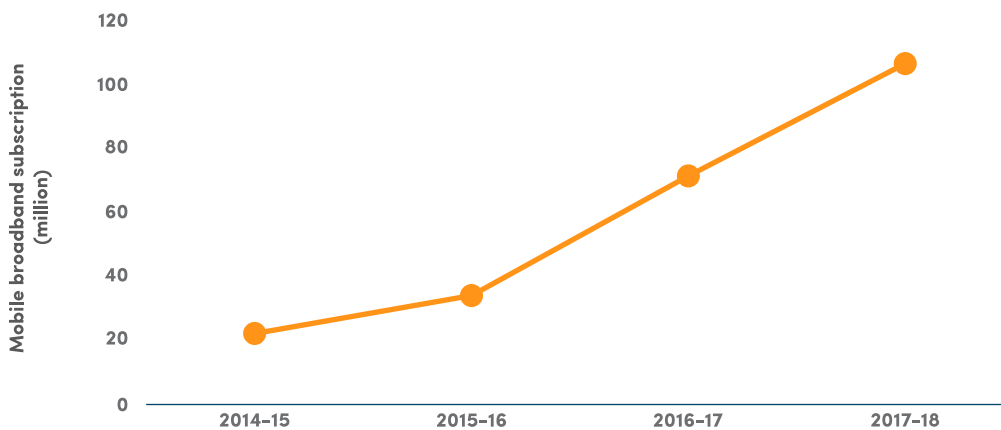
A recent survey from CEEW across six states of Uttar Pradesh, Bihar, Jharkhand, Odisha, Madhya Pradesh

and West Bengal revealed that unelectrified households have a willingness to pay INR 100 (USD 1.5) per month for electrification¹⁰. Thus, this segment represents a potential demand for distributed standalone solar products to be sold through commercial routes.

Mobiles charging needs

In the last decade, the mobile growth story has shaped rural India. It continues to do so as users move beyond basic connectivity to using smart-phones and consume media as well as other services on the Internet. Smart phones are increasingly getting used in rural India, which requires more power consumption. The total broadband subscriptions in rural areas in India has increased by 71% between 2014-15 and 2017-18. Four interviewees (manufacturers and MFIs) shared that lanterns are increasingly being used for charging mobile phones and as the phone power demands have gone up on account of increased phone battery sizes. As a result, the wattage of the lanterns is being scaled up to keep pace.

Figure 4: Year-wise mobile broadband subscriptions in rural areas in India during 2014-18 (million)



Source: Department of Telecommunications¹¹

⁸ The study engaged 50+ stakeholders and the methodology is outlined at the end of this document

⁹ Deendayal Upadhyaya Grameen Viduyutikaran Yojana (evolved from the Rajiv Gandhi Grameen Viduyutikaran Yojana – RGGVY scheme)

¹⁰ Access to clean cooking energy and electricity- https://www.ceew.in/sites/default/files/CEEW_Access_to_Clean_Cooking_Energy_and_Electricity_Survey_of_States_Report_30Nov18.pdf

¹¹ <http://dot.gov.in/sites/default/files/statistical%20Bulletin-2018.pdf>

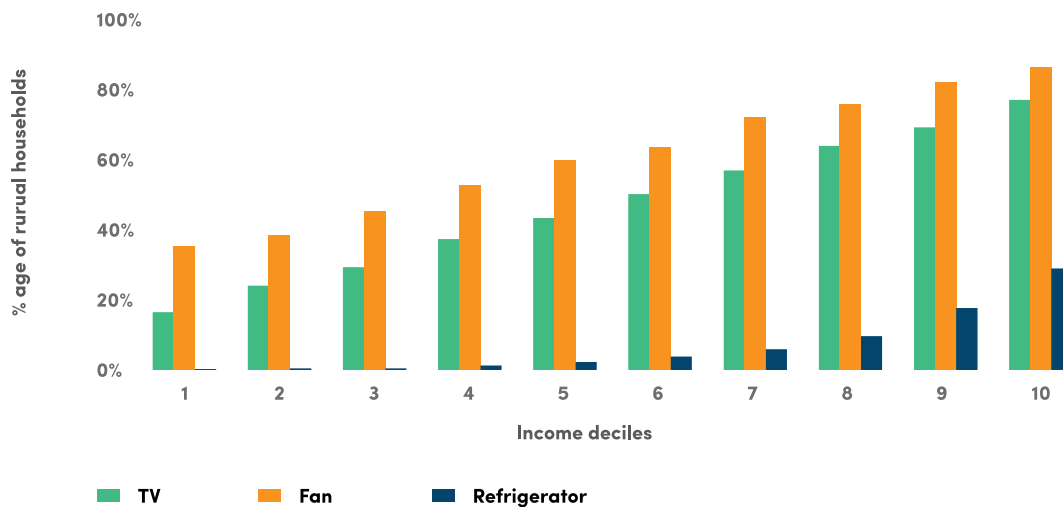
Aspirations rising with increasing income

All this while income levels in rural areas, both in the heartland of the country and peri-urban areas have been rising. The annual per capita income (at constant 2011-12 prices) in rural areas has observed an increase from INR 40,772 in (2011-12) to an estimated INR 52,829 in 2017-18¹². The rise in income brings with it an increased aspiration for goods that enable personal

cooling (fans), provide cooling for food (refrigerators) and provide entertainment (television). Figure 5 outlines how ownership of some key appliances varies with income levels in rural areas. There is a potential to target the mid-deciles with solar powered systems and devices.

Demand from these consumers is also being stimulated by increased electrification

Figure 5: Appliances penetration in rural India across income deciles



Source: Household Consumption of Various Goods and Services in India, NSSO 66th Round

One of the leading indicators of future growth is the increasing product variety

When any sector emerges, its product or service offerings are limited. As the sector grows, the number of products or service offerings increase. One can see examples in sectors ranging from mobile telephone to laundry detergent to clothing to restaurants. An increase in the number of offerings is an indicator of the sophistication of a sector – **the more choice offered, the more mature the sector**. Moreover, the increase in choice is usually co-related with the growth of a sector (correspondingly, when growth of choice of products stagnates, the sector also stabilizes). **Number of choices also indicates the outlook and confidence of the producer (of a products or service) as well as the level of interest of the consumer**

included the different models as well as the different colors that they come in.

Lanterns which were originally provided only to cater for lighting needs have now evolved to include multiple features such as illumination control, and battery performance.

Historically basic lanterns (0-1.49 Wp) have seen most growth in the number of variants, and have also witnessed the maximum number of sales¹³. However, the rate of increase in product variety in this category appears to be slowing. This also corresponds with the outlook for the segment where sales are expected to flatten and then decline. Hence manufacturers do not seem to be focusing too much on this sub-category.

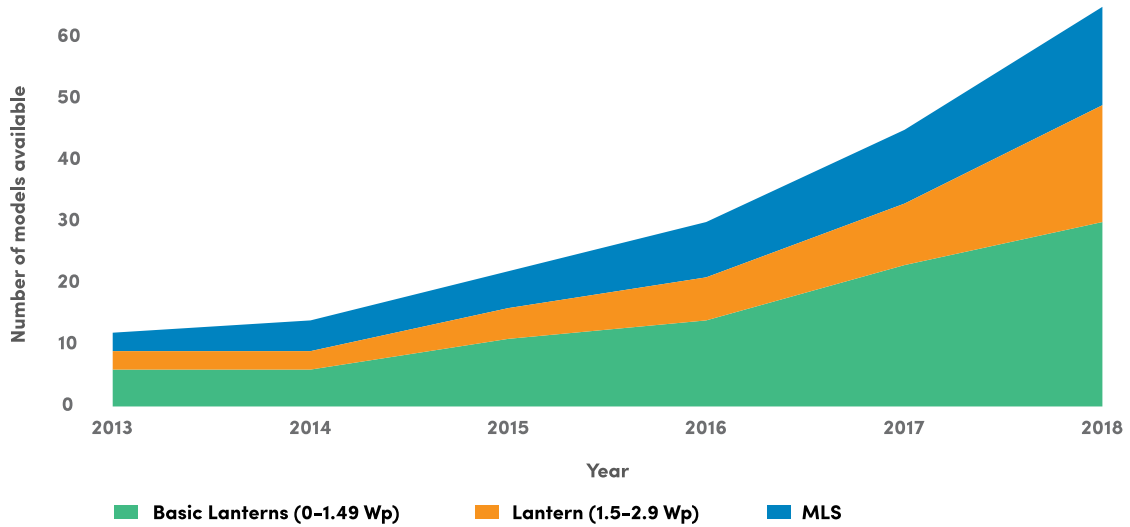
As far as solar lanterns are concerned, the study tracked the number of product variants of 11 manufacturers/assemblers over time (Figure 6). Product variants

Over the last two to three years, lanterns (1.5-2.9 Wp) (having chargers or inbuilt radios) have emerged with growth expected to continue. Multi-light systems

¹² Data compiled from <http://www.esopb.gov.in/Static/PDF/GSDP/Statewise-Data/StateWiseData.pdf> and cKinetics analysis

¹³ To help put these numbers in context, the fan market in India has approx. 600 product variants being offered by the top 7 players, and the refrigerator market has approx. 400 variants by the top 5 players.

Figure 6: Variants of lighting products (2013–2018)



Source: cKinetics analysis of 11 manufacturers, data extracted from various portals

have also been emerging as ‘entry-level’ SHS, and are particularly well-positioned to meet the needs of individual rural households as well as small shops in rural and semi-urban areas.

Confluence or competition with the mainstream consumer durables market?

The dynamics of the private player market are also evolving. With increased electrification, almost every major appliance manufacturer in India is also extending (or looking to extend) its product range to cater to rural areas. Mainstream players such as Bajaj Electricals, Crompton Greaves, V-guard, and Havells have shared goals and plans in their public filings to cater to households that have become electrified (but may continue to have intermittent supply).

As per the study analysis, the distributed standalone solar products market excluding government driven sales is presently at INR 7,051 billion (USD 105 million); about 0.5% of the approx. INR 1.4 trillion (USD 20 billion) overall consumer durables market¹⁴.

The next few years could see an increasing number of companies competing for the rural consumer who has just been electrified (and quite likely to be receiving intermittent electricity). In order to capture this market, private players will have to focus on product differentiation, which will be driven through product design, brand building, distribution channel capabilities and financing (for the distribution channel as well as for end users). This is especially on account of transition from B2B to B2C market, particularly for the SHS segment.



Photograph credit: Simpa Networks

¹⁴ IBEF Consumer Durables Report Jan 2018

Government driven market

The Indian government has shifted its focus towards the solar pumping segment. This segment received a fillip in March 2018 with the announcement of KUSUM (Kisan Urja Suraksha Utthaan Maha Abhiyaan) scheme wherein a key component of the scheme includes an outlay of INR 220 billion (USD 3.3 billion) to set-up 1.75 million off-grid solar pumps by 2022 (planned), that is nearly 10 times the number of current installed pumps (177,000) installed.

