Distributed Energy Storage in India

Harsh Thacker, Director, Consulting Services

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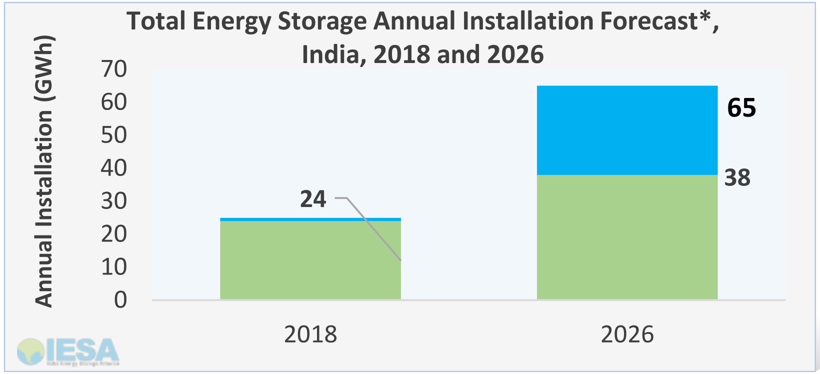
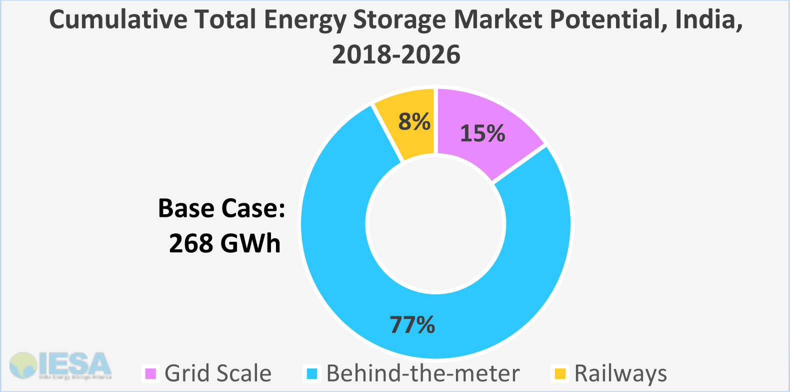
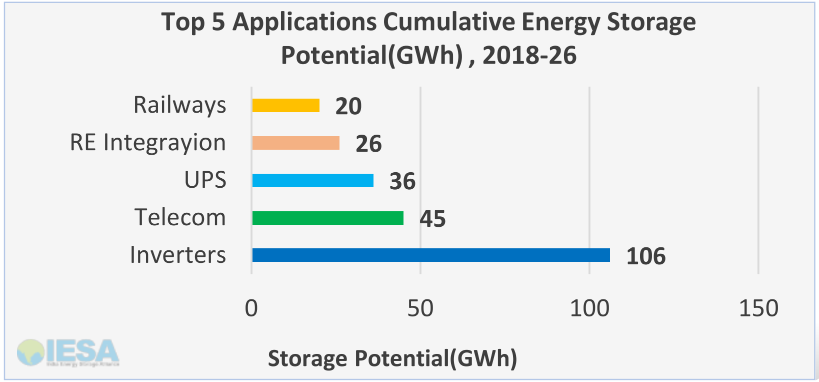
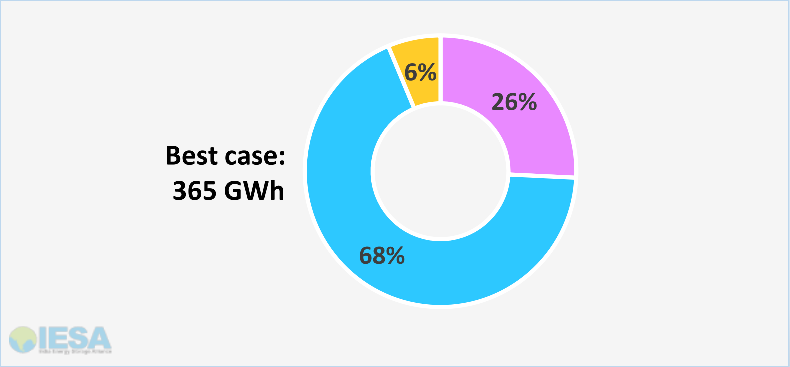
INDIA ENERGY STORAGE MARKET 2018 - 2026









