LOW VOLTAGE SMART POWER AND APPLIANCE (LVSPA)

A Roadmap for Building New Technology Markets to Strengthen Electricity Supply and Service for Grid Customers

September 2022

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List of abbreviations

ACC	Advanced Chemistry Cell
ADSI	Accidental Deaths and Suicides in India
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
BLDC	Brushless DC
CAPEX	Capital Expenditure
CEA	Central Electricity Authority
CEEW	Council on Energy, Environment and Water
CMIE	Centre for Monitoring Indian Economy
DISCOM	Distribution Company
DRE	Decentralized Renewable Energy
EE	Energy Efficiency
ELVDC	Extra Low Voltage DC
HAD	Hybrid AC - DC
JWIRES	JEEViKA Women Initiative Renewable Energy & Solution
LED	Light Emitting Diode
LVDC	Low Voltage DC
LVSPA	Low Voltage Smart Power & Appliances
MDZ	Model Distributed Zone
MEPS	Minimum Energy Performance Standard
MNRE	Ministry of New and Renewable Energy
MTF	Multi Tier Framework
NABARD	National Bank for Agriculture and Rural Development
OBF	On Bill Financing
OEM	Original Equipment Manufacturer
OPEX	Operating Expenditure
PAYGo	Pay as you go
PLI	Production Linked Incentives
R&D	Research and Development
SDG	Sustainable Development Goals
SHS	Solar Home System
SIDBI	Small Industries Development Bank of India
SNA	State Nodal Agency
SPI	Smart Power India
SRLM	State Rural Livelihood Mission
UJALA	Unnat Jyoti by Affordable LEDs for All

Executive Summary

The Problem – *weak grid*

Availability: Grid supply hours

Rural areas	*Worst case**	16 Hours
	National average	21 Hours
Urban areas	*Worst case**	22 Hours
	National average	23.5 Hours

Source: CEA Annual Report 2020-21

** Worst case corresponds to the lowest value of supply hours*

Reliability

According to the study conducted by Smart Power India (SPI) and NITI Aayog in the year 2020 - **70% of household customers of electricity grid reported one or more power cuts in the past year**

Around 81% of 25,000 customers surveyed in both urban and rural, had the least degree of electricity access, considering all dimensions of access equally

Safety issues

Accidental Deaths and Suicides in India (ADSI) report **indicate a total of 15,258 deaths due to electrical shocks and fires** in the Calendar year 2020 - **Major cause of deaths is electrocution**

16% of customers reported electrical accidents in the past year as per the study conducted by Smart Power India (SPI) and NITI Aayog in the year 2020

Solution – LVSPA: *a $ 2-5 billion market in India*

The fastest, cheapest, and greenest way of increasing the quality of electricity access for households and businesses on the grid is with:

Low Voltage Smart Power & Appliances (LVSPA) - Grid power that integrates with solar, battery storage and high-efficiency appliances

Strategies for building LVSPA market:

Innovative partnerships are essential for scale-up	*State rural livelihood missions offer an effective last mile distribution channel*	*Consumer finance (PAYGo or EMI with digital finance) can dramatically enhance affordability*	*Policy & regulatory incentives are essential to incentivize consumers and manufacturers*

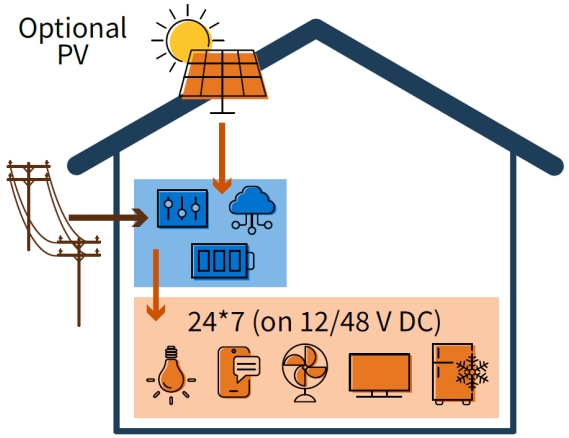
STRENGTHENING THE GRID WITH LVSPA TECHNOLOGIES HAS A VAST OPPORTUNITY FOR THE OFF-GRID SOLAR INDUSTRY

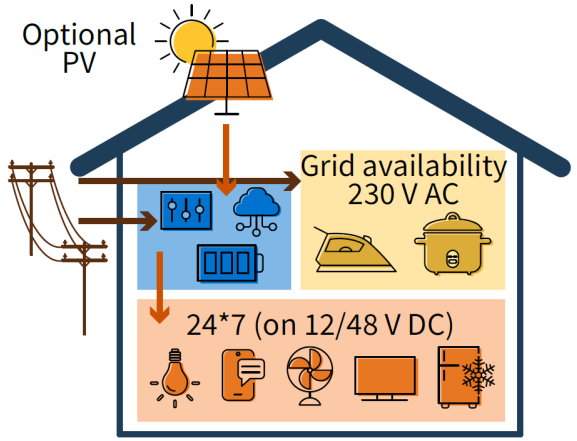
IT ALSO BENEFITS UTILITIES BY ENHANCING CUSTOMER SATISFACTION, IMPROVING REVENUE, AND OFFERING ANCILLARY SERVICES

LVSPA – *four system architectures*

Four market segments of LVSPA, defined by the system architecture, that are emerging with high potential:

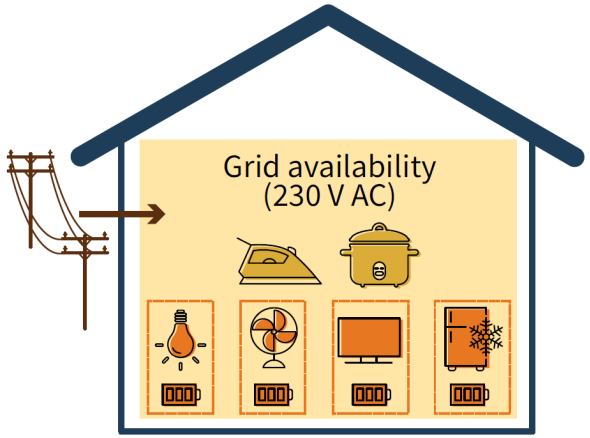
Segment One
Low voltage for all loads and appliances

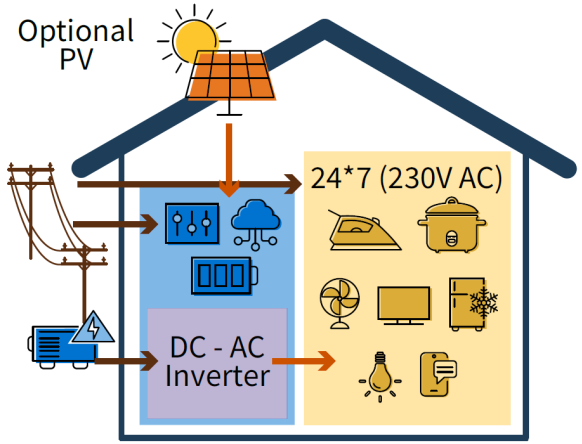




Segment Two
Low voltage and grid voltage in parallel

Segment Three:
Grid voltage using appliances with in-built battery back-up

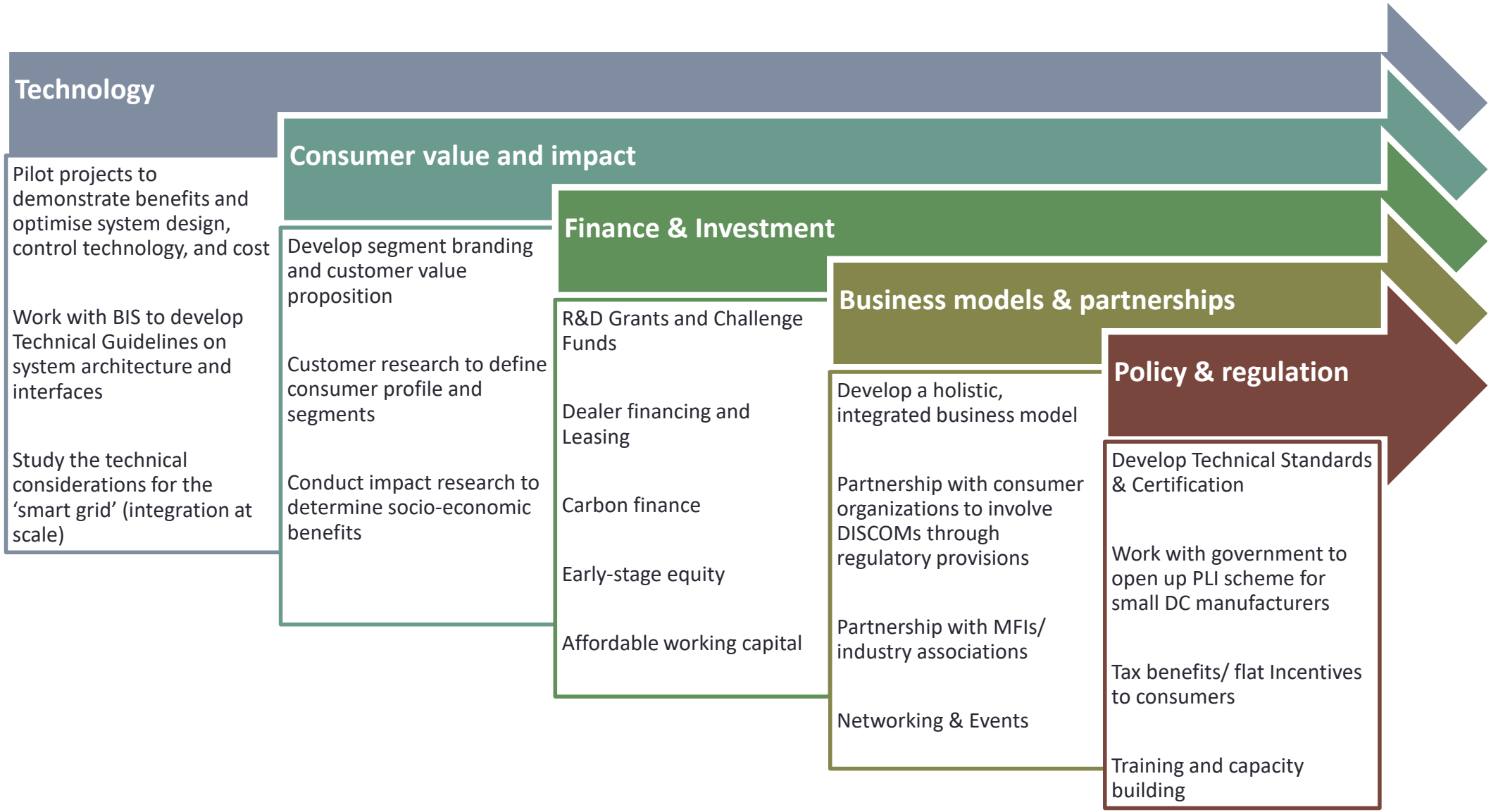




Segment Four:
Grid voltage with battery back-up and inverter

THE COMPONENT TECHNOLOGIES FOR LVSPA ON WEAK GRID ARE MATURE AND AVAILABLE. HOWEVER, FURTHER R&D IS NEEDED ON SYSTEM DESIGN, INTEGRATION, AND CONTROL

LVSPA Roadmap - *activities to build the market*



Improved Energy Access

Higher uptake of Renewable Energy systems

Increased adoption of Energy Efficiency practices

Introduction

Context of the study

What is LVSPA

LVSPA system architecture/ segments

Study objective & research themes

Context

- India reportedly achieved 100% electrification of all households by 2019. Reliability and quality of grid supply still a major issue in semi-urban, rural, and remote areas – thus a weak grid *(refer to next slide)*
- Weak grid market fragmented with use of SHS/ solar rooftops, Inverter battery, DC appliances at different consumer levels *(refer to next slide)*
- India has committed to achieve Net Zero by 2070 and at the same time, has pledged to decrease its CO_2 emissions intensity of GDP by 45 percent by 2030 from 2005 levels, and increase renewable energy to about 50 percent of installed capacity in 2030 in the updated NDC submission to UNFCCC (2022)

- *Low Voltage Smart Power & Appliances (LVSPA) – that brings together whole ecosystem of battery energy storage, distributed solar, and energy efficient DC appliances – will be an effective way to improve the availability and reliability of power for weak grid customers*
- *LVSPA will be significant in meeting the above targets by supporting adoption of energy efficient appliances across households as well as supporting the distributed solar installations*
- *LVSPA has the potential to unite off-grid and weak grid customers in Africa and Asia with a common technology base*

Status of grid supply and back-up appliance market in India

Grid electricity supply in India

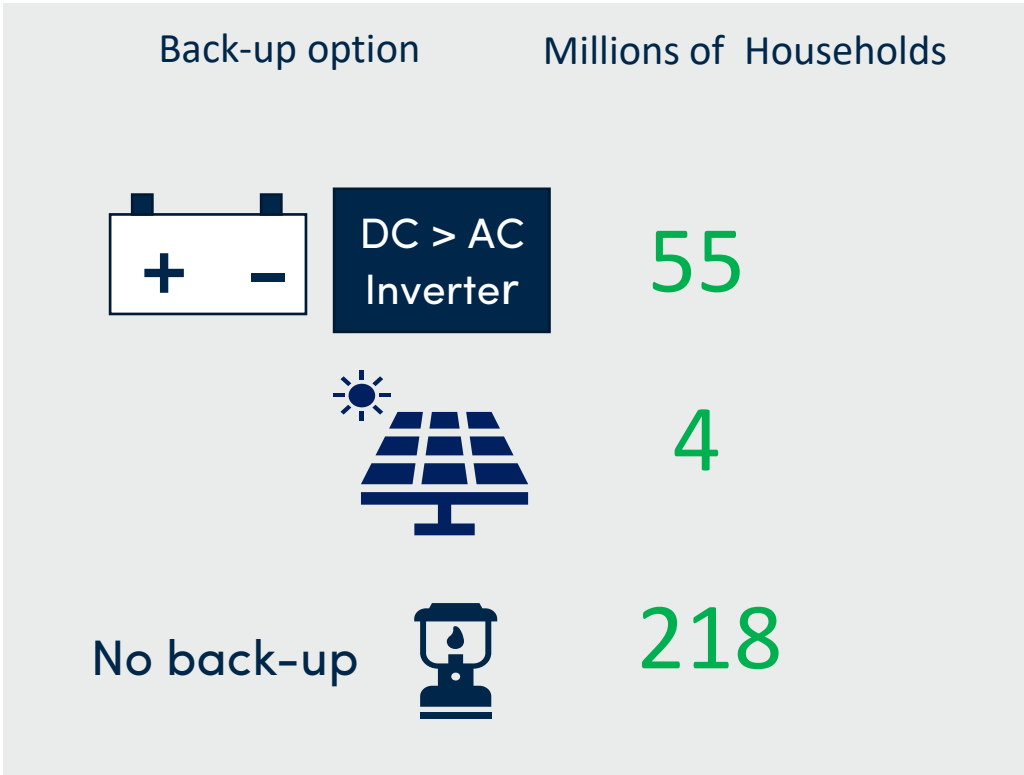
Rural areas	*Worst case**	16 Hours
	National average	21 Hours
Urban areas	*Worst case**	22 Hours
	National average	23.5 Hours

Source: ***CEA Annual Report 2020-21 Annexure 8A***

** Worst case corresponds to the lowest value of supply hours*

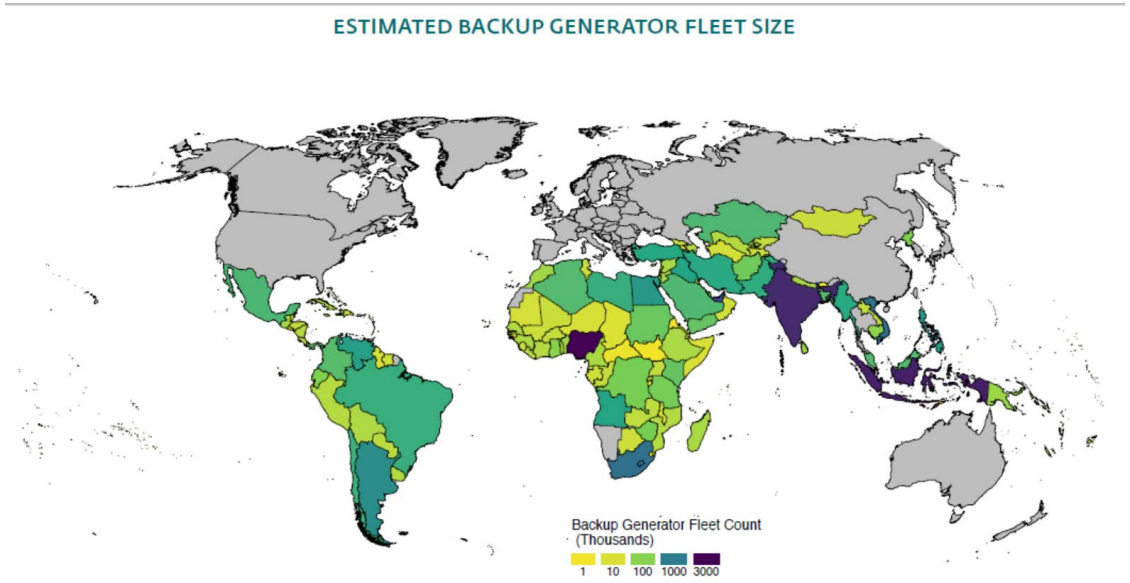
According to the study conducted by Smart Power India (SPI) and NITI Aayog in the year 2020, 70% of household customers of electricity grid reported one or more power cuts in the past year (Source link)

Back-up appliance market size



Source: ***GOGLA-pManifold 'Opportunities for Hybrid AC-DC Infrastructure in India' Report 2020***

Global trends - potential for LVSPA market



*Countries in grey are not modelled
Source: The Dirty Footprint of the Broken Grid, IFC