As of January 2019, the scheme is awaiting final budgetary approval of the cabinet and is being looked at with a lot of interest by key stakeholders in the space

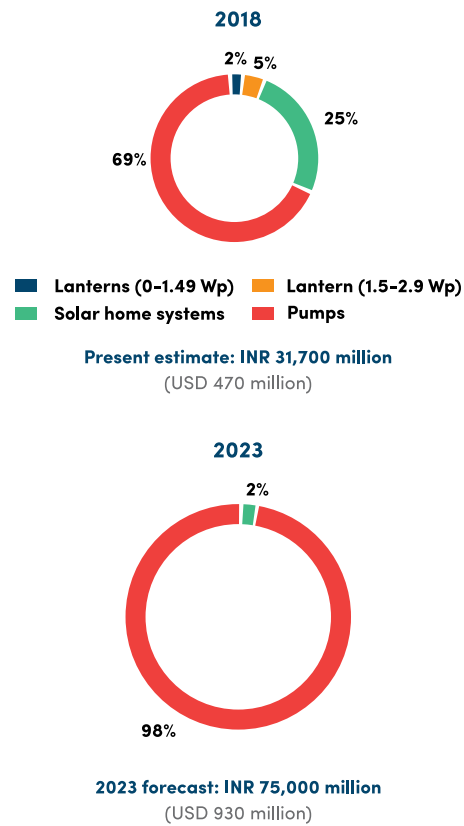
Given the volumes expected in KUSUM, the price of solar pumps is expected to fall in the next one to two years. This is because several established players in the mainstream pump sector are likely to enter the segment.

For other distributed solar lighting products (lanterns and solar home systems), the government driven market has crossed its peak size and will decrease over the next two to three years. The Indian government has stepped away from lanterns and the only current funding that remains is for the '70 Lakh Solar Study Lamp Scheme' which provides lighting for school children in remote rural communities¹⁵.

As far as solar home systems are concerned, the Indian government has pushed this model aggressively in the past 12 months to provide electrification in areas that would not be reached by the electric grid-unlike the private driven market, the government sales have exclusively targeted un-electrified regions. There is an allocation for about INR 170.74 billion (USD 2.5 billion) for 352,502 households under the government plans.

These subsidies are likely to be spent by 2020 (initially planned by 2018) and the systems will be owned by the households. As a consequence, there is a large near-term demand emerging from government-led schemes to distribute, install and service the solar home systems across 17 states. In future, large government programs around solar home systems seem unlikely. This sub-segment is likely to evolve and merge with the low capacity residential solar rooftop market.

Figure 7: Present and forecasted government driven market



¹⁵ 70 lakh solar study lamps is 7 million solar study lamps (70 lakh = 7 million). Details at <http://souls100.in/>

India as a possible global hub for design and manufacturing

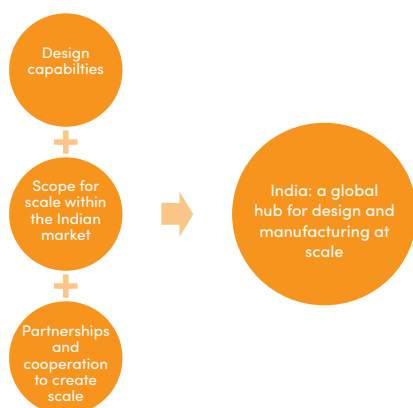
One could not have imagined 10 years ago that the price of solar-led renewable power would fall so rapidly in India¹⁶. One could also not have visualized five years ago that the prices of LEDs would crash¹⁷, correspondingly making LED bulbs commonly available. In both cases, the Indian government played a key role: serving as a large customer and driving economies of scale. In the latter case, this triggered establishment of a robust and diversified manufacturing base for LEDs in the country. Several private enterprises have emerged as a consequence of these opportunities.

Opportunity to breakdown silos to frame pathways for manufacturing at scale

Building on the above approach of riding on the wave of aggregated demand, the sector has three ingredients which are present in India for enabling the country to emerge as a competitive design and manufacturing hub: (1) design capabilities, (2) scope for scale within India for the products, and (3) Partnerships and cooperation to create scale. **Presently each of the three ingredients operate in silos.**

There is an opportunity to bring these together and to make India a global hub for design and manufacturing of standalone solar products. Building off India's existing strengths, the government needs to intensify efforts at harnessing the ecosystem. In particular, manufacturing focused competitive credit lines as also funding to industry for sustained R&D are key requisites to enable continuous upgradation of product features and efficiency which meet the global benchmarks. This needs to be strategically implemented with long-term commitment and accorded requisite priority.

Figure 8: Breaking silos: bringing together design, aggregation and local demand



In the recent KUSUM scheme, the government is looking to catalyze growth worth nearly 10 times the present installed base of 177,000 pumps over a four-five period. This will reduce the price and also increase capacities of players to provide more sophisticated pumps within India. India already has a strong manufacturing capability on the pumps front and this accords an opportunity to enhance solar manufacturing at scale, with distributed solar segment enabling the way. The same capabilities could then be leveraged in the global market.

The government of India is also working with the International Solar Alliance (ISA) to enable Indian players to engage with the global market.

The opportunity for private players is to explore ways of strengthening design capabilities and develop competencies to implement at scale, which could be deployed within India itself or extended to global markets.

Figure 9: Illustrative market seeding by the Indian government



Solar pumps

- ISA along with MNRE has recently selected Energy Efficiency Services Limited (EESL) to implement the global tender of 500,000 solar water pumping systems in its 15-20-member countries of the total 121 member nations. Of the total tender, India plans to acquire 100,000 pumps



Standalone solar lighting products

- The Government of India is attempting to provide up to 1.5 million solar lamps under a Line of credit to all ISA countries. Under the line-of-credit, 75% of the value will be sourced from India – effectively a mechanism to propel India based procurement/assembly
- Rajasthan Electronics and Instruments Limited has exported approximately 1500 distributed standalone solar solutions to Egypt through credit line from ISA

Source: Industry conversations and International Solar Alliance (ISA)

¹⁶ The National Solar Mission was announced in 2010 and in 10 years the tariff of power generated from solar power producers has fallen from nearly INR 18/ kWh to INR 2.44/ kWh

¹⁷ The Indian government sponsored EESL (Energy Efficiency Services Limited), has been able to successfully aggregate demand to buy LEDs in bulk and drive down price. LEDs which were sold at INR 400 per bulb in 2013, have recently been procured by EESL at INR 40: a 90% decline. EESL has now also started to procure LEDs in bulk for other countries e.g. UK, Malaysia, amongst others

Investment and financing needs over the coming years

Channel financing, working capital and end-user financing are key drivers for the sector. So far Microfinance Institutions (MFIs) have played a key role in the small-ticket-sized items to address product affordability by providing end-consumer financing. They are likely to continue to play a key role for lanterns and multi-light systems. Channel finance and working capital will play an equally important role as newer distribution channels develop.

The table below presents an overview of the capital

needs of key distributed standalone solar products segments.

Presently microfinance institutions (MFIs) and in some limited way, Regional Rural Banks (RRBs) have been a source of small-ticket consumer financing. However, with the scale-up and transition towards relatively larger ticket sizes, competitive and seamless consumer financing would be a core influencer. Dedicated financing institutions (with linkages to solution suppliers or to specialized distributors) are likely to emerge to tap into this opportunity.

Enterprise financing is beginning to emerge and is likely to play a key role (discussed later in this document).

Table 2: Financing needs of INR 78.5-93 billion (USD 0.98-1.1 billion) projected for the sector annually (in 2022)

	Lanterns and Multi-light Systems	Solar Home Systems (Private)	Solar Home Systems (Govt.)	Solar Pumps (Govt.)
Business model reliance on government subsidy	No	No	Yes	Yes
Enterprise financing				
Working capital financing	INR 2 – 3.1 billion (USD 25 – 39 million)	INR 1.1-2.6 billion (USD 14- 33 million)	INR 600 million (USD 9 million)	INR 28.9 billion (USD 432 million)
Asset financing	Not applicable	INR 2.3-5.3 billion (USD 29-67 million)	Not foreseen	INR 3.6 billion (USD 54 million)
Retail/end-consumer financing	INR 8 –12.5 billion (USD 100- 159 million)	INR 3.5 – 8.0 billion (USD 44 – 100 million)	INR 857 million (USD 13 million)	INR 27.4 billion (USD 410 million)

Source: cKinetics DRE sector model

Future demand for distributed standalone solar products

This study calculated the demand potential for distributed standalone solar products (excluding solar pump segment) from the following areas:

1. From grid connected areas where there is intermittent electricity
2. From areas that have been designated by the government to remain unelectrified/are remote

Grid connected areas with intermittent electricity

In five years, around 95% of the potential demand is expected to come from households that have intermittent electricity supply. The reducing grid outages are likely to affect the basic lantern market which is expected to shrink. On the other hand, grid electrification is expected to stimulate demand in other segments (given that the grid is likely to remain intermittent in selected pockets).

Areas that have been designated to remain unelectrified

Approximately two million households are presently officially designated as being off-grid. These areas are remote and the population in those areas are estimated to grow marginally over the next few years.

Location of the market

The map below outlines where the markets would be. The circles represent the states of India in which the demand will be located. The size of the circles represents the relative size of the demand. Green

circles represent areas where there are households that have been designated to be off-grid remote. They have been supplied electricity and lighting so far through standalone solar solutions under various government scheme. There is potential to cross-sell and up-sell to these households as they are likely to remain disconnected from the grid.

Blue circles represent states where grid is likely to continue to provide intermittent electricity over the next five years.

Circles that have blue and green represent states that have both kinds of households and the relative size of the pie of each color indicates the level of demand.

Figure 10: States in India likely to have demand for distributed standalone solar products in five years



● Intermittent electricity ● Off-grid

Realizing the potential

The industry is going through a transformation with the private player driven market growing in most device segments and the government shifting its focus towards solar pumps. A few levers are key to realizing the potential.

Realizing the optimism around solar home systems

63% of assemblers interviewed for the study believe that SHS has a role to play as a back-up system where electricity is intermittent (calculations indicate that they will be competitive vis-à-vis inverters where outages will be for more than five hours a day).

Several players (Cygni, Basil Energetics) have outlined plans of working in a scenario where DC and AC co-exist. One model is where hybrid AC-DC microcontrollers would allow a consumer to have DC devices and draw power from AC when AC is available; and operate on DC (powered by Solar and battery) at other times. Deployments that work in such a scenario are still few and consumers preference /confidence in DC products needs to be developed. In addition, standards need to be developed and harmonized to ensure that AC-DC hybrid architecture emerges in a resilient manner.

Strengthening distribution for an expanded product range

The sector's growth is linked to its ability to deliver an array of products to its customers across a larger price band, from INR 2,000 to INR 70,000 (USD 30 – USD 875), than what it has been doing thus far. The incumbents have an opportunity to further build on the brands they have developed, and on the relationships with the consumers they have won over the last decade. A key component to enable the growth potential is a distribution and after-sales support network, that can support a wider range of newer products.