Source: CES analysis

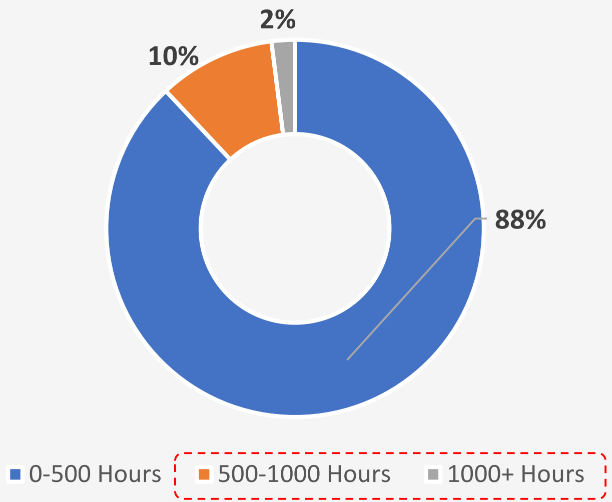
DIESEL USAGE IN COMMERCIAL AND INDUSTRIAL SET-UP

Threat of diesel replacement is still underplayed in the market due to high cost of hybridization. However, the fact, that Diesel Genset OEM lost opportunity to sell $150 million worth of DG mostly in telecom towers, can also be attributed to advent of Li ion batteries. Similarly over 9,000 MVA of diesel genset installed, with annual runtime of over 500 hours, also face the threat of hybridization if not replacement.

Peak power deficit – a hitherto major driver of DG installations in India, has been reducing over the course of this decade. Peak power gap is expected to improve from -2.1% in 2017-18 to +2.5% in 2018-19. Given this backdrop, the future growth in DG installations will be mainly dependent on the commercial and industrial segments. Notably,

- DG sets sales are likely to increase in the higher KVA segment (>750KVA) with end users in the commercial and industrial (C&I) space such as IT/ ITES data centre, hospitals, metro projects and road construction.
- The lower KVA segment with major users in residential and Telecom space will see a slower growth on account of a) increasing lifespans of DG sets due to shorter power cuts and hence lower need for replacement b) use of hybrid system involving renewables and c) use of energy storage systems
- The diesel usage in C&I space is expected to reduce mainly for users with more than 1000 hours of annual DG use initially as adoption of ESS for such users makes economic sense. As the battery costs reduce over the next few years, we expect even the users with 500+ hours of annual DG use to switch to ESS by 2022.

Annual Run wise split of 90 GVA of diesel genset installed capacity, India. 2018



Target market for Diesel Optimization

Source: Primary inputs, CES Analysis

Customized Energy Solutions

Key Value Propositions and Way Forward

Key shift from equipment seller to Energy Service Company is required

Customer pain points and segments that can be addressed

- **Diesel Savings**
- **Production Loss Savings**
- **Optimized Sizing of DG and Increase in Efficiency**

- **500+ hours of power cuts**
- **Process Industries**
- **Construction sites, variable and spike loads**

100 kVA DG Set

CAPE
X

Diesel Usage

44,00,000 INR (60,000 USD)

80 kW, 80 kWh

2018 ESS CAPEX

Electricity Cost

40,00,000 INR (55,000 USD)

2025 ESS CAPEX

Electricity Cost

29,00,000 INR (40,000 USD)

Assumptions: 5 year operation, 60 kW avg load, 500 hours annual diesel genset runtime savings Diesel power 25 INR/kWh, Electricity Charging cost 10 INR/kWh, with Solar Charging Costs can be much lower

Customer pain points and segments that can be addressed

- **Identify key customers and segments – work with Diesel Genset channels**
- **Allow them to run ESCO models and help arrange a pool of fund to finance CAPEX**
- **Alternative is to tie up with companies working in ESCO business like Rooftop solar players**

