



PV + Storage Cheaper than Coal in India

Dr. Rahul Walawalkar

President, India Energy Storage Alliance

Chair, Global Energy Storage Alliance

President & MD, Customized Energy Solutions (India)



VISION

To make Indian energy grid & transportation sector more competitive by providing a knowledge sharing platform for creating awareness about advanced energy storage and e-mobility solutions.

MISSION

Enabling India to become a global leader in research, manufacturing and adoption of advanced energy storage, microgrid and e-mobility technologies by 2022.

STRATEGIC PARTNERS



Founding Partners of:



OUR MEMBERS

LEADERSHIP CIRCLE



Customized Energy Solutions
Analyze · Simplify · Implement



EXICOM
POWER SOLUTIONS



SB Energy
SoftBank Group

GOLD



AES



AMARA RAJA



amco



APPLIED MATERIALS



BOSCH
Invented for life



CLP INDIA
The power of new standards



EESL



GE

SILVER



Fortum



Himadri



AICL



JAKSON



Inguard



OLA ELECTRIC



OKAYA
NEVER STOP INDIA

BRONZE



ACME
Leading Through Innovation



Bry-Air



HERO FUTURE ENERGIES
planet positive power



mi solar

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NantEnergy
FLUID ENERGY



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NEC ENERGY SOLUTIONS



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ATHER



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COMSOL



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future
LITHIUM TECHNOLOGY

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GREENFUEL



GRINTECH



Gelo



HOP



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Matsui Energy, Inc.



PASTICHE



PLUSS
TECHNOLOGY FOR A BETTER WORLD



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VNT



Vision Mechatronics



VENTURES



FLOW TECH



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adani Electricity



ARAI
Progress Through Research



BSES
BSES Rajghat Power Limited



BSES
BSES Yamuna Power Limited



CLIMATE POLICY INITIATIVE



Government of India



MET



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STANFORD UNIVERSITY



THE WORLD BANK



TATAPOWER-DDL



WORLD RESOURCES INSTITUTE



Government of India



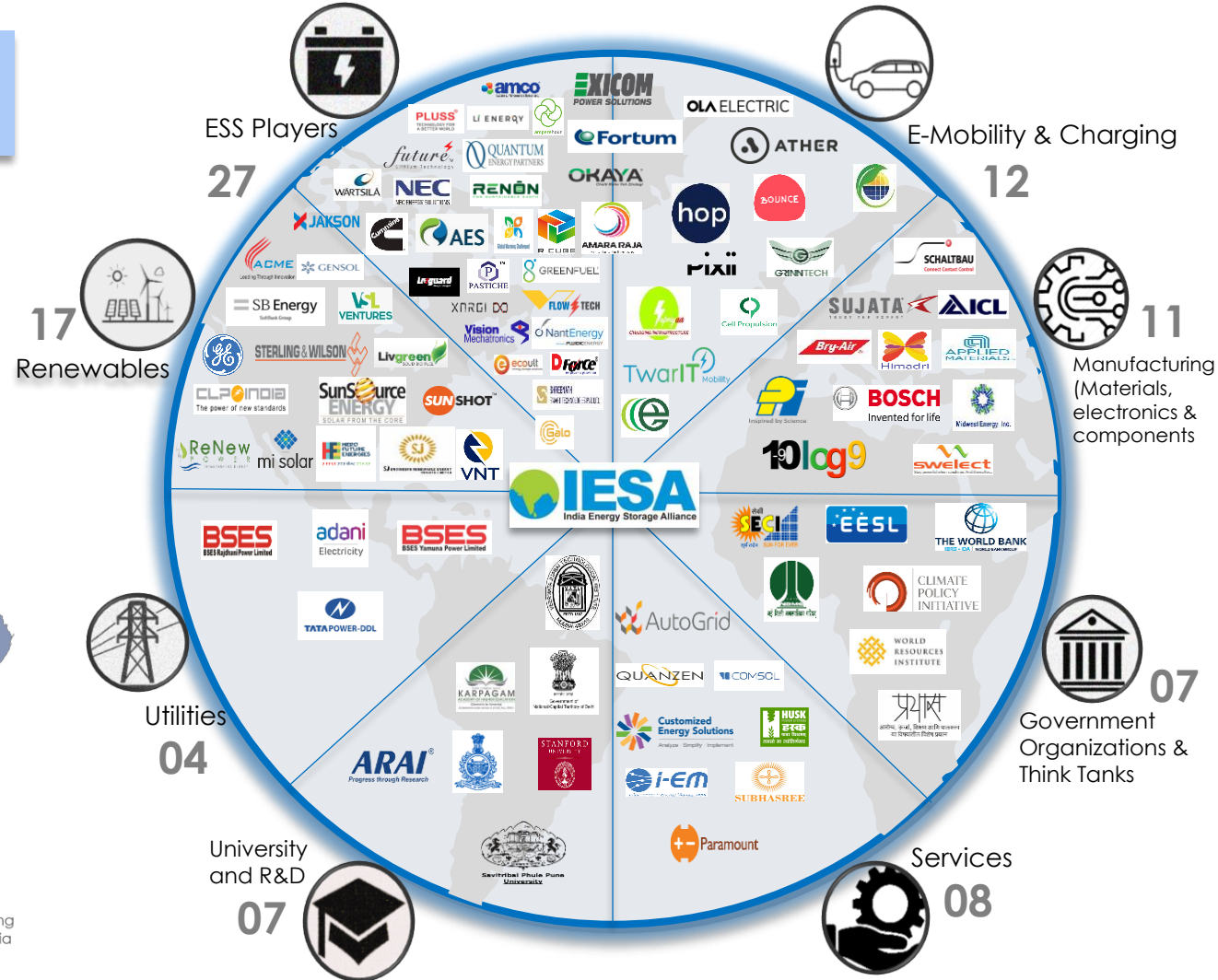
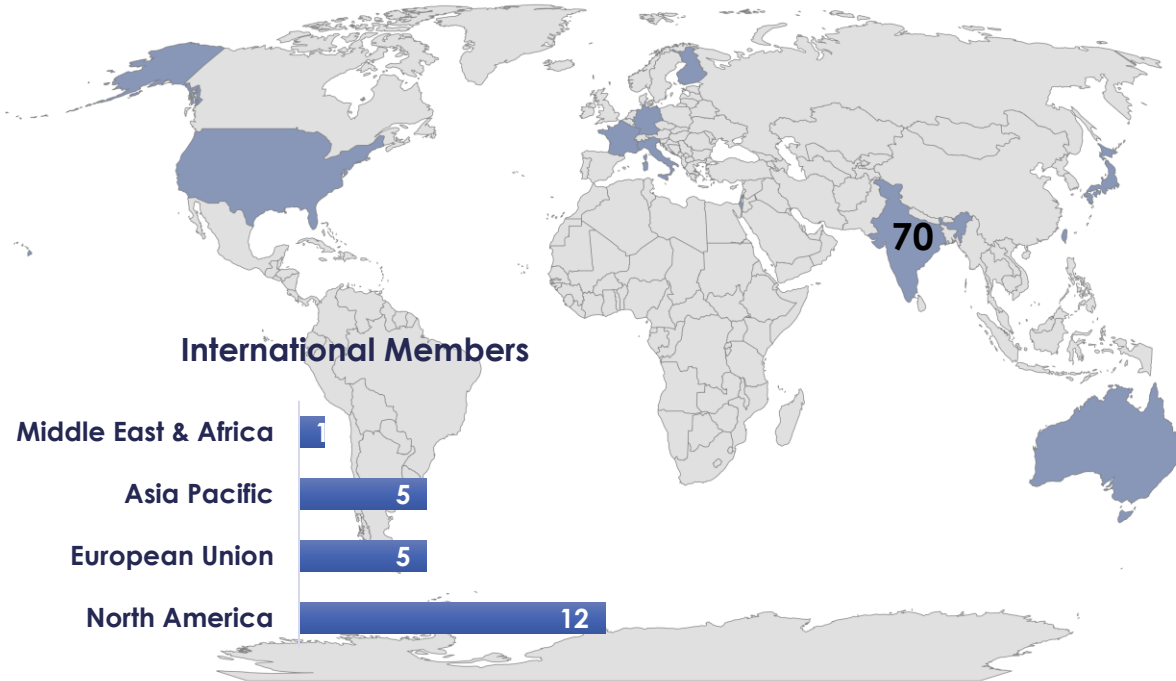
Government of India



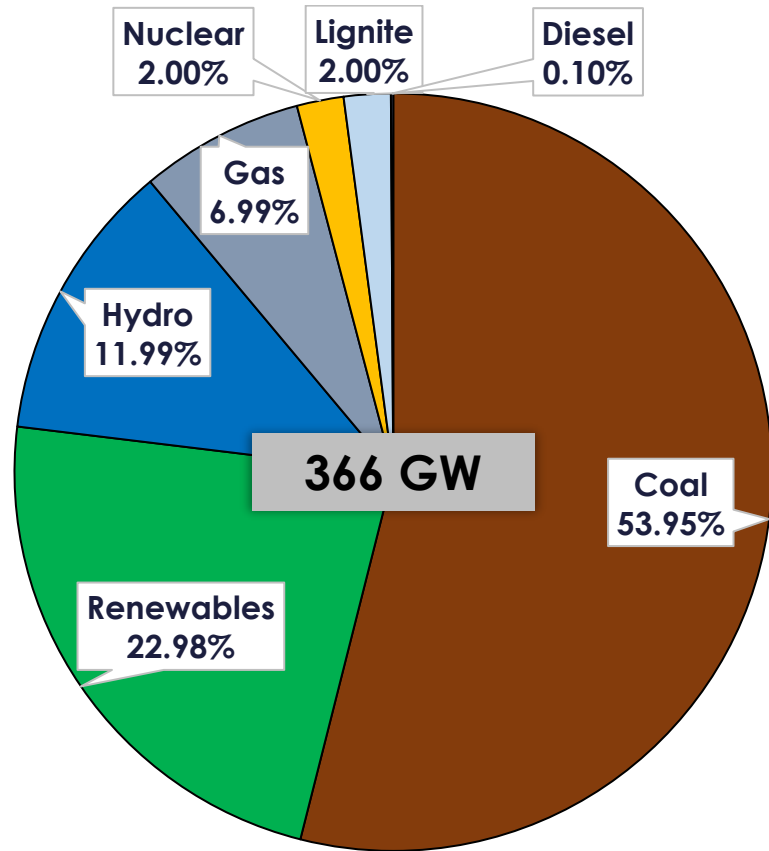
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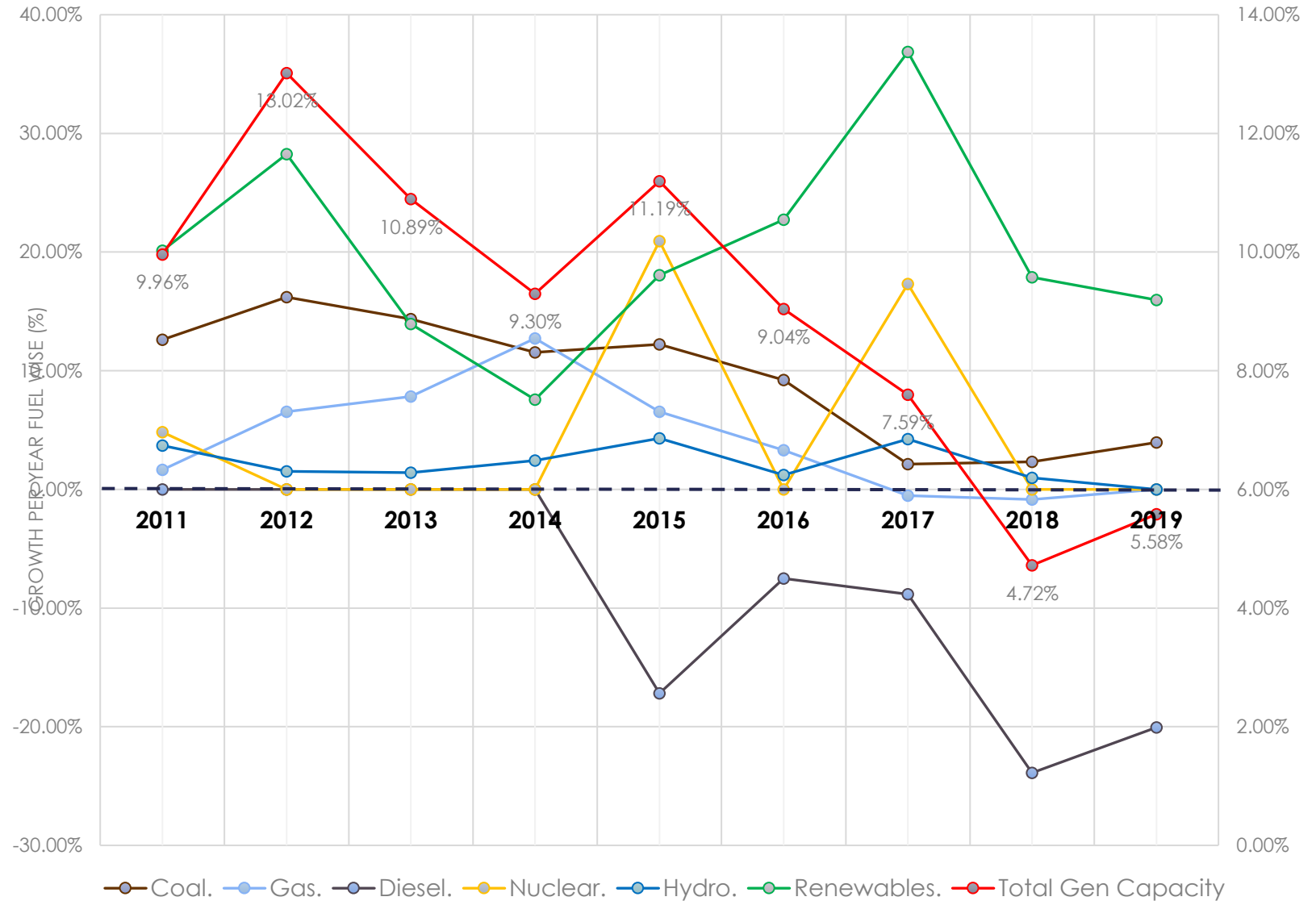
We are Proud to have members across the Globe and across the energy value chain