Specialized distributors such as Frontier Markets, Dharma Life and Pollinate Energy are growing as channels for distributed standalone solar products. These organizations focus their efforts in certain geographies by creating networks that can sell/distribute products and by building deep customer relationships. Their models can become templates for specialized distribution networks in geographies where none exist.

Specialized segment-specific financing

The demand in the sector is slowly evolving from being primarily focused on lighting to other applications. As a result, the cash-flows of the firms will get altered accordingly. A specialized set of segment-aligned debt products for enterprise working capital and/or inventory financing is seen as a core need. Ideally the enterprises are seeking financing as a two to three-year term loan to ensure their working capital cycle is properly tied up.

A few specialized financiers have been evaluating (and funding) opportunities in the sector. Amongst them are cKers Finance (sustainable energy specialist) and Caspian (impact debt provider). In addition, financial institutions such as Maanaveeya, Bandhan Bank and ESAF (small finance bank) are also exploring additional opportunities in the segment. From within the mainstream banking sector, RBL Bank has attempted some lending programs in the space. As enterprises mature, more financiers (especially the small finance banks) are likely to lend to the sector.

Exploring models in the solar pumping segment

There are possibilities of the private sector to develop models in the solar pump segment, where a significant investment will flow in the next five years. These efforts are likely to align with the government priorities and hence touch-points between the two (private players and government) need to be coordinated.

Irrigation as a service

For the KUSUM scheme to meet its goals, financing is going to be a key component. In addition to the government subsidy of 60% of the system cost, banks are expected to provide 30% of the pump cost and farmers are expected to invest 10% from their own sources. However, most private banks and financiers have shied away from lending to the farming sector given the high risk. That is because farmer-loans have often been waived by the government in the past. Hence there is a potential for newer private-player driven irrigation-as-a-service models in providing water to farmers for irrigation. The charges in this model equate to a nominal fee of INR 70-100 per hour (lower than what is paid for diesel-generator powered pumping). Such models would be more affordable to the farmers as compared to making the large up-front payment for the ownership of solar pump (expected to be INR 30,000 i.e. USD 447).

Innovative ownership models emerge at scale for solar pumps

In addition, there is an opportunity with farmers that have small land holdings. There are a number of small agricultural holdings in India with a land area of less than two acres. These farmers do not need the large

capacity solar pumps. For these farmers, there is an opportunity to share the asset. Onergy Solar has so far deployed 500 solar irrigation pumps under 'Joint liability group' (JLG) model wherein a single pump is owned by a group of farmers. Such JLGs where subsidies are also passed on to the farmer, may emerge as a scalable model under the solar pumping segment.



Photograph credit: Simpa Networks

Things to watch out for

There are a few factors that may change the dynamics within the sector.

24x7 electricity reaches all parts of India

The operating landscape has been changing with the thrust towards 24x7 electrification. However, as outlined earlier, at present supply of power is still intermittent in several parts of India. At the same time, most of the players surveyed expect that the government would take longer to meet its electricity-intensification goals. Their investments and plans are based on that assumption. This study has also tried to evaluate the extent to which the potential market will change over the next five years. It is possible, that 24x7 electricity reaches all parts of India in the next 5 years and this market changes. At the same time, it is also possible that the government sees the private players as providing valuable solutions; and there are collaboration touch-points. One such potential collaboration is where distribution companies see investments in solar home systems as an avenue to avoid-cost¹⁸.

SHS and the residential rooftop solar segment become one

If power supply remains intermittent in many areas and five+ hours of outages remain common, then solar home systems would be a viable solution for many consumers. At the same time, if the installations of solar home systems increase then it is possible that they are seen by the government as a core solution to support their resilient electrification goal¹⁹. The government might then also promote SHS in areas that are grid-connected with intermittent electricity. In such a case, it is also possible that SHS may be allowed to get interconnected with the grid at smaller wattages (500W or 1 kW). Consequently, this will be seen as part of the residential rooftop solar market.

DC -AC hybrid infrastructure gets traction

One of the needs described earlier outlines how some firms are working on a DC-AC hybrid architecture. Should this approach get traction, then the way in which the consumer is engaged would alter. Consumers would not be faced with choices such as making an investment in a DC versus an AC appliance; or whether to have a solar home system versus inverter; etc. The sales pitch to the consumer would change as would the product economics.

India emerges as a global hub for design

Solar pumps, solar induction cookstoves, solar powered freezers are items with high capital expenditure today where there is a demand in India and prices can be driven down through design and bulk demand aggregation, which is also in line with government's Make in India initiative. The next few years will bring clarity on (a) how Indian assemblers and system integrators respond to the present requirements in India driven through government tenders, and (b) how the government engages with the International Solar Alliance country members. Indian government owned integrators such as REIL (Rajasthan Electronics and Instruments Limited) and CEL (Central Electronics Limited); as well as large B2G contractors could play a key role here.

Blockchain in the space

With solar becoming an attractive and resilient source of self-generation, the distributed deployments of systems (SHS and rooftops) can see unexpected but welcome scale leveraging block chain technologies. These are expected to provide a catalytic and disruptive effect by enabling newer peer to peer models to emerge - allowing owners of different systems to undertake exchange of electricity (operating over virtual 'micro-grids') thus creating a boost for the SHS as also other distributed systems.

¹⁸ Presently distribution companies lose money when they supply power in some of the remote/rural electrified areas

¹⁹ As outlined earlier in this document, the Solar home system was seen by the government as a quick solution to electrify 350,000 households under the Saubhagya scheme.



1 Policy landscape

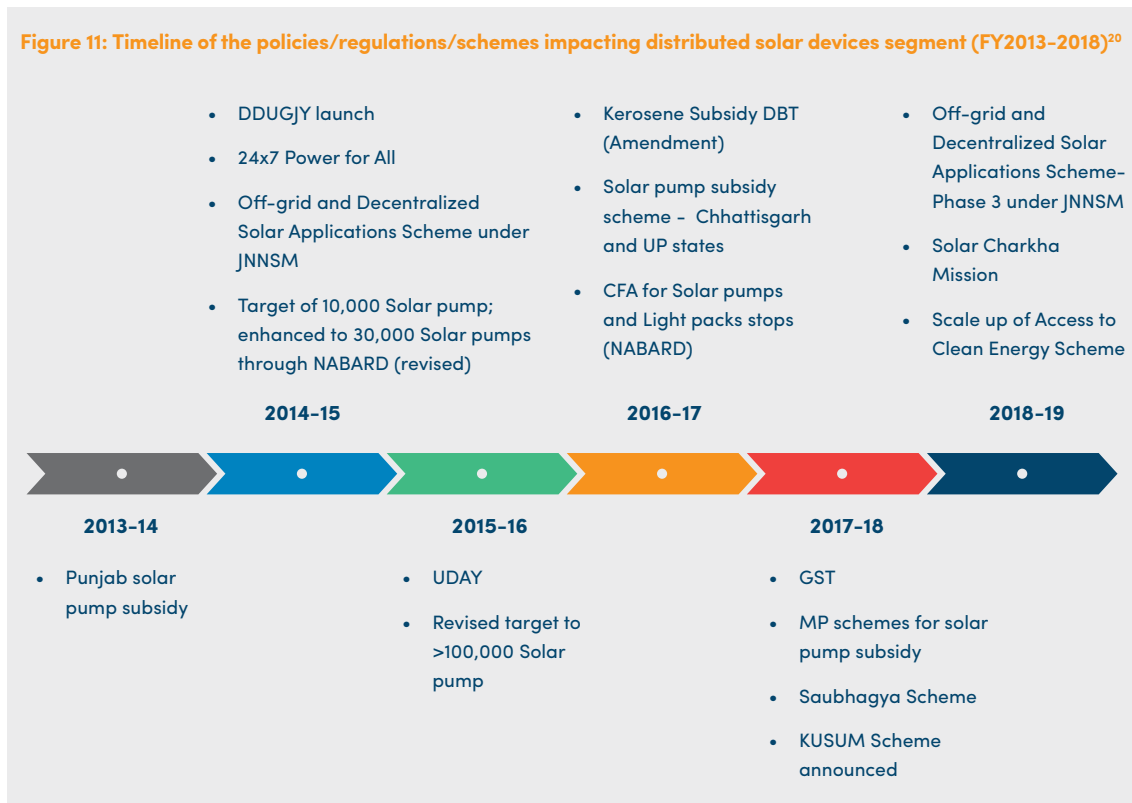
The solar sector in India has witnessed significant policy-level changes since 2010 which have had a direct and indirect impact on the distributed solar standalone segment.

During 2013-18, the policies aiming at rural electrification have become more granular with a shift from village electrification under Deen Dayal Upadhyaya Gram Jyoti Yojana (**DDUGJY**) to household electrification under **Saubhagya** (Pradhan Mantri Sahaj Bijli Har Ghar Yojana) scheme. Under Saubhagya (2017-

19), the government floated tenders for procurement of 0.35 million solar home systems and been the single largest customer in the sector for this period.

In addition, the government has looked at distributed solar energy solutions to support populations and those that are away from the grid. This has included supporting efforts through distributed standalone solar devices such as study lamps, home lighting systems, solar packs, etc.

Figure 11: Timeline of the policies/regulations/schemes impacting distributed solar devices segment (FY2013-2018)²⁰



1.1 Summary of key government initiatives influencing the market

This section outlines the following key actions / policies of the Indian government that are shaping the sector in the immediate term:

1. Saubhagya
2. KUSUM (solar pump scheme)
3. 70 Lakh solar lamp scheme (Solar Urja Lamps)
4. Goods and Services Tax

Saubhagya

The Saubhagya scheme was launched in October 2017 with the aim of providing 100% electrification to the 23.30 million unelectrified households in India and has been concluded as of December 31, 2018. Under the scheme, electricity connections are provided to the unelectrified households. These includes free connections to beneficiaries based on Socio Economic and Caste Census 2011 data and connections at a nominal amount of INR 500 (USD 7.5) to remaining households, which will be recovered by distribution companies through ten instalments. One portion of the scheme also sanctioned 0.35 million households to be electrified through 200-300 Wp standalone SPV systems²¹. All the systems are

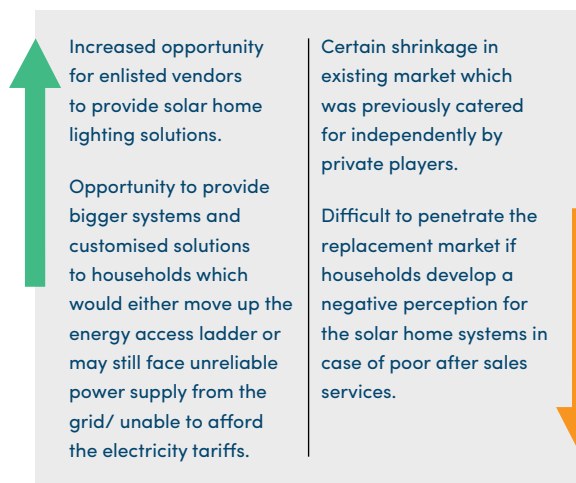
²⁰ Policies/regulations/schemes highlighted in blue have an indirect effect on the overall sector

²¹ Minutes of the 3rd monitoring committee on Saubhagya held on 07.06.2018

provided free of cost of the households. The project cost for providing these systems is INR 50,000 (USD 746) per household. Under the scheme, the suppliers are required to provide after-sales services and support for a period of five years. The orders for these SHS have been issued by the relevant state agency and the implementation is likely to be completed in the next 12 months.