Customized Energy Solutions

Early Adopters in India

Over 100,000 towers

Over 5,000 ATMs

Over 1000 Microgrids

Over 100s of Petrol Station

Approx 5-10 sites

Approx 5-10 sites

ENERGY STORAGE SCOPE FOR RURAL ELECTRIFICATION

Rural Electrification

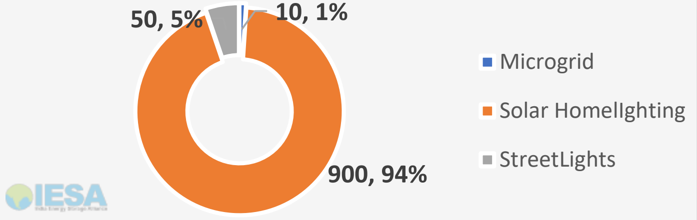
- **Off-grid Solutions**
  - **Micro grids**
  - **Solar home lighting systems (SHLS)** (Only under Saubhagya Scheme, constituting 2% of Outlay in 2018)
  - **Solar streetlights(SSL) (AJAY Scheme)**
  - **Solar Agriculture Pumps (KUSUM Scheme) ***
  - **Solar Induction Cooker***
- **Grid Expansion** (98% of Saubhagya Outlay in 2018)
- **Grid Expansion** (98% of Saubhagya Outlay in 2018)

- In 2018, 2.46 crore households were electrified under Saubhagya scheme, of which nearly 9 lakh were supplied solar home lighting systems. Rest were electrified through grid expansion (which doesn’t require batteries).
- Around 80,000 Solar Street lights(SSL) with batteries(360Wh each) were installed under AJAY scheme in 2018.
- Dull year for microgrid projects as the government funded microgrids under Saubhagya scheme was scrapped in 2018.

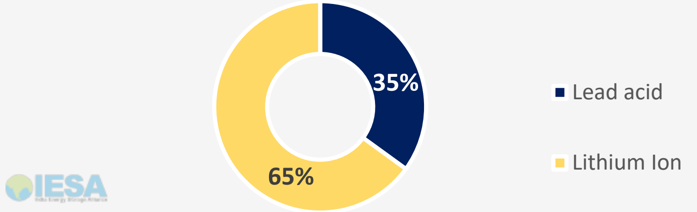
Scope for Energy Storage

* Not covered as part of this report

Energy Storage Market for Rural Electrification in MWh, India, 2018



Energy Storage Market By Chemistry for Rural Electrification, India, 2018



Lead acid batteries are majorly used in microgrids, while the percentage of Li ion batteries are higher in SHLS and SSL segments.

Cumulative potential for battery storage to be nearly 1GWh during 2019-2026.

Source: Primary Inputs, Saubhagya Dashboard, CES Analysis

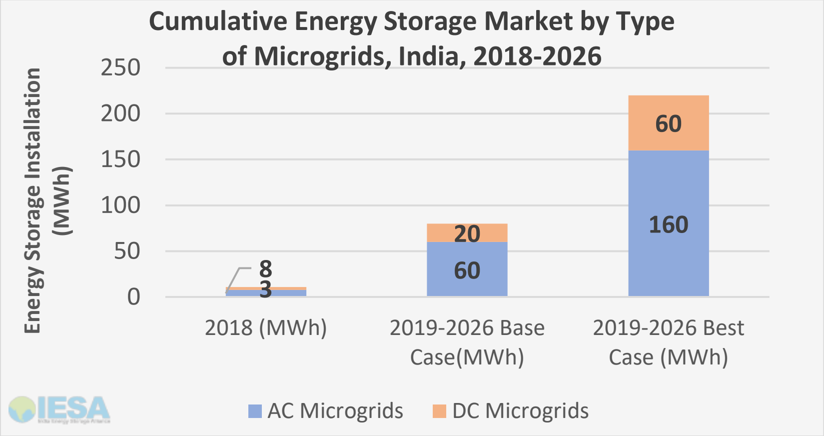
POLICIES AND SCHEMES IN RURAL ELECTRIFICATION