- 840 million people without any access to electricity and over 1 billion connected to an unreliable grid
- 3 million+ SHS kits and 2 million+ appliances (TVs, Fans, Fridges, etc.) sold by GOGLA members since 2017
- 20-30 million small gasoline generators being used in 167 countries across the world
- Average price of lithium-ion batteries have fallen 85 percent from 2010 to 2018; refurbished battery market is growing
- Loads being served by today's AC grid are becoming more natively DC due to the proliferation of electronics, LED, and DC plug loads
- Growing penetration of Brushless DC motor applications in Indian household appliances; UJALA scheme transformed Indian lighting market towards LED based lighting

These points to an emerging market of LVSPA which offers a viable pathway for an efficient and reliable electricity services in weak grid areas

Source: GOGLA OGS Market trends report 2020; IFC – The Dirty Footprint of the Broken Grid

Safety issues with AC power supply- case for LVSPA

- Accidental Deaths and Suicides in India (ADSI) report **indicate a total of 15,258 deaths due to electrical shocks and fires** in the Calendar year 2020 (Jan – Dec)

- CEA reports **7,717 fatal human accidents in 2020** (financial year – Apr 2019 to Mar 2020)

- **Major cause of deaths is electrocution** which are caused due to low priority to safety, bad design, poor maintenance, un-authorised repair, bad quality earthing, and inadequate protection systems

What is Low Voltage Smart Power and Appliances (LVSPA)

Smart Power:

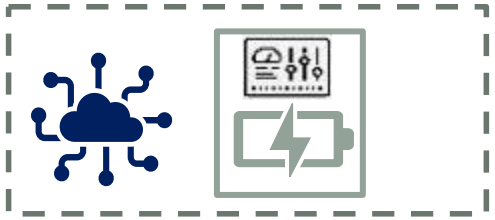
Combines grid electricity with a battery back-up (preferably Lithium-Ion) for 24*7 power supply. Solar panel is optional

12 V DC | 48 V DC | 230 V AC (w Inverter) | Hybrid AC-DC

Smart appliances: Energy efficient appliances (DC appliances) complement Smart Power and reduce bills

Few examples of smart household appliances

Smart Apps: In-built battery, AC and DC modes, digital controls, Internet of Things enabled



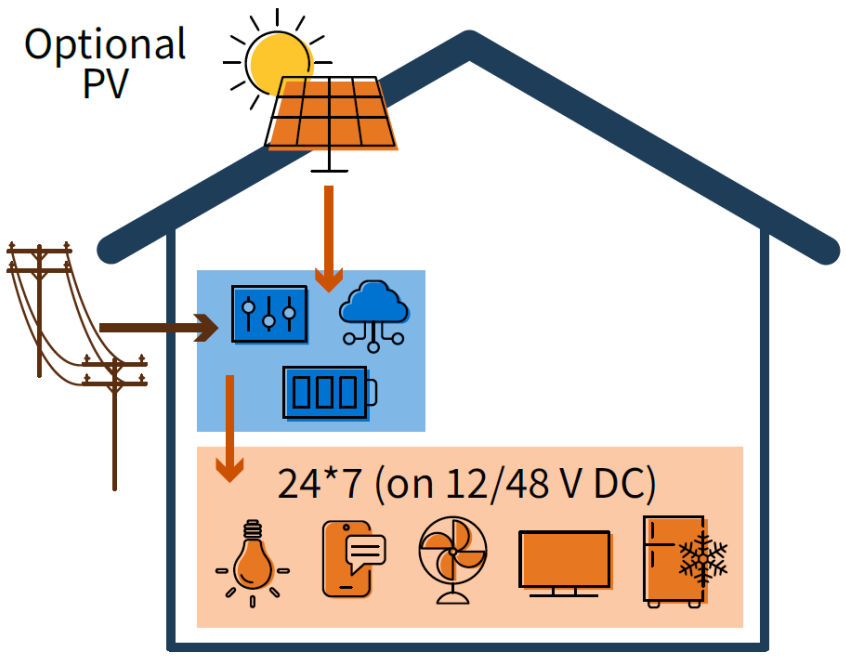
Much innovation has happened in LVSPA space, targeting solutions that are affordable and scalable. However, it is a complicated and fragmented market, making it challenging to standardize and commercialize

Four market segments, defined by the system architecture, with high potential are emerging and are discussed in next slide

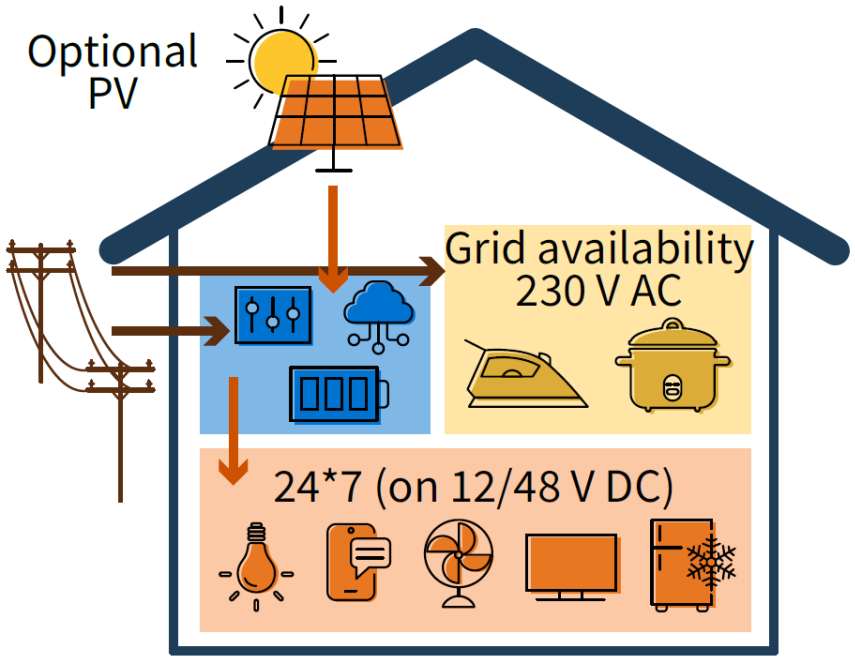
Courtesy: GOGLA- pManifold presentation on Smart Power & appliances

LVSPA – *system architectures*

Four market segments of LVSPA, defined by the system architecture, that are emerging with high potential:



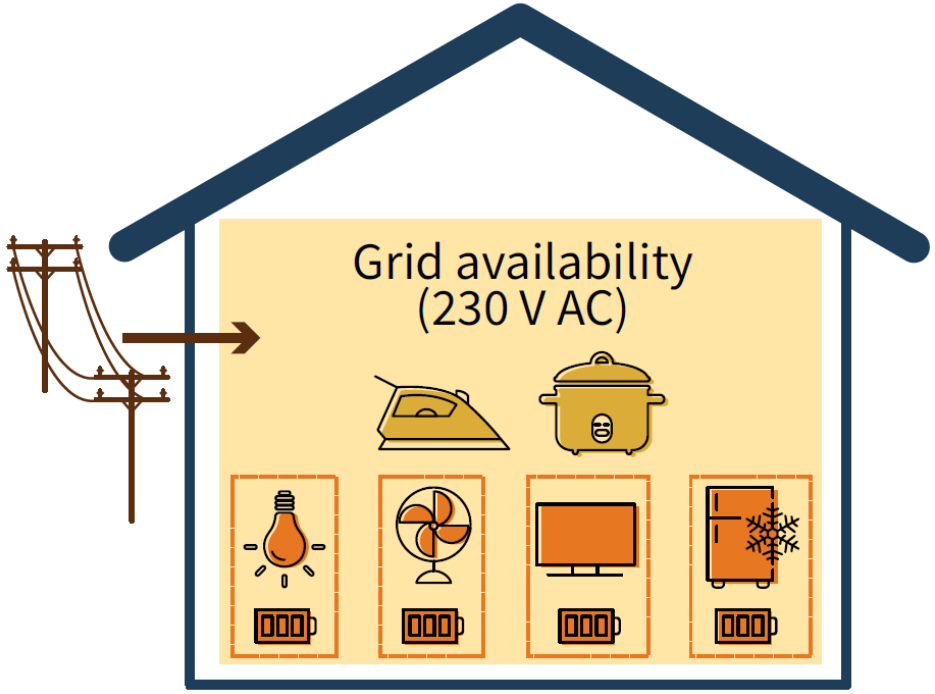
Segment 1: The grid supply is converted to low voltage (12V or 48V) DC with a rectifier. When the grid is available, it powers the loads through a rectifier and charges the battery. When the grid is not available, the battery powers the loads directly. All the loads are high-efficiency LVDC. A smart meter enables metering, billing, and payments, and the IoT manages system performance



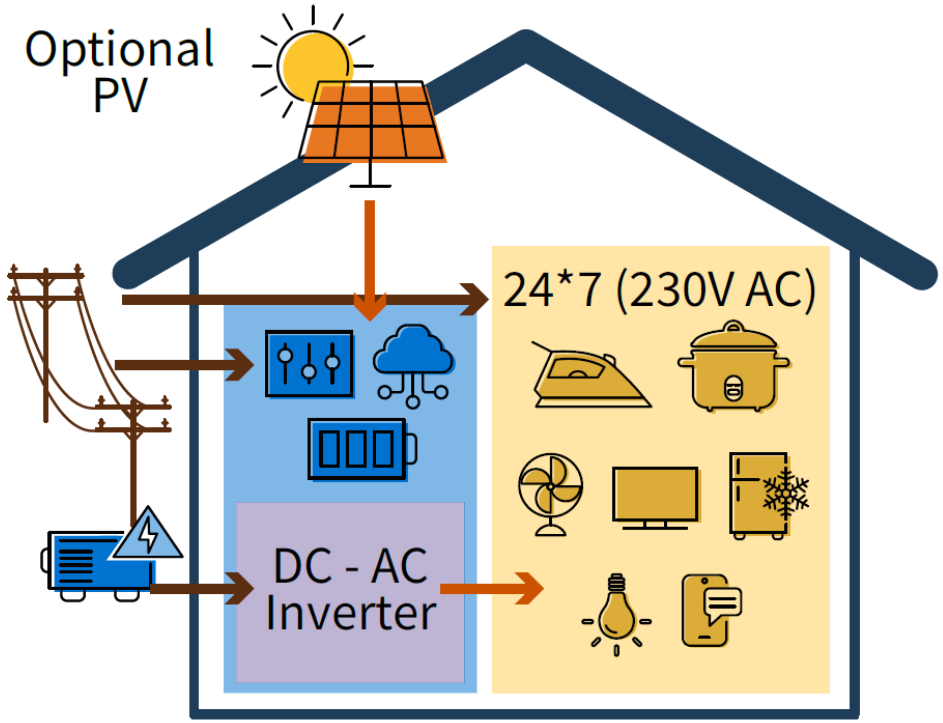
Segment 2: As with Segment 1, a range of 'core' loads are on the LVDC line, with the battery back-up. High power loads are on a parallel grid-voltage AC line and can only be used when the grid is available

Segments 1 and 2 are entirely compatible, that is, a household could expand from 1 to 2, or from 2 to 1

LVSPA – *system architectures (continued…)*



Segment 3: All the loads and appliances are powered by the grid-voltage AC line. Lights, fans, TVs and other select appliances have inbuilt batteries and electronics that enable continued operation during power outages



Segment 4: When the grid is available, it directly powers the AC loads and charges the battery. When the grid is not available, the battery powers the loads via an inverter. Solar PV and/or a generator may be used for additional generating capacity to supplement the grid and boost the battery during outages

THE COMPONENT TECHNOLOGIES FOR LVSPA ON WEAK GRID ARE MATURE AND AVAILABLE. HOWEVER, FURTHER R&D IS NEEDED ON SYSTEM DESIGN, INTEGRATION, AND CONTROL

Study objective and research themes

Objective: To map out the status, opportunity and challenges for LVSPA sector in India and prepare a Roadmap of necessary set of actions to establish and scale this market

Commencement of the study: Mid January 2022

The study has

- Undertaken research on key themes to explore the viability of the LVSPA for two consumer segments,
- Convened roundtable and one-to-one meetings to discuss and map out the status, opportunity and challenges
- Produced a Roadmap that articulates the opportunity and how to tap into it

Research themes

- Technology
- Business model & partnerships
- Market size & investment opportunity
- Consumer value & impact
- Policy & regulation

Consumer segment focus

- Segment 1 (low-income)
- Segment 2 (low-middle income)

Research methodology

Desk research

Consultations and roundtables

Cost modelling

Desk research

Desk based literature review was undertaken to assess the existing landscape of weak-grid sector in India

Information areas:

1. Status of grid supply in India
2. Appliance use in rural areas and status of DC appliances
3. Available technologies in the market
4. Consumer profiles
5. Business and delivery models
6. Ongoing policy and programmatic initiatives
7. Barriers/challenges for the sector

Main sources of information/data:

(a) Research and market studies and published reports on the weak-grid sector;

(b) Databases by the government, development partners

(c) Policy guidelines by the government and program information documents by donor agencies

(d) Websites of stakeholders including companies, development partners and financial institutions

Consultations and roundtables

Consultations and roundtables with stakeholders active in the space were conducted to map out the status, opportunities, challenges and actions for LVSPA sector in India

Stakeholders reached out: 150+

Stakeholders participated in roundtables/ one-to-one consultations: 60

Total roundtables conducted: 7 (in-person - 3)

Total one-to-one meetings conducted: ~15

Stakeholders mapped under eight key groups

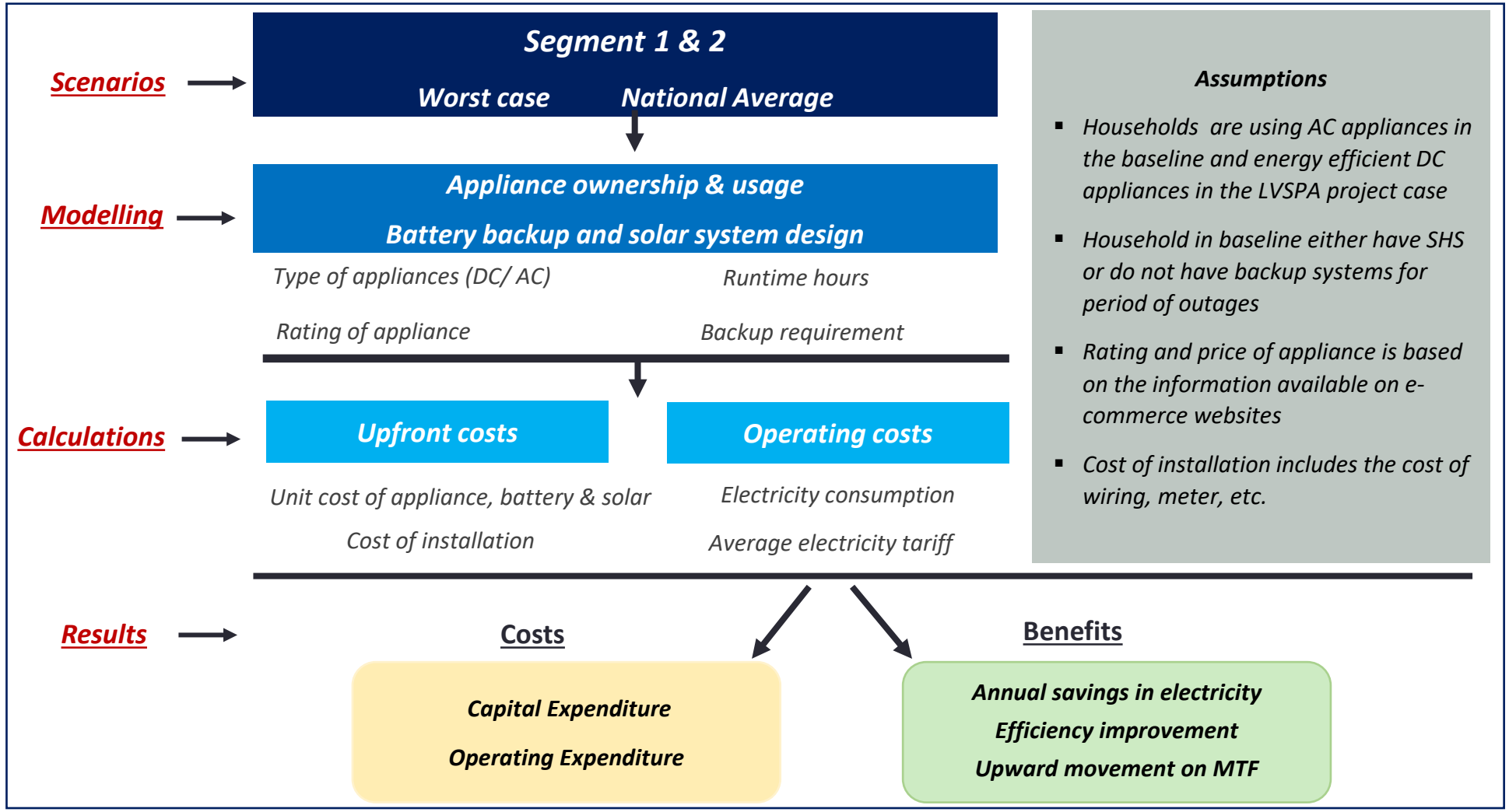
1. Government/ private utility companies
2. Central & State Nodal Agencies, Government Organizations
3. Manufacturers/ Service Providers/ Distributors/ O&M Providers of Solar lights/ SHS/ Charge controllers
4. Manufacturers/ Service Providers of DC system and appliances
5. Financial institutions
6. Consumer organizations/ non-government organizations (NGOs)
7. Thinks Tanks/ Technical institutions/ Donors
8. International companies

Key highlights from roundtable discussions

Roundtable	Location	Key highlights
First	Online	Highlighted the importance of consumer awareness and training for increasing the uptake of LVSPA in rural areas by all stakeholders including the participant from the consumer group
Second	Kolkata	Included participants from remote corners of West Bengal, India, who highlighted the opportunities for LVSPA technologies in off-grid small households/ shops located in remote fields and emphasized the importance of engaging with people to discuss the benefits of solar and DC products
Third	Ranchi	Provided good insights from stakeholders on appliance affordability and access issues for rural households in these regions
Fourth	Online	Discussed the possible alternatives for Li-ion battery such as second life Li-ion battery and Gel batteries which are much cheaper and potential benefits for struggling DISCOMs from implementation of LVSPA in segments 1 & 2
Fifth & sixth	Online	Highlighted the importance of standardization and last mile distribution channel with after sales service for creating market transformation for LVSPA and significance of strategic partnerships and conducive policy for DC appliance manufacturers in creating a pull market for LVSPA
Seventh	New Delhi	Emphasized the importance of partnership with micro finance institutions (MFIs) that have deep grassroot connections with the rural communities and pushing the market from the standard and financing sides to make the market larger and sustainable

Cost modelling

A cost model was developed to evaluate the costs and benefits of LVSPA applications and allow for comparison over different scenarios of targeted consumer segments



This model is an initial attempt to quantify and compare these segments.