While previous schemes, such as remote village electrification programme and DDUGJY, had the provision for home solar systems, these were limited to meeting only basic lighting requirements. Saubhagya, on the other hand, offers provisions for LED lights, lithium-ion batteries, DC fans and an optional provision for DC televisions as well, as part of the home lighting system. The scheme has allowed private players to provide energy access to households in remote and in-accessible areas through solar home systems via government support.. On the contrary however, it has led to scepticism amongst players regarding continued demand for these systems on completion of the programme. exclusively targeted un-electrified regions. There is an allocation for about INR 170.74 billion (USD 2.5 billion) for 352,502 households under the government plans.

Figure 12: Implication of the Saubhagya scheme for the private players



Source: Industry Interactions

KUSUM

The solar pump segment witnessed a significant push with the announcement of KUSUM (Kisan Urja Suraksha

Utthaan Maha Abhiyaan) during the 2018-19 budget. The scheme envisages a total capacity of 28,250 MW through four components which includes²²:

- Installation of 1.75 million stand-alone solar powered agriculture pumps with an aggregate capacity of 8,250 MW
- Solarization of 1 million grid-connected powered agriculture pumps with an aggregate capacity of 7,500 MW and
- Solarisation of 50,000 grid-connected tube-wells/ lift irrigation and drinking water projects of with an aggregate capacity of 2,500 MW.
- 10,000 MW of decentralised ground mounted grid connected solar power plants of intermediate capacity of 0.5-2 MW

The target of 1.75 million stand-alone solar pumps represents an increase of the current installed base of 0.17 million solar pumps by nearly ten times by 2021-22. Under the scheme, the central government and state government will each provide a subsidy of 30% on the capital cost, collectively aggregating to INR 220 billion (USD 3.3 billion). Meanwhile, for the remaining 40% of the amount, 30% is proposed to be financed by banks while 10% of the cost is to be borne by beneficiaries.

70 Lakh solar lamp scheme (Solar Urja Lamps)

One of the key flagship programmes supported by the government has been the 7 million Solar Study Lamp scheme which was launched by Ministry of New and Renewable Energy in December 2016. The scheme has been scaled up from the previous 'Million Solar Urja Lamp' program, which was implemented by Indian Institute of Technology (IIT) Bombay during 2014-16. The 7 million solar study lamp scheme aims to provide solar lamps to students in the rural areas of Assam, Bihar, Jharkhand, Odisha and Uttar Pradesh.

As of November 1, 2018, a total of 3.43 million solar lamps have been provided under different initiatives of the SoUL programme. The '70 lakh solar lamp scheme' initiative integrates both lighting and rural livelihood, by associating with the state nodal agencies under National Rural Livelihood mission and engaging women from self-help groups to assemble and distribute the lamps.

²² Thirty Ninth report on demand of grants of MNRE for 2018-19, link- http://164.100.47.193/lssccommittee/Energy/16_Energy_39.pdf

Table 3: Overall deployment of study lamps under 70 lakh solar lamp scheme



State	Total Deployment
Uttar Pradesh	608,628
Bihar	820,514
Jharkhand	591,185
Chhattisgarh	12,882
Odisha	89,961
Assam	245,919
Maharashtra	198,130
Rajasthan	324,708
Madhya Pradesh	538,550
Meghalaya	6,116

Source: SoUL

Goods and Services Tax

Introduced in September 2016, the Goods and Services Tax (GST) marked a turning point in India's tax reform.

GST subsumed multiple indirect taxes (except a few) on various goods and services, under a single uniform regime at the central and state level. The tax, which encompasses 1,300 goods and 500 services has been divided into four brackets of 5%, 12%, 18% and 28%.

Table 4: GST brackets for different solar devices and components for 2018 (%)

Renewable energy devices and spare parts for their manufacture	GST Rate
Solar power-based devices	
Solar lantern/solar lamp	5%
Photovoltaic cells, whether or not assembled in modules or made up into panels	
Solar Inverters	18%
Solar charge controller	18%
Batteries*	18/28%
Cables	28%

*GST Rate for lithium ion batteries reduced from 28% to 18% in July 2018

Source: MNRE, discussion with market players

While the aim has been to simplify the tax structure, the regime has caused confusion among certain enlisted suppliers since the rate at the central level is decided at 5% for solar power-based devices and pumps, however, certain state tenders for solar pumps such as in Rajasthan and Maharashtra have defined the supply of these materials as 'services of power supply' and thus a GST of 18% has been levied. This has correspondingly increased the rate for the end-consumer thereby creating a barrier for scale-up.

Peering into the markets of tomorrow

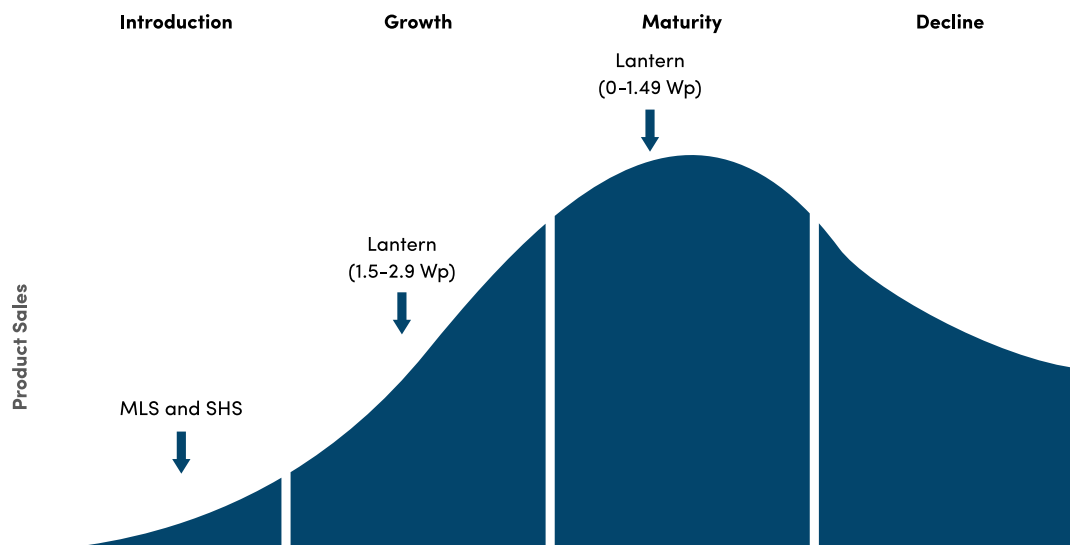


2 Outlook for the different segments

This section synthesizes the outlook of the different distributed standalone solar products segments, after incorporating sentiment and market information.

The product life cycle is a traditionally accepted framework to look at the evolution of a product²³. As a product evolves, it goes through multiple stages that has been captured below.

Figure 13: Product Life Cycle: How the Distributed solar products fare across the four basic stages



Customers	Early Adopters	Mainstream	Late Adopters	Laggards
Sales	Low	High	Flattening	Moderate
Investment cost	High	Moderate	Low	Low
Competition	Low	Moderate	High	Moderate
Business Focus	Awareness	Market share	Customer retention	Transition/ consolidation
Product variety	Few products	Increasing growth in variety	Stabilization in growth of variety	Stable number of variety/ decreasing products

The phrase 'crossing the chasm'²⁴ is typically applied to the transition from an early adopter audience to the mainstream audience. Many of the products fail to make that transition and a key contributing reason is inability to either comprehend and/or address the difference in consumer mindset. The **distributed standalone solar products sector has successfully transitioned a few products across that chasm: driven by their understanding of the consumer and the brand relations built.**

²³ For more background refer the Harvard Business Review- 1965 (<https://hbr.org/1965/11/exploit-the-product-life-cycle>) and [https://en.wikipedia.org/wiki/Product_life-cycle_management_\(marketing\)](https://en.wikipedia.org/wiki/Product_life-cycle_management_(marketing))

²⁴ For more background: https://en.wikipedia.org/wiki/Crossing_the_Chasm

2.1 Outlook for basic lanterns (0-1.49Wp)



Present uses

- Basic lighting
- Back-up lighting

Segment evolution stage



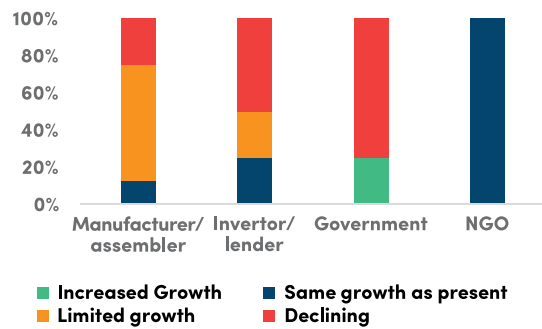
Present annual sales estimated (units)

7.32 million

Present annual value of products (INR/USD)

4,118 million (61.5 million)

Segment sentiment based on respondents interviewed



<p>Key channels</p> <ul style="list-style-type: none"> Local retailers (serviced through conventional distribution networks) Microfinance Institutions (MFIs) Specialized distributors emerging Study lamps also sold through specialized networks <p><i>Modest sales from institutional sales (NGOs)</i></p>	<p>Price range (INR/USD)</p> <p>300-700 (4-10)</p>
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Outlook

- Nearly 60% of the manufacturers surveyed believe that the sales of basic lanterns are reaching a saturation point and there is limited scope of innovation for this product segment, both in terms of product quality and distribution. The sales for basic lanterns/study lamps in 2017-18 is estimated to be around 7.28 million, of which 85% is driven by private players through both B2G and B2C sales. While the absolute quantum of sales is likely to stabilize over the next 1-2 years and then decrease to 3.32 million units by 2022-23. The slowdown is expected to take place on account of shift of usage from primary lighting to back-up and emergency lighting as well as migration of consumers from basic lighting to upgraded lantern models with mobile charging.
- There exists a plethora of private players in the market for basic lanterns resulting in existence of various sub-standard products in the market which are available for as low as INR 120-140 (USD 1.8-2.1) per unit. Despite this, the market for lanterns is dominated by three to four players. This indicates that rural consumers accord weightage to product quality and consumer relationship. Typically, a two year product warranty and 10-12

hours run-time per day is offered on branded products.

- The government market for basic lanterns has moved in spurts and lately with the advent of Saubhagya scheme, the government has moved away from the space. Presently the SouL scheme is the only one running and reaching out to students with Solar study lamps. Most of the units (around 40%) have been supplied in Gaya and Nawada districts in Bihar.²⁵
- The demand for lanterns is likely to stay limited to the need for basic lighting from Below-poverty line (BPL) households in regions such as Bihar, Rajasthan, Uttar Pradesh, Odisha, North-East states; and from flood/cyclone affected districts in Uttarakhand, Kerala, Jammu and Kashmir, etc.
- Microfinance Institutions that have been a large channel for the basic lantern of the organized sector are reporting a stabilization in sales.
- Present consumers in this segment are migrating towards larger lanterns that have built-in chargers.