Name of Scheme	Authorities & Duration	Definition and Objectives	Impact	Outlay/Target
Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY)	MNRE 2015-2018	Focussed at electrification of villages. Inclusion of metering; Feeder separation for T&D improvement.	As on Dec 2018 3982 villages including 177053 households were covered	756 crore (108 Mn)
Saubhagya Scheme	MNRE Oct 2017-March 2019	Electrification of rural and urban poor households through grid expansion or by providing solar home lighting systems.	To complete electrification of 2.48 crore households, 10 Lakh SHLS with batteries.	16253 Cr. Of which 14,000 Cr is for rural households and rest for unelectrified urban households.
Kisan Urja Suraksha Evam Utthaan Mahabhiyan (KUSUM)	MNRE 2019-2022	For providing financial and water security to farmers through solar pumps and solar power plants.	Stand Alone Solar Agri Pumps will be mostly installed with a battery for	(a) 10 GW of Ground Mounted RE plants, (b)17.50 lakh standalone Solar Agri-Pumps (Scope of , (c)10 Lakh Grid-connected Solar Agriculture Pumps.

Source: CES Analysis

* Not considered in the study for market forecast.

ENERGY STORAGE POTENTIAL IN MICROGRIDS



	Units added in 2018	Range of Size of microgrids	Battery Size Range (kWh)
AC Microgrids	~600	10- 50 kWp	10-100kWh ~30%-70% of microgrid size
DC Microgrids	~1000	250Wp-3kWp	1-6kWh

Sources: CES Analysis, Primary Input

Microgrid Trends in 2018

- Due to maintenance issues related to microgrids, REC diverted most of its funding towards grid expansion and SHLS projects in 2018, which affected the microgrid funding during the year.
- Private companies are constructing rural Microgrids with funding support from NGOs, CSR funds of corporates and from agencies such as Rockefeller foundation.
- Microgrids were constructed to support partially electrified grid connected villages during off-grid hours.

- **Key locations of microgrids in 2018**: Jammu & Kashmir, Uttar Pradesh, Meghalaya, Assam, Arunachal Pradesh, Jharkhand, Maharashtra, UP, Karnataka, Bihar.
- **Key microgrid Players:** Global Himalayan Expedition, Gram Oorja, Tara Oorja, Mera Gao Power, Husk Power, Onergy
- **Battery Suppliers:** Exide, Amara Raja, Southern Batteries , Eccoult
- **Battery Types:** VRLA and flooded lead acid batteries are mainly installed in AC and DC Microgrids. In 2018, Li ion and Ultra batteries were used in microgird pilots.

