

エネルギー貯蔵技術及び用途

Presented by

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President, India Energy Storage Alliance (IESA) &
President & MD, Customized Energy Solutions India Pvt. Ltd

エネルギー貯蔵に15年を超える経験

Electricity Value chain



Applications offered by Energy Storage

✓ Electric Energy Time Shift
 ✓ Capacity Management
 ✓ Ancillary services

Generation

✓ Voltage Support
 ✓ Transmission Congestion Relief
 ✓ T&D Upgrade deferral
 ✓ Sub-station onsite power

Transmission

Distribution

✓ Time of use- Energy cost management
 ✓ Power Quality
 ✓ Power Reliability

End-Use applications

- CES has worked with various clients – technology developers, system integrators, strategic investors, VCs, utilities - in grid-scale storage
- CES has advised clients on various applications of energy storage
 - Energy arbitrage
 - Industrial applications
 - Ancillary Services
 - Renewable integration
- CES 24 Operations Center manages several large grid-scale storage projects in US and Canada
- CES collaborating with project developers for deployment of hundreds of MWs of ESS in US
- CES has launched India Energy Storage Alliance (IESA) to create awareness among various stakeholders in India

エネルギー貯蔵：多様な資産区分

Electro-Chemical



(Flow battery / Lithium Ion)

Mechanical



(Flywheel)

Bulk Mechanical



(Compressed Air)

Thermal



(Ice / Molten Salt)

Bulk Gravitational



(Pumped Hydro)

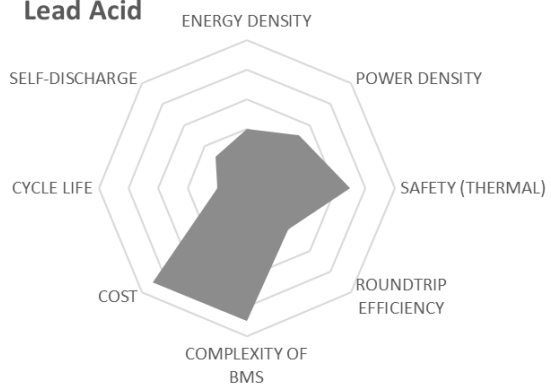
Transportation



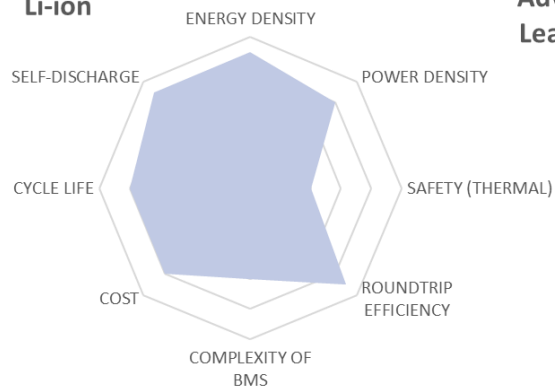
(Electric Vehicles)

技術の比較

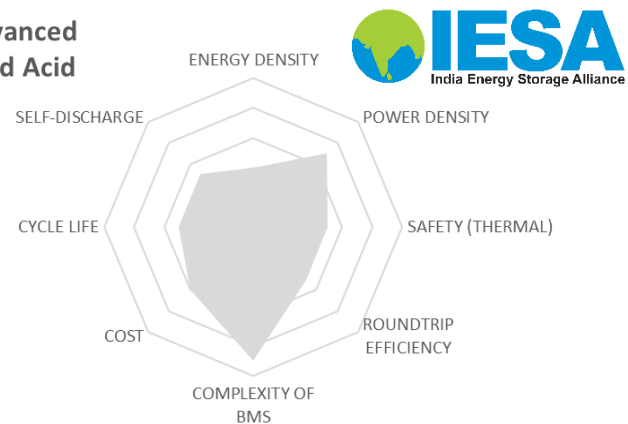
Lead Acid



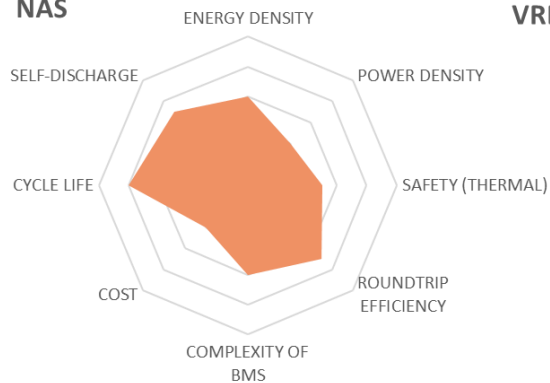
Li-ion



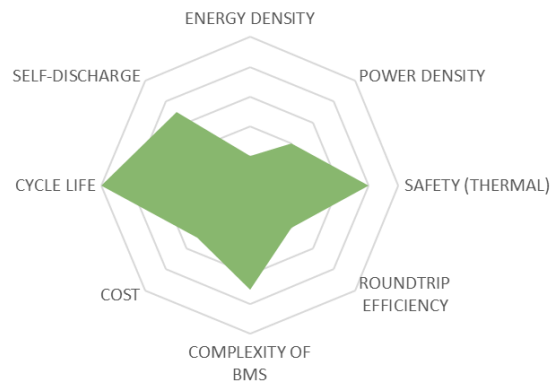
Advanced Lead Acid