<p>2023 sales estimated (units)</p> <p>2.03 million – 2.74 million</p>	<p>2023 value of products sold (INR/USD)</p> <p>1,017 million – 1,374 million (13 million – 17 million)</p>
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²⁵ SoUL Dashboard: <http://souls100.in>

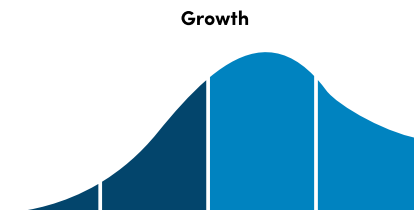
2.2 Outlook for Lighting (1.5Wp- 2.9Wp)



Present uses

- Basic and back-up lighting
- Mobile charging (and connectivity)
- Entertainment (when Radio is built in)

Segment evolution stage



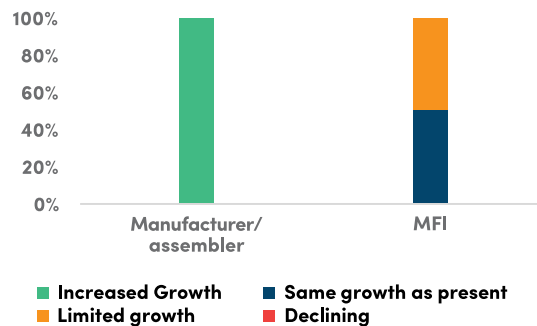
Present annual sales estimated (units)

2.63 million

Present annual value of products (INR/USD)

3,447 million (51)

Segment sentiment based on respondents interviewed



Key channels

- Local retailers (serviced through conventional distribution networks)
- Microfinance Institutions (MFIs)
- Specialized distributors emerging

Price range (INR/USD)

900- 2500 (13-37)

Outlook

- Lanterns (1.5-2.9 Wp) are expected to be a key growth segment for the sector for the next few years
- This product category goes beyond lighting and caters to multiple needs, including charging and portable entertainment in the form of FM radio and bluetooth speaker
- One of the factors that has led to increased sales of 2.6 million in 2017-18 in the segment has been the increase in mobile subscribers in rural areas from 435.75 million in 2015 to 502.42 million in 2017
- Around 60-70% of these products are financed through MFIs, particularly in states of Uttar Pradesh, Bihar, Jharkhand, West Bengal Odisha and Assam. As per a few MFIs, manufacturers will have to continue to focus on providing more battery run-time and ensuring charger port compatibility with the increased penetration of mobile phones and smartphones in rural areas
- Successful launch of lanterns with in-built radio in Punjab/ Haryana that have high electricity indicates a potential for these devices in other regions as well

2023 sales estimated (units)

3.01 million – 3.88 million

2023 value of products sold (INR/USD)

7,184 million – 9,098 million
(90 million – 114 million)

2.3 Outlook for Multi-light system (3Wp- 10.99Wp)



Present uses

- Basic and back-up lighting
- Mobile charging

Segment evolution stage

Early



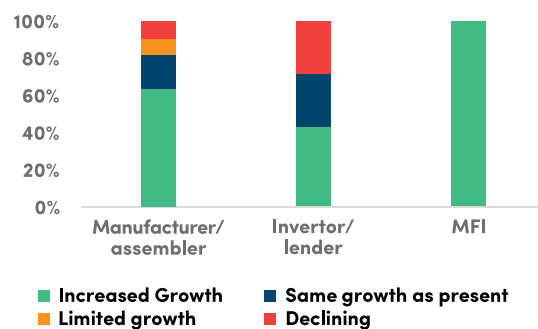
Present annual sales estimated (units)

53,000

Present annual value of products (INR/USD)

265 million (4)

Segment sentiment based on respondents interviewed



Key channels

- Local retailers (served through conventional distribution networks)
- Microfinance Institutions (MFIs)

Price range (INR/USD)

2,700–7,000 (40–105)

Outlook

- Multi-light systems are being sold as an ‘entry level SHS’; both to individual rural households and petty shops in rural as well as semi-urban areas
- Several manufacturers have expressed positive sentiment for multi-light systems. Even with electrification, there is unreliable power during peak hours. According to the Ministry of Power data, the average daily hours of power supply to rural areas is 20 hours as of September, 2018. However, based on the ground experience of various social enterprises, even as there has been a significant improvement in grid expansion in rural areas, there continues to be frequent fluctuations and load shedding at a household level. The Prayas ESMI data indicates that only 11% of rural areas across 66 locations in 23 states receive five hours of evening supply from 5 pm to 11 pm.²⁶ In such cases, this might translate into demand for multi-light systems from rural households for reliable power supply during evening. Further, households with a solar lantern are also expected to upgrade to a multi-light system as they move up the energy access ladder
- Increased electrification is likely to increase demand for an MLS (and larger SHS as well) as consumers seek to have more permanent fixtures in their homes
- While lanterns (both entry-level and with device charging) still form nearly 90% of the MFI solar loan portfolio, certain large MFIs have upgraded from simple solar lamps and forged partnerships in 2017-18 to provide multi-light systems in states of Bihar (across Muzaffarpur, Begusarai, Chapra and Gaya) and Uttar Pradesh (across Varanasi, Allahabad, Gorakhpur, Balla and Sultanpur)
- Multi-light systems meet the needs of consumers who are aspirational and cannot afford an SHS; and are **likely to remain a transitional product**. At higher incomes, consumers will use an SHS. However, for players to ‘own the consumer journey’ providing an MLS product is important

2023 sales estimated (units)

200,452 – 312,692

2023 value of products sold (INR/USD)

1,279 million – 1,995 million

(16 million – 25 million)

²⁶ https://www.watchyourpower.org/location_map.php

2.4 Outlook for solar home systems by private players



Photo credit: Simpa Networks

Present uses

- Basic and back-up lighting
- Mobile charging
- Entertainment (with television)
- Cooling (with fans and/or refrigerators)

Segment evolution stage

Growing



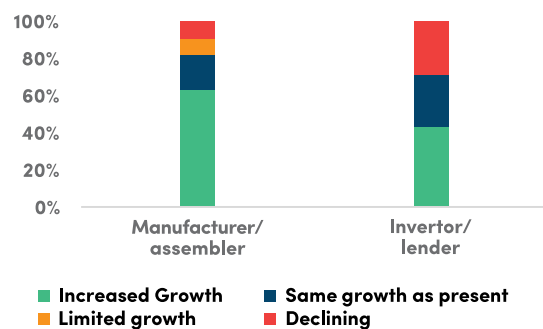
Present annual sales estimated (units)

51,833

Present annual value of products (INR/USD)

1,234 million (18)

Segment sentiment based on respondents interviewed



Key channels	Price range (INR/USD)
<ul style="list-style-type: none"> • Direct system sales • Direct implementation of pay-as-you-go systems 	7,500-55,000 (median is approx. 15,000) (112-820; median is approx. 224)

Outlook

- SHS is the oldest segment having started in the mid-1990s and is still engaged with early adopters. Several attempts have been (and are being) made to make inroads into this segment
- The operating landscape has changed recently with the thrust towards 24x7 electrification. However, most of the players are optimistic about the space, driven by (a) the consumer need for more electricity and amenities; and (b) expectation that the government would be unable to meet its goals
- 63% of assemblers interviewed believe that SHS has a role to play as a back-up system and some are exploring designs where the SHS operates in conjunction with the electricity from the grid. In the latter case, the system design entails a hybrid charge controller (selecting AC or DC power sources) and employs DC appliances. Efficiency of the DC appliances is an additional value proposition
- As per recent estimates, around 14% of surveyed households across the six states of Uttar Pradesh, Bihar, Jharkhand, Odisha, Madhya Pradesh and West Bengal are still unelectrified and have a willingness to pay of INR 100 (USD 1.5) per month for electrification²⁷. Therefore, while demand would still exist, the challenge for private players would be to: (a) service the market in grid-connected areas with unreliable power supply (and therefore be uncertain of the level of demand); (b) manage supply chains and transaction costs in areas such as the north-east regions where the rural population density ranges from 17-350 people per square km²⁸. The low population density could significantly increase the transaction costs and consequently affordability of the systems. The challenge is exacerbated by the fact that the penetration of MFIs in north-eastern region is still extremely low.
- Over the next few years, the size of SHS is expected to increase from 40-100 Wp to 300-400 Wp to power appliances such as DC TV, DC fans and refrigerators, etc. To this end, based on power consumption of different appliances, we have assumed in this study that DC TVs would be bundled with SHS of 200-300 Wp systems (which includes a DC fan). Further, DC refrigerators would be bundled with SHS of 400 Wp systems (which includes a DC TV and a DC fan). The price of these 300 Wp and 400 Wp systems (inclusive of appliances) are estimated to range from INR 45,000 to INR 67,000 i.e. USD 567 and USD 840 respective.
- Financing is both, a key driver and a need for this segment. Several initiatives have been undertaken; but mainstream finance is yet to be forthcoming. GIZ is engaged in a pilot with Bandhan Bank to explore a financing model for solar home systems which can potentially be replicated with others (and have financed 10,000 SHS)
- There are emerging players such as Basil Energetics, who offers integrated solar home systems (along with DC appliances such as DC Fan, DC refrigerator and DC TV) which can work on both AC and DC power. The system is managed through a smart hybrid controller. The controller ensures that power requirements of appliances are met through solar system when the power supply from grid is unreliable or insufficient. Moreover, the power consumption of these appliances is three times lesser than conventional appliances
- It is quite possible that the unorganized sector will lead the volume in this space by assembling different 'branded' components. In such a case the market for devices (DC Fans) and components (panel, controllers, etc.) will increase. The opportunity for the organized sector is to develop its brand and after-sales service. Financing, through tie-ups with regional banks and commercial banks amongst others, can be a key differentiator for the organized sector

2023 sales estimated (units)	2023 value of products sold (INR/USD)
100 Wp (including DC fans): 100,803 – 112,901	100 Wp (including DC fans): 2,468 million – 2,777 million (31 million – 35 million)
200-300 Wp (including DC fans and DC TVs): 55,226-154,634	200-300 Wp (including DC fans and DC TVs): 2,507 million – 7,018 million (USD 31- 88 million)
400 Wp (including DC fans, DC TVs and DC refrigerator): 26,708- 53,416	400 Wp (including DC fans, DC TVs and DC refrigerators): 1,795 – 3,590 million (USD 22- 45 million)

²⁷ Access to clean cooking energy and electricity-https://www.ceew.in/sites/default/files/CEEW_Access_to_Clean_Cooking_Energy_and_Electricity_Survey_of_States_Report_30Nov18.pdf

²⁸ Census 2011

2.5 Outlook for solar home systems driven by government subsidies (37 Wp-200 Wp)



Present uses

- Basic lighting
- Mobile charging
- Cooling (with fans)
- Entertainment (Provision for powering TV load)