MICRO

18%/50%
Battery Utilization

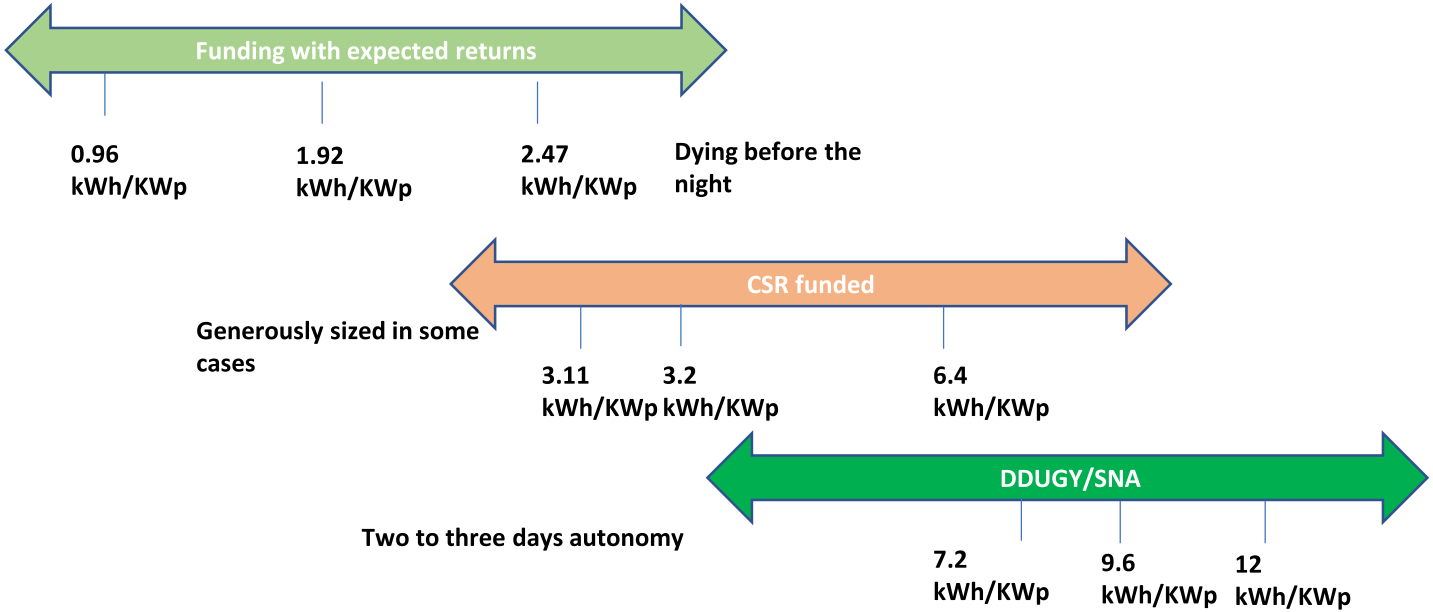
2.5/5
Solar units generated per day per kW

69%/80%
Storage Efficiency

Monitored Rural Microgrids Stats

Actual/Planned

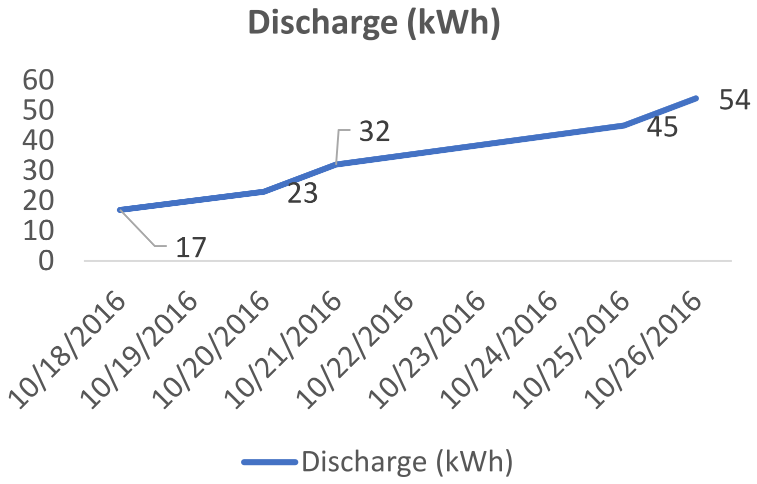
Observations on battery sizing (not co-relating)



Battery Utilization Case Study

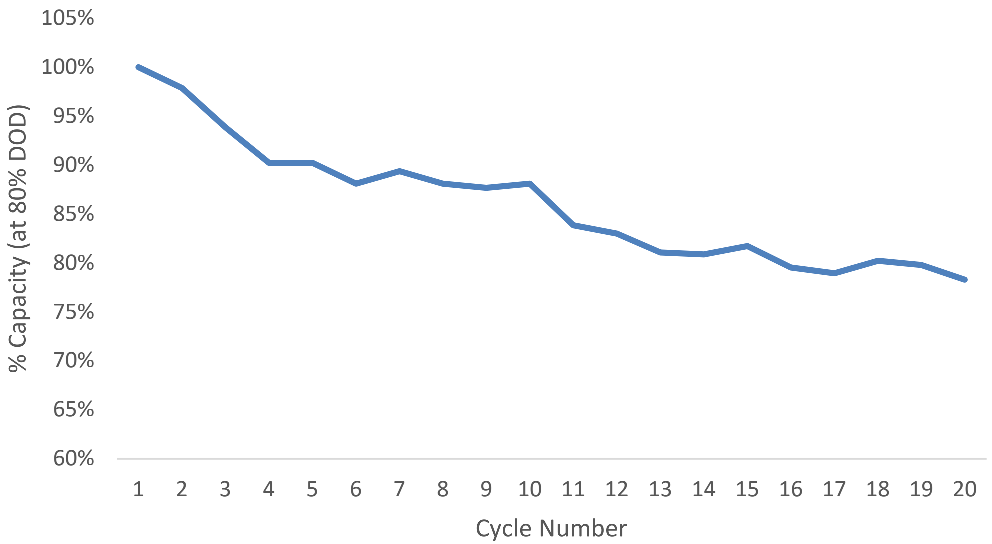
Plant Details:
35 kWp Solar PV, 86.4 kWh Lead Acid Battery
Age of microgrid: 1.5 years
Location: Balrampur, UP, India
Funding Type: Soft Loan