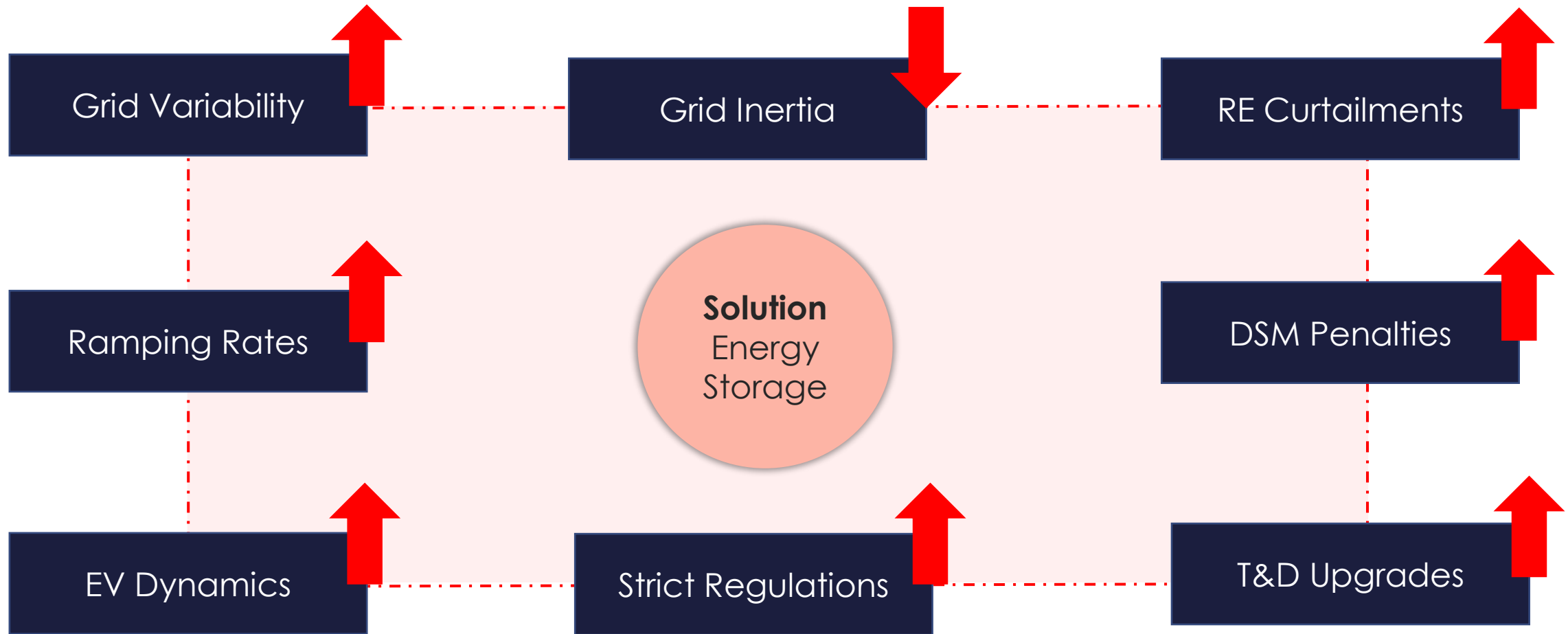
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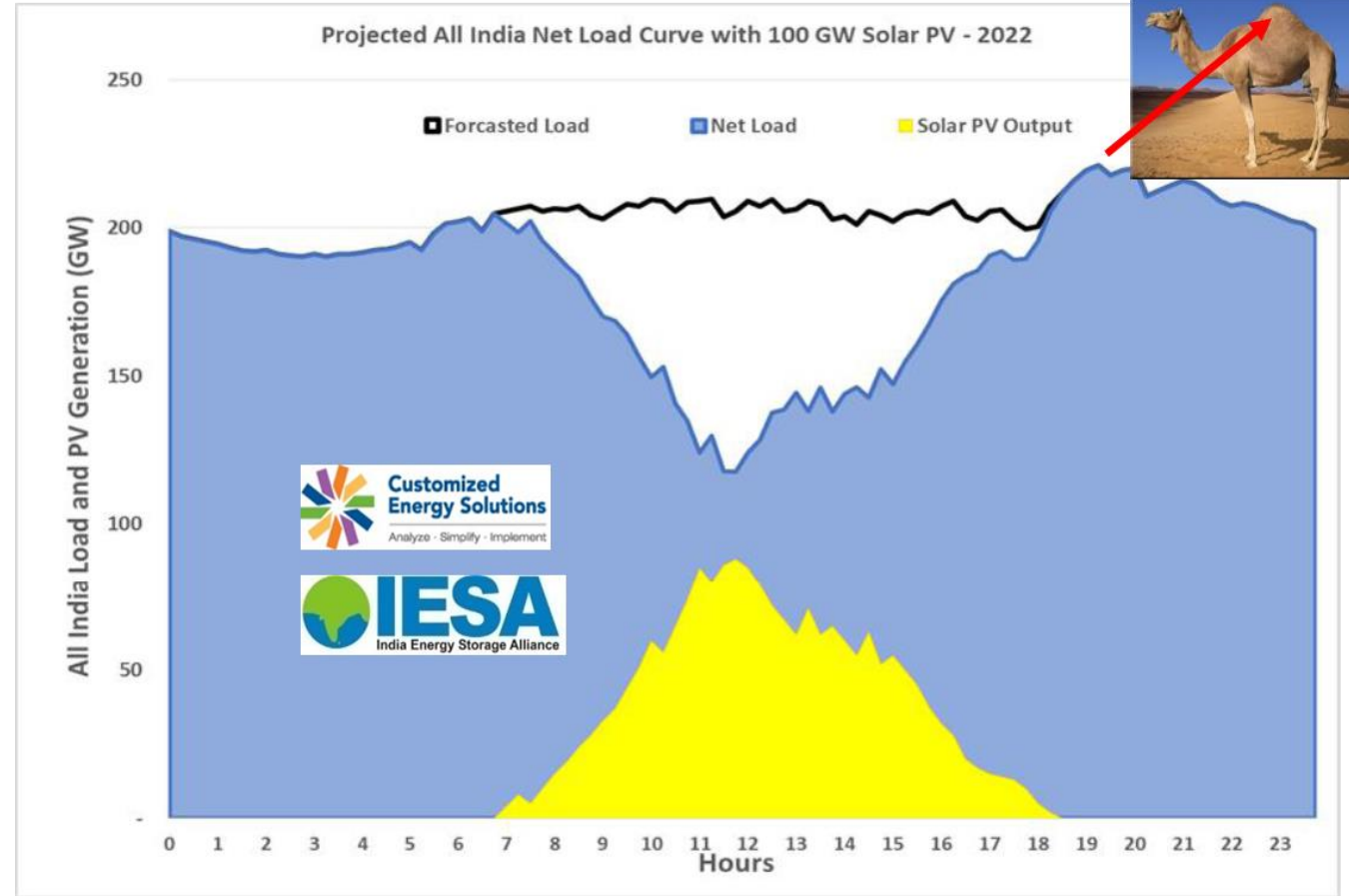
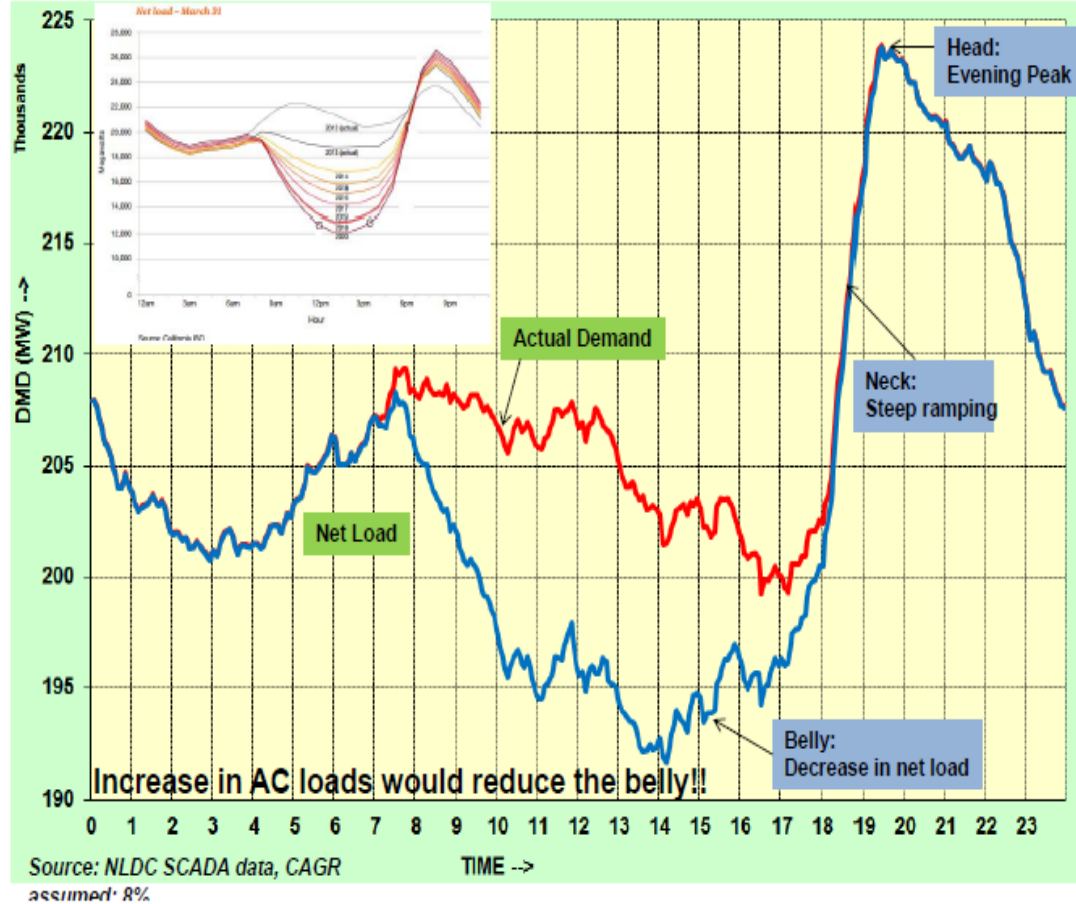
YOY Growth of Various Fuel Capacity in Gen Mix – India – 2010-2020



WHY RE+ ENERGY STORAGE?

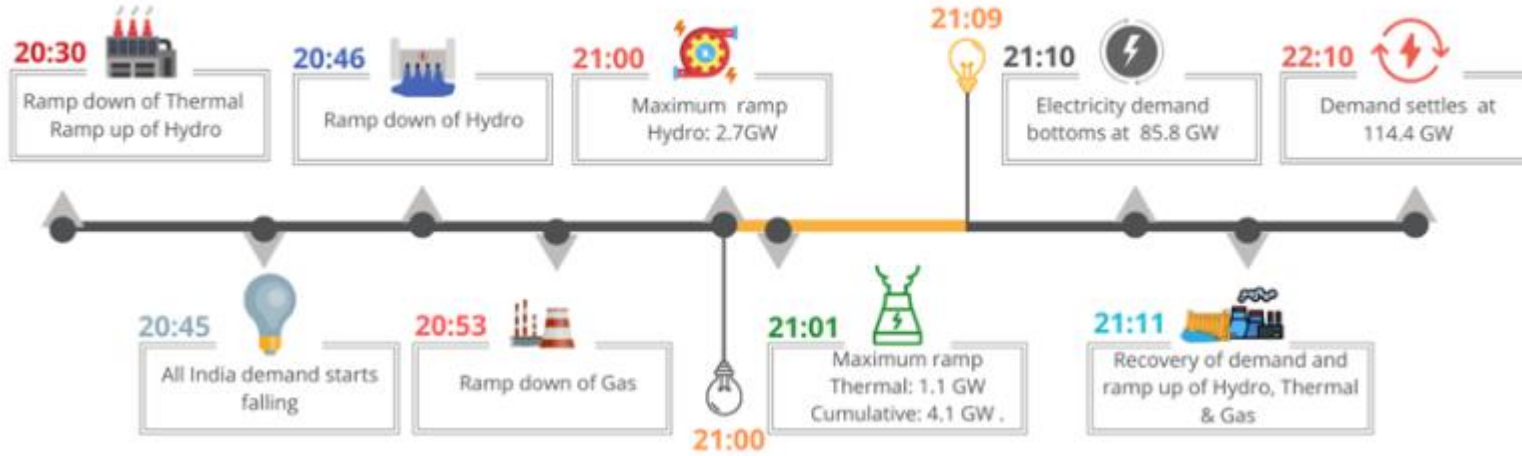


Expected India Net Load Curve 2022 (with 100 GW of Solar Generation)



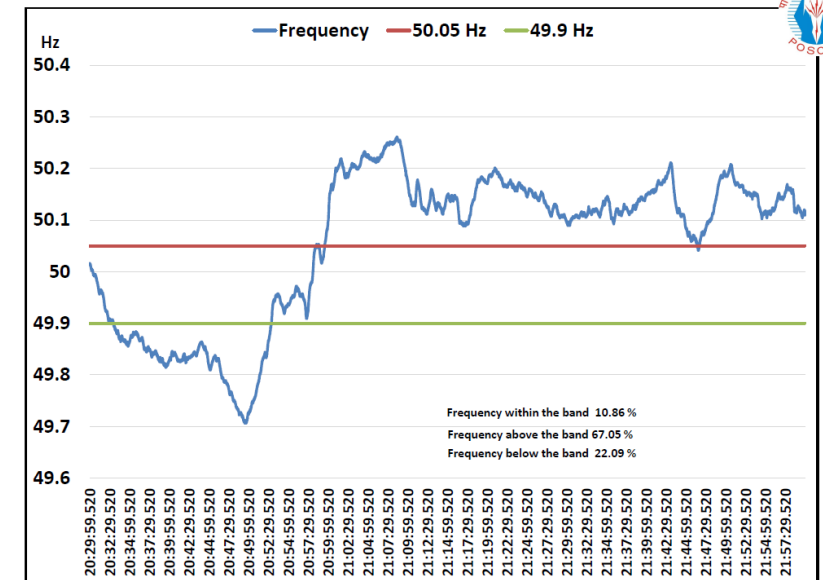
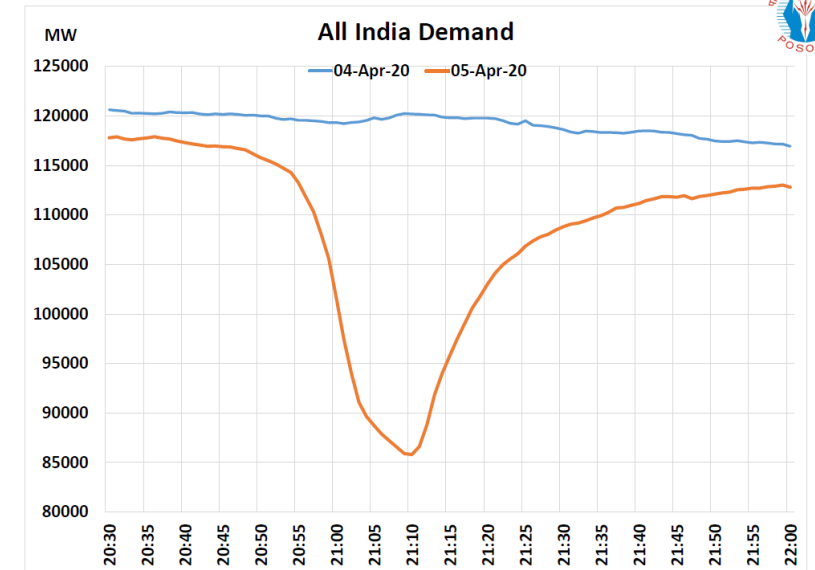
Original projections by POSOCO for 20 GW solar target