Segment evolution stage

Nearing maturity



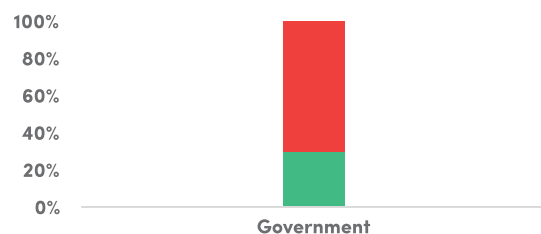
Present annual sales estimated (units)

0.29 million

Present annual value of products (INR/USD)

7,827 million (117)

Segment sentiment based on respondents interviewed



- Increased Growth
- Limited growth
- Same growth as present
- Declining

Key channels	Price range (INR/USD)
<ul style="list-style-type: none"> Direct implementation; initiated from government tenders 	37 Wp-9,300 (139) 100 Wp-20,000 (299) 200 Wp-27,000 (403)

Outlook

- There will be significant expenditure of INR 17,074 million (USD 255 million) over the next two to three years as the Saubhagya scheme subsidies sanctioned by the government reach the market. To illustrate the lag, the state of Uttar Pradesh recently announced its tender for 100,000 units only on July 12, 2018²⁹
- The SHS segment has been excluded under Phase-3 of the Off-grid and Decentralised Solar PV Applications Scheme³⁰. Going forward, the SHS segment is likely to be driven through state schemes only, given that deployment under Saubhagya are being targeted to be concluded in 2019. From a central government standpoint, the thrust would be focused towards rooftop and grid-interactive solar PV systems. **Correspondingly, there is likely to be significant decline in government spend on SHS after 2021**
- More than 90% of the SHS have been deployed in off-grid and remote rural areas under the various central government scheme. So far, nearly 1.7 million SHS have been provided under off-grid and decentralized solar application scheme
- The benchmark cost for SHS has reduced by 30% over the past five years on account of falling solar module prices and shift from CFL to LED models for home lighting systems. The present benchmark cost for an SHS is INR 340 per Wp
- Some of the stand-alone systems under Saubhagya have a provision for powering a 12V DC TV³³, there is a likelihood that the penetration of DC appliances will increase on account of increasing energy consumption
- Going forward, the size of systems is likely to increase from 200 Wp to 300-400 Wp

2023 sales estimated (units)	2023 value of products sold (INR/USD)
70,000	1,715 million (21 million)

²⁹ Source: UPNEDA, http://www.upneda.org.in/UploadedFiles/TenderDirectory/UPNEDATnder_doc.pdf

³⁰ Source: MNRE, mnre.gov.in/sites/default/files/schemes/Off-grid-%26-Decentralized-Solar-PV-Applications-Programme-Phase-III-for-FY-2018_19-%26-2019_20.pdf

³¹ This deadline is unlikely to get met and Saubhagya deployment is likely to spill over next 2-3 years.

³² Source: MNRE, <https://mnre.gov.in/file-manager/UserFiles/Off-Grid-Benchmark-Cost-2017-18.pdf>

³³ Source: MNRE, mnre.gov.in/file-manager/UserFiles/led_spls_2015_16.pdf

2.6 Outlook for solar pumps



Present uses

- Irrigation and drinking water

Segment evolution stage

Growth



Present annual sales estimated (units)

62,000

Present annual value of products (INR/USD)

21,800 million (326)

Segment sentiment based on respondents interviewed

Key channels

- Direct implementation; initiated through government tenders

Price range (INR/USD)

2-3 HP (DC)- 240,000-360,000 (3,582-5,373)
 >3-5 HP (DC)-285,000-475,000 (4,254-7,090)
 >5-10 HP (DC)- 475,000-950,000 (7,090-14,179)

Outlook

- The solar pump market has been driven primarily by the government which is catering to farmers as a key constituency
- Solar pumps stand out as a distinct segment and has been primarily government driven so far. The central and the state governments of India have provided subsidies that have ranged from 60% to 90% depending on the state
- Over INR 36 billion (USD 0.5 billion) has been provided by the state and central governments in the last four years.
- The recently announced KUSUM scheme is expected to significantly increase the uptake particularly amongst farmers by nearly ten times compared to the current installed base of 177,000 pumps³⁴.
- Even for the KUSUM scheme to meet its goals, financing is going to be a key component. Banks are expected to provide 30% of the pump cost and farmers are expected to provide 10% of the pump cost. Most private banks and financiers have shied away from lending to the farming sector given the high risk³⁵
- Given the volumes expected in KUSUM, the price of solar pumps is expected to fall in the next one to two years. Additionally, several established players in the pump sector are likely to enter the segment
- Recently, the Maharashtra government undertook a pilot of solarizing agricultural feeders by installing solar plants at the substation level rather than solarizing individual pumps through subsidies. This could emerge as an alternative to solar pumps since it doesn't require any behavior change or heavy subsidy quantum
- There remains scope for irrigation-as-a-service as a wild-card (discussed later) to cater to this segment

2023 sales estimated (units)

0.37

2023 value of products sold (INR/USD)

73,333 million

(918 million)

³⁴ As outlined earlier in this report, the KUSUM target is 1.75 million solar pumps

³⁵ Loans to farmers have often been waived by the government.

3 Emerging segments

The emerging segments that follow are those that hold promise. Some of them are being piloted by different players and represent future growth engines.

3.1 DC Fans (sold stand-alone)



Present uses

Personal cooling

Price range (INR/USD)

2,000-2,500 (-37)

Rationale for the emergence and outlook

- DC fans can emerge as a new growth segment. As per several discussions, the demand in rural areas is expected to grow from lighting to mobile charging to fans. Moreover, fans have a rural penetration rate ranging from 24% to 53% even in the first five income deciles³⁶. Thus, increase in appliances penetration and upward movement in consumer need for the product will drive the demand exponentially in rural areas
- Since the price point of a DC fan is in the same range of a lantern (1.5-2.9 Wp) segment, several MFIs have included DC fans in their loan portfolio, given the demand for it.
- DC fans offer two to three times the energy efficiency as compared to a regular AC fan, leading to lower wattage consumption of 12 to 15 W. Therefore, it can be powered even through small solar home kits of 75 Wp
- The only factor which may restrict the penetration of this appliances is the relatively high price point, particularly for fans with BLDC (brushless DC) technology
- The scope of DC fans would be driven through pedestal fans in the off-grid areas. For grid-connected areas, the product would be feasible only where a DC ecosystem is available. The value of products estimated below for DC Fans (sold on standalone basis) is based on a combination of: (a) up-selling to consumers already having an SHS from the government scheme; (b) fans being sold separately than the SHS in cases where a consumer starts with a low priced SHS, (c) selling to the historically installed base of SHS'

2023 sales estimated (units)

87,417-130,400

2023 value of products sold (INR/USD)

219 million-326 million

(3 million- 4 million)

³⁶ Household expenditure on consumer durables and services, 66th round, NSS

3.2 DC Television



Photo credit: Simpa Networks

Present uses

Personal and community entertainment

Price range (INR/USD)

15,000-20,000 (224-299)

Rationale for the emergence and outlook

- The penetration of TVs in rural areas stood at nearly 53% in 2015-16³⁷
- Given the demand for entertainment in rural areas, a few manufacturers have expanded their portfolio by including a DC TV over the past six months and a few others are planning to launch the product in the coming fiscal year
- The DC TVs are expected to be provided as part of a 200-300 Wp SHS (which includes a DC fan)
- There is an opportunity for manufacturers to target the off-grid households catered through Saubhagya scheme since the systems have a provision and capacity to power a DC TV as well.
- The main challenge facing the manufacturers/distributors of DC TVs is to match the price point of AC TVs (i.e. reduce the price to INR 15-16 k (USD 224-299) for a standard 24" TV)

2023 sales estimated (units)

55,226-154,634*

2023 value of products sold (INR/USD)

906 million-2,537 million
(11 million- 32 million)

*Sold as part of 200-300 Wp SHS as mentioned in section 2.4

³⁷ National Family Health Survey (NFHS-4), 2015-16, <http://rchiips.org/NFHS/NFHS-4Reports/India.pdf>

3.3 DC Refrigerator

Present uses

- Food and dairy storage and cooling
- Storage of vaccines

Price range (INR/USD)

100 Litre refrigerators: 10,000-14,000 (104-209)

Rationale for the emergence and outlook

- The rural market for refrigerators is largely untapped, with only 9.4% penetration as of 2011. Amongst the various states, only Tamil Nadu, Punjab, Kerala and Goa, have moderate penetration ranging from 4-52% in the first five income fractiles³⁸
- As per socio-economic and caste census survey 2011, there were 25% (44 million) rural households which have monthly income of more than INR 5,000(USD 75). This is complemented by increase in per-capita income of rural households which indicated affordability of these product for the rural consumer
- However, a refrigerator is unique amongst all consumer durable products since its purchase depends significantly on hours of power supply, rather than affordability alone. Therefore, this product will have to be tied up with bigger home systems (400 Wp) since a DC refrigerator of 40 W, would at minimum consume 240 W from six hours of consumption
- There is expected to be a moderate uptake for refrigerators, particularly small-sized one, with only positive temperatures because of the value derived from refrigeration in rural areas. This is evident by the fact that even Godrej, a large home appliance player, has forayed into the small refrigeration segment through its customized product for rural markets (Chhotukool refrigerator)

2023 sales estimated (units)

26,708 – 53,416*

2023 value of products sold (INR/USD)

351 million-701 million
(4 million- 9 million)

*Sold as part pf 400 Wp as mentioned in section 2.4

³⁸ Household expenditure on consumer goods and services, 66th round, NSS

3.4 Solar powered deep freezer



Present uses

- Storage of medicines, insulin, vaccine
- Food and dairy storage

Price range (INR/USD)

40,000-50,000 (150 litres)
(597-746)

Rationale for the emergence and outlook

- A DC freezer is equally important in rural areas as in a semi-urban area with poor electricity. Even with electricity available for 8-10 hours, there would be spoilage in the remaining hours when there is no back-up
- There have been pilots for DC freezers in Uttar Pradesh, Rajasthan, Odisha, Assam, Madhya Pradesh and Maharashtra and the product is reported to be in regular use by the customers
- Currently, DC freezers are deployed through NGOs and other institutional and commercial affiliates (such as medical institutes, food trucks, dairy enterprises). Going forward too, the product is expected to cater the needs for cold storage facilities for food and dairy storage in rural areas and provide refrigeration systems to rural health facilities and laboratories
- Financing will play a role in this segment since the product involves high upfront cost

³⁷ National Family Health Survey (NFHS-4), 2015-16, <http://rchiips.org/NFHS/NFHS-4Reports/India.pdf>

4 Conversations for this study

4.1 Interviewees reached out to

Acumen Fund: Sachindra Rudra

Aga Khan Rural Support Programme: Apoorva Oza

Arohan: Ananya Jana

Atomberg: Arindam Paul

Asha Impact: Raghav Rungta

Asha Impact: Riya Saxena

Basil Energetics: Dr. Ram Ramarathnam

BFIL: Ritesh Chatterjee

Boond Solar: Kunal Amitabh

CCI: Anurag Mathur

CEL: Amandeep Singh

Claro pumps: Adarsh Gautam

CLEAN: Harihara Mohapatra

Contura Solar: Lakshmanan J.