- 18 months old battery was found accepting a charge of close to 23 kWh which is only 27% of a 86.4 kVAh system.
- The battery's charge acceptance and discharging capabilities were improved over a period of a week as shown in the graph after monitoring and analysis.
- The battery at the site required equalizing every 30 days which was not done efficiently as seen from the data.
- Savings of over 30 kWh of units from diesel generator almost every day which was equivalent to 1/4th of consumption everyday.
- $ 900 saved every month, which is over 1% of plant capital expenditure.



Capacity Drop for Lead Acid Battery at 80% DOD cycles

Capacity Drop happens more gradually lesser the DOD.



Source: Tests Done by CES

- Invest in skill sets for O&M of Lead Acid Battery
- Invest in better technology
- Allow use of second life battery (import of used refurbished batteries is difficult in many emerging markets)

Split of 40 GW of RTPV

RTPV Split - Categories	Commercial (MW)	Industrial (MW)	Residential (MW)	Total (MW)
Metros-Saturated	850	680	170	1,700
Metros-Growing	1,720	2,150	430	4,300
Rural Residential	3,400	4,250	850	8,500
Peri-Urban/Tier2 Centres	7,650	15,300	2,550	25,500
TOTAL	13,620	22,380	4,000	40,000

Category	Network Expansion Costs	Feeder/Xmer ~ Loading	Load Growth	TOD	Power Cuts (hours/year)	Connected at	Possible PV Penetration
Metros-Saturated Residential	High	80%	3-5%	No	< 100	415 V	20%-50%
Metros-Saturated Commercial	High	80%	3-5%	Yes	< 100	11 kV	20%-50%
Metros-Saturated Industrial	High	80%	3-5%	Yes	< 100	11 kV	20%-90%
Metros-Growing - Residential	High	50%	5-7%	No	< 100	415 V	20%-50%
Metros-Growing - Commercial	High	80%	5-7%	Yes	< 100	400 V	20%-70%
Metros-Growing-industrial	High	80%	5-7%	Yes	< 100	11 kV	20%-90%
Rural Residential	Low	80%	7-9%	No	< 1000	415 V	20%-70%
Rural Commercial	Low	80%	7-9%	No	< 1000	415 V	20%-70%
Rural 11 kV	Low	80%	7-9%	No	< 1000	11 kV	20%-90%
Peri-Urban/Tier2 Centres R*	Medium	50%	5-7%	Yes	< 300	415 V	20%-70%
Peri-Urban/Tier2 Centres C*	Medium	50%	5-7%	Yes	< 300	415 V	20%-70%
Peri-Urban/Tier2 Centres I*	Medium	50%	5-7%	Yes	< 300	11 kV	20%-90%

Multiple Use Cases

T&D Deferral

System Peak Shavings Benefits

Energy Arbitrage

PF Correction and Ramp Control

DR Revenue

Diesel Minimization

ESS FOR MEETING ROOFTOP PV TARGETS

40 GW RTPV Scenario, India

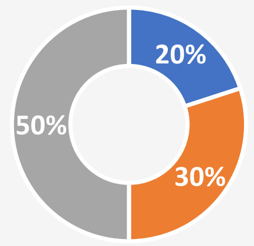
Scattered Installation Scenario:
40 GW @ 20% RTPV penetration scenario at distribution network