CHRONOLOGY OF EVENTS

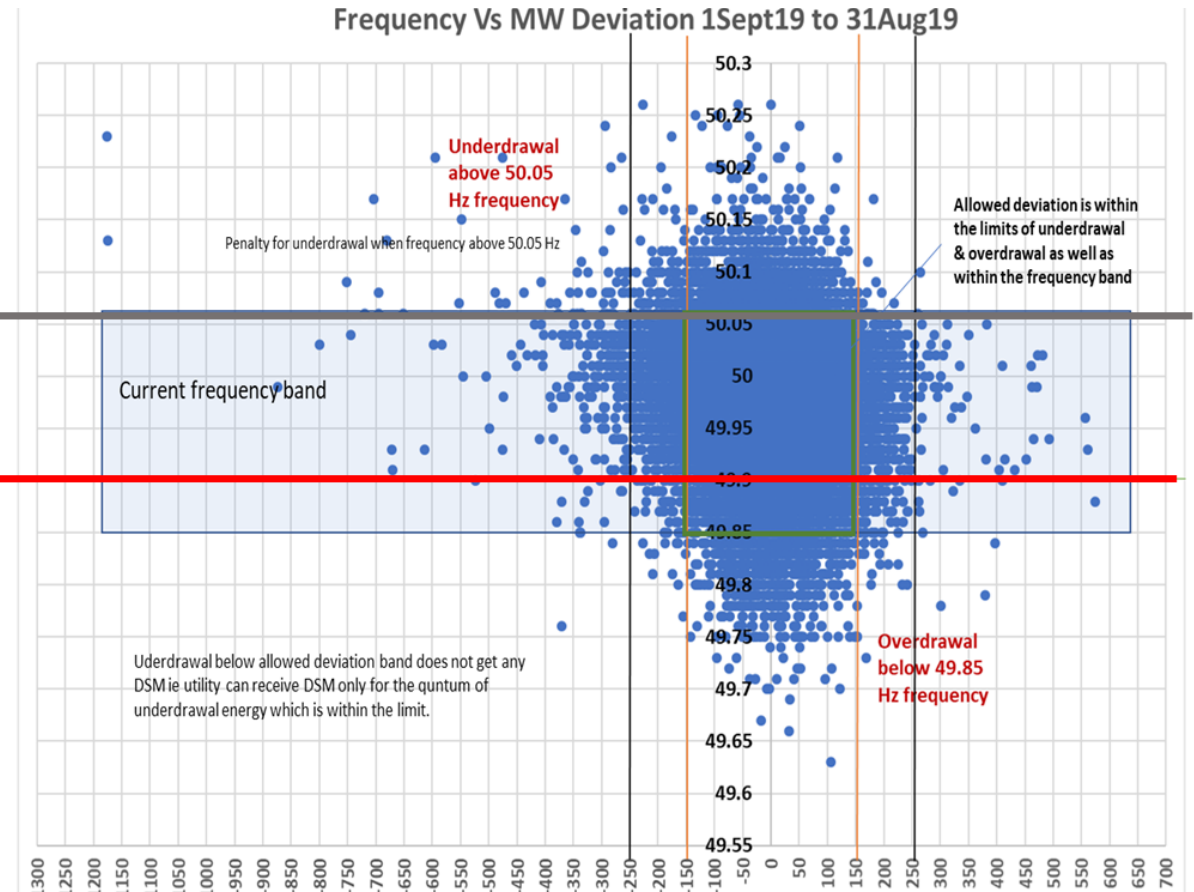
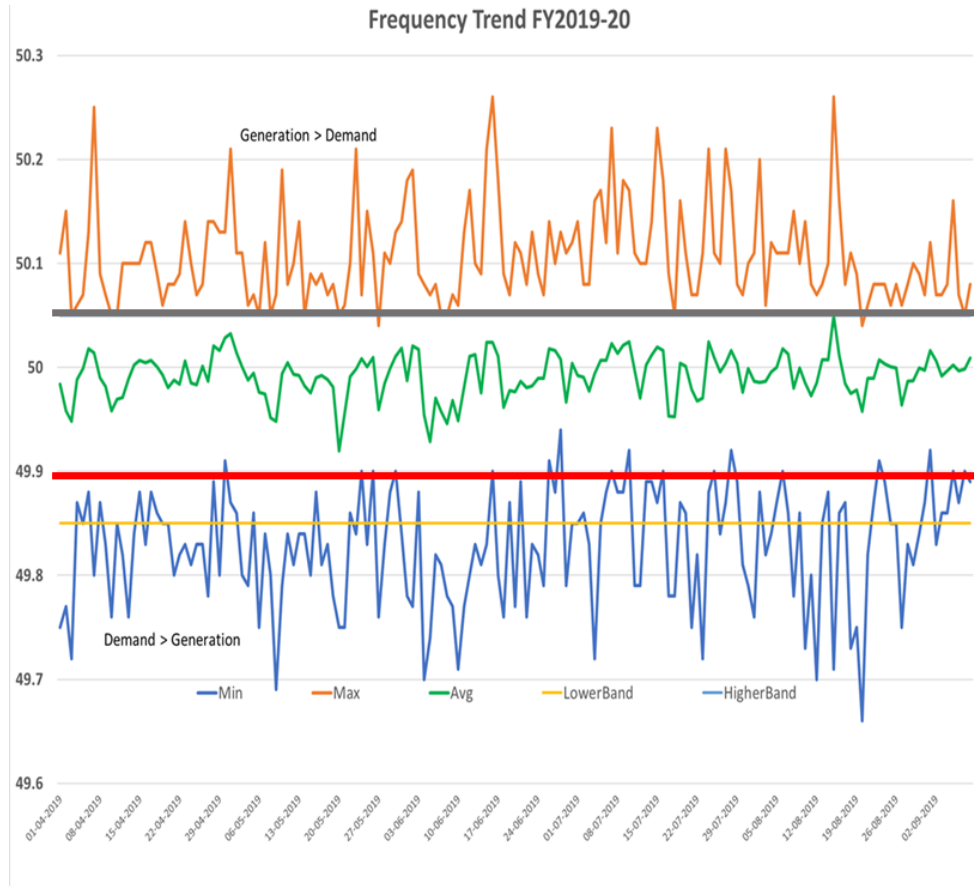


- ❑ 32 GW drop of electricity demand was managed in a short time span of just 49 minutes.
- ❑ Initial drop of 4.5 GW happened initially, thereafter falling sharply by another 11.6 GW in a span of next 5 minutes.
- ❑ Electricity demand bottomed at 85.8 GW, recording a sharp decline of approximately 16 GW in a span of 9 minutes.
- ❑ Thermal assets also played a key role along with Hydro, as their capacity ramped down by 9.5 GW during the event.

Annexure-III

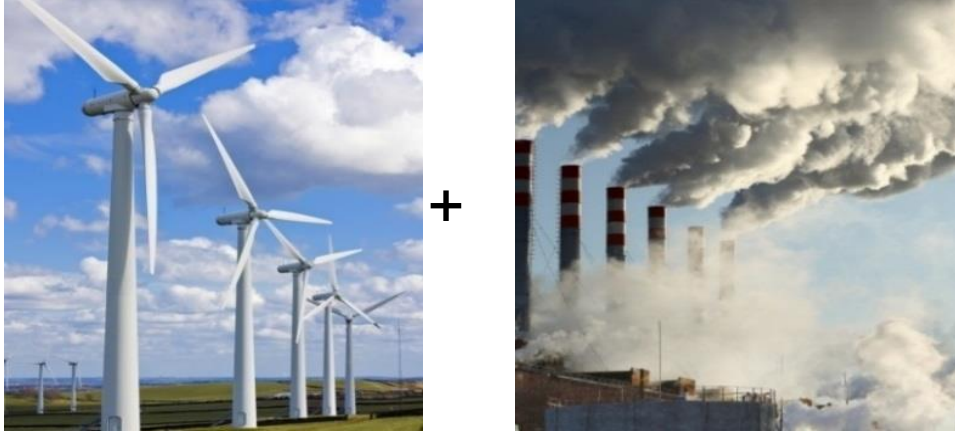


Grid Frequency Pattern and need for DSM & Ancillary Services



Balancing Variable Renewable Resources Technology choice: Environmental Impact

Conventional Grid



Smarter Solution: Storage



- • Manage renewable variation by fossil generators varying output
 - Decreases efficiency
 - Increases fuel consumption
 - Requires more maintenance
 - Increases emissions

- • Store energy when supply exceeds load; inject energy when load exceeds supply
 - High round trip efficiency
 - Low operating cost
 - Near instantaneous response
 - Zero direct emissions
 - Frees up generation capacity

20% of the CO2 emission reduction and up 100% of the NOX emission reduction expected from wind and solar power may be lost because of ramping fossil plants

* Katzenstein, W., and Jay Apt. Air Emissions Due To Wind And Solar Power. *Environmental Science & Technology*. 2009, 253-258.

We have been on the forefront in discussing and raising concerns in the Energy Storage & EV space with all Central and State Nodal Agencies like MNRE, DST, MoP, MeITY, NITI to name a few. A few snapshots of interactions are shown below



via NaMo App



Call on Prime Minister by panelists of Pravasi

Invited by MEA & PMO to discuss the Role of Indian Diaspora in Capacity Building for Affordable Solar Power & Energy Storage in August 2018.

MNRE Meeting on National Energy Storage mission (2018)



India EV R&D Roadmap for DST (2018)

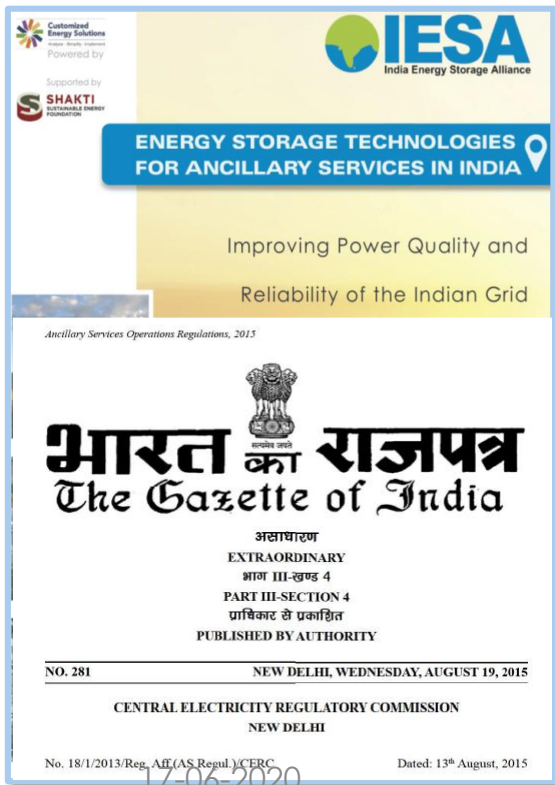
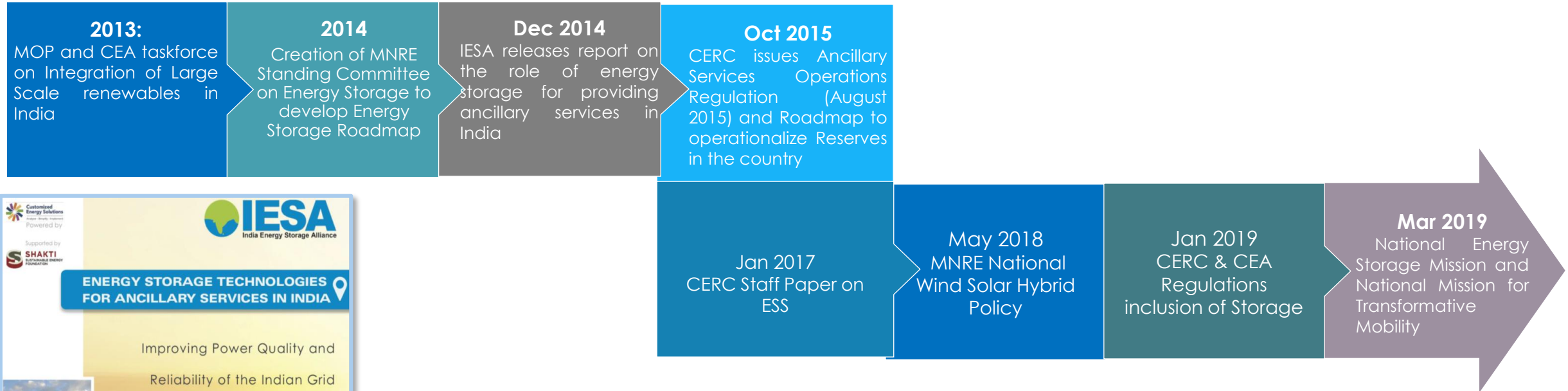


Meeting with Sri Amitabh Kant, NITI Aayog on Giga Factories (2019)



MoU signing between MeITY and IESA (2019)



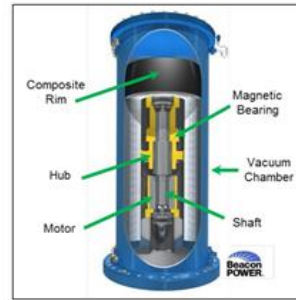


Electro-Chemical



(Lead Acid / Lithium Ion / Flow batteries / Sodium / Metal Air batteries)

Mechanical



(Flywheel)

Bulk Mechanical



(Compressed Air)

Gravitational



(Pumped Hydro)

Thermal



(Ice / Molten Salt)

Chemical



(Hydrogen / Fuel Cells)