CREDA -

Cygni: B. Krishna Prasad

D.light: Vikram Raman

Doen foundation: Michelle de Rijk

Engie: Rahul Banerjee

Engie: Ranjith Nair

ESAF: Shibu M G

Factor-e Ventures: Amanda Delcore

Fourth Energy: Divykant Vishwakarma

Gautam Solar: Shubhra Mohanka

GIZ: Dr. Harald Richter

Greenlight planet: Sahil Khanna

Greenlight: Gaurav Bhandari

Greenway: Sameeksha Shere

Havells: Sameer Darbari

IFC, Lighting Asia-India: Anjali Garg

IIT Bombay (SouL Project): Komal Gupta

JREDA: Jigar Joshi

Kaho Solar: Hemant Tyagi

Kinetica Solar: Hitesh Gupta

NTPC: Gopalakrishnan Sridhar

Onergy Solar: Piyush Jaju

Onergy Solar: Enakshi Pal

Oxfam, India: Rajita Kurup

Premier Solar: Priyanka Sharma

Propel Clean energy: Matt Jordan

REC: S.N. Srinivas

REIL: Himanshu Sharma

ResponsAbility: Sameer Tirkar

Rockfeller Foundation: Suman Sureshbabu

Rotosol: Sukriti Mishra

Samhita: Anushula Madhavan

Samhita: Sandhya Tenneti

SELCO: Thomas Pullenkav

SHAKTI Pumps: Manu Sharma

Shell Foundation: Deepak Goel

Signify: Shiv Seth

Sunfunder: Alycia Kellman

UPNEDA: Ashok Kumar Srivastava

4.2 Selected quotes from interviews held



Assembler quotes

"Once the government targets are achieved, there is still likely to be demand for bigger systems and appliances, and private players who have their own distribution channels (outside government network) are better placed to cater to that demand than other companies which specialize only in manufacturing or assembling."

"It is not feasible for the government to reach out to the population even in the next 5-6 years and 24*7 (power) is still a distant dream in states such as Rajasthan. Currently, power is available on an average for 18 hours and there is still load shedding during peak evening hours."

"The market for lighting is dying and the government is focused towards on-grid solutions and grid-connected solar plants and solar pumps"

"Demand for bigger SHS going forward even if the electrification targets are met, since the customers demand for electricity and appliances are going to increase, so the smaller systems would potentially be replaced by a bigger system"

"Consumer financing is the key for uptake of DC appliances. Currently, the volumes are extremely limited because of the capital cost of the product. We need the MFIs, NBFCs and all to come in."

"Consumer financing is the key for uptake of DC appliances. Currently, the volumes are extremely limited because of the capital cost of the product. We need the MFIs, NBFCs and all to come in."



Investor quotes

"In the decentralized solar segment, there is a transition. The systems, which have been positioned to provide reliability, will evolve in a manner wherein the tariffs come into play. In Odisha, particularly in semi-urban areas, people are buying these systems because the costs are cheaper (especially wherein one room in the house is dedicated to a shop and the discom tariffs rates are higher than that of solar tariffs)."

"India, in particular, is a difficult market to invest in because of prohibitive lending norms for a foreign entity. Even though the multinational companies funded through debt financing do service the Indian market but the exposure is more skewed towards African market where Pay-as-you-go models are more mature. Currently, we are planning to diversify in commercial and industrial solar segments where there seems to be scope for more innovative financial models"

"While there are other challenges with respect to consumer financing and cost reductions, those are still there but can be managed once the govt. signaling is clear. Currently, we are in-between and waiting for a clear market to emerge."

The question is whether the companies are willing to explore growth models which provides some forms of consumer financing."



Government quotes

"In off-grid scenario, the main challenge we think we will face is the reliability of the off-grid solution (in case higher load appliances are plugged in). The off-grid products (lighting solutions) don't provide any direct monetary gains. For SHS, the demand has been there on account of Saubhagya, however, going forward, bigger hybrid systems (1 kWp) is expected to pick up which can enable households to plug in higher load appliances and allow them to feed-back surplus power into the grid." - State Nodal Agency (JREDA)

"The thrust is on solar pumps and rooftop solar plants through central government and state specific schemes. Most of the pumps are currently being deployed by medium and large farmers. However, it is expected that with KUSUM, there will be an increase in uptake amongst the small and marginalized farmers as well." - State Nodal Agency (UPNEDA)



Microfinance Institutions (MFIs) quotes

MFI

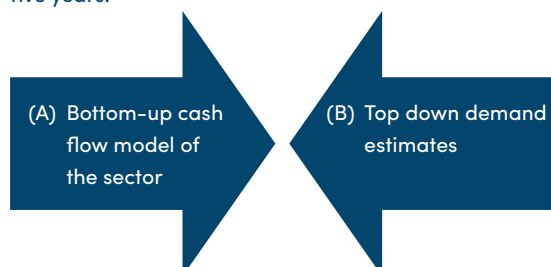
"For lanterns, we plan to move away from stocking the product and instead plan to procure the products from nearby Kirana shops, where the products are placed. However, the manufacturers would need to work out the cost/margin so that the price for final consumer remains the same.... from a consumer perspective, the price of certain lanterns is still a bit high and there are compatibility issues at times for smartphone mobile charging. Going forward, we will start selling MLS and DC fans in Jharkhand and Odisha since there has been a demand for these products."

Investor

"Currently, nearly 90% of our solar loan portfolio is used for financing solar lanterns. There is scope for selling solar lanterns with mobile chargers. However, we have started to finance solar pedestal fans as well and do plan on introducing new products."

5 Data model for building the forecast

This study's forecast combines a bottom-up cash-flow model of the sector along with top-down demand estimates after electrification has happened. The two are triangulated to arrive at the forecast for the next five years.



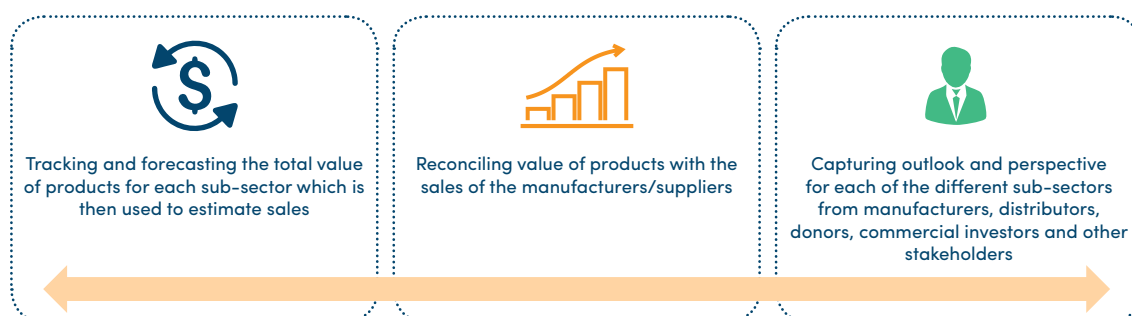
1. Solar lanterns
2. Multi-light systems (MLS)
3. Solar home systems (SHS)
4. Solar Pumps
5. DC Appliances (DC Fans, DC Televisions, DC refrigerators and DC water purifiers)

The study has used both primary and secondary research to capture sentiments of various stakeholders and estimate the future of distributed stand-alone solar product market in India. A total of 45 stakeholders have been interviewed which includes manufacturers, suppliers and distributors, market catalysts, MFIs, CSR departments, NGOs and investors. Of these, 22 are manufacturers/ assemblers, eight are investors/ lenders, and remaining share is formed by other stakeholders.

5.1 Bottom-up cash flow model of the sector

The study captures the cash flows deployed for the following distributed stand-alone solar products:

Our approach follows three broad steps:



Projecting the value of products

The model estimates the cash flowing (for each year) across the following components:

1. Government subsidies
2. End-user contribution i.e. beneficiary share under government subsidies.
3. End-user financing (includes financing provided by MFIs, RRBs, Local banks)
4. CSR grants
5. Exports

Subsidies

For estimating the subsidies, the study first identified key schemes sanctioned for the different product categories and tracked the actual deployment/installations under the schemes from 2013-14 to 2017-18. The actual installations/deployments have been multiplied with the corresponding central and state subsidies and the benchmark cost of the product during the particular year. For 2017-18, subsidies for solar lantern and SHS, is based on CFA specified under SoUL, Saubhagya and off-grid decentralised and solar PV applications scheme. Meanwhile, the subsidy for solar pumps has been calculated at the state-level and subsequently aggregated at the national level.

CSR

In order to estimate the CSR spends, the study tracked the annual CSR spends of 37 companies from 2015-16 to 2017-18. However, the split of CSR spends on different distributed stand-alone solar products has been assumed to be equal (wherever applicable) where the split or individual spend for these products was not available. Further, the spends include grants disbursed towards solar lanterns under the SoUL programme by IIT.

MFI and retail financing

The information for solar financing were mapped for five key MFIs in the space, which were identified and shortlisted on the basis of conversation with assemblers and distributors. These MFI's are assumed to form 80% of the market share. The overall spend has been extrapolated based on the share of the shortlisted MFIs as part of the total solar financing. Further, the split between MFI and retail financing for different product categories has been assumed on the basis of conversation with key integrators/assemblers in the market.

RRB/ Pay-as-you-go

For SHS financed by either pay-as-you-go or through RRBs/local banks (outside of government scheme), the cash flow has been extrapolated from the revenue of key players engaged in this space i.e. SELCO and Simpa networks.

Reconciling all the above with actual revenue of the manufacturers/ assemblers

The cash flows have been subsequently reconciled with the revenue and self-reported sales of the players that are providing the products in the market. These estimations have been validated based on the annual returns filed with Ministry of Corporate Affairs (MCA) for 36 players, including the manufacturers/assemblers interviewed.

While the information gathered does not cover all the players in the segment, the data encompasses the market leaders in each segment. Accordingly, the deployment has been calculated based on the cash flow under different channels and per unit price of the respective products.

Combining sector outlook and cash-flow forecasts

The assumption for the segment outlook for different distributed stand-alone solar products has been shaped by the sentiments these stakeholders as well as the potential unaddressed demand for different product, particularly DC appliances.

Based on the outlook of the different players, the cash-flows forecasts were developed. That in-turn helped create a bottom-up view of the market over the next five years.



Ranges for the future

The forecast has two scenarios:

1. Lower range estimate, which assumes market growth in new segments follow a business-as-usual trajectory
2. Upper range forecast, where a concerted effort is made to grow the market in new segments.