The study recognizes that further work is required to refine and capture the complexity and variety of scenarios

Status of LVSPA market in India

Profiling of consumer segments

Drivers & benefits for consumers

Cost – benefit analysis for Segment 1 & 2

Investment opportunity

Profiling of targeted consumer segments

Parameters	Segment 1 (Low income households)	Segment 2 (Low-middle income)
Average annual income (INR) – *as per Centre for Monitoring Indian Economy (CMIE)*	< 100,000 ($1,280)	100,000 – 200,000 ($1,280 - $2,560)
Appliance ownership	Lamp, Fan, Mobile	Lamp, Fan, TV, Refrigerator (single door), Mobile
Number of households – *as per Statista, projections for 2025*	~ 55 million	~ 140 million

Centre for Monitoring Indian Economy (CMIE) has divided households into five income classes

- Low-income households that earn less than INR 100,000 a year
- Lower middle households earning between INR 100,000 and INR 200,000 a year
- Middle income households earns between INR 200,000 and INR 500,000 a year
- Upper middle class earns between INR 500,000 and INR 1 million a year
- Rich households earn more than INR 1 million in a year

As per Statista, projections for 2025, about 55 million households in India will belong to the low-income (potentially segment 1) bracket and ~140 million households to Low-middle income (potentially segment 2).

Drivers & benefits for consumers in Segments 1 & 2

- **Potential energy savings and reduced electricity bill over the lifetime of the product** as DC appliances have better life hours and are more efficient than their AC counterparts
- **Availability & reliability of electricity supply to household marked by grid outages up to 8 hours in rural areas** as LVSPA system ensures 24/7 supply
- **Shift to higher World Bank Multi Tier Framework level** *(discussed in next slide),* as consumers will enjoy electricity for greater number of hours through LVSPA
- **No threat of electrocution from DC appliances operating at 12V/ 24V DC** as very less current is transmitted at 12V/24V DC voltages and are considered safer to touch even when energized
- **Affordability of the LVSPA system for the consumer** would be essential for making a switch
- **Increased opportunities for consumer financing** are also a big driver for the consumer. LVSPA linked with digital tech for remote control, monitoring and payments enables the PAYGo business model
- **Possibility of going completely off-grid with LVSPA** architecture of solar power, Li-Ion battery and DC appliances

World Bank Multi Tier Framework

- Multi-Tier (MTF) Framework, developed by the World Bank, is used to track electricity access solutions and assigns Tier from Tier 0 (no access) to Tier 5 (the highest level of access)
- The framework uses parameters such as capacity, availability, reliability, quality, affordability, safety.
- The assigned MTF tier is the lowest tier rating across the six attributes
- A ***Partial Tier*** *(used specifically for this study)* rating means the scenario meets the MTF standard for power supply hours, but not all for that Tier

			Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Attributes	1. Peak capacity	Power		Very low power, minimum 3 watts	Low power, minimum 50 watts	Medium power, minimum 200 watts	High power, minimum 800 watts	Very high power, minimum 2 kilowatts
		and Daily capacity		Minimum 12 watt-hours	Minimum 200 watt-hours	Minimum 1.0 kilowatt-hours	Minimum 3.4 kilowatt-hours	Minimum 8.2 kilowatt-hours
		or Services		Lighting of 1,000 lumen-hours per day	Electrical lighting, air circulation, television, and phone charging are possible			
	2. Duration	Hours per day		Minimum 4 hours	Minimum 4 hours	Minimum 8 hours	Minimum 16 hours	Minimum 23 hours
		Hours per evening		Minimum 1 hour	Minimum 2 hours	Minimum 3 hours	Minimum 4 hours	Minimum 4 hours
	4. Affordability					Cost of a standard consumption package of 365 kilowatt-hours per annum is less than 5 percent of household income		
	3. Reliability						Maximum 14 disruptions per week	Maximum 3 disruptions per week of total duration less than 2 hours
	5. Legality						Bill is paid to the utility/prepaid card seller/authorized representative	
	6. Health and safety						Absence of past accidents/ no perception of high risk in the future	
	7. Quality						Voltage problems do not affect use of desired appliances	

Cost – benefit analysis: Segment 1 (Low income)

Scenarios

'National average'

Baseline

LVSPA

LVSPA w solar

'Worst Case'

Baseline

LVSPA

LVSPA w solar

Baseline w SHS back-up

Summary results

Analysis of results

Baseline (for the national average*)

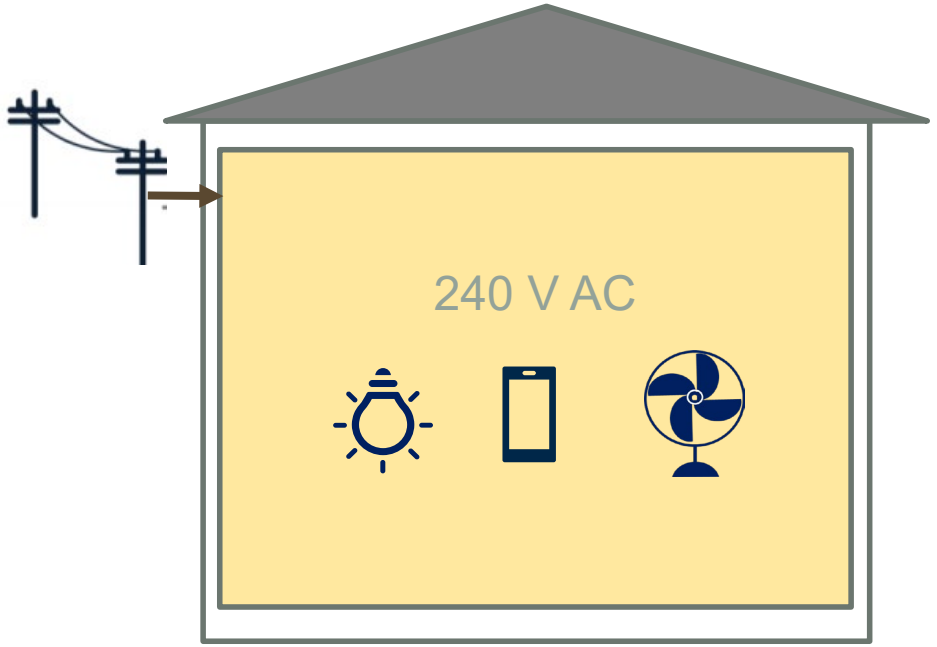
Power availability & WB MTF
- 21 hours supply from grid/ day
- Partial Tier 4

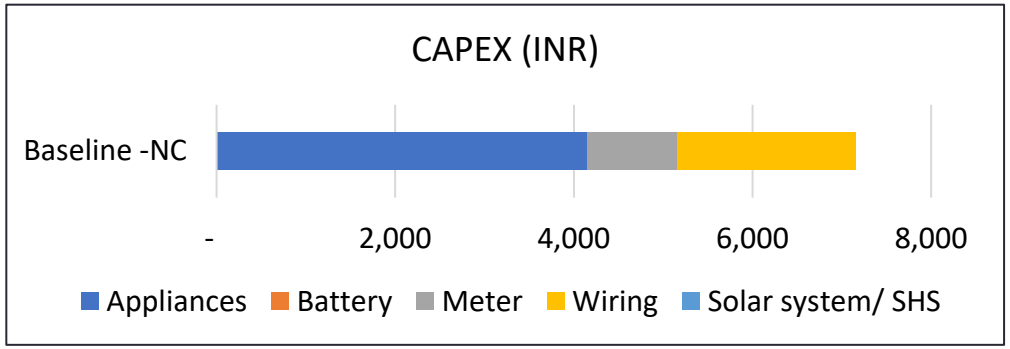
Consumption
- 3,521 Wh / day

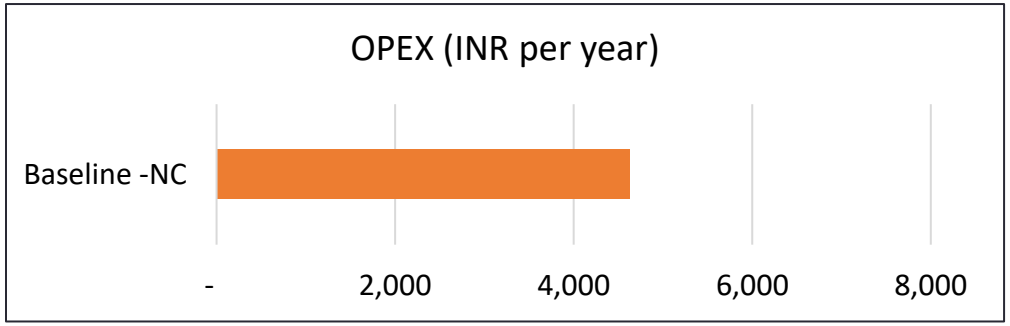
Connected load
- 205 W

No. of power cuts/ supply disruptions per day
- 1-10/ day

Efficiency rating[i]
- 1.2







** National average scenario relates to the situation where rural household receives grid supply for 21 hours i.e. the national average power supply for rural areas*

*[i] **E**fficiency rating = [Power supply (hours) x Connected load (W)] / Daily consumption (Wh)]*

24*7 LVSPA (for the national average)

Power availability & WB MTF

- 21 hours supply from grid/ day and 3 hours supply from battery/ day
- Partial Tier 5

Consumption

- 2,171 Wh / day

Connected load

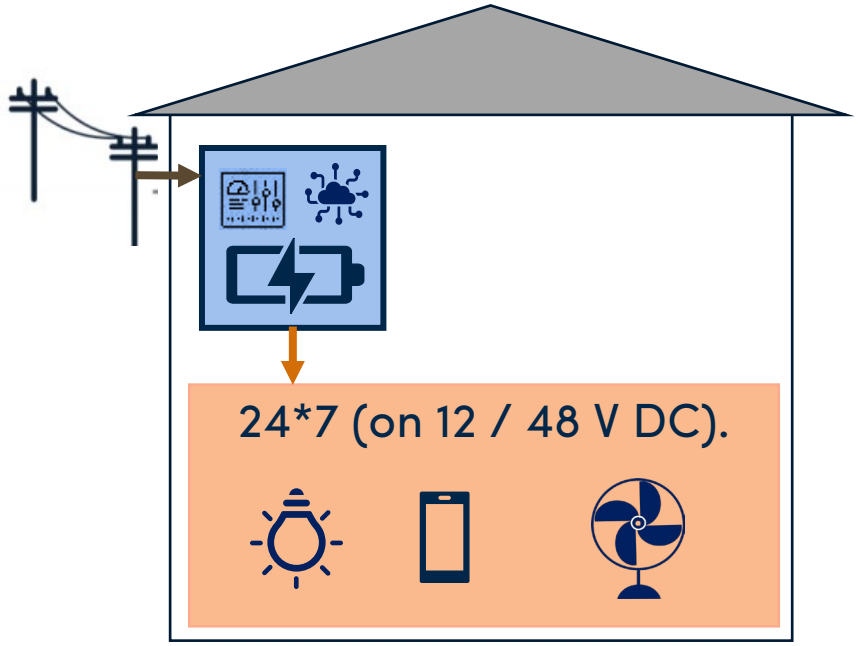
- 228 W

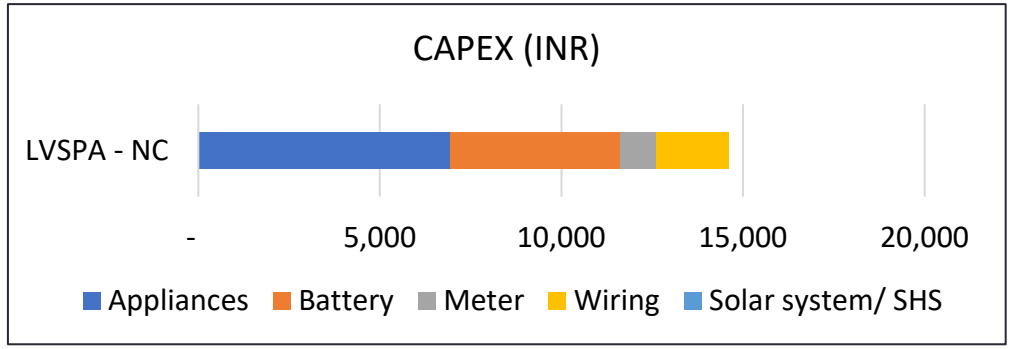
No. of power cuts/ supply disruptions per day

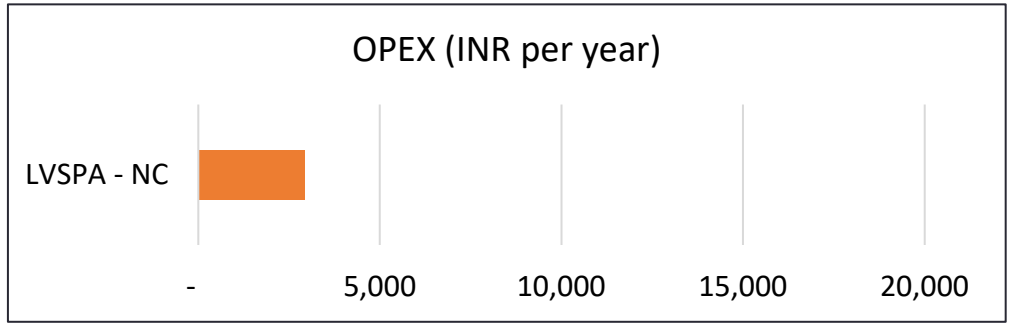
- No cuts

Efficiency rating

- 2.5







24*7 LVSPA w solar PV (for the national average)

Power availability & WB MTF

- 21 hours supply from grid/ day and and 3 hours supply from battery/ day
- Partial Tier 5

Consumption

- 1,993 Wh / day

Connected load

- 228 W

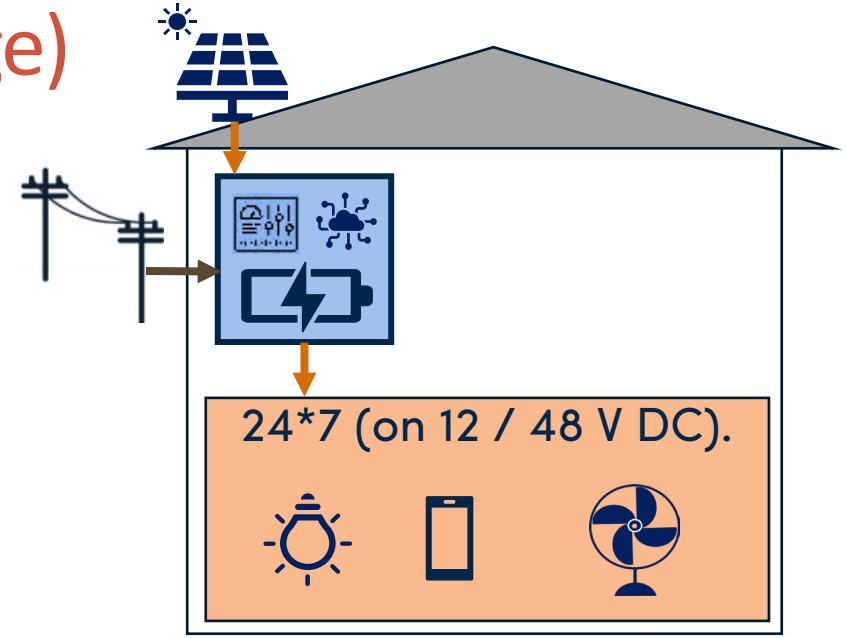
No. of power cuts/ supply disruptions per day

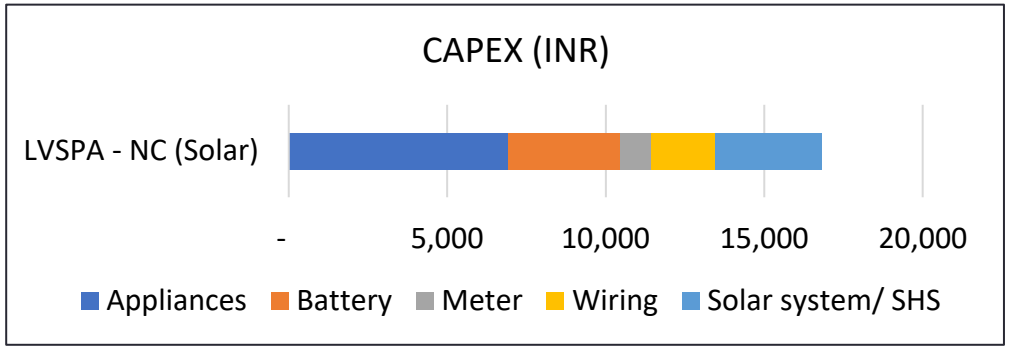
- No cuts

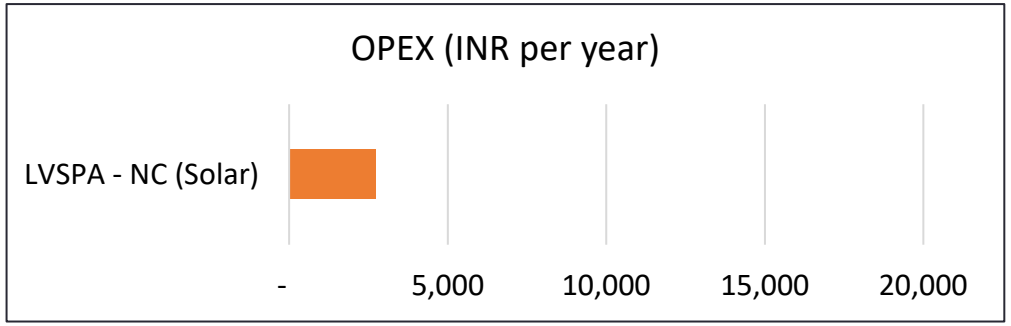
Efficiency rating

- 2.7

A simple assumption that, with solar PV, the battery size could be 25-30% smaller has been used to build the scenario with solar PV. An accurate modelling requires inclusion of lot of variability in the availability of grid and load demand timing. Power controls are also complicated (and expensive)