Electrical



Ultra Capacitors

Power Electronics



Bidirectional inverters / Charging Infrastructure

IPPs/Project Developers

PCS Suppliers/ SI

Metal Air

Thermal Energy Storage

Chemical (Hydrogen) Storage

Pumped Hydro Storage

Compressed Air

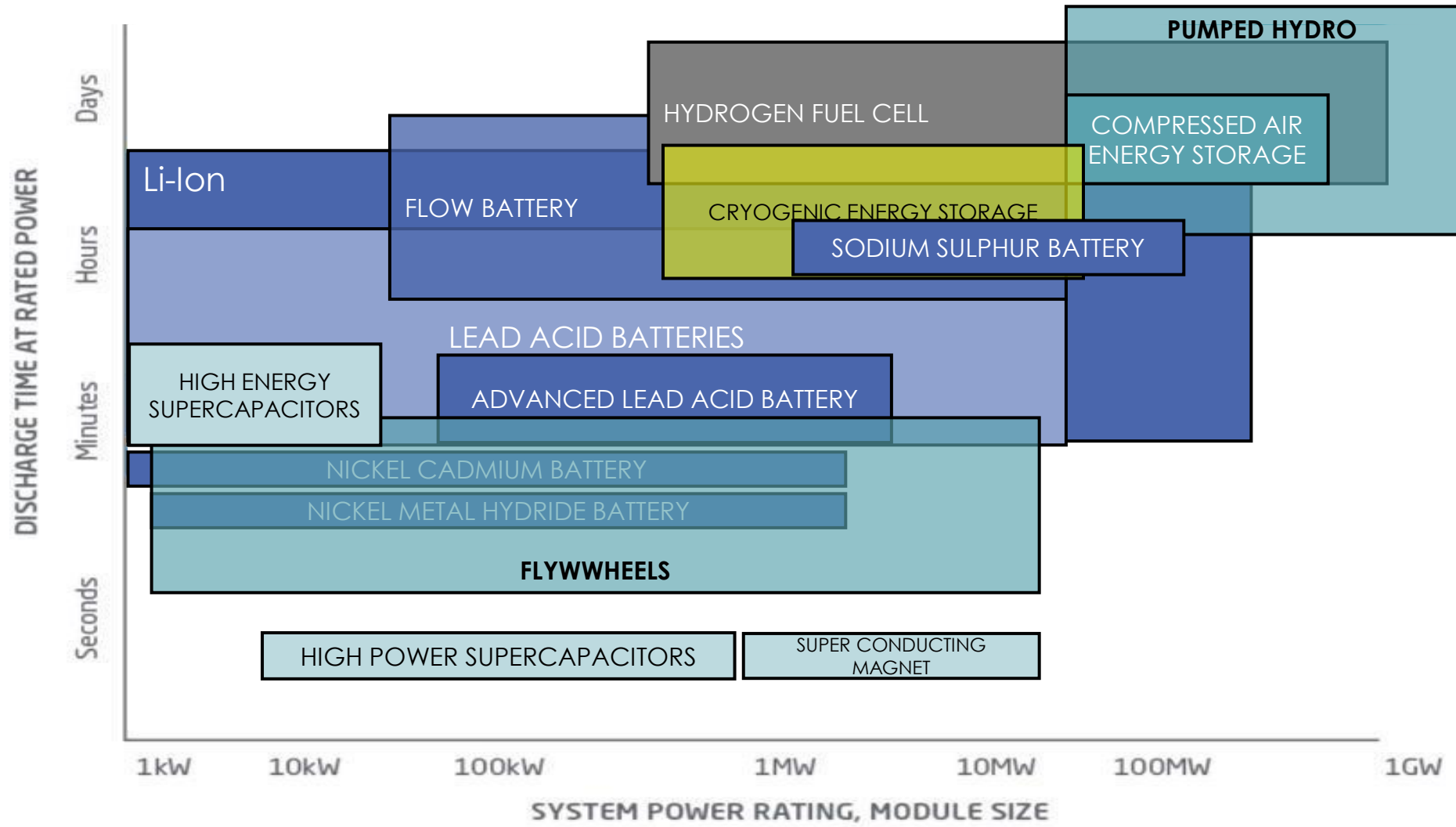
Sodium

Flywheel

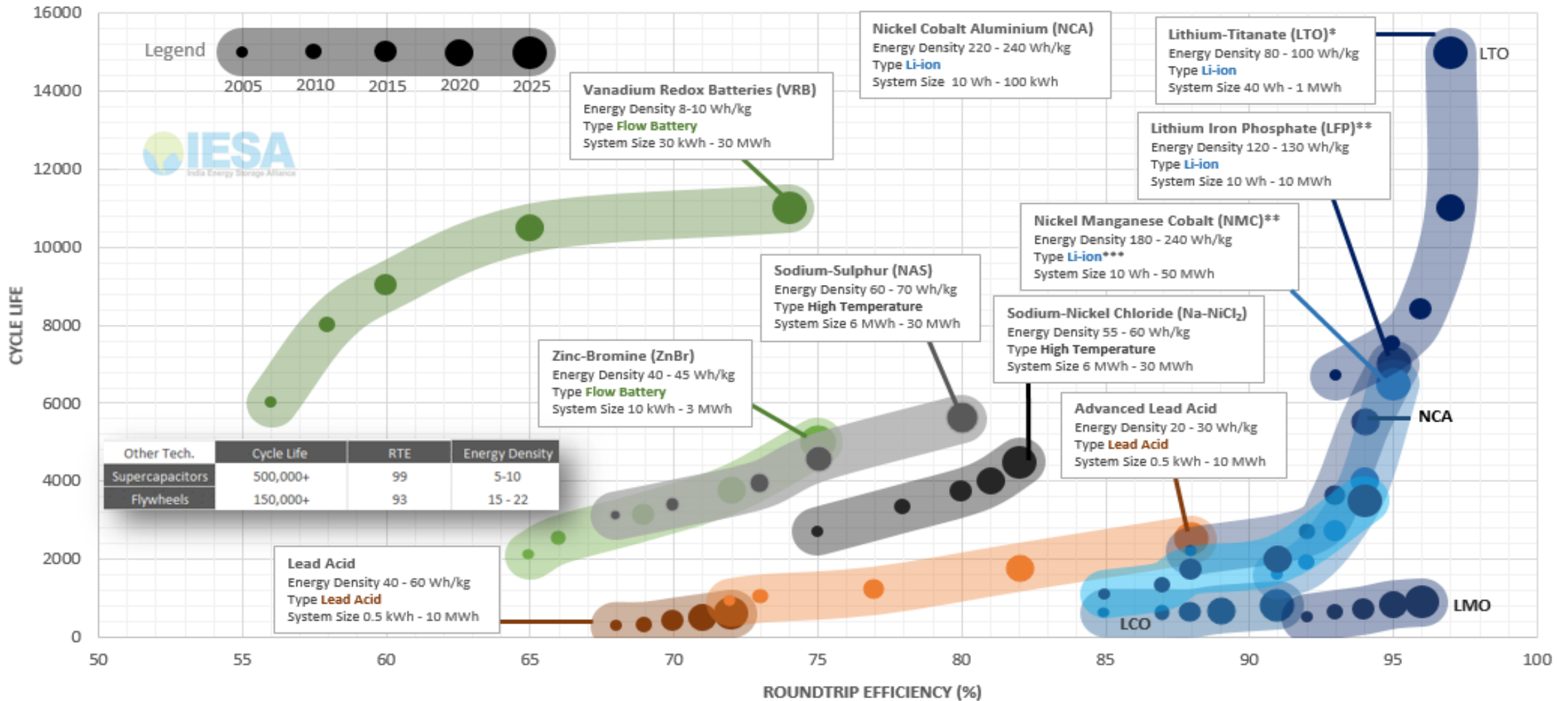
Flow Batteries

Lithium Ion Batteries

Lead Acid Batteries



Projections of Cycle Life and Energy Efficiency Improvements during 2019-2025

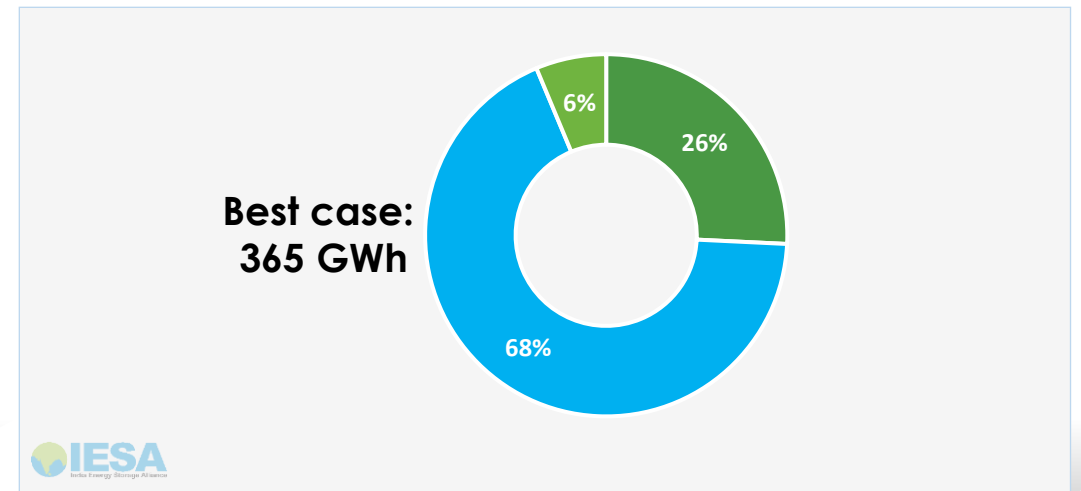
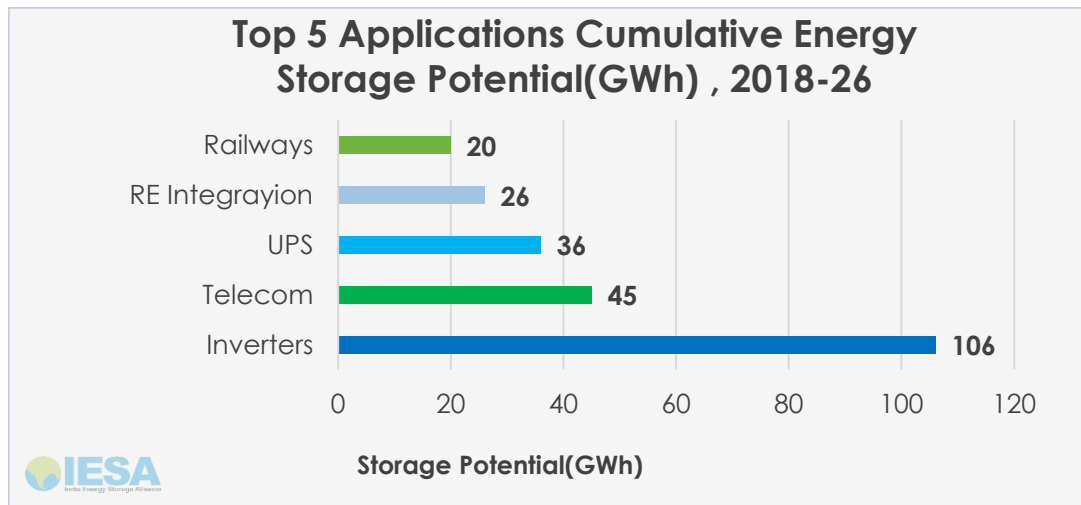
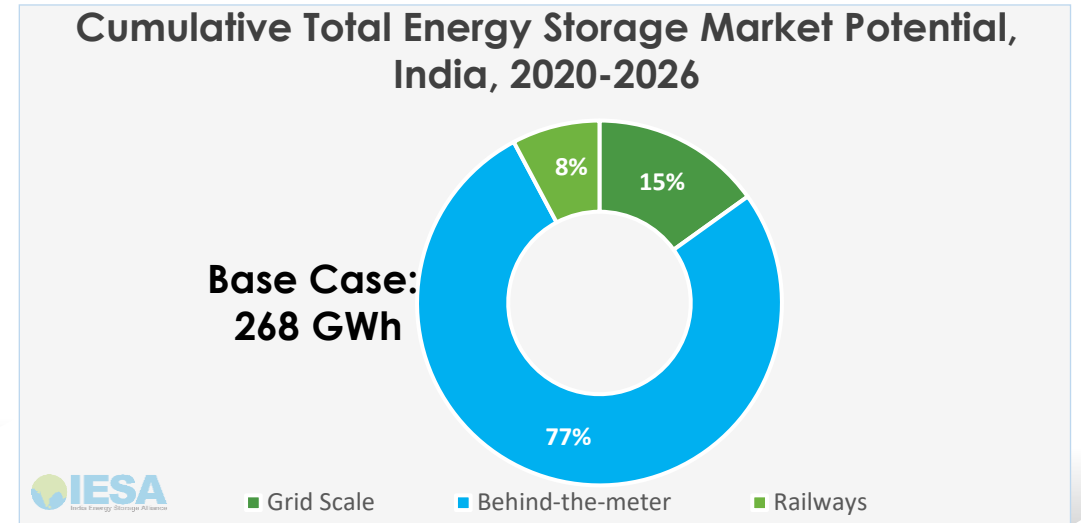
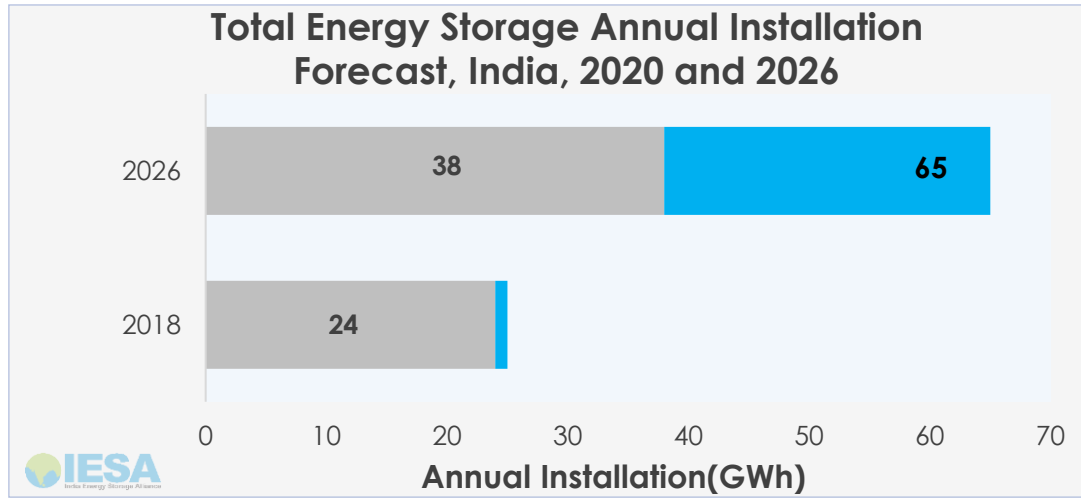


*Data is shown for LTO cells with NMC cathode. In other variations, an LFP or LMO cathode may be used