5.2 Top-down estimates of demand potential

The demand potential, has been estimated based on:

1. Expected trend of electrification across (based on peak deficit and hours of supply)
 - a. Across states of India
 - b. Rural and urban households within those states

Evaluating likelihood of interrupted power supply over the next few years

2. State-wise income of households in rural areas on electricity across different income deciles (10%, 20% and so on) and estimating affordability
3. Replacement demand

Step 1: Identify unelectrified and under-electrified households

The first step in the analysis involved identification of households based on their electrification status for different states. Households have been split into:

1. Grid-connected households with reasonable hours of supply
2. Grid-connected households with intermittent hours of supply
3. Disconnected/ remote households

This information has been estimated state-wise based on the following information:

1. Households have been and are deemed to be electrified under Saubhagya
2. Households deemed to be electrified through distributed stand-alone solar systems under Saubhagya, DDUGJY and MNRE's 'Off-grid and decentralised solar PV applications' scheme.
3. Hours of supply in rural areas of a state
4. Peak deficit of the state.

Step 2: Estimate demand of different devices based on energy spends for different income levels; and comparing it with the cost of ownership of the devices

Using the Monthly Per Capita Expenditure (MPCE) data from the NSS Data on 'Household Consumption of Various Goods and Services in India', we estimated the state-wise annual electricity spends of households in rural areas across ten income deciles. Estimates for household spends are based on actual consumption expenditure patterns on electricity and Kerosene, extrapolated at a household level.

The above information is then compared with the annual cost of all the alternative sources of lighting. These costs are aligned with the annual electricity spends of households in states where power supply is likely to remain intermittent, despite grid electrification. The annual cost of alternative options is based on the market price and pay-back period of the product.

House hold category based on level of electrification	Product categories for which demand has been estimated
Grid-connected households with reasonable hours of supply	Inverters
Grid-connected households with intermittent hours of supply	Inverters Lanterns (0-1.49 Wp) Lanterns (1.5-2.9 Wp) MLS SHS Others (DG Set/Kerosene)
Disconnected/ remote households	Lanterns (0-1.49 Wp) Lanterns (1.5-2.9 Wp) MLS SHS Others (Mini-grid/Pico-grid)

Step 3: Creating a forecast for demand potential in 5 years based on increased electrification and rising income

The forecast assumes that (a) outages from the grid will reduce over the next 5 years and (b) incomes will rise. Correspondingly the following will happen:

- a. Some consumers will move up the energy ladder and graduate to higher-capacity devices
- b. Some consumers will move out of the market

Based on these factors the demand potential was built for the different states and for different product types. These demand potential estimates have been compared with the bottom-up cash-flow forecasts.

5.3 Future demand for distributed standalone solar products

The demand potential was calculated from the following areas:

1. From grid connected areas where there is intermittent electricity

- From areas that have been designated to remain unelectrified/ remote by the government

Grid connected areas with intermittent electricity

Around 95% of the total potential has been estimated to stem from grid-connected areas with intermittent power supply.

In five years, the potential demand from this category of households is expected to shrink to 27 million units

on account of grid outages reducing. However, this shrinkage will largely affect the basic lantern market and grid electrification is expected to stimulate demand in other segments (given that the grid is likely to remain intermittent in selected pockets).

As of September 2018, there are seven states which hours of supply less than 18 hours in rural areas. Further, around three north-eastern states receive power supply in the range of 11-16 hours/day.

Table 5: States with high likelihood of intermittent power supply over the next 5 years

States	Peak Deficit (MW) (As of September 2018)	Hours of Supply in rural areas (hours/day) (As of September 2018)
Arunachal Pradesh	2	16.3
Bihar	5	18.52
Jammu and Kashmir	590	16
Jharkhand	0	15.4
Mizoram	2	11
Sikkim	0	16.5
Uttar Pradesh	225	17.85

Source: Central Electricity Authority, Ministry of Power¹

Areas that have been designated to remain unelectrified

The table below combines information from different government schemes and announcements that explicitly define areas not feasible to be connected to the grid.

¹http://www.cea.nic.in/reports/monthly/executivesummary/2018/exe_summary-09.pdf

Table 6: Total households deemed to be off-grid/remote

State	Total Unelectrified/off-grid villages	SHS Deployed by MNRE	HH covered through SHS under Saubhagya	DDUGJY-HH	Total No. of HH deemed to be off-grid
Andhra Pradesh		22,972		10,958	33,930
Arunachal Pradesh	714	18,945	5,430	16,582	40,957
Assam	467	6,926	6,376	45,520	58,822
Bihar	208	12,303	45,385	-	57,688
Chhattisgarh	475	7,754	45,417	55,890	109,061
Gujarat		9,253			9,253
Haryana		56,727			56,727
Himachal Pradesh	35	29,342			29,342
Jammu & Kashmir	79	65,319	2,046	-	67,365
Jharkhand	250	9,450	3,738	25,726	38,914
Karnataka	27	52,638		2,707	55,345
Kerala		41,912		731	42,643
Madhya Pradesh	63	4,016	17,562	15,834	37,412
Maharashtra	37	3,497	23,560		27,057
Manipur	270	3,900	196	3,026	7,122
Meghalaya	86	7,844	428	7,902	16,174
Mizoram	58	6,801	-		6,801
Nagaland	-	1,045	-		1,045
Odisha	411	5,274	7,088	12,157	24,519
Punjab		8,626			8,626
Rajasthan	96	166,978	86,720	-	253,698
Sikkim		15,059			15,059
Tamil Nadu		273,015			273,015
Telangana		-		1,275	1,275
Tripura	26	32,723	-		32,723
Uttar Pradesh	31	235,909	100,000	3,765	339,674
Uttarakhand	24	91,595	8,556	1,093	101,244
West Bengal	-	145,332			145,332
Total	1,039	1,335,155	352,502	203,166	1,890,823

Source: Ministry of New and Renewable Energy, Ministry of Power

Estimated demand in these areas after overlay with need and affordability

The data above, was combined with the data on income levels in the respective states (which has been assumed to increase over time) and the data on spends on electricity/ lighting. That was then compared with the affordability of the different products and it was assumed that consumers would seek to graduate up the energy ladder to more aspirational products. That was used to arrive at potential number of units that could be sold after five year.

Table 7: Estimated demand potential for distributed standalone solar products

	2018	2023 (estimated)
(a) in grid connected areas with intermittent electricity		
Lantern (<1.5 Wp)	16.33	4.03
Lantern (1.5 - 2.9 Wp)	12.25	13.43
MLS	4.08	5.37
SHS	0.41	0.81
Sub total	33.08	23.63
(b) in unelectrified/ remote areas		
Lantern (<1.5 Wp)	0.19	0.09
Lantern (1.5 - 2.9 Wp)	0.28	0.57
SHS	1.70	2.30
Sub total	2.17	2.96
Total demand potential		
Lantern (<1.5 Wp)	16.52	4.12
Lantern (1.5 - 2.9 Wp)	12.53	13.99
MLS	4.08	5.37
SHS	2.11	3.10
Estimated demand potential for standalone solar products	35.25	26.59

5.4 How the cash flows across the channels that are used to sell the products

Based on the modeling above, cash flows have been estimated for 2018 for both, the total market (including government and non-government financing sources) and the private player driven segment. It includes the different type of financing for each of the product segment and the channel through which a product is financed. However, solar pumps have been excluded, since it involves large sums, which skews the overall numbers.

Around INR 9 billion (USD 135 million) is flowing towards the SHS segment, of which nearly INR 3.3 billion (USD 49 million) is financed through nationalized banks, regional rural banks (RRBs) and MFIs cumulatively under government schemes and through partnership with private players. Further, the estimated value of product for lanterns (0-1.49 Wp) is INR 4.1 billion (USD 61 million). Of this, INR 1.2 billion (USD 19 million) is financed through MFIs, while INR 1.86 billion (USD 28 million) has been sold through the retail channel.

The total estimated value of product for the private driven market is INR 7,015 million (USD 105 million) including standalone DC Fans. For the private segment, end-user financing plays a key role, as MFIs, local banks and RRBs etc. have been estimated to finance nearly INR 3.86 billion (USD 180 million) worth of distributed standalone solar products. Meanwhile, nearly INR 2 billion worth of distributed standalone solar products have been sold through the retails channel.

5.5 How the cash will flow through different channels in 2023: financing channels will play a key role

The sector will be private sector led by 2023

Setting aside the solar pumps segment, the private sector driven market which is 41% of the present market will become between 87% and 90% of the market.

Electrification and rising incomes are stimulating demand and hence the product mix is likely to undergo a shift. Basic lanterns (0-1.49 Wp) which is the largest product (in terms of units) appears to have reached market maturity: sales are flattening (or have flattened) and fewer models are being introduced.

At the same time, Lanterns (0-1.49 Wp) are going through a growth phase. Solar Home Systems (SHS) will continue to grow at their present moderate pace, and there is a chance that they could be a wild card and grow rapidly.

Most of the future sales will come from lanterns with additional services (like mobile charging, radio, etc.) and solar home systems. Consumers in the lower income brackets in areas with intermittent electricity will transition from basic lanterns to multi-light systems and lanterns (0-1.49 Wp) as incomes rise. Increasing penetration of smart phones with data plans; is leading to greater charging needs (and need for devices with higher charging capacity) and is accelerating this transition.

Solar home systems, particularly with wattages between 40Wp and 200Wp will emerge as back-up systems in rural areas with intermittent supply of electricity. The systems will do well in areas where good quality electricity availability is likely to be less than 18-19 hours a day, as they will be competitive vis-à-vis inverter solutions.

The growth will come mainly in the states of Jammu and Kashmir, Chhattisgarh Jharkhand, Arunachal Pradesh, Uttar Pradesh, and Mizoram where there is increased electrification but outages are likely to remain for the next few years.

In addition, the sector is beginning to provide a range of energy efficient DC appliances compatible with the solar-system infrastructure. DC Fans, DC televisions and DC refrigerators are likely to find increasing demand as the base of solar home systems expands (driven both by the private sector market and the government driven SHS programs).

Government driven sales outside of pumps will reduce

As outlined in the segment-wise outlook (sections 3.1 and 3.2), the government is stepping away from programs focused on subsidizing devices and standalone home lighting systems. Instead it is stepping up its efforts in areas such as solar pumps, agriculture/ dairy processing, energy efficient appliances etc.

In lanterns, the Indian government has stepped away from lanterns and the only current funding that remains is for the '70 lakh solar lamp' program which provides lighting for school children in remote rural communities. That is likely to be completed in the next 2 years. In future, the government may end up sporadically supporting some minimal lantern programs but no policy outlook is clear on this

As far as solar home systems are concerned, future large government programs around solar home systems are unlikely. The sub-segment itself is likely to evolve and emerge into a continuum with the low capacity residential solar rooftop market.

The increase in cash flows for the private segment would be mainly facilitated by MFI, banks and NBFCs, which are estimated to provide financing of INR 13.2 billion (USD 165 million) in the base scenario and INR 21.6 billion (USD 271 million) in the optimistic scenario. In optimistic scenario, 38% of the total financing provided by MFI, banks and NBFCs is estimated to flow towards lanterns (1.5Wp-3Wp), while 43% is estimated to flow towards SHS (including appliances).