Baseline (for the worst case*)

Power availability & WB MTF
- 16 hours supply from grid/ day
- Partial Tier 3

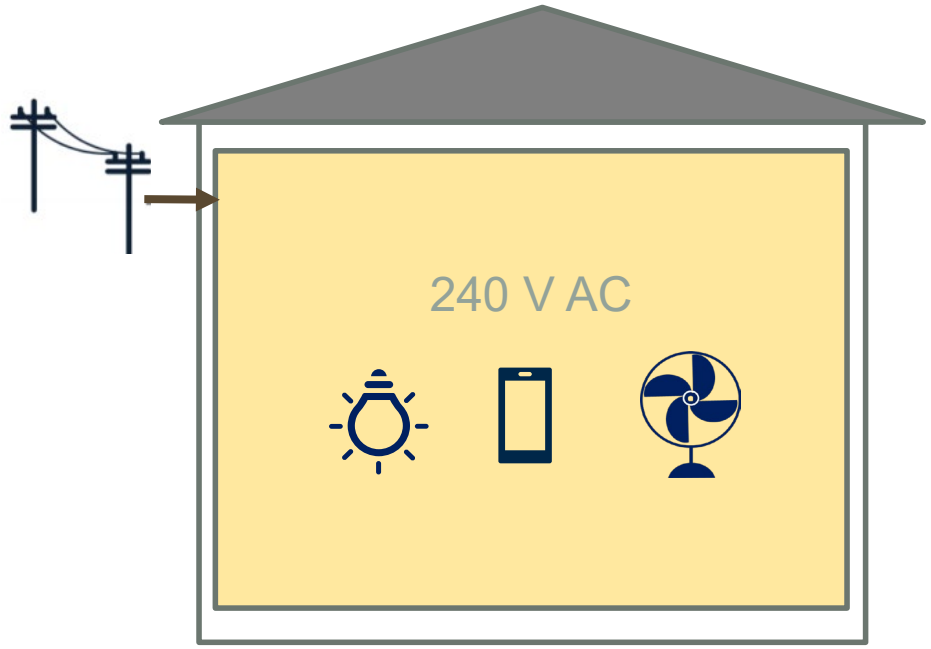
Consumption
- 2,576 Wh / day

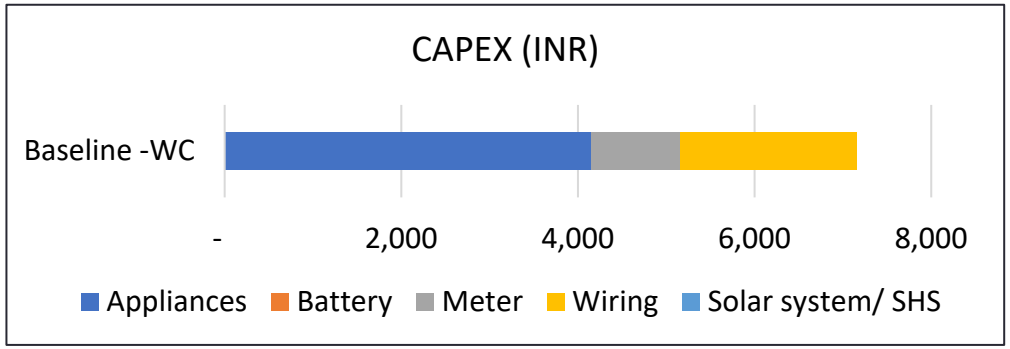
Connected load
- 205 W

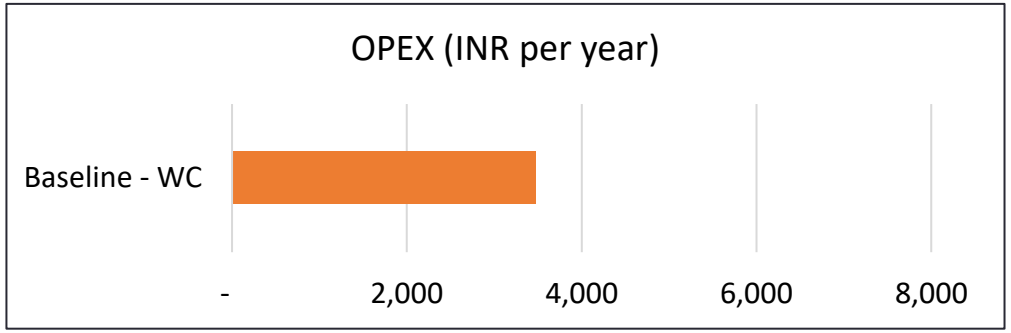
No. of power cuts/ supply disruptions per day
- 10-15/ day

Efficiency rating
- 1.3

** Worst case scenario relates to the situation where rural household receives grid supply for 16 hours i.e. the lowest power availability for rural areas*







Baseline w SHS back-up* (for the worst case)

Power availability & WB MTF
- 16 hours supply from grid/ day + SHS
- Partial Tier 4

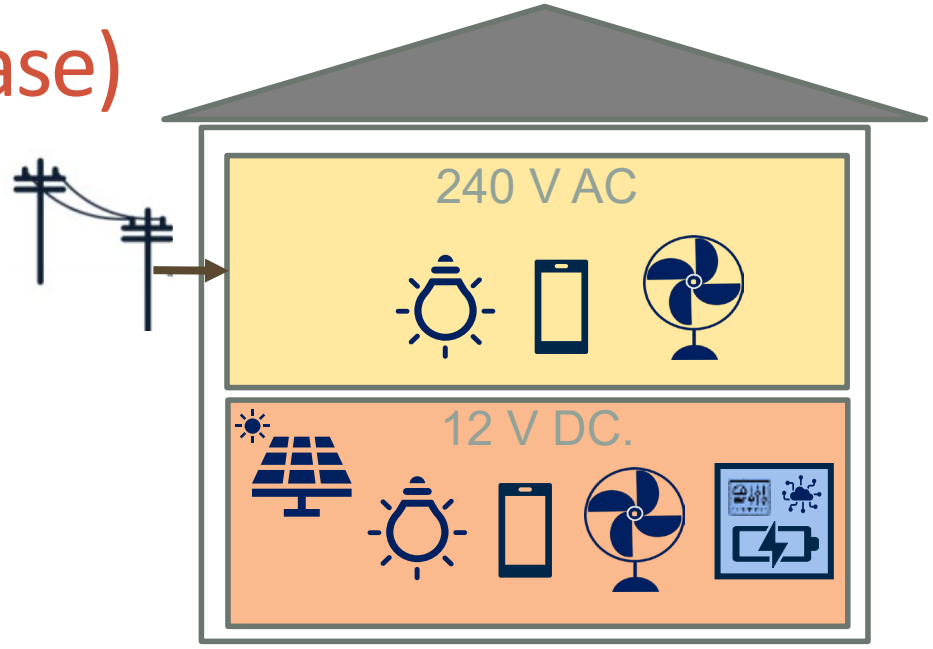
Consumption
- 2,576 Wh / day

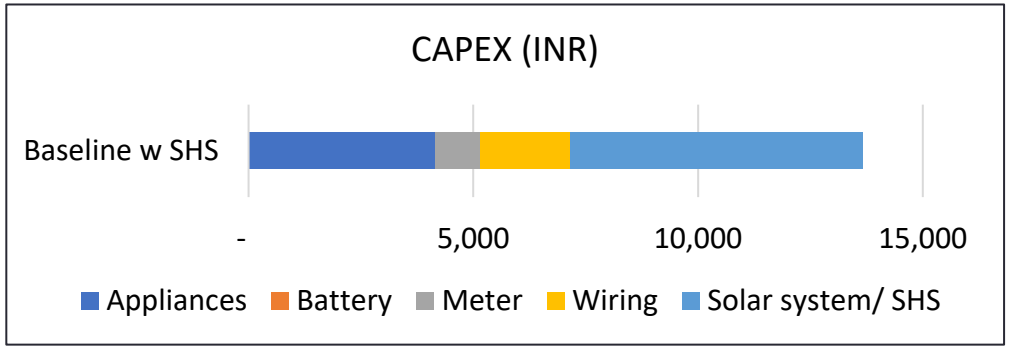
Connected load
- 205 W

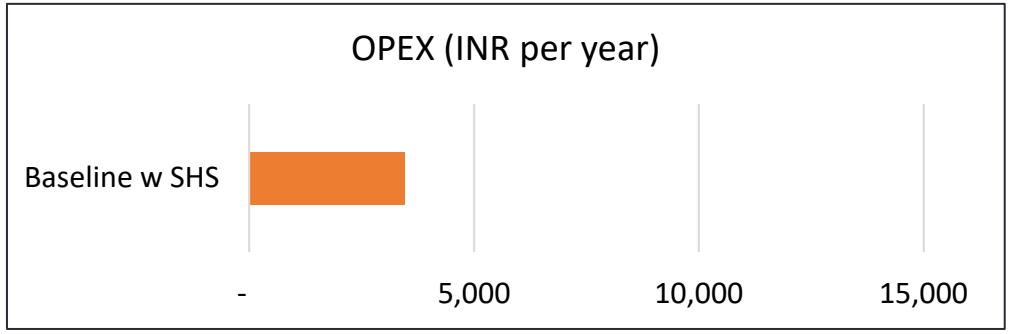
No. of power cuts/ supply disruptions per day
- 10-15/ day

Efficiency rating
- 1.3

** SHS is in parallel and not integrated*







24*7 LVSPA (for the worst case)

Power availability & WB MTF

- 16 hours supply from grid/ day and 8 hours supply from battery/ day
- Partial Tier 5

Consumption

- 2,272 Wh / day

Connected load

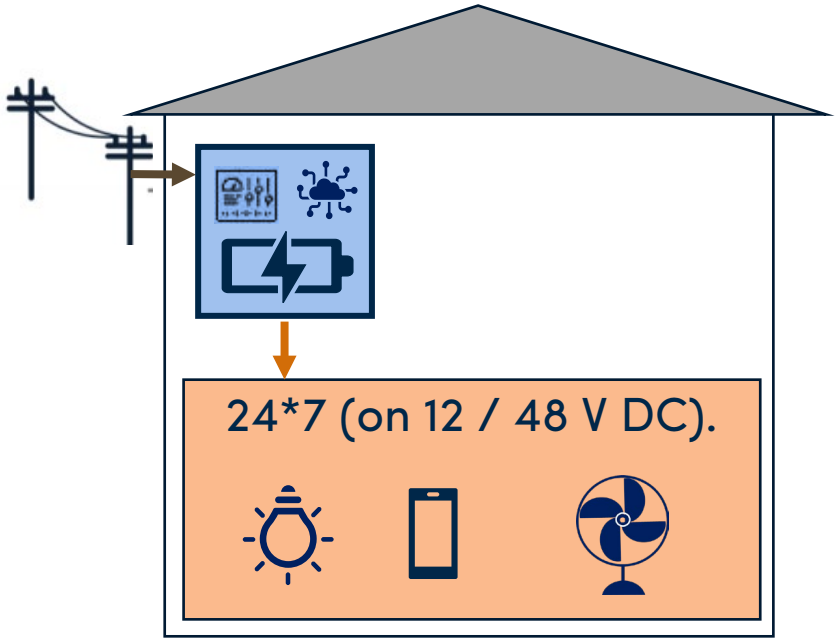
- 228 W

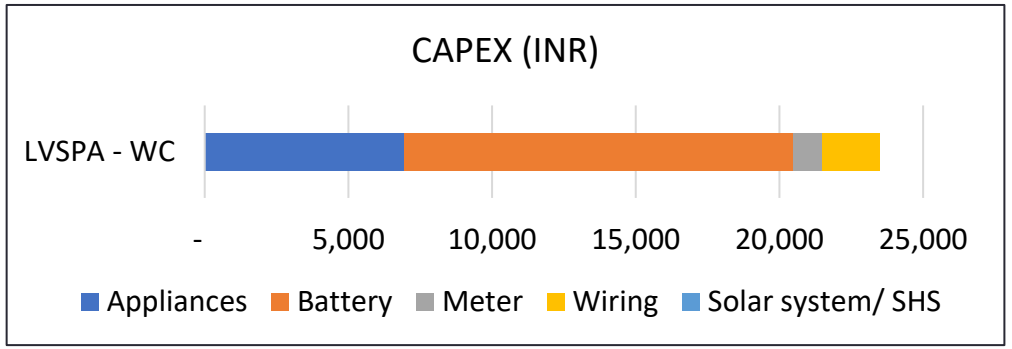
No. of power cuts/ supply disruptions per day

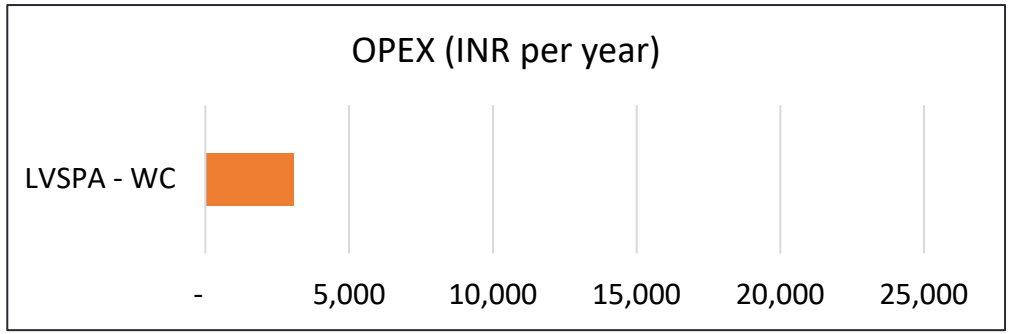
- No cuts

Efficiency rating

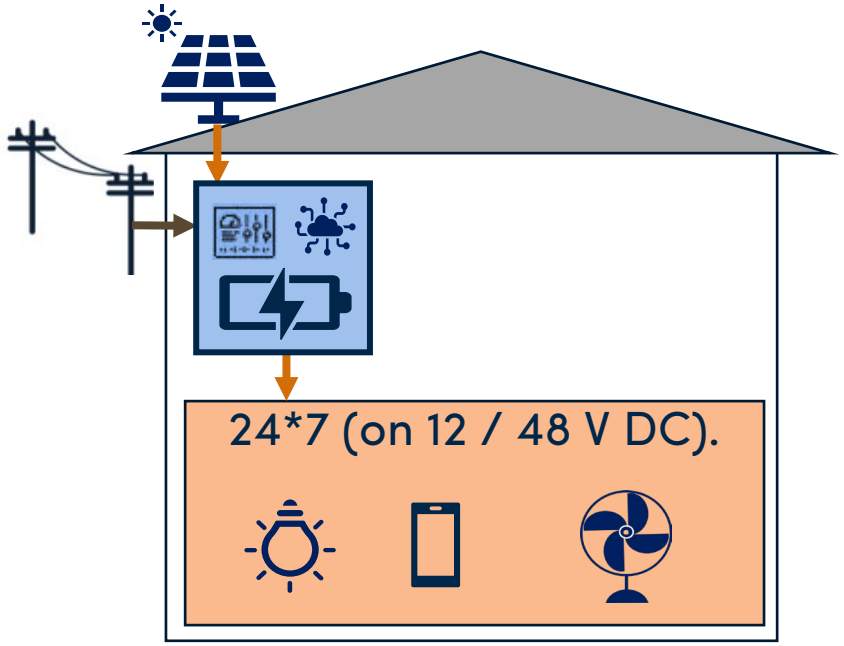
- 2.4







24*7 LVSPA w solar PV (for the worst case)



Power availability & WB MTF

- 16 hours supply from grid/ day and 8 hours supply from battery/ day
- Partial Tier 5

Consumption

- 1,917 Wh / day

Connected load

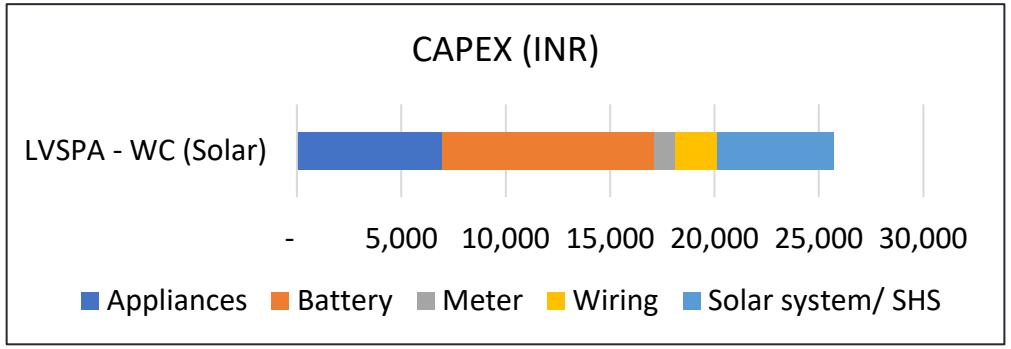
- 228 W

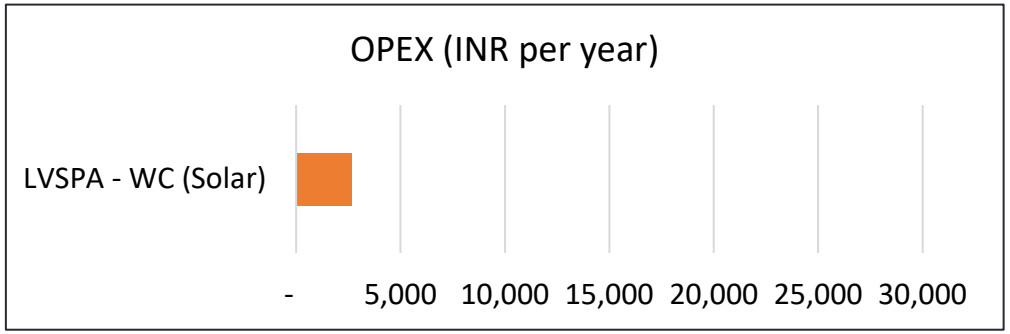
No. of power cuts/ supply disruptions per day