ESS requirement
- At 11 kV: 12 GW, 14 GWh
- At 400 V: 4.5 GW, 4.5 GWh

ESS requirement
- **At 11 kV: 3.5 GW, 5 GWh**
- **At 400 V: 1.5 GW, 1.5 GWh**

Industrial feeders in peri-urban centers will have highest requirement for ESS at distribution network

Network-wise ESS requirement split



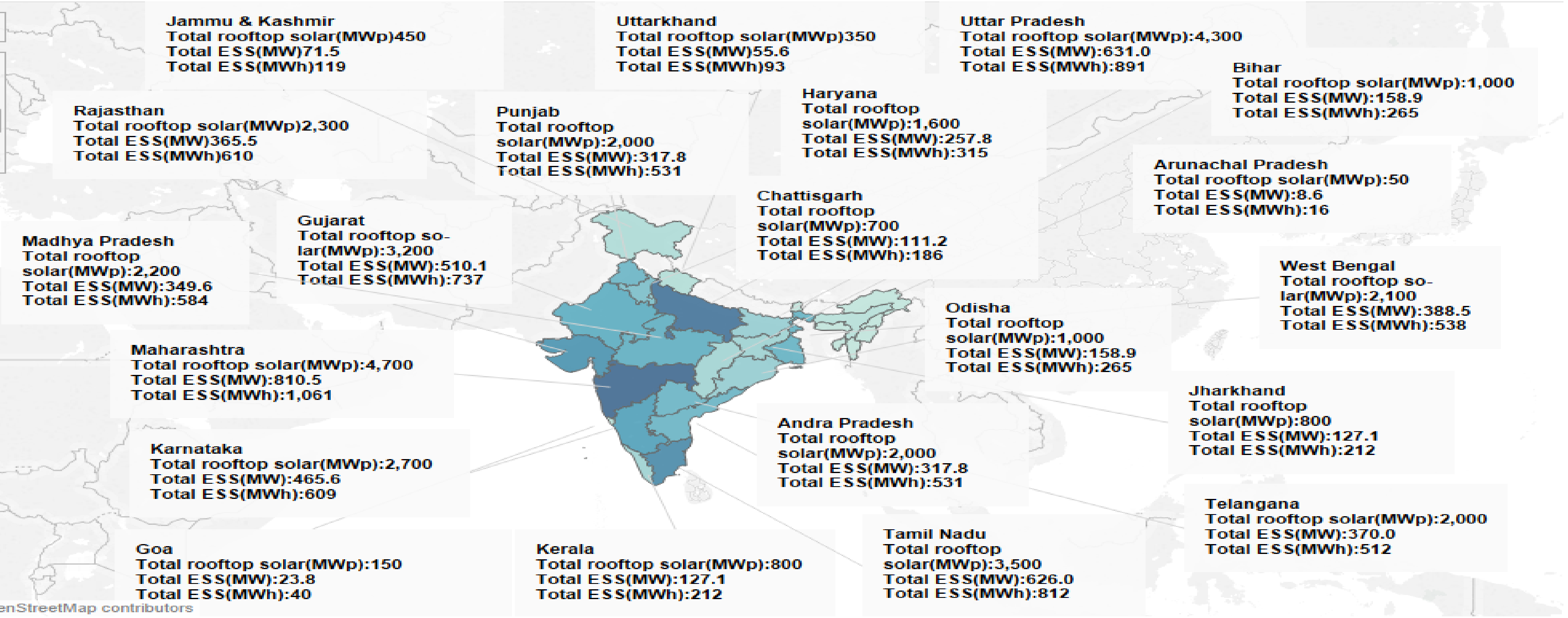
Concentrated Installation Scenario: 40 GW @ Over 50% RTPV penetration scenario at distribution network

When there is scattered RTPV installations, the ESS capacity required to support these are higher and equally scattered, as compared to the concentrated RTPV installation scenario.