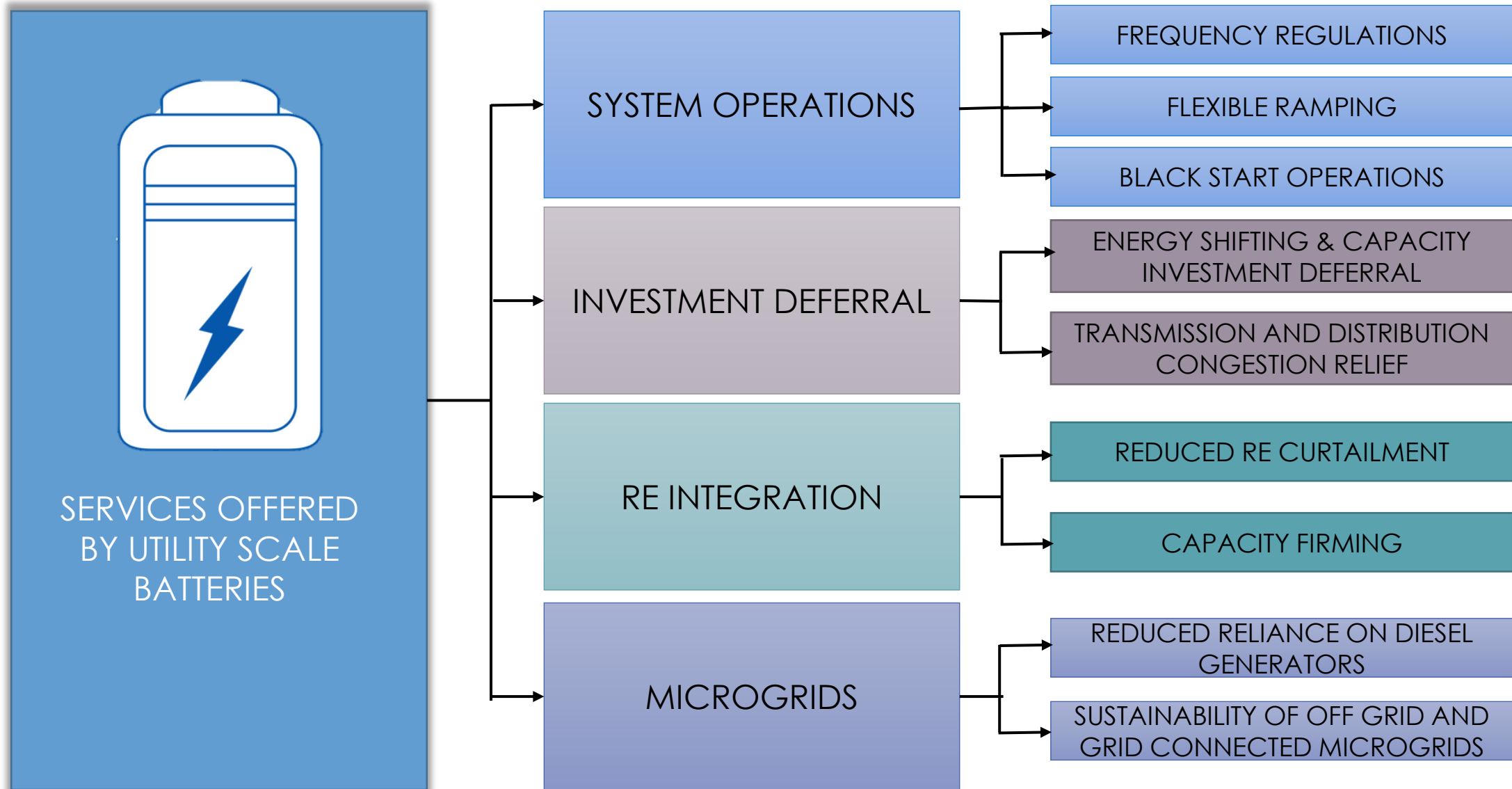
**Data is shown for 'Energy cells'. 'Power cells' have longer cycle life and lower energy density

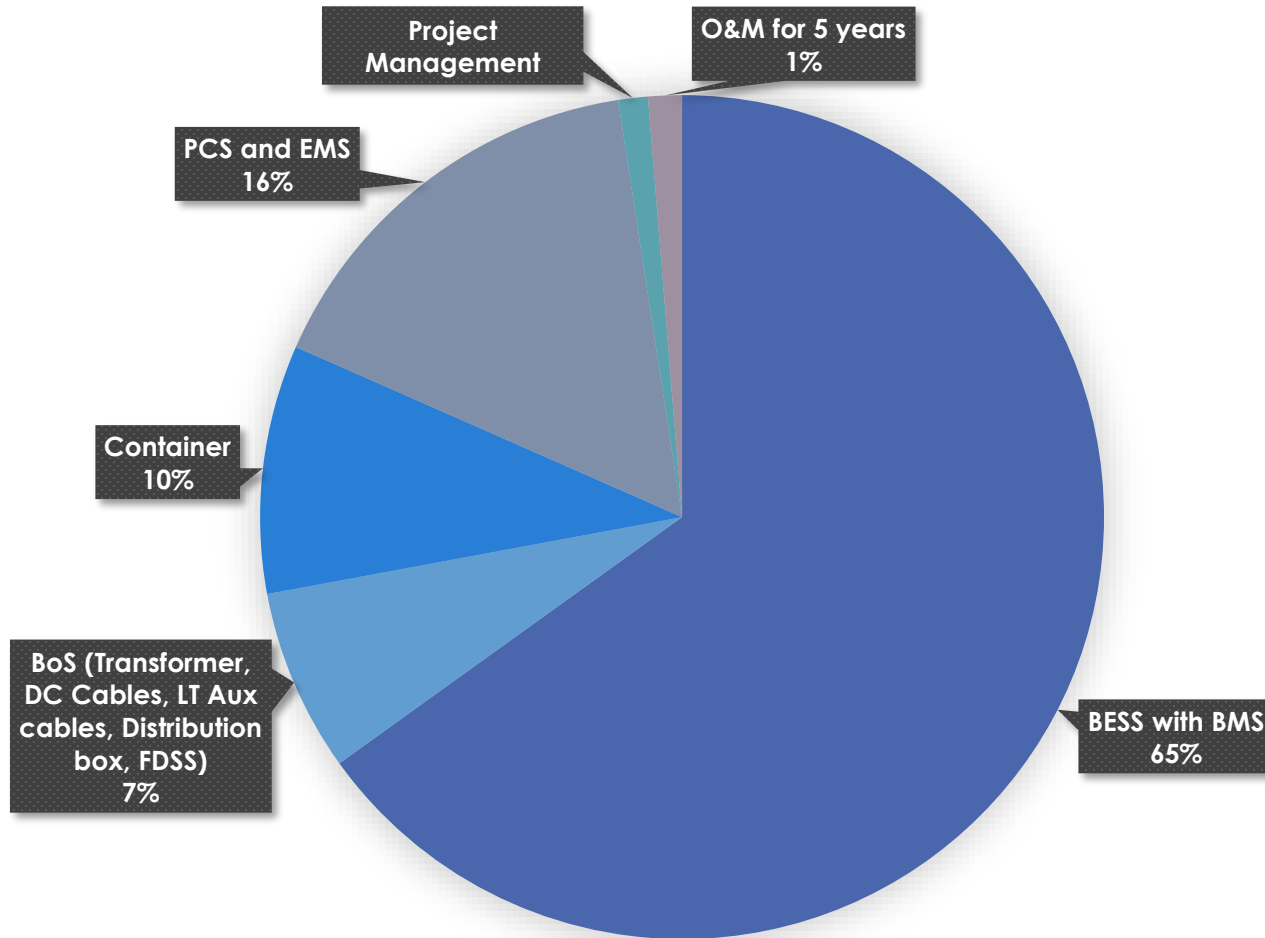
EOL (End-of-life) = 80% of Initial Capacity

Source: CES Internal Analysis. Graph prepared as of 2019



Source: CES analysis

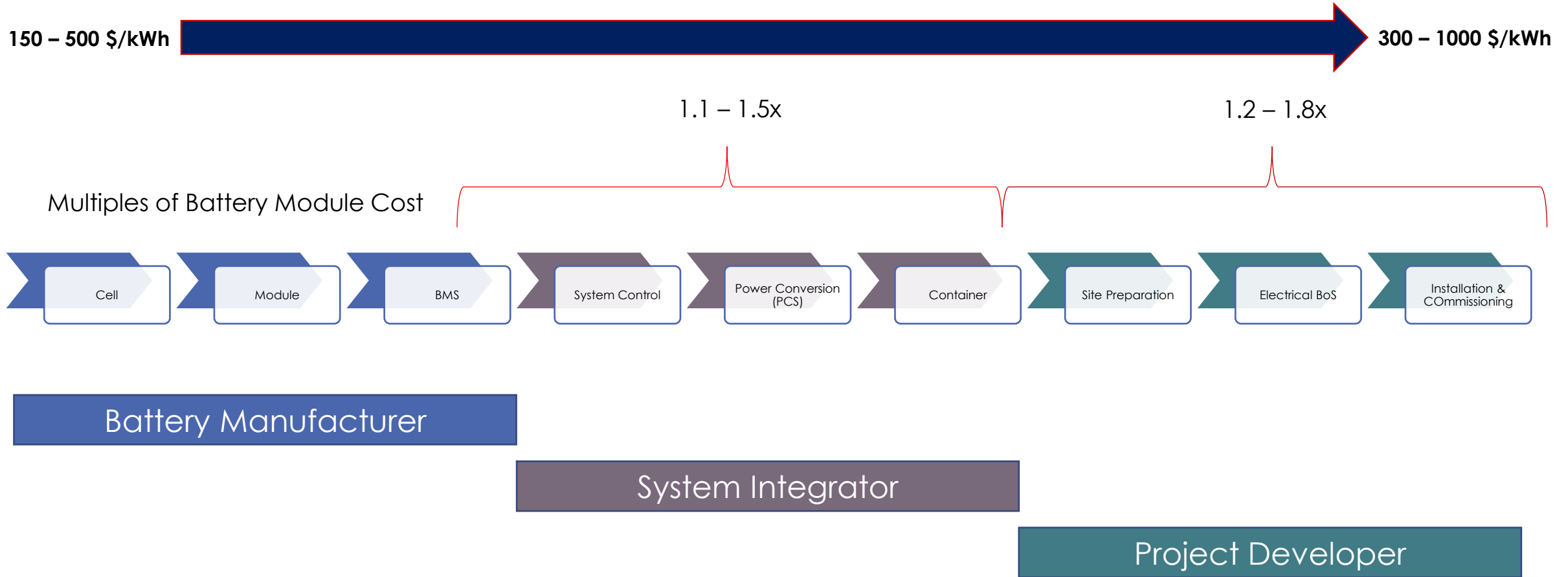




Trends being observed:

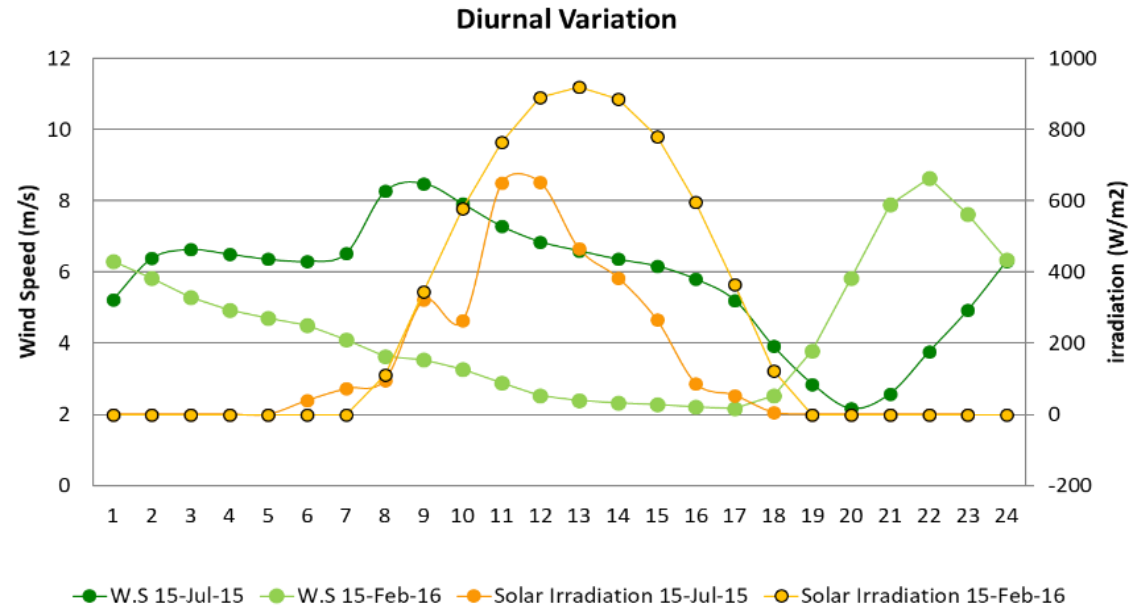
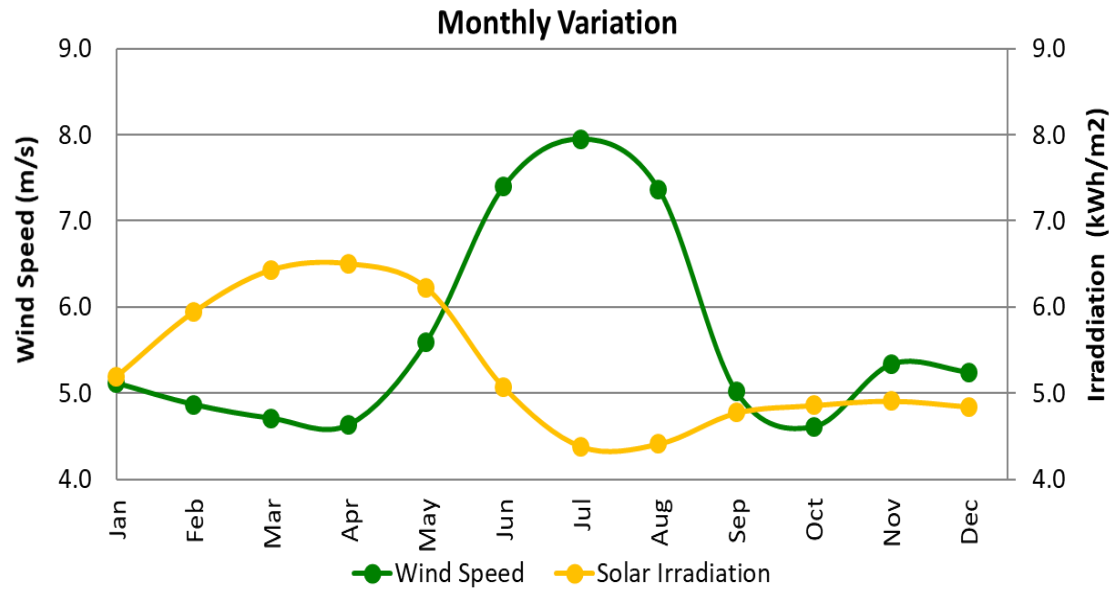
1. Insurance costs: 25 – 30%
2. Battery Warranty: 5 – 7 years
3. O&M Charges: 0.5 – 1%
4. Capacity Guarantee Charges: 8 – 10 \$/kWh
5. Round trip Efficiency: ~85%
6. System Availability: 95%
7. Interest Rate: 10%

Exclusions: GST Charges, Civil Costs, Transportation costs, Financial Charges, Insurance Charges



- India's ministry of new and renewable energy released a solar-wind hybrid policy in 2018. This provides a framework to promote grid-connected hybrid energy through set-ups that would use land and transmission infrastructure optimally and manage the variability of renewable resources to some extent.
- The policy aims to provide a framework for large-scale hybrids, while also encouraging new technologies and methods to carry out hybridization. It also encourages the procurement of hybrid power through transparent bidding processes, which could consider capacity delivered at grid interface point, effective capacity utilization factor (CUF), and the unit price of electricity.
- Existing projects wishing to go hybrid may do so under various conditions. These mainly relate to transmission charges and transmission capacity as well as separate rules for AC and DC integration of such projects.
- The policy states: "In case of fixed speed wind turbines connected to the grid using an induction generator, the integration can be on the HT side at the AC output bus. However, in case of variable speed wind turbines deploying inverters for connecting the generator to the grid, the wind and the solar PV system can be connected to the intermediate DC bus of the AC-DC-AC converter."
- The original draft policy first issued in June 2016 had targeted 10GW of hybrids by 2022, but no target has been set in the final policy.
- Some of the Indian States has also come out with state specific hybrid policies. Andhra Pradesh, Kerala and Rajasthan has released DRAFT versions of the policy, while it is expected that more States will follow suit.