- No cuts

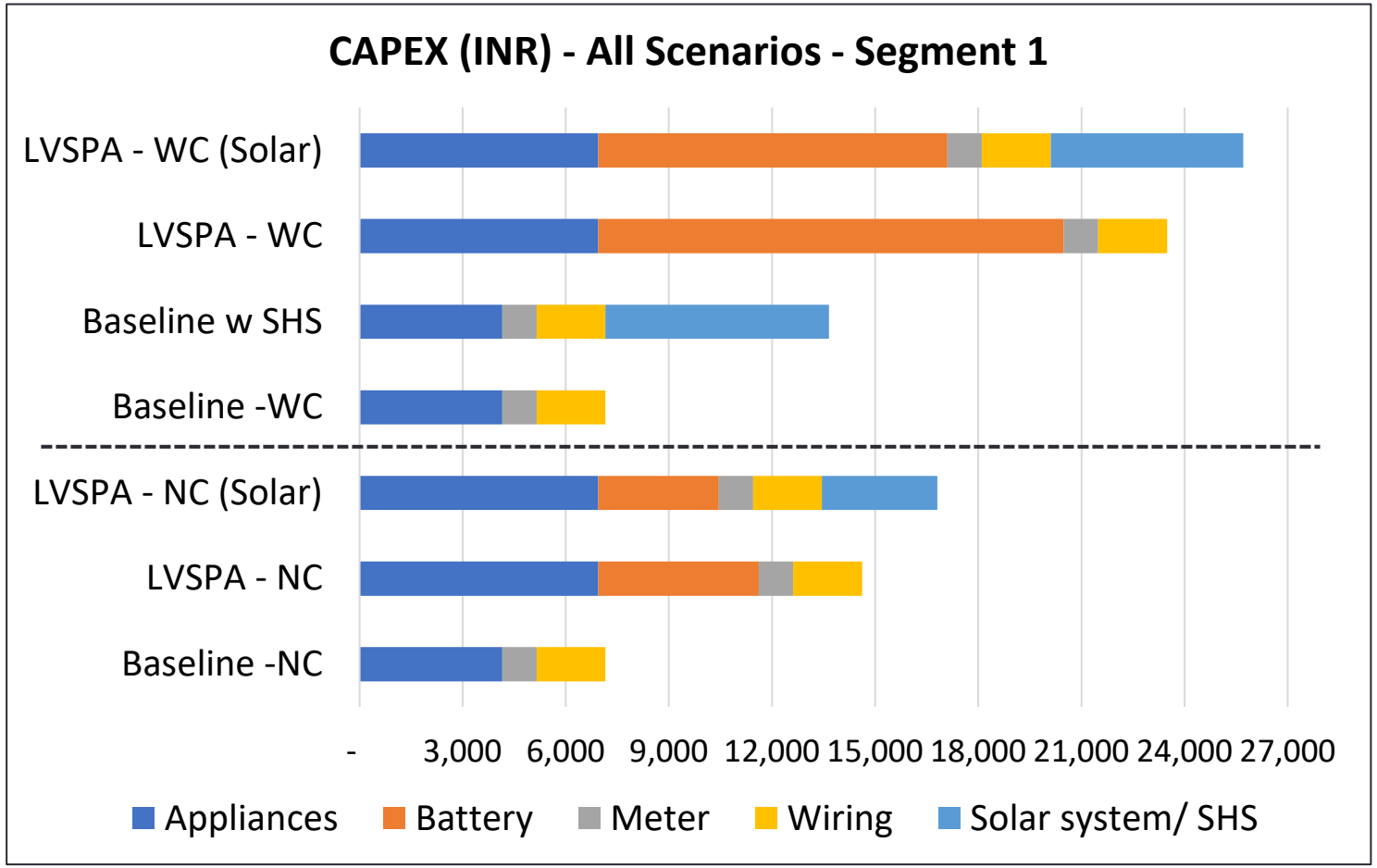
Efficiency rating

- 2.9





Summary of results



Hours/day w electricity	OpEx (INR per year)	Efficiency Rating
24	2,640	2.9
24	3,067	2.4
16	3,467	1.3
16	3,467	1.3
24	2,724	2.7
24	2,937	2.5
21	4,628	1.2

Analysis of results

- *Capital cost (CAPEX) of the LVSPA is 2-3 times that of conventional AC system; a large proportion of the CAPEX is due to the battery cost*
- *Annual electricity consumption (OPEX) is 10-40% less than the baseline scenario although household consuming more, signaling an improvement in energy efficiency*
- *Consumers have an electricity supply for 24 hours in a day i.e. move to Partial Tier 5 from Partial Tier 3/ 4 on the Multi-Tier Framework*
- *The payback period is high. More research is needed to evaluate consumers' willingness to pay for the benefits associated with the improved quality of supply*
- *There is potential to reduce the CAPEX (particularly of the batteries) through upfront capital subsidies, or using second life Li-ion battery/ other battery types and helping the market to achieve economies of scale*

Cost – benefit analysis: Segment 2 (Low-Middle income)

Scenarios

'National average'

Baseline

LVSPA

LVSPA w solar

'Worst Case'

Baseline

LVSPA

LVSPA w solar

Baseline w SHS back-up

Summary results

Analysis of results

Baseline (for the national average)

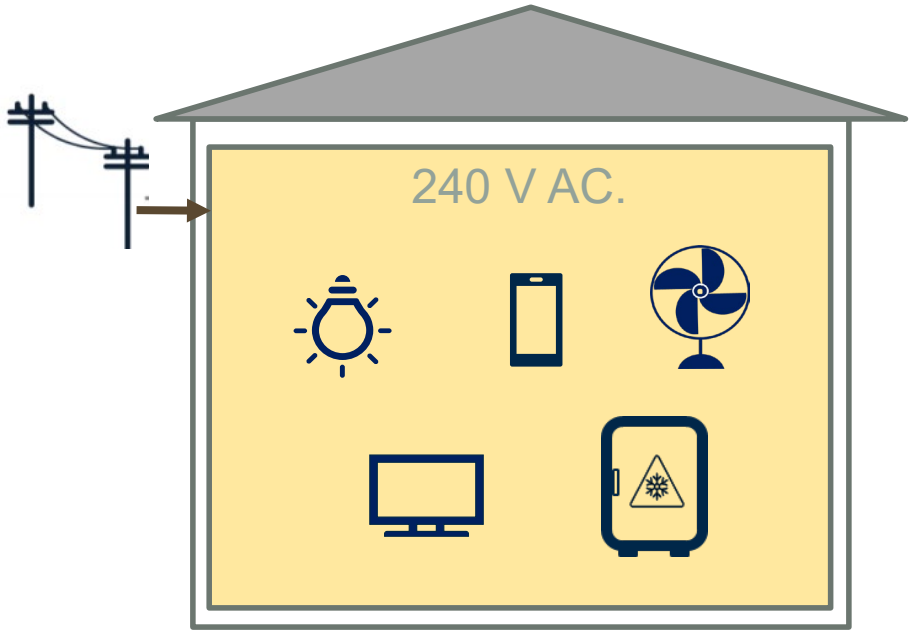
Power availability & WB MTF
- 21 hours supply from grid/ day
- Partial Tier 4

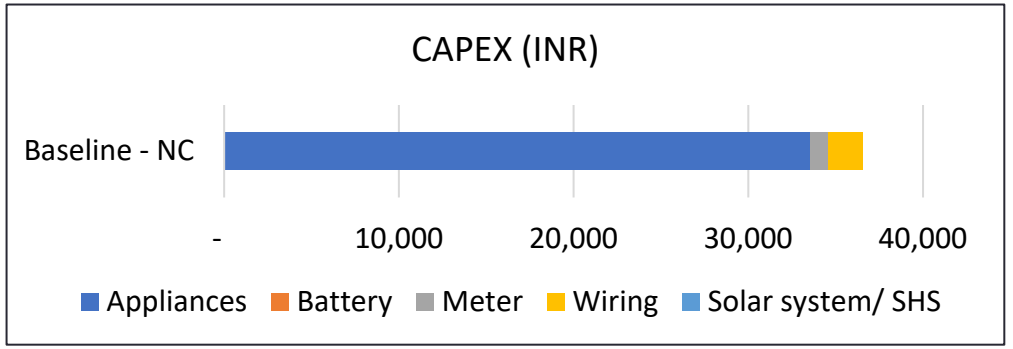
Consumption
- 7,118 Wh / day

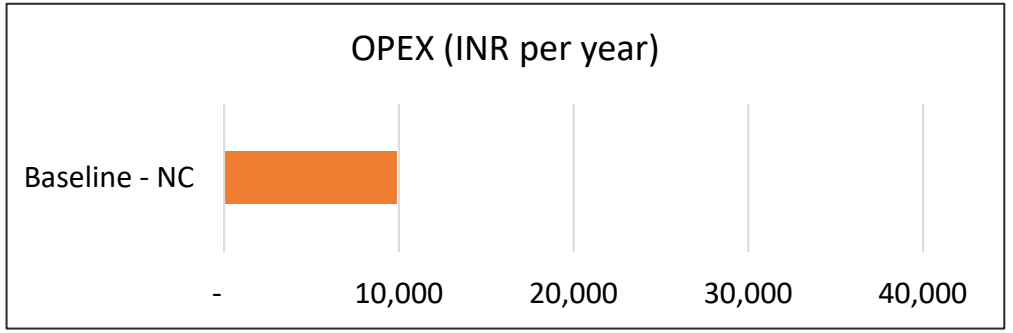
Connected load
- 489 W

No. of power cuts/ supply disruptions per day
- 1-10 cuts/ day

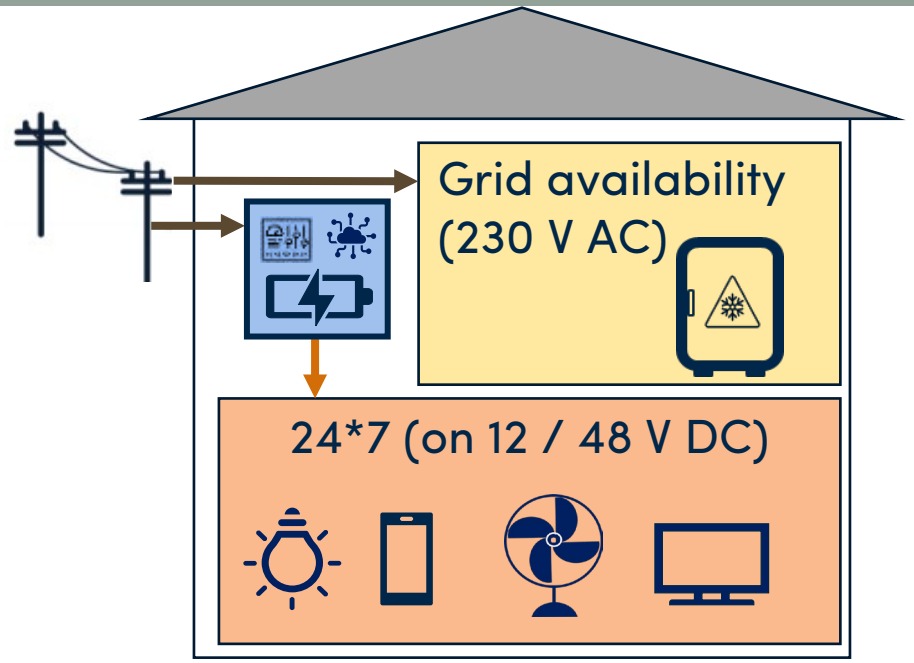
Efficiency rating
- 1.4







24*7 LVSPA (for the national average)



Power availability & WB MTF

- 21 hours supply from grid/ day and 3 hours supply from battery/ day
- Partial Tier 5

Consumption

- 4,968 Wh / day

Connected load

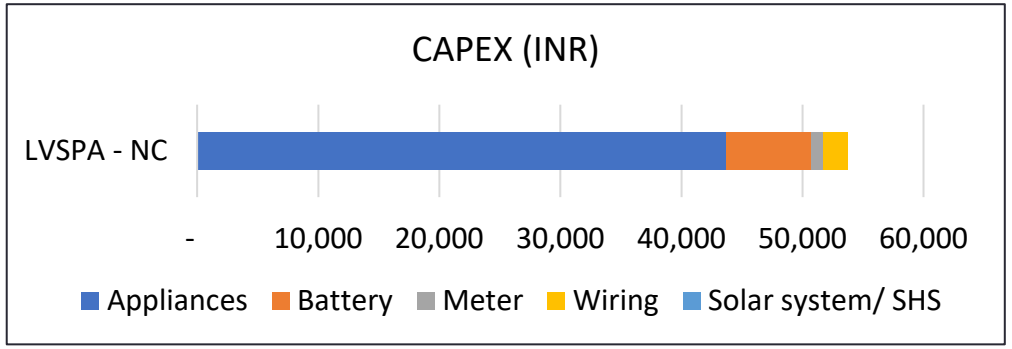
- 471 W

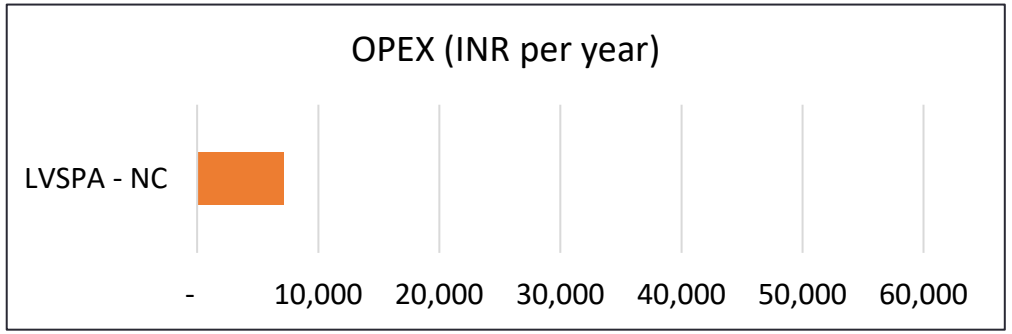
No. of power cuts/ supply disruptions per day

- No cuts

Efficiency rating

- 2.3





24*7 LVSPA w solar PV (for the national average)

Power availability & WB MTF

- 21 hours supply from grid/ day and 3 hours supply from battery/ day
- Partial Tier 5

Consumption

- 4,768 Wh / day

Connected load

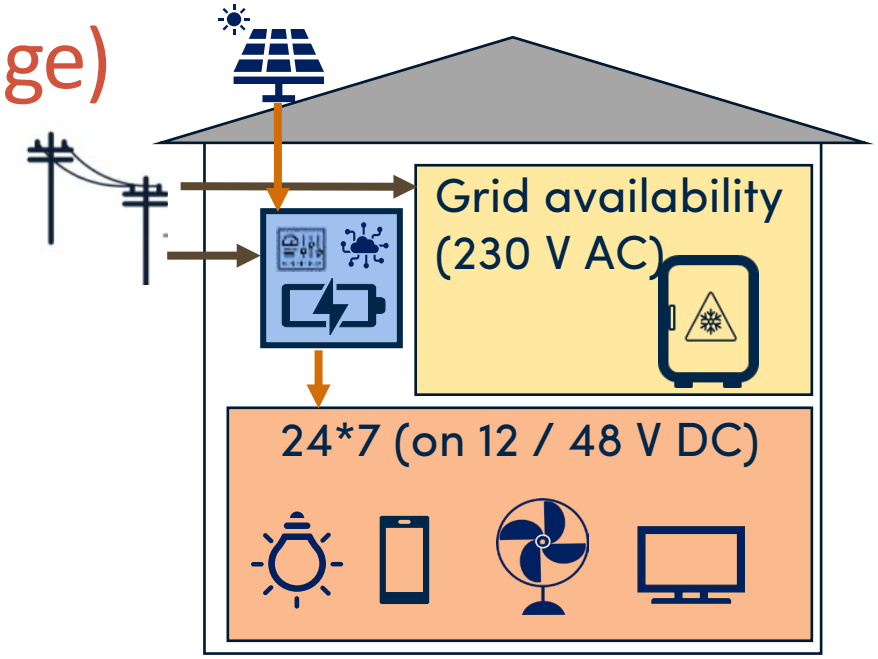
- 471 W

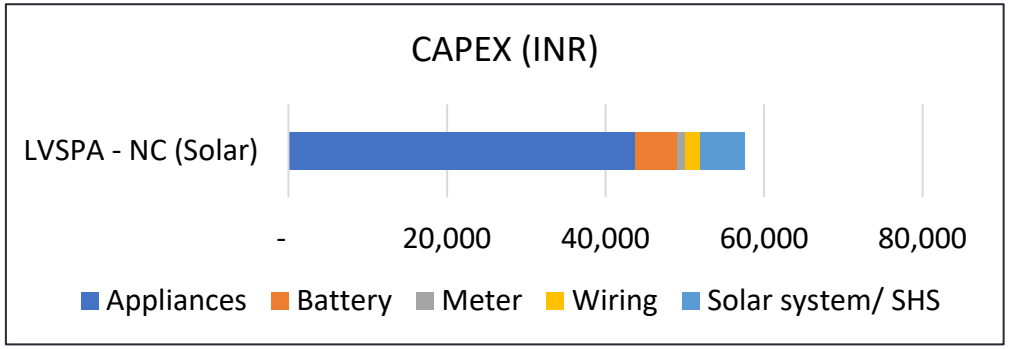
No. of power cuts/ supply disruptions per day