RTPV = Rooftop Photovoltaic

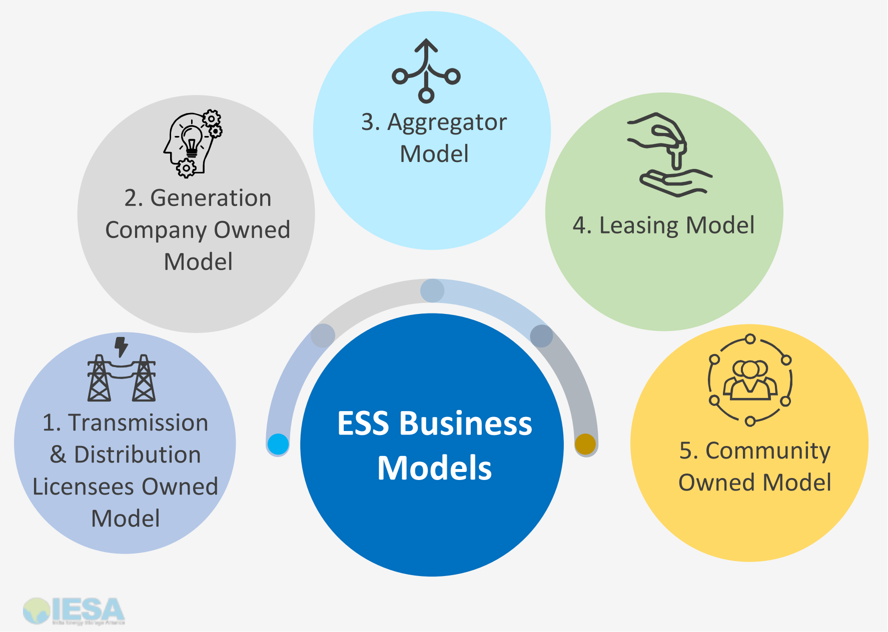
CES Analysis; Image Source: Observer Research Foundation

Energy Storage Roadmap for India: 40 GW Rooftop Solar Penetration and Requirement of Energy Storage till 2022



EMERGING BUSINESS MODELS IN THE GLOBAL ESS MARKET

T&D licensee model, GENCO owner model are CAPEX intensive models. Leasing Model, and Community Owned models are less Capital intensive and more preferable during the initial phase when ESS market is catching up. Aggregator or virtual power plant model can be adopted in a mature market.



1 **T&D Licensee Owned Model:** In this model, Transmission licensee owns and operates the ESS, which are mostly grid scale storage systems mainly for ancillary services. CAPEX intensive model, revenue recovery is only through utilizing the services over a long term.

2 **GENCO Owned Model :**A third party , mostly a private entity owns and operates the ESS, and offers its services in the electricity market or to C&I customers. Readily accepted by the market as the burden of CAPEX doesn't fall on its customers.

3 **Aggregator model:** A third party aggregators collates the distributed ESS units to participate in demand response bids in the electricity market. The Aggregators gets paid the DR incentives which is distributed among the ESS participants.

4 **Leasing Model:** Energy storage system is leased by the utility or a third party mostly with a solar plant. Usually, an upfront cost which partly covers the battery and solar plant installation cost along with a monthly consumption fee is charged on the consumer.

5 **Community Owned Model:** A community invests in ESS system with a control room, which enables trading of energy amongst themselves. Another version is the community operates as an ESS aggregator of distributed ESS and utilize it to bid for ancillary services.

Source: CES analysis

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Presented By: Harsh Thacker
Designation: Director, Consulting Services
Mail: hthacker@ces-ltd.com
Mobile: +91 9840266125
LinkedIn/Twitter: harshnthacker

Contact us:
India Energy Storage Alliance
C/o Customized Energy Solutions
A-501, GO Square, Aundh
Hinjewadi Link Road, Wakad
Pune -411057, Maharashtra, India
Phone: 91-20-32407682
Mail: contact@indiaesa.info
Website: www.indiaesa.info

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