“The complimentary Nature of Renewable Resources”

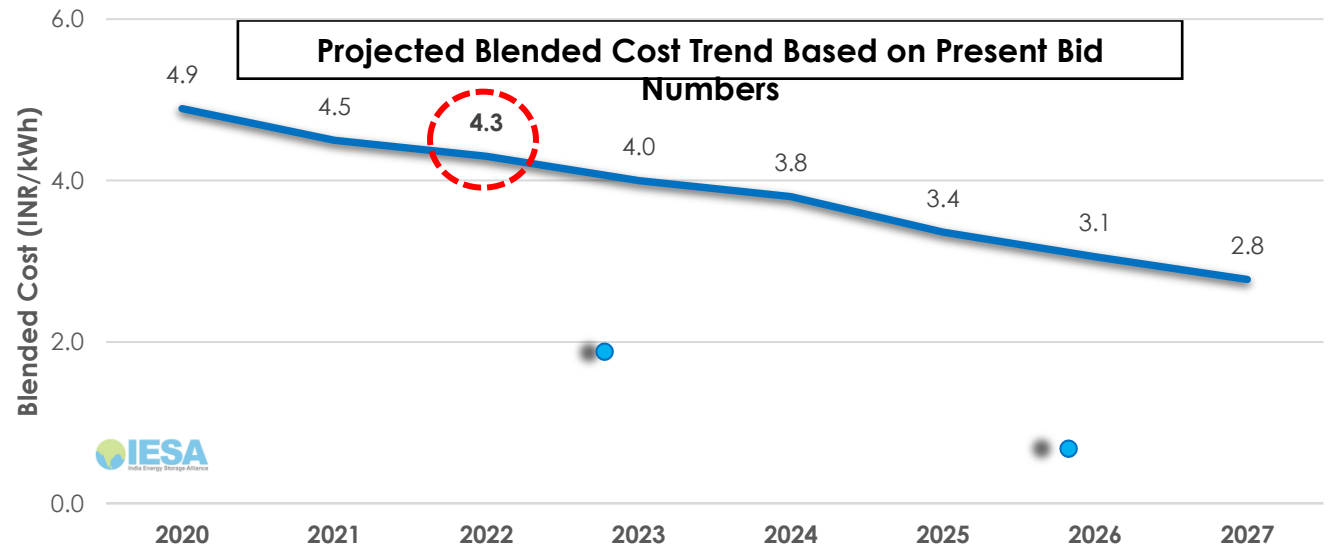


Hybrids – The way forward

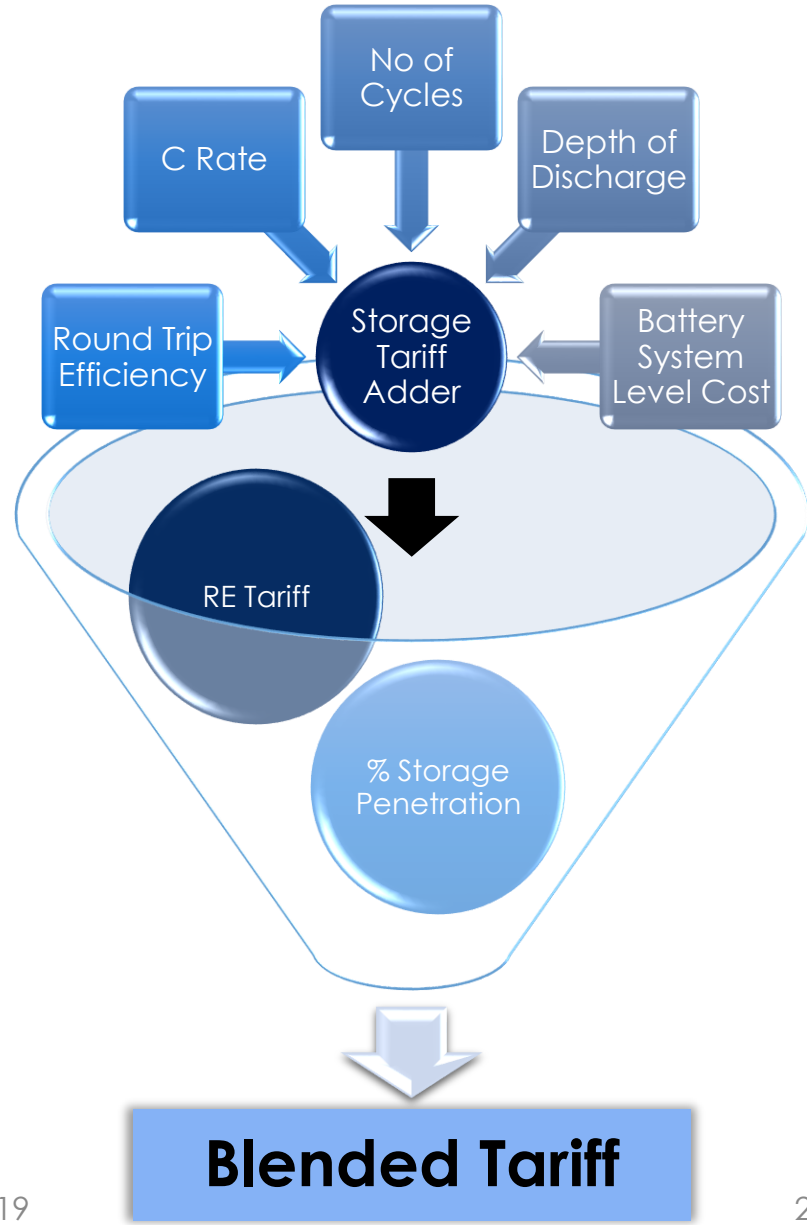
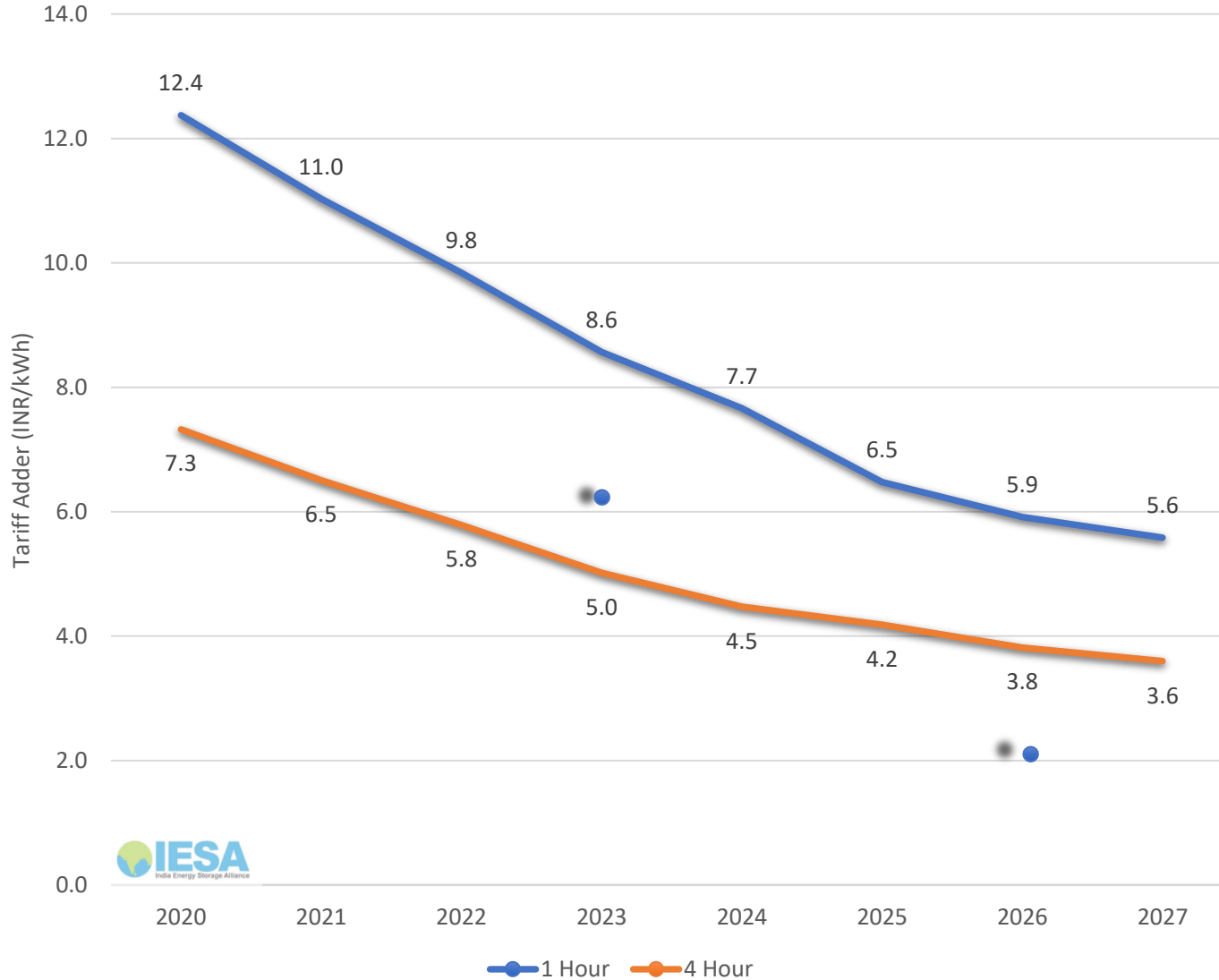
SECI / ISTS / 1200 MW WIND SOLAR HYBRID STORAGE PROJECT - SNAPSHOT

- Project Capacity**
• 1200 MW
- Storage Capacity**
• 600 MWh for 6 Hours
- Division of Peak Hours**
• 2 Hours in Morning and 4 Hours in Evening
- Off Peak Tariff**
• INR 2.88/kWh
- Annual Minimum CUF**
• 35%
- Project Timeline**
• 18 months from Effective signing date

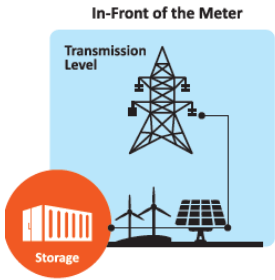
Details		Greenko	Renew Power
Capacity	(MW)	900	300
Peak Tariff	(INR/kWh)	6.12	6.85
	\$/kWh	0.086	0.096
Off-Peak Tariff	(INR/kWh)	2.88	2.88
	\$/kWh	0.04	0.04
Weighted Average Tariff	(INR/kWh)	4.04	4.3
	\$/kWh	0.057	0.06
Technology being Used		RE + Pumped Hydro	RE + Battery Storage



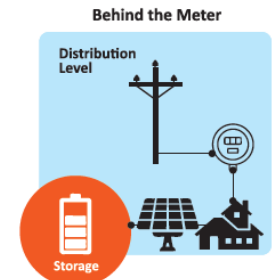
Tariff Adder Trend (50% Storage) - 1Hour vs 4 Hour | 2020 - 2027



CES Comprehensive Market Evaluation Tools for Storage (CoMETS) is a proprietary suite of models the helps technology and project developers evaluate and optimize energy storage resources for standalone and renewable energy integrated in-front-of-the-meter (IFOM), behind-the-meter (BTM) and Microgrid applications

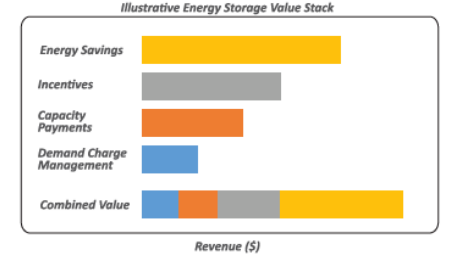
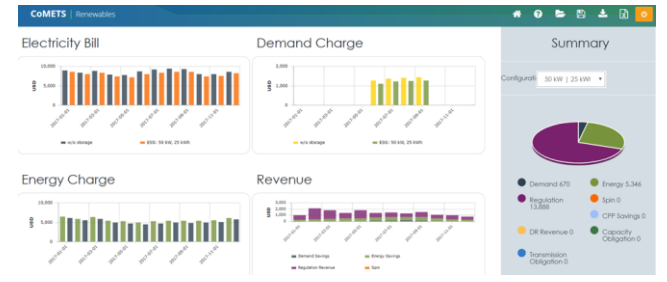
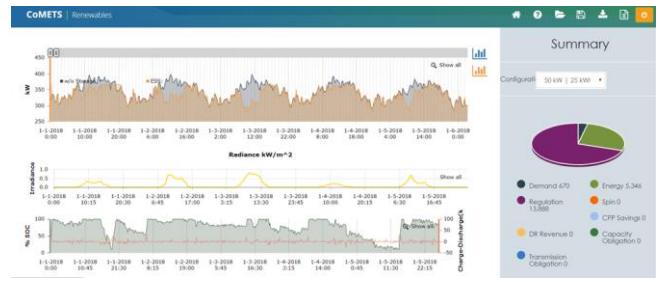


An optimization model for grid connected stand-alone storage or RE integrated hybrid resources using multiple value streams available in wholesale energy markets. These models include consideration of Wholesale Capacity, Energy and Ancillary services.