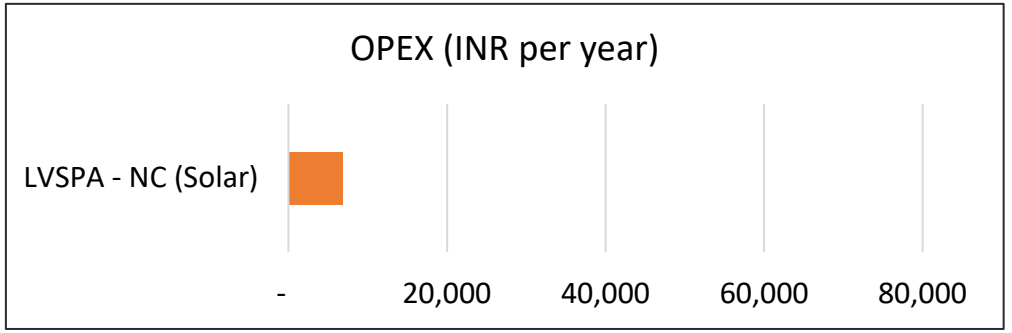
- No cuts

Efficiency rating

- 2.4







Baseline (for the worst case)

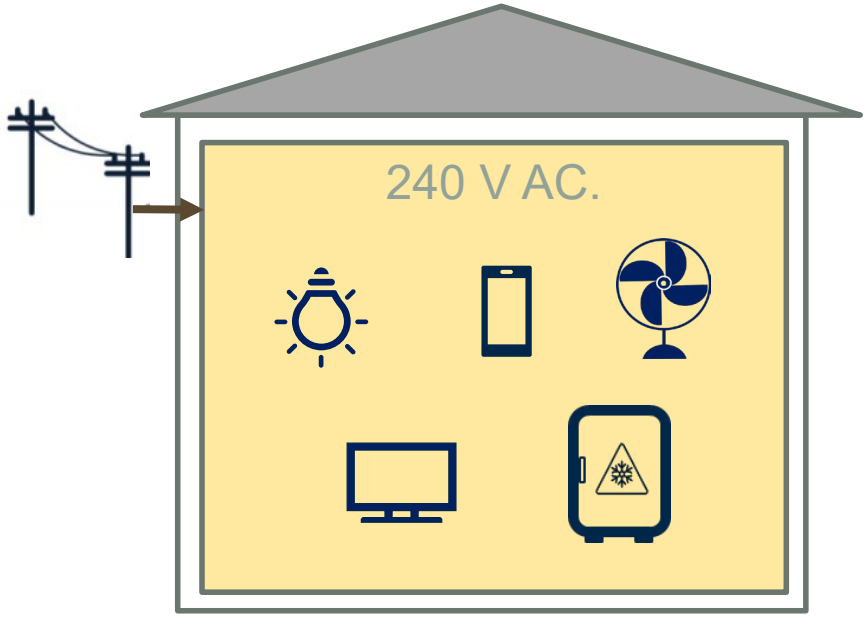
Power availability & WB MTF
- 16 hours supply from grid/ day
- Partial Tier 3

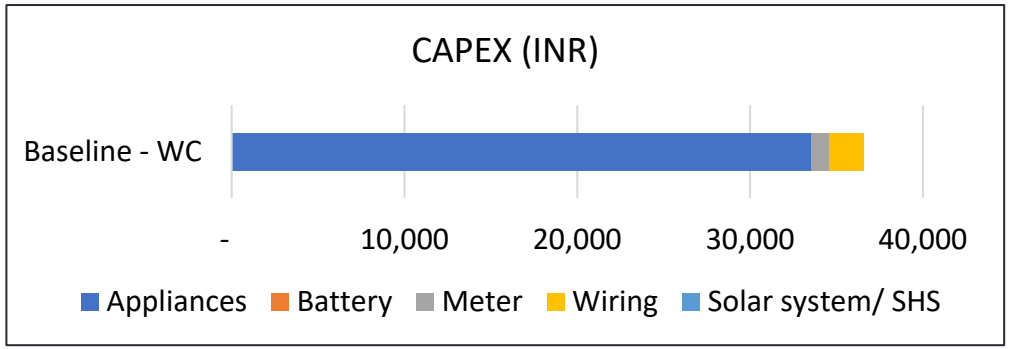
Consumption
- 5,939 Wh / day

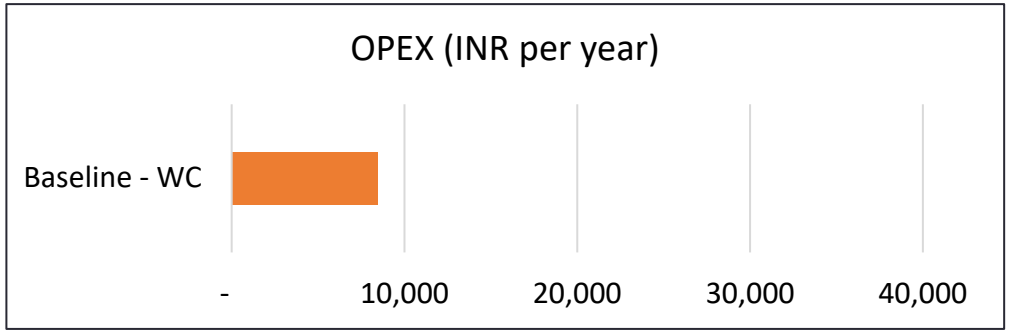
Connected load
- 489 W

No. of power cuts/ supply disruptions per day
- 10-15 cuts/ day

Efficiency rating
- 1.3







Baseline w SHS back-up (for the worst case)

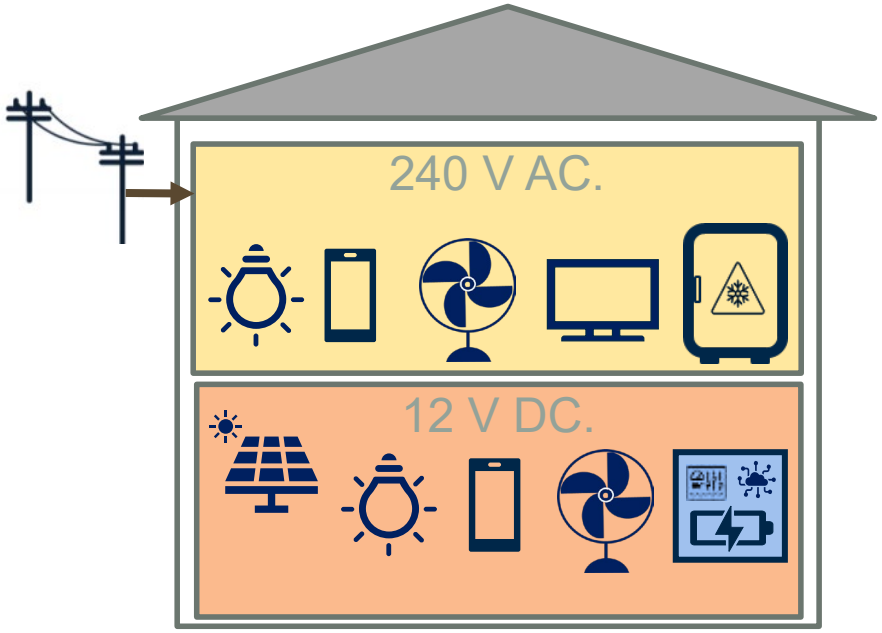
Power availability & WB MTF
- 16 hours supply from grid/ day + SHS
- Partial Tier 4

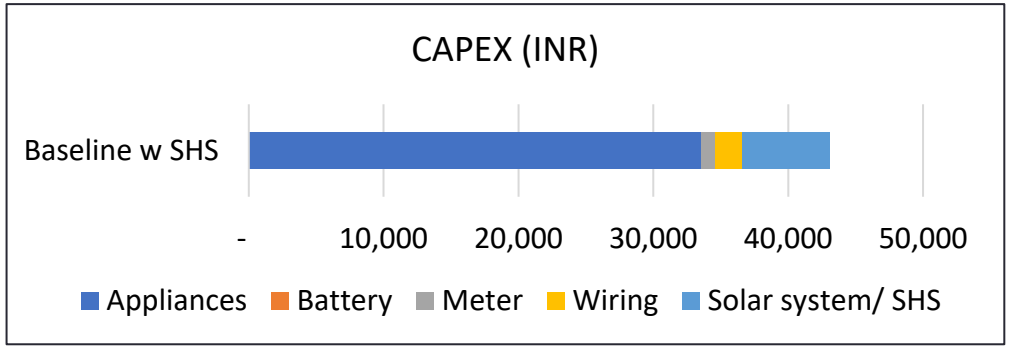
Consumption
- 5,939 Wh / day

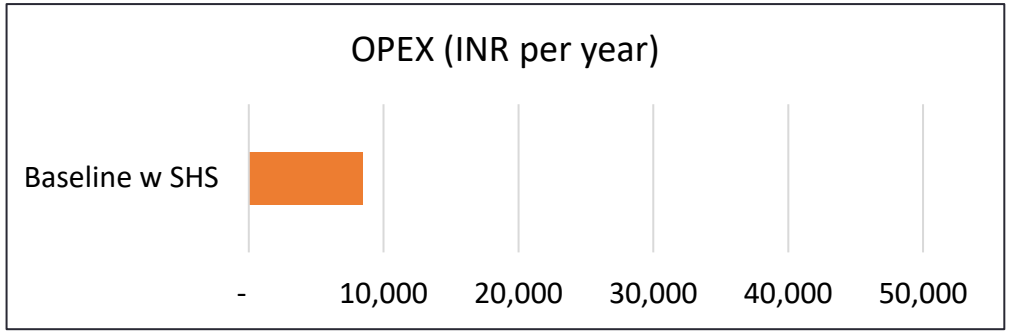
Connected load
- 489 W

No. of power cuts/ supply disruptions per day
- 10-15 cuts/ day

Efficiency rating
- 1.3







24*7 LVSPA (for the worst case)

Power availability & WB MTF

- 16 hours supply from grid/ day and 8 hours supply from battery/ day
- Partial Tier 5

Consumption

- 5,116 Wh / day

Connected load

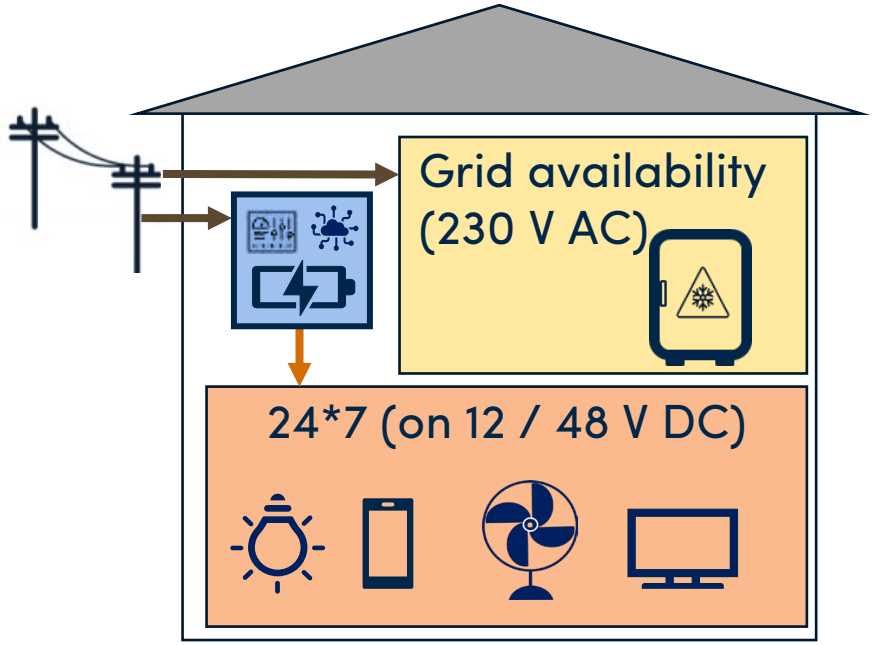
- 471 W

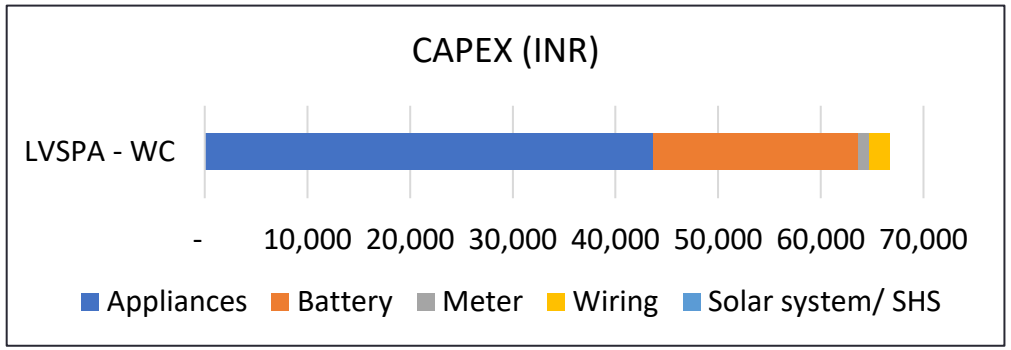
No. of power cuts/ supply disruptions per day

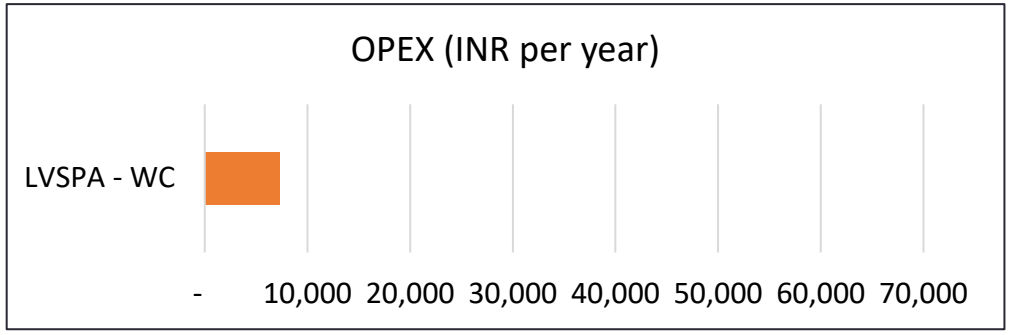
- No cuts

Efficiency rating

- 2.2







24*7 LVSPA w solar PV (for the worst case)

Power availability & WB MTF

- 16 hours supply from grid/ day and 8 hours supply from battery/ day
- Partial Tier 5

Consumption

- 4,583 Wh / day

Connected load

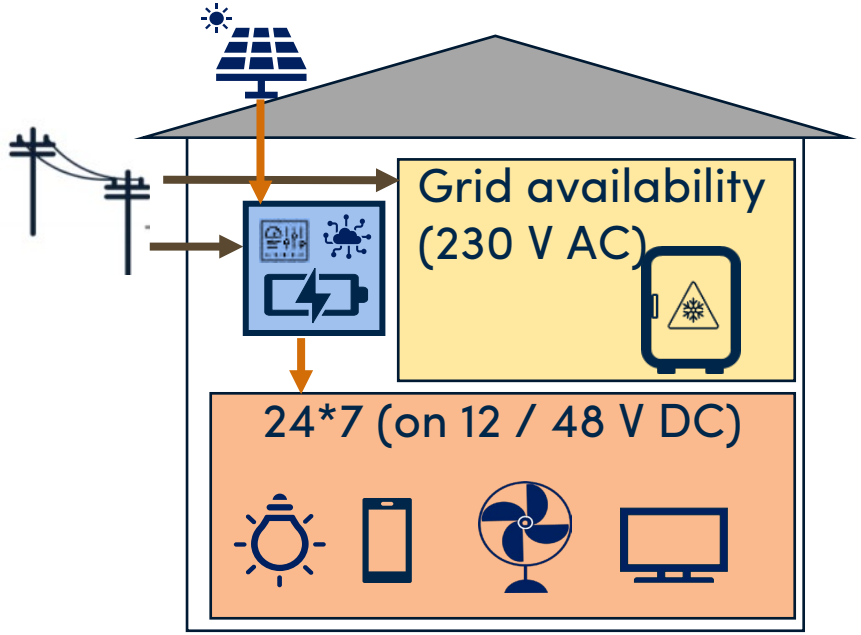
- 471 W

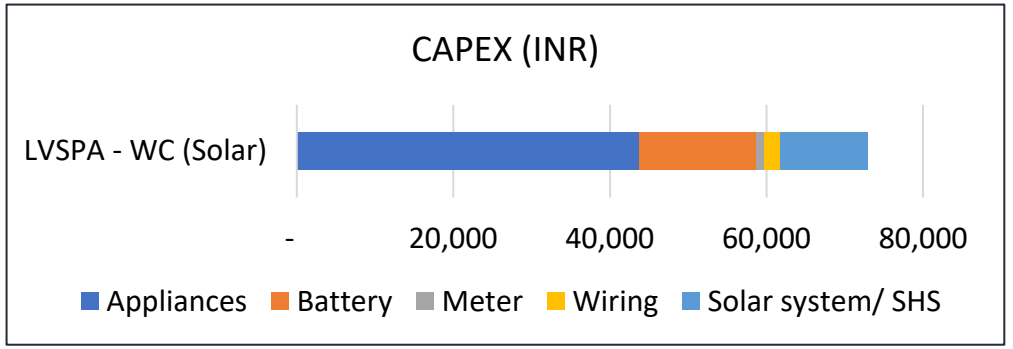
No. of power cuts/ supply disruptions per day

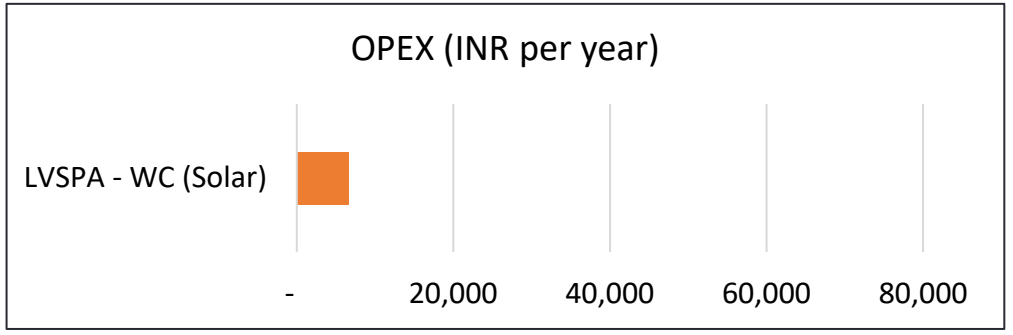
- No cuts

Efficiency rating

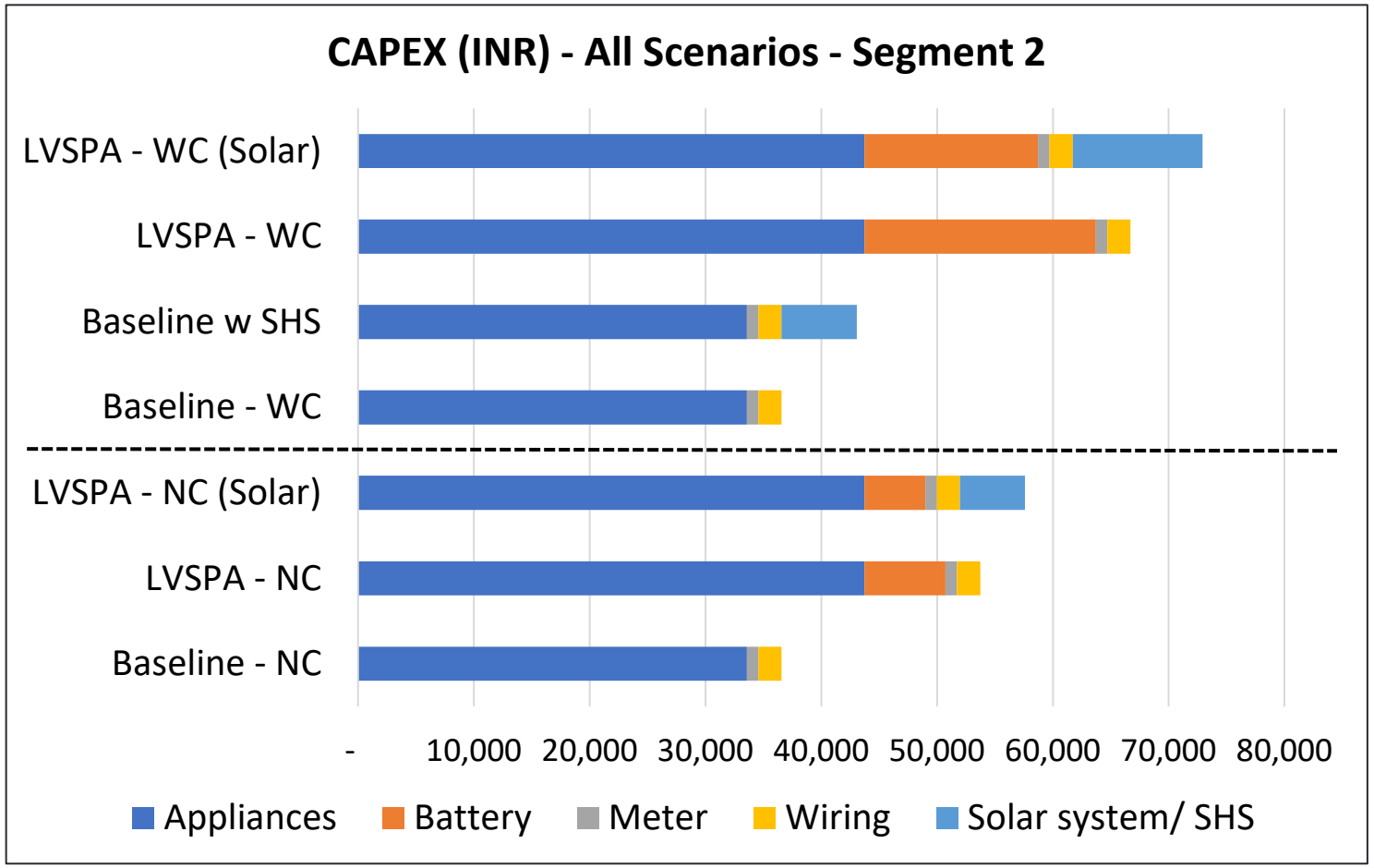
- 2.5







Summary of results



Hours/day w electricity	OpEx (INR per year)	Efficiency Rating
24	6,673	2.5
24	7,313	2.2
16	8,440	1.3
16	8,440	1.3
24	6,886	2.4
24	7,126	2.3
21	9,888	1.4

Analysis of results

- *Capital cost (CAPEX) of the LVSPA is 1.5-2 times that of conventional AC system; a large proportion of the CAPEX is due to the DC appliance cost*
- *Annual electricity consumption (OPEX) is 10-30% less than the baseline scenario although household consuming more, signaling an improvement in energy efficiency*
- *Consumers have an electricity supply for 24 hours in a day i.e. move to Partial Tier 5 from Partial Tier 3/ 4 on the Multi-Tier Framework*
- *The payback period is high. More research is needed to evaluate consumers' willingness to pay for the benefits associated with the improved quality of supply*
- *There is potential to reduce the CAPEX (particularly of DC appliances and Batteries) through upfront capital subsidies, or using second life Li-ion battery/ other battery types, or incentives to DC manufacturers and helping the market to achieve economies of scale*

Investment opportunity in Segment 1 & 2 consumers

Segment 1

Maximum Potential Market Size:

39 million HH, $9bn

Addressable Market Size:

8 million HH, $2bn

*Maximum potential market size = No. of low-income HHs * percentage of people reporting power cuts in past year (i.e.70%)*

Addressable market size = Maximum potential market size 20% (assumed)*

Market value = Market size * Average CAPEX of LVSPA for Seg 1

Segment 2

Maximum Potential Market Size:

98 million HH, $76bn

Addressable Market Size:

6 million HH, $5bn

*Maximum potential market size = No. of low-middle income HHs * percentage of people reported power cuts in past year (i.e.70%)*

Addressable market size = Maximum potential market size 5% (assumed)*

Market value = Market size * Average CAPEX of LVSPA for Seg 2

Barriers & strategy for creating a Pull market

Technical, market, policy and regulatory barriers

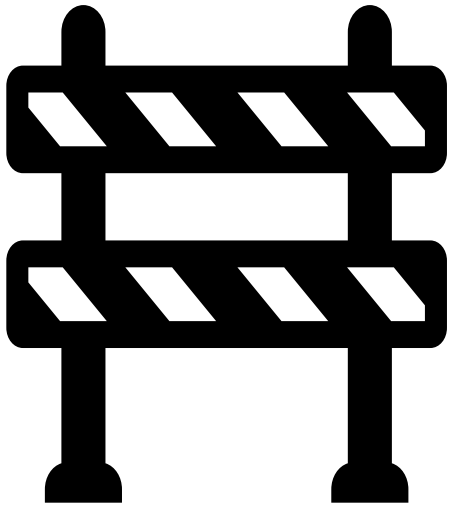
Market strategy (push to pull)

Partnership models

Policy & regulatory reforms

Overall barriers for the industry

High upfront cost of LVSPA system outweighs the benefits



Manufacturing, Distribution & Finance partnerships not in place

Lack of consumer awareness on technology, benefits, and lifetime costs

Lack of consumer retail financing

Product segment not well developed (terminology, hardware and software standards, labels)

Lack of R&D funds for technology & business model innovation

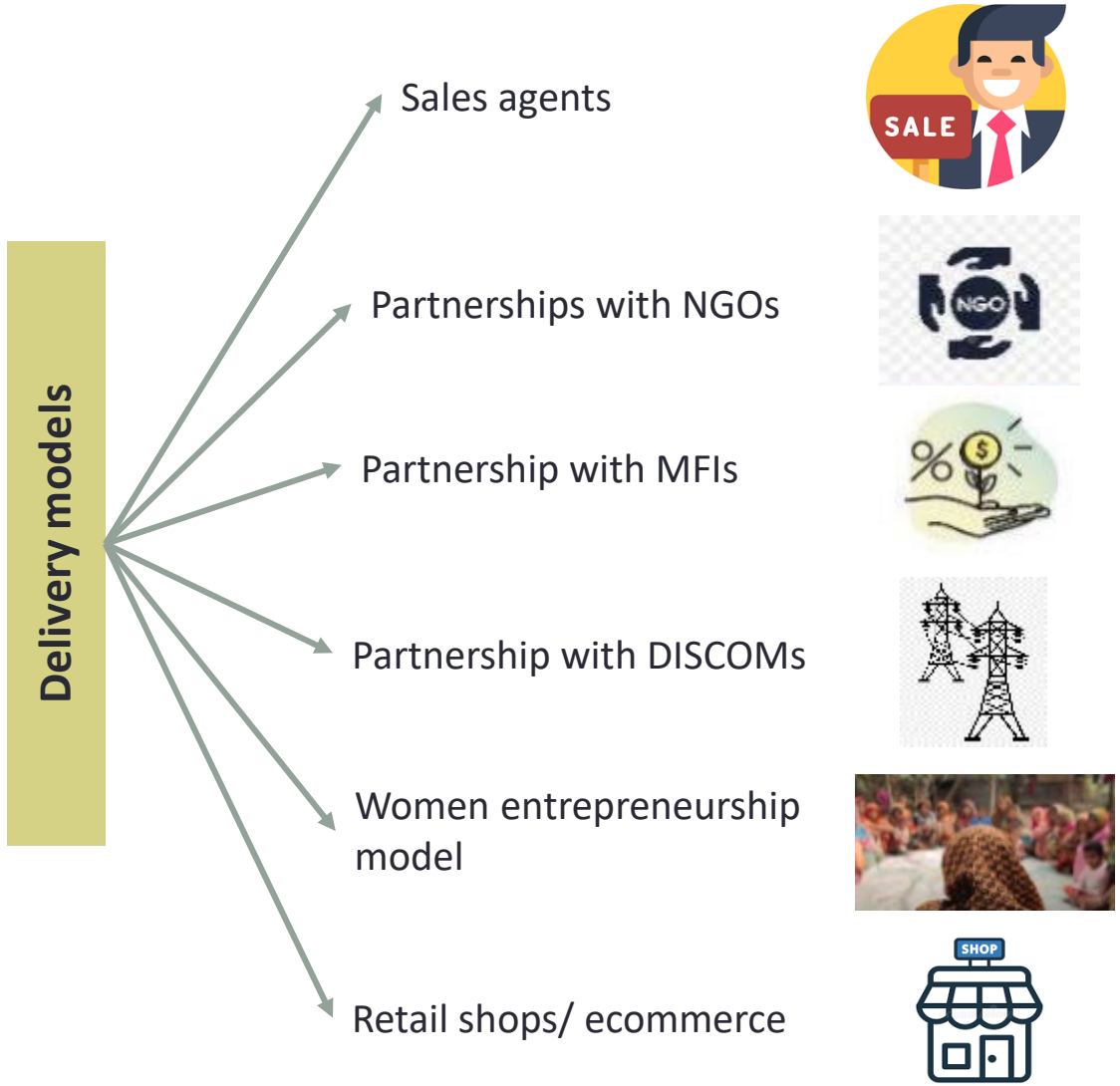
AC dominant market and poor consumer awareness

- **Appliance market mostly dominated by AC appliances** due to easy availability, AC supply architecture and people's awareness about these products in terms of cost, quality, and benefits
- As per Efficiency for Access study on "Off-and weak grid solar appliance market in India", **most ceiling and table fans (88%) are marketed as AC/ DC compatible and only 12% are DC compatible.** Around 89% of the televisions are also AC based and there is little-to-no market presence of DC refrigerators
- Few companies in India such as Intelizon and Cygni have **pioneered Lithium-ion battery-based hybrid DC systems** to provide safe and reliable power *(see slide 60 – case study on Intelizon)*
- **Low demand for DC products results in a limited number of manufacturers** and products in the market and interest of major market players

Consumer Awareness

- According to a CEEW study, about 19 per cent of the rural households and 38 percent of urban households are aware of BEE star-label/ BEE star labelled appliances (Source link)
- States with richer, more urban population, more educated households, and higher ownership of appliances have higher awareness levels (Source link)
- Consumers are often influenced by retailers, friends and family, and the internet while making an appliance purchase decision (Source link)

Limited delivery models & financing options in weak grid sector



Weak and off-grid consumers needs are often served by small businesses which have a **limited funds for strengthening their product design**, development of technology and improving manufacturing capabilities

Limited financing options available for rural consumers:

- Some are provided by the dealer or some bank tie-ups for loans, but all are on a case-to-case basis
- Self-help groups run by State Rural Livelihood provide loans

Pay-as-you go (PAYGo) model is little explored in India compared to Africa

Technical standards- need to do more

- Bureau of Indian Standards (BIS) has developed **standard for 48V ELVDC (Extra low voltage DC) distribution system**. It covers essential requirements for distribution of power from 48 ELVDC power source

- Recently BIS has **started the development of standards for DC appliances** such as DC motors, DC water Pumps and DC Ceiling fans. Apart from these, the standards for various accessories such as MCBs, Plugs and socket outlets, switches, fuses will also be developed. In the next phase, BIS will develop standards for refrigerators, TV, Table fans, etc.

- *There is a need for consensus on one common DC voltage for appliances i.e., 12V/ 24V/ 48V and for universal design & standards of connectors for DC appliances from BIS or industry in India*

- *Standards exist for components but not the system architecture*

BIS Compulsory Registration Scheme of Solar PV

IS Number	Title of the Standard
IS 14286	Crystalline Silicon Terrestrial Photovoltaic (PV) modules
IS 16077	Thin-Film Terrestrial Photovoltaic (PV) Modules
IS 16221 (Part 2)	Safety of Power Converters for Use in Photovoltaic Power Systems Part 2-Particular Requirements for Inverters
IS 16169	Utility-Interconnected Photovoltaic Inverters
IS 16270	Secondary Cells and Batteries for Solar Photovoltaic Application

Regulatory landscape for integrating LVSPA in households- grey area

Currently there is no regulation that govern the electrical installation of DC systems in grid connected households. However, it has been found that DC installation by manufacturers/ suppliers are allowed, since the existing AC line from the grid is not tampered by them

National Electric Code 2011, *which is intended to be advisory, also does not specify any rules or regulation on low voltage DC distribution (below 50 V) nor restrict them*

Segment 1 & 2 *consumers having solar PV system or SHS are not expected to have a net-metering arrangement at their premise and hence no restriction from the distribution utility*

From a Push market to a Pull market

Push Market – Current scenario

- ***High cost of appliances and battery*** and hence of LVSPA system
- Segments 1 & 2 ***consumers economically not affluent***
- ***DC appliances not easily available*** in market
- ***Product segment not well developed***
- ***Lack of Consumer finance***, R&D funds
- ***Consumers not aware*** on technology, benefits, costs

Pull Market – Proposed strategies

- ***Strategic partnerships*** to address manufacturing, distribution & financing issues
- ***Capital subsidy support*** from government to reduce CAPEX
- ***Incentives for manufacturing*** DC appliances and battery
- ***Standardization of products*** and system architecture
- ***Government sponsored R&D*** initiatives for new products
- ***Consumer awareness campaigns***

Proposed strategic partnerships

Proposed models	Benefits to Partners	Features
Partnership with DISCOM	Opportunity to reduce electricity demand, losses in rural areas and redirect saved electricity	• Demand aggregation and bulk procurement • On-bill financing (OBF) for repaying the cost of system • Decentralized logistics for distribution of LVSPA systems • DISCOM as a facilitator to guarantee offtake
Partnership with Government programme	Platform to promote energy conservation measures, improve electricity services in rural households, meet SDGs	• Upfront capital subsidy program run by MNRE • Partnership with NABARD/ SIDBI for providing low-cost credit • Utilizing existing partnerships with distributors and retailers • Additional incentives such as reduced tax rates on appliances
Partnership with Boutique/ special programme	Opportunity to reorient the existing business, develop new products and enhance capacities of women self help groups on new technologies	• Upfront capital subsidy scheme for consumers • Production linked incentives on DC appliances • Utilizing existing distribution channels of these organizations • Loans from community institutions; existing financiers
Partnership with consumer finance/ PAYGo company	Opportunity for financiers to enter a new market and tap into sovereign green bonds Opportunity for PAYGo companies to develop and market their technology	• Upfront capital subsidy scheme for consumers • Production linked incentives on DC appliances • Utilizing existing partnerships with distributors and retailers • Collateral-free loans with flexible repayment terms; low- or no-interest credit

Partnership with DISCOM

Distribution companies (DISCOMs) facilitating the implementation of LVSPA in partnership with system integrators/ suppliers

Key organizations/ actors: DISCOMs, System integrators/ suppliers

Proposed measures:

- Demand aggregation and bulk procurement by DISCOM based on market & demand potential studies
- DISCOM guarantees offtake from System integrators/ suppliers
- On-bill financing (OBF) option for consumers to repay the cost of system monthly through existing utility bill
- Decentralized logistic system for distribution of LVSPA systems utilizing existing distribution channel of System integrators/ suppliers
- DISCOMs can take lead in engaging with consumers through various media: advertisements through printed and online power bills, etc.