For simulation of optimal operation of behind the retail meter energy storage and distributed energy resources (DERs) to enable users to determine the right technologies, size and strategies for operation, including Demand Charge Management, Time of Use Energy Shifting, Demand Response and Wholesale Energy Market Participation

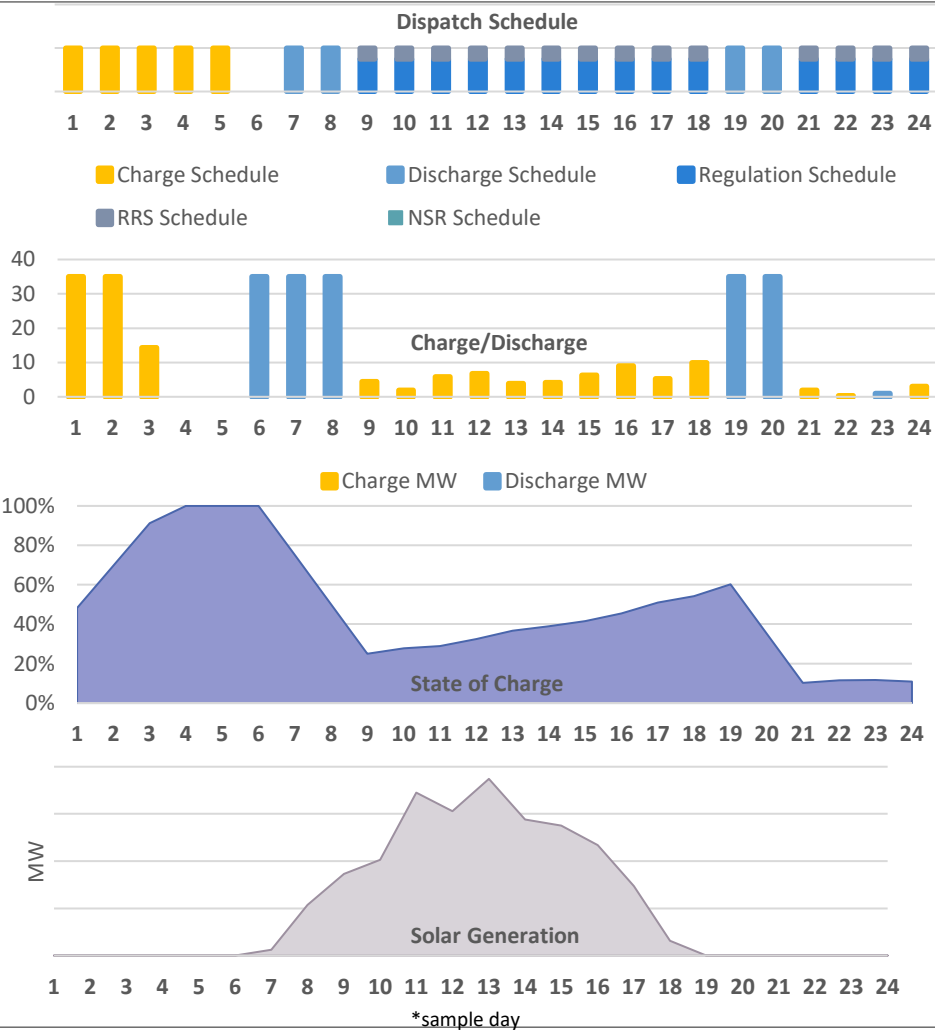
For simulation of Microgrid layouts with a variety of generators such as Solar, Wind and DG coupled with Energy Storage. The model provides technical and commercial insights for designing



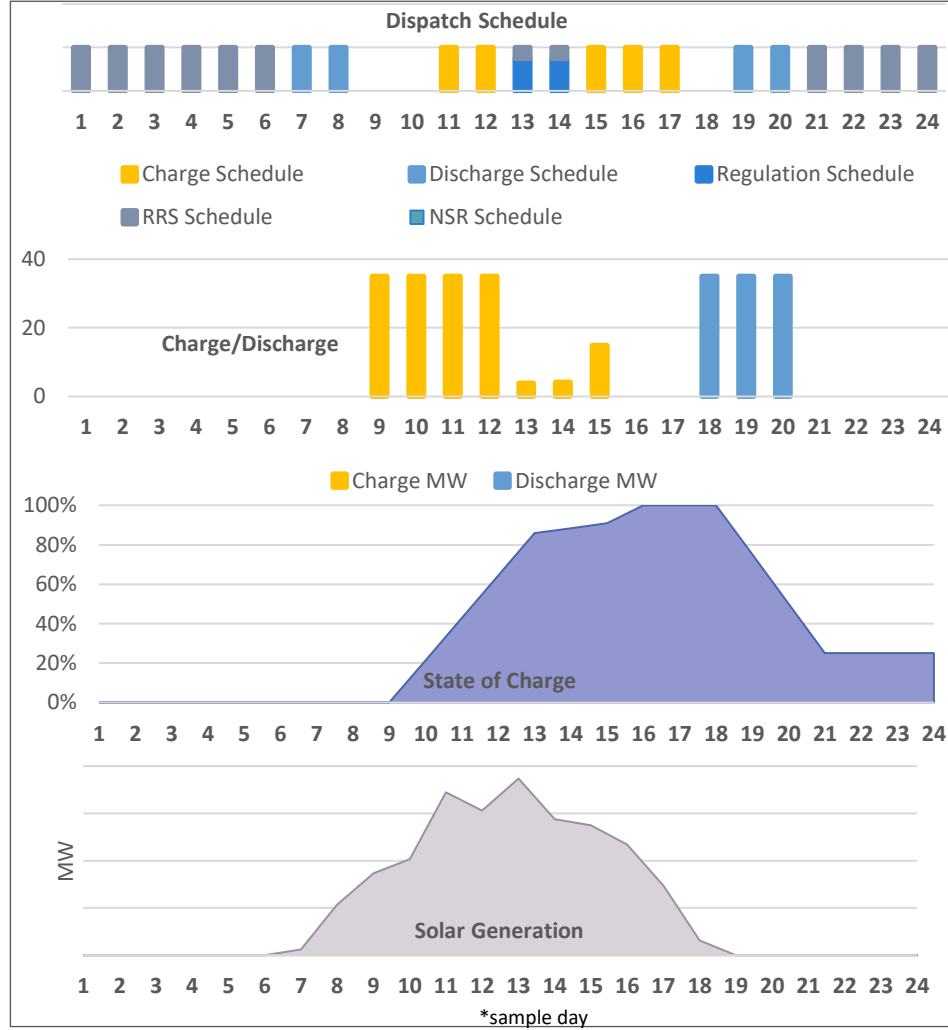
CoMETS models are designed to simulate asset dispatch and evaluate revenues by optimal value stacking
CoMETS offers a highly customizable suite of models that allow for advanced modeling of standalone, aggregated and hybrid energy storage

BESS providing Energy Arbitrage, Frequency Regulation (FRS) and Spinning Reserve (RRS) Services to the ERCOT Market

BESS Coupled with Grid

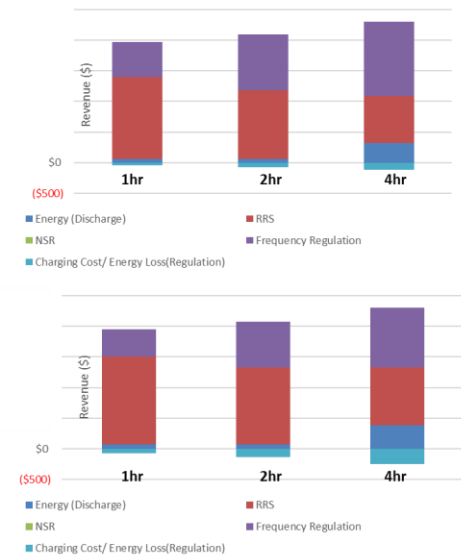


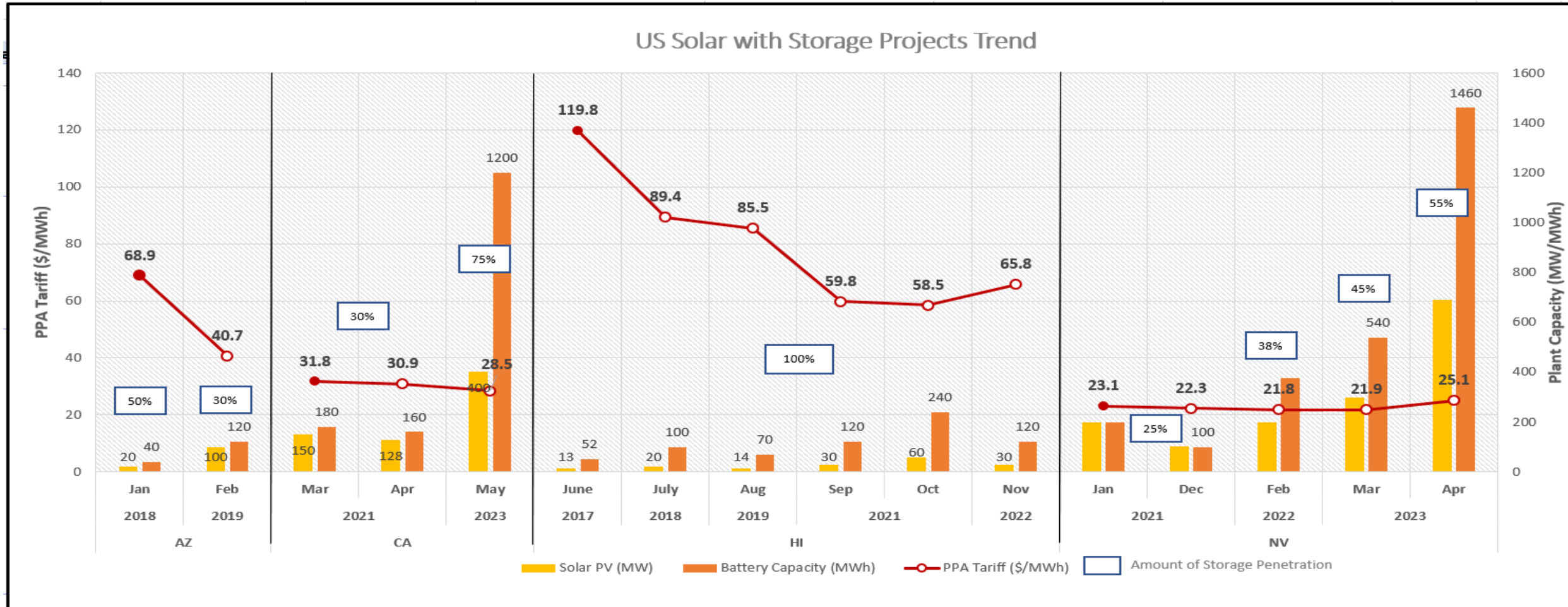
BESS Coupled without Grid



Factors Influencing BESS Dispatch

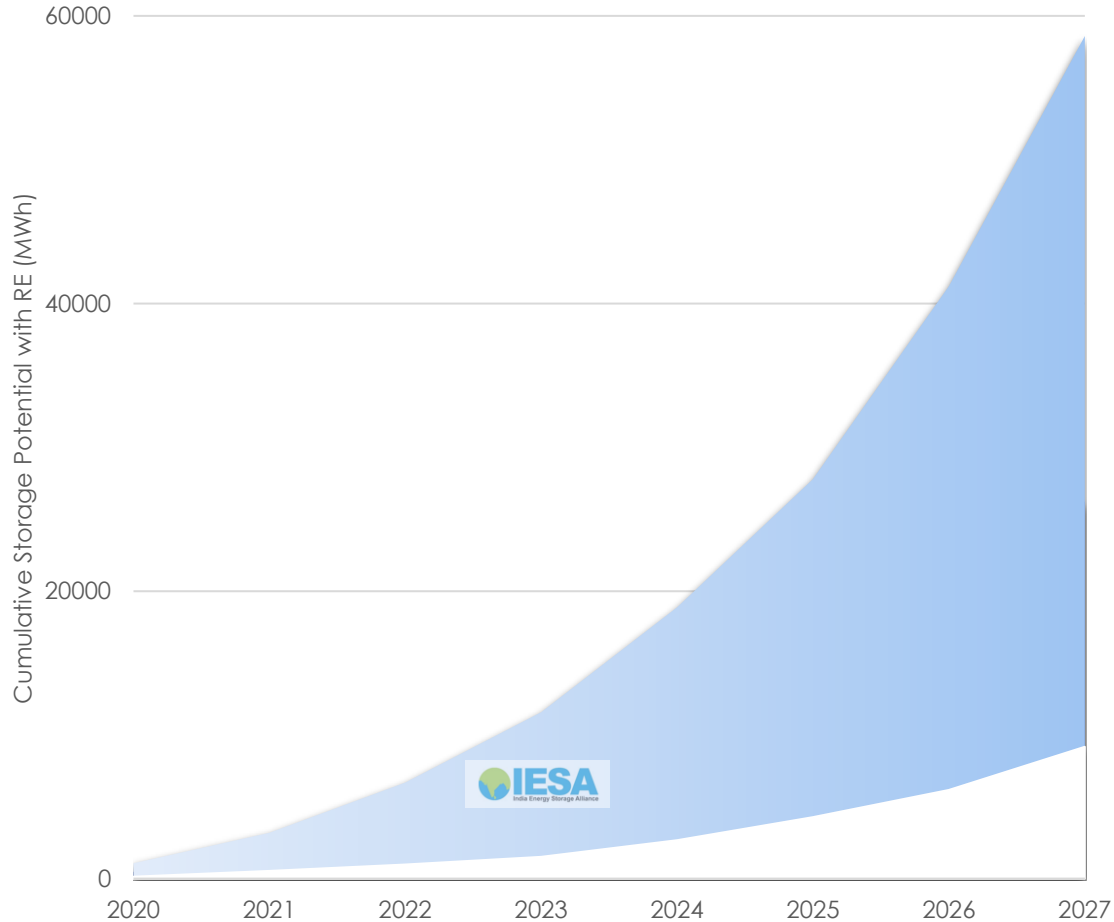
- Availability of RE generation
- PPA commitments, hedging contracts
- BESS sizing, reserve capacity
- Opportunity Costs of RE Generation
- Market participation rules
- Selection of services
- State of Charge Management
- Battery Degradation and Cycling
- Provision of multiple services in the same market hour
- Value Stacking