DISCOMs' benefits:

1. Reduced electricity demand and losses in rural areas
2. Monetary savings by redirecting saved electricity to higher tariff consumers
3. Better customer satisfaction with more reliable, less dangerous, and less damage to electronic equipment
4. Increased payment rates and incomes

- *A DISCOM will save 2 million units of electricity daily on average if all rural customers in weak grid areas switch to LVSPA*
- *A monetary benefit of 15 million INR ($192,300) if saved electricity is redirected to commercial consumers*

DISCOM stands to gain a lot, however, their priority is mostly towards improving supply side infrastructure and metering to increase billing and collection

Partnership with Government program

Ministry of new and renewable energy (MNRE) through state nodal agencies (SNAs)/ rural electrification department facilitating implementation of LVSPA under existing or new program in partnership with system integrators/ suppliers

Key organizations/ actors: MNRE, SNAs, State rural electrification department, System integrators/ suppliers

Proposed measures:

- Upfront capital subsidy program run by government
- Partnership with NABARD/ SIDBI for providing low-cost credits
- Utilizing existing distribution channel of system integrators/ suppliers for last mile connectivity
- Nationwide awareness campaign run through State nodal agencies/ rural electrification department

MNRE/SNAs' benefits:

1. Platform to promote energy conservation measures
2. Improve electricity services in rural households meeting sustainable development goals
3. Opportunity to set up demonstration project to generate awareness and popularize the use of EE appliances among the people

Partnership with boutique/ special programme

Special programs such as Model Distribution Zone (MDZ) program of Smart Power India (SPI)/ Renewable energy programs of State Rural Livelihood Mission (SRLM) facilitating implementation of LVSPA utilizing their existing distribution channels and financing resources *(see slide 61 - case study on MDZ)*

Key organizations/ actors: SPI's MDZ Program/ RE programs of SRLMs such as J-WIRES in Bihar or Prerna OJUS in UP, System integrators/ suppliers

Proposed measures:

- Upfront capital subsidy scheme for consumers from the government
- Existing distribution channels of SRLMs or MDZ program to be utilized for last mile connectivity
- Loans from SRLM community institutions or existing financing mechanism in MDZ program can be extended
- SRLM/ MDZ to identify and train local 'champions of LVSPA to lead the consumer awareness campaign among the local community

Benefits for special programs:

1. Opportunity to reorient the existing business to benefit from the new opportunity in weak grid areas
2. Develop new products and enhance capacities of women self help groups on new technologies

- *SRLM offer an effective last mile distribution channel for LVSPA.*
- *For example, J-WIRES in Bihar has 340+ outreach points in terms of solar shops and daily consumer turnout/ engagement of 7,000+ through these shops*

Partnership with consumer finance/ PAYGo company

System integrators/ suppliers entering into partnership with consumer finance or PAYGo companies to facilitate implementation of LVSPA through low-cost financing and flexible payment terms

Key organizations/ actors: System integrators/ suppliers, consumer finance/ micro finance institutions or PAYGo companies

Proposed measures:

- Upfront capital subsidy scheme for consumers by the government
- Utilizing existing partnerships with distributors and retailers of System integrators/ suppliers for last mile connectivity
- Collateral-free loans with flexible repayment terms; low- or no-interest credit
- Consumer engagement and awareness building program

Benefits to consumer finance/ PAYGo providers:

1. For financiers, an opportunity to enter a new market with system integrators/ suppliers and tap into sovereign green bonds.
2. For PAYGo companies, an opportunity to develop and market their technology in weak grid areas

- *PAYGo service model is getting popular amongst urban centers and developed countries. Studies are showing that the manufacturer earns lot more than that by selling the product*
- *MFIs, having deep grassroot connections with the rural communities, can be a game changer by bridging the last mile gap between the utility and community. However, the cost of financing with MFIs is high (~24%) and does not make the appliance affordable*

Relevant policies & programmes identified for catalyzing LVSPA

Existing policy/ programme	Features and/or outcomes
Off-grid and decentralized solar PV application scheme	▪ Oldest MNRE programme providing solar PV applications in off-grid areas ▪ 30-40% central subsidy for SHS, Solar lanterns, Solar power plants ▪ Temporarily stopped, likely to be reinstated
Policy framework on DRE Livelihood applications	Issued on 14th February 2022 for promoting DRE livelihood applications and has proposed following ▪ Mapping of needs of beneficiaries; Development of guidelines and standards ▪ Incubation and pilot support; Incentives ▪ Development of financing facility; Awareness campaigns
Renewable energy Research and Technology Development (RE-RTD) programme	▪ Aims at scaling up R&D effort in the areas of new and renewable energy ▪ Financial assistance up to 50% - 70%
Production linked incentive (PLI) schemes	**PLI Scheme for Advanced Chemistry Cell (ACC) Battery Storage** ▪ Intends to establish local manufacturing capacity of 50 GWh of ACC and 5 GWh of Niche ACC capacity **PLI Scheme for White goods** ▪ Supports component manufacturing for ACs and LED Lights; Finished white goods not included
Standard & Labelling program	▪ Started in 2006 by Bureau of Energy Efficiency (BEE) ▪ Laid down minimum energy performance standards (MEPS) for 28 appliances so far ▪ Mandatory labelling for 10 appliances and voluntary for 18 appliances
Super-efficient equipment programme	▪ Support the introduction and deployment of super efficient ceiling fans ▪ Providing a time bound incentive to manufacturers for selling at a discounted price

Policy & regulatory incentives for catalyzing LVSPA market

- **Upfront capital subsidy program for LVSPA under the umbrella of 'Off-grid and decentralized solar PV application programme' or another programme**
  - to bring down the upfront cost of LVSPA and make them affordable for weak grid customers
  - 25% & 65% capital subsidy required to breakeven the upfront cost of LVSPA within 7 years in case of segment 1 & 2 consumers respectively with national average grid supply
- **Extending 'Production Linked Incentive' scheme to LVSPA components**
  - to facilitate growth of DC appliances in the market and bring down their cost in the long run
  - will provide a cost advantage of 10-11% to local manufacturers*
- **Introducing LVSPA in MNRE program on DRE Livelihood applications**
  - to support development of technical guidelines and standards, incubation/ pilot projects on LVSPA, and facilitate nationwide consumer awareness program

** Source: Hindu Business Line*

Policy & regulatory incentives for catalyzing LVSPA market

- **Introducing Minimum Energy Performance Standards (MEPS) for DC appliances and extending Standard & Labelling to AC-DC appliances with in-built battery, hybrid inverters**
- **Emphasis on product testing infrastructure and faster development of national standards**
- **Extending 'Super-efficient equipment programme' to DC appliances**
  - to support/ incentivize manufacturing of DC appliances and help in bringing down the cost of DC appliances
- **Including LVSPA in RE-RTD programme of MNRE**
  - to provide financial assistance to manufacturers of LVSPA components for strengthening their product design, development of technology and improving manufacturing capabilities

Case studies

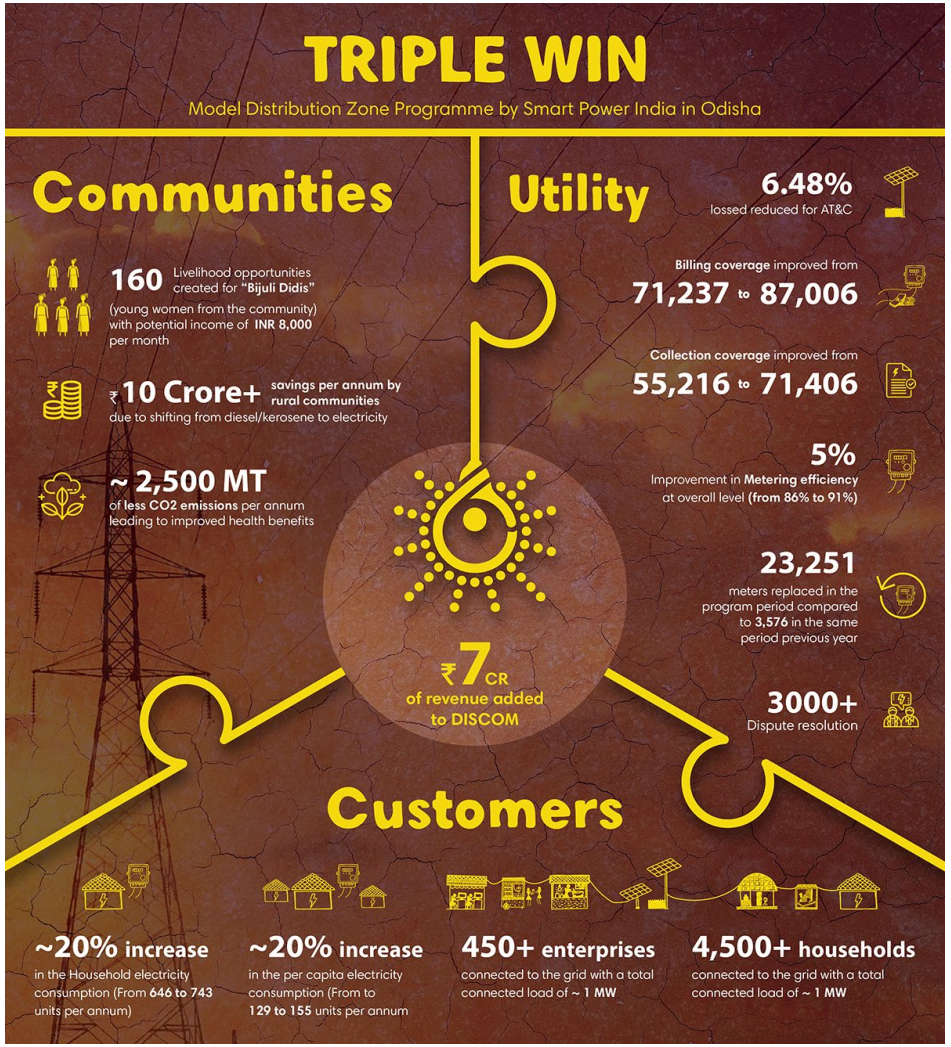
Case study 1 – Model Distribution Zone (*effective partnership model*)

Smart Power India's Model Distribution Zone (MDZ) Programme - partnership with the public utility in Odisha

The objective of the program is to address the challenges associated with the reliability and quality of power delivery services in the region. The program engaged Women Self Help Group (WSHG) as micro-franchisees to improve the last mile electricity access and quality of service. The program helped WSHGs, also known as 'Bijulee Didi's' also known as "Power Sisters" find employment.

The program created a Win-Win-Win model for the Utility, Customer and Communities

- For the utility, it demonstrated a "sustainable rural electrification service" model which is not only viable but also improves the electricity access profile, enhances consumption of grid electricity and better quality of supply to customers
- For the customer, it provided better quality of electricity, supply, improvement in metering, billing, and collection service
- For the communities, it provided income opportunities to 160 rural women, enabling rural enterprises to save on the expensive diesel consumption thereby generating better income and health benefits



Source: Report on the SPI Model Distribution Zone Program – Odisha; 2021

Case study 2 – Intelizon (*technology deployment*)

Delivering smart energy to remote communities: The Intelizon Story

Intelizon, a pioneer in energy-based product innovation, have developed energy-efficient solutions using a combination of lithium-ion batteries with solar, LED, BLDC fans and advanced electronics technology to provide high quality and reliable electricity at affordable prices. They have a wide range of home products from simple lighting solutions to versatile energy solutions that can use unreliable grid power much more efficiently.

The Zonhome+ system that includes solar panels, energy efficient DC appliances and lithium battery can save up to 90% of electricity bills. It can operate both on solar and grid. As part of their last mile village network creation, over 60+ villages and townships in Odisha have been introduced to the Zonbulb and Zonhome systems as a reliable substitute for their daily power needs.

Intelizon's offering is built on meeting the three key constraints of information, awareness and access, which currently handicaps the rural consumer. Their smart solutions are customised through an innovative financial package in partnership with micro finance institutions, banks to address the issue of upfront cost.

Source: Intelizon

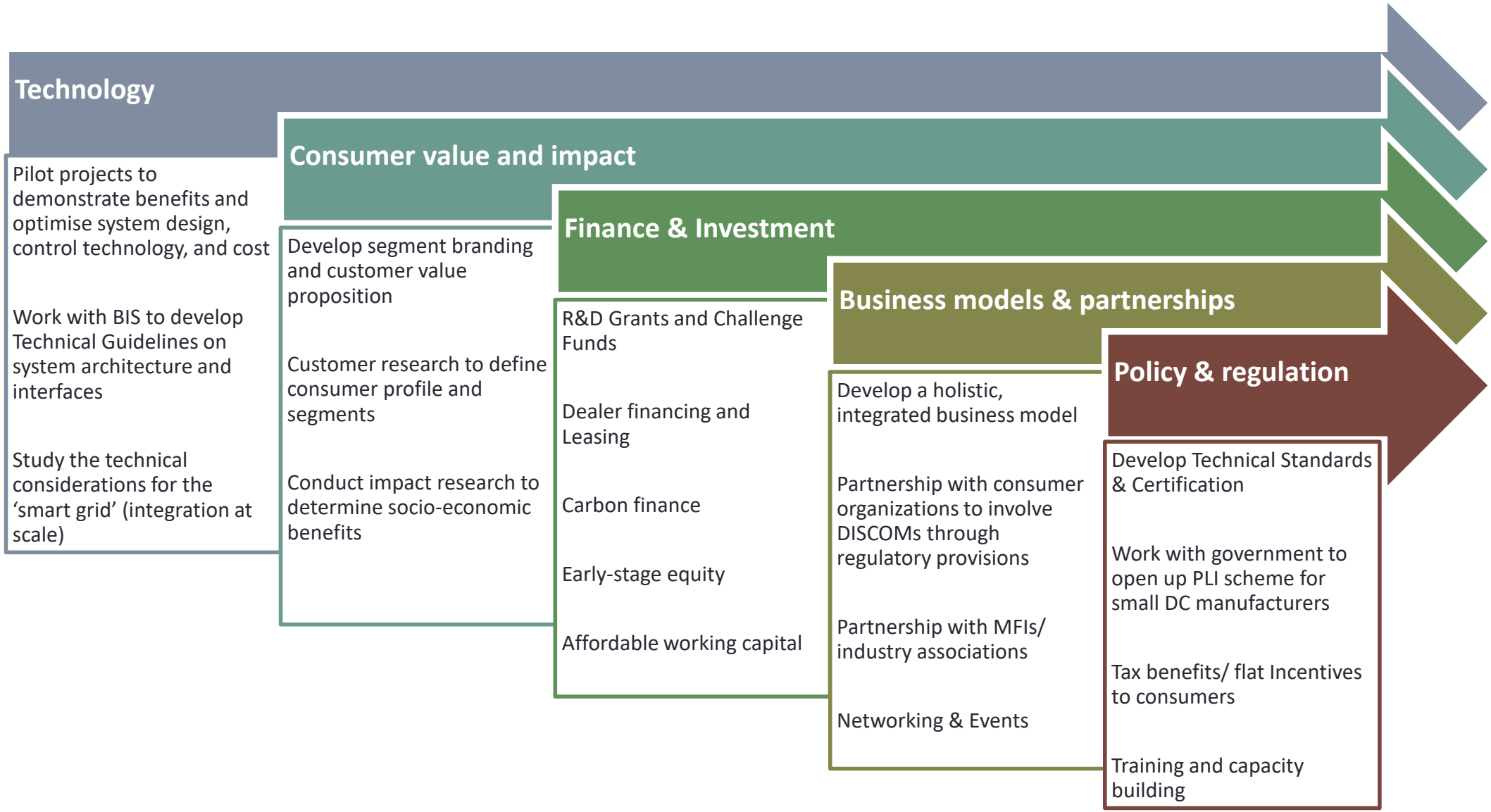
LVSPA roadmap activities and way forward

Conclusion – *a recap*

- Reliability and quality of grid supply - a continuing issue in semi-urban, rural, and remote areas of India
- Several solutions that are affordable and scalable are being used, making the market fragmented
- LVSPA, an integrated solution, has the potential to achieve:
  - improved electricity access
  - improved Renewable Energy usage
  - improved Energy Efficiency practices
- LVSPA is thus a big commercial opportunity, however, there are few challenges
- Industry, government, donors, etc. need to work together to build a scalable market

Roadmap activities discusses activities that will build a scalable market

LVSPA Roadmap - Activities to Build the Market



Improved Energy Access

Higher uptake of Renewable Energy systems

Increased adoption of Energy Efficiency practices

The future of electricity access

LVSPA, if deployed at scale, could transform electricity networks into smart grids which will have following attributes:

- Decarbonised
- Electrified
- Decentralised
- Digital
- Productive
- Resilient

LVSPA is an investment in the 'infrastructure of the future'

We believe that Low Voltage Smart Power & Appliances have an important role in the future of electricity access

If you are interested, please contact:

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Participants of the roundtable

Additional slides

Feedback from stakeholders

Stakeholders	What were your expectations from the study at the start?	How has the study answered your expectations?	Next steps for GOGLA
Stakeholder 1	To understand the integration of the technology and the market and policy direction for implementation	Provided understanding of technology utilization and its market opportunity	▪ **Piloting projects in the Healthcare/ Institutional sector** to better understand sustainability of the technology, financial viability and need for creating incentive models for larger acceptance and awareness
Stakeholder 2	To explore the possibilities of addressing distribution and financing issues in adoption of these technologies in rural areas	Provided partnership models and policy reforms required to catalyze the market	▪ Doing some **ground-based work** to understand the practical issues in implementing the technology ▪ **Conducting awareness** among the consumers
Stakeholder 3	To understand the right steps for market development, including the business models and strategies and the policy reforms required to take this forward	Provided understanding of the LVSPA technology, its benefits and potential market	▪ **Pilot initiatives to demonstrate results** on the ground ▪ **Work towards introducing policy support** for manufacturing LVSPA devices
Stakeholder 4	To understand the national/global market trends, barriers/ opportunities, role of various stakeholders and information/ideas to boost interest of key stakeholders	Through information on policies & programmes, likely business models and/or potential program/initiatives	▪ **To expand into few areas where key market players have shown their interest**

Recommendations for GOGLA

1. Piloting
    i. LVSPA technology with different system configurations to demonstrate benefits and optimise design
    ii. Partnership with Micro Finance Institutions (MFIs) or Pay-as-you go (PAYGo) companies
    iii. Consumer awareness programs on energy efficient technologies
2. Collaborating with Alliance for an Energy Efficient Economy (AEEE), to work on policy and standards for DC appliances