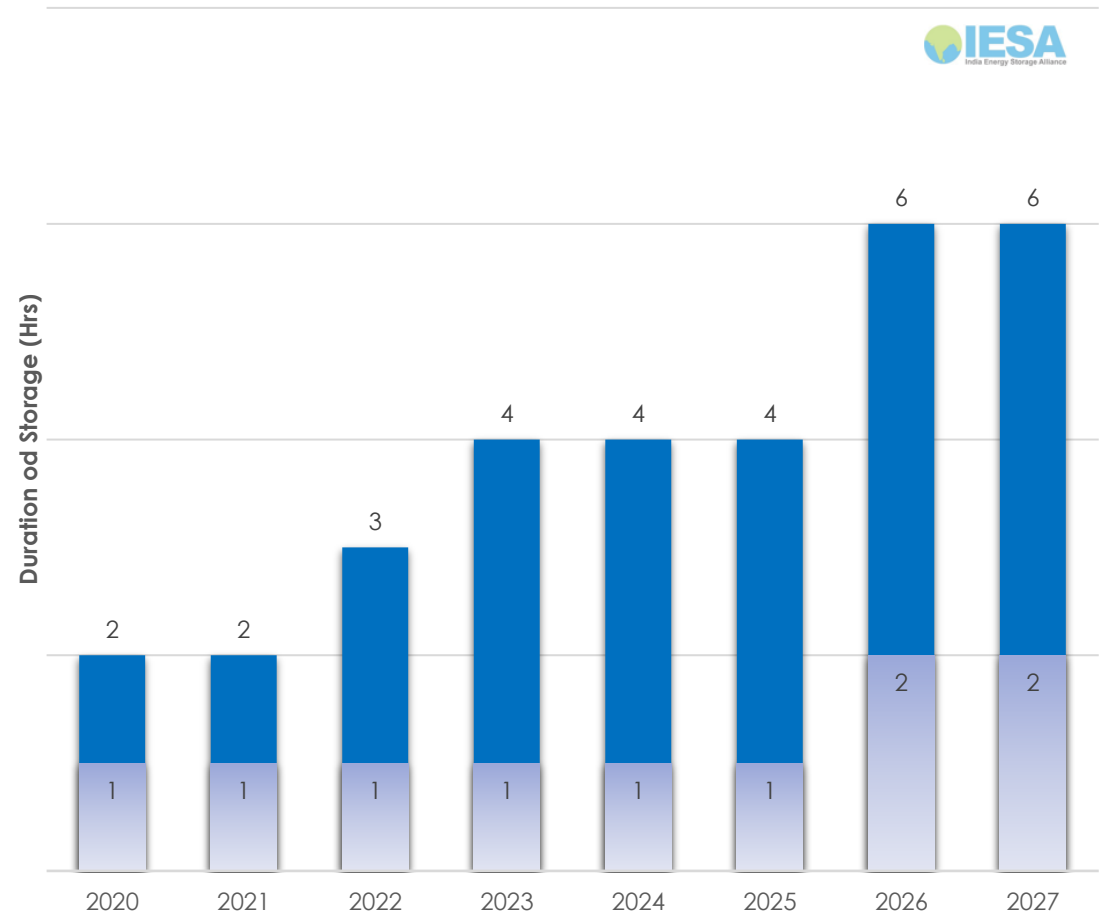


A 4-hour battery that is sized at roughly 25% of the PV capacity adds about \$4/MWh to the overall PPA price. But as the battery capacity increases to 50% and 75% of the PV capacity, the levelized storage adder increases linearly to ~\$10/MWh and ~\$15/MWh, respectively.

India Battery Storage Potential with Renewables | 2020 - 2027



Battery Storage Penetration in Renewables | 2020 - 2027





Knowledge Paper on
**The Need of Hybrids in
Renewables sector**

The inflection point in the renewables sector

MONTHLY MARKET INTELLIGENCE REPORT



Storage IQ India covers Indian Power & eMobility sector monthly updates and analysis. on energy storage and electric vehicle market. Get the latest developments on policy and regulatory announcements by state and central government, ongoing tender details, & status, upcoming meeting dates, regular news updates, and IEX prices. Government initiatives, notices, battery raw material price trends, partnerships, investments etc. are monitored and presented in this monthly Storage IQ. Get expert analysis by subscribing to this monthly report.

WHAT'S IN THE MONTHLY REPORT

**Section
01**

STATIONARY ENERGY STORAGE MARKET

- Central & State Policy/Regulations/Notifications announced in that respective month along with IESA analysis
- Forthcoming meeting dates
- Tender Dashboard
- Other important updates

**Section
02**

ELECTRIC VEHICLE MARKET

- Central & State Policy/Regulations/Notifications announced in that respective month along with IESA analysis
- Forthcoming meeting dates
- Tender Dashboard
- Other important updates (EV/Charging/Battery swapping)

**Section
03**

MANUFACTURING AND GENERAL INFORMATION

- Government Regulation and analysis with IESA responses
- Raw material prices – Monthly Trend
- IEX Prices – Monthly Overview

**Section
04**

OTHER UPDATES

- Industry news
- Updates on Innovative Start Ups, Investment & Partnership
- Beyond Batteries (Hydrogen & Fuel Cell, thermal storage, mechanical storage) Updates
- Safety & standards/Recycling & Second Life Policy Updates

ALSO AVAILABLE

**Get updates on
US market**

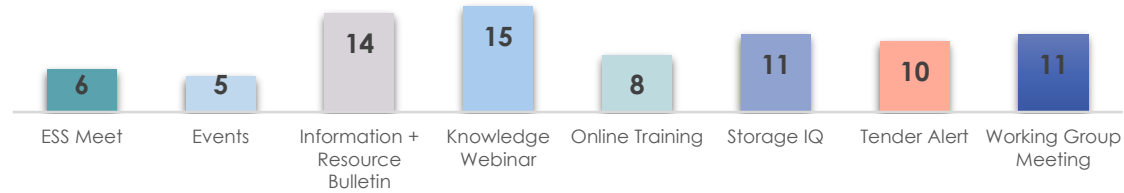


Monthly market intelligence reports covering regional energy markets that provide the latest updates on ISO/RTO activities, rule making, key changes as well as state and regulatory proceedings that impact energy storage.

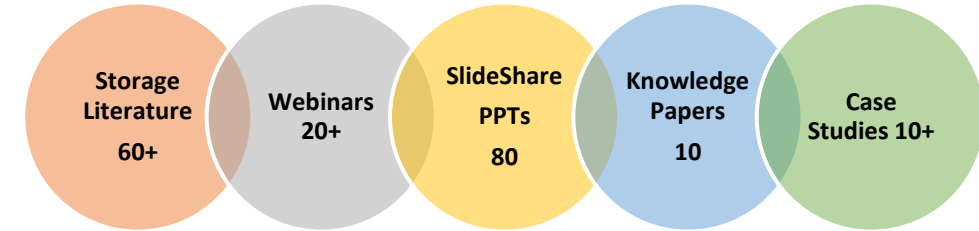
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- Stay informed on tenders & policy update through exclusive newsletters
- IESA Academy: Online platform for skill development
- Network with partners & customers at IESA events
- Access member exclusive reports & webinars
- Showcase products at events, online product catalogue and publications

Activities – 2019-20



Member Exclusive Resources



National and International Events

All year round, IESA organizes various regional and international events catering to every stakeholder of the energy storage and EV ecosystem. These conferences and workshops are a great place for learning, business networking and showcasing your company capabilities.

India Energy Storage Week	IESA Industry Excellence Awards	ESS Meets for C&I Customers	India E-mobility Conclave
Manufacturing Masterclass for CXOs	Li Ion Cell Making Hands-on Workshop	ESS & EV Investment Summit	IESA Startup Competition

ESS Meets & EV Roundtables



ESS meet & EV Roundtables provide an exclusive platform for members to reach out to commercial and industrial consumers and early adopters. Till date, IESA has successfully organized 10+ regional meets, held in the cities of Coimbatore, Pune, Bangalore, Delhi, Ranchi and Kanpur.



Storage IQ and Resource Bulletins

Storage IQ and Resource Bulletins give a detailed monthly update on activities and developments in the stationary energy storage and EV space in India. They cover tender updates, policy updates, draft policy recommendations, various meeting updates and information about upcoming meetings. Resource Bulletins serve as a one-stop-guide to all the important activities in the market over the month.



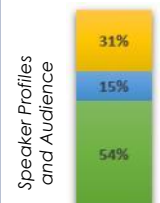
Annual Reports and White Papers



IESA releases two annual market overview reports covering stationary energy storage and e-mobility market. This year, IESA is releasing four Emerging Tech Reports. IESA also releases knowledge papers on a regular basis to help members stay on top of the latest industry trends.



IESA Knowledge Webinars

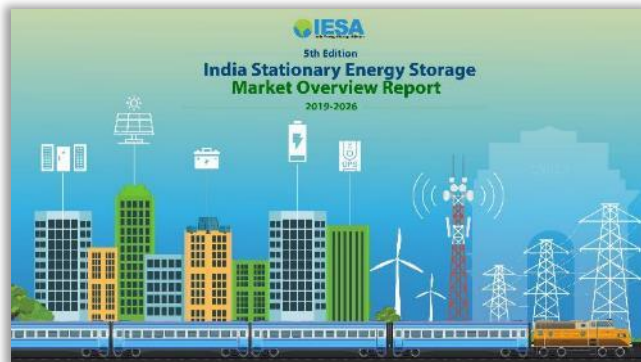


IESA Academy conducts 'knowledge series' webinars which cater to global audience. The motto of the webinar is *by the members, for the members*. The webinars cover areas from technology, business models, to operations and recycling. IESA invites top thought leaders from the industry and attracts 100s of participants for these webinars.

Utilities	Battery Manufacturers	ESS Technology Providers	EV Manufacturers
EV Fleet Operators	Utilities and C&I Customers	Financial Institutes	RE Developers / IPPs

IESA Publications, Podcasts and Outreach

IESA Industry Reports

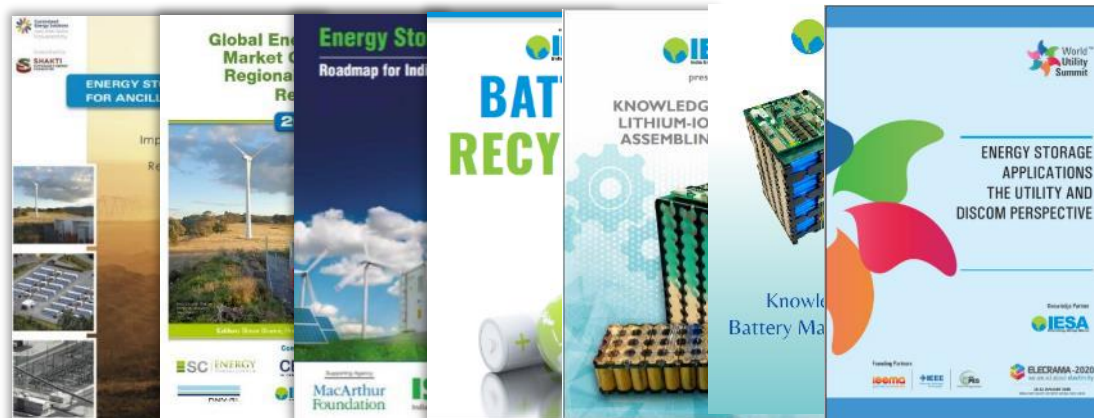


ETN Magazine



<https://indiaesa.info/magazine>

IESA Knowledge Papers



Storage IQ – Monthly Report



Available at Soundcloud, iTunes, Stitcher and other podcast services



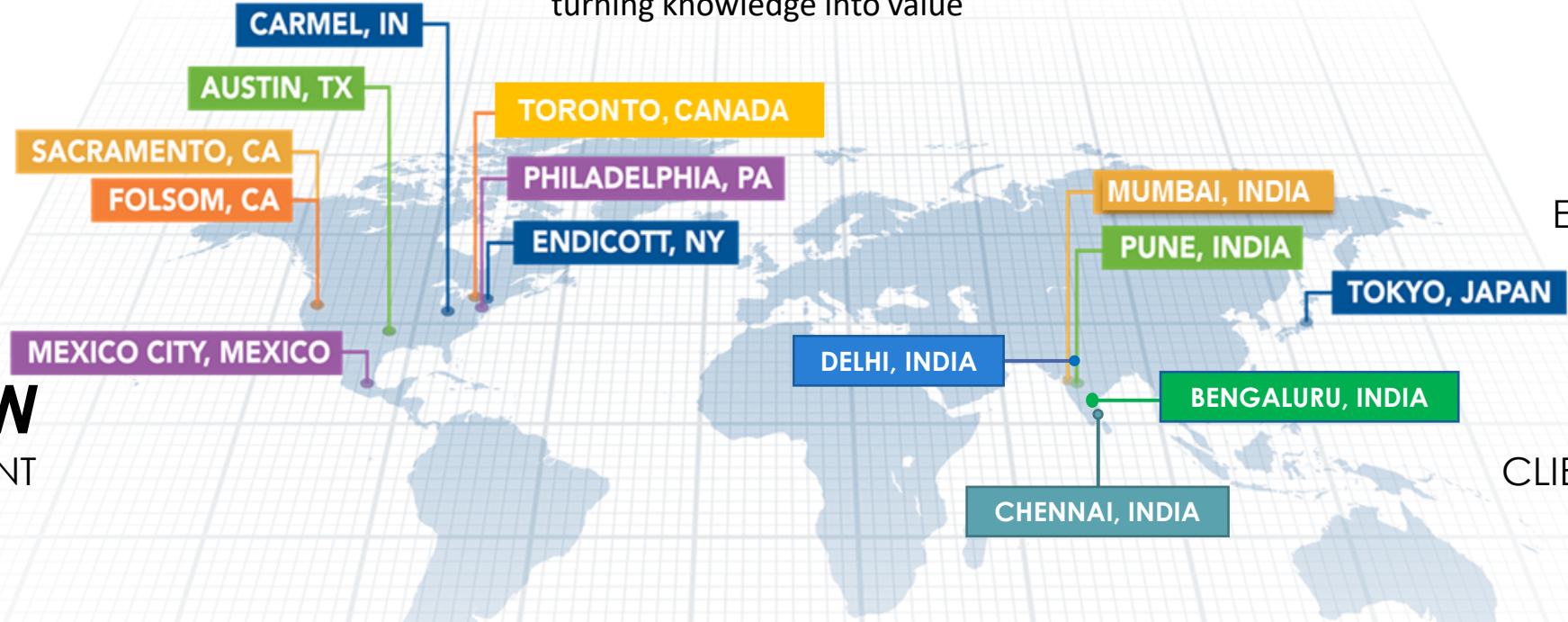
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Our consulting services enables competitive suppliers, technology providers, marketers, utilities and customers to prosper through change, by turning knowledge into value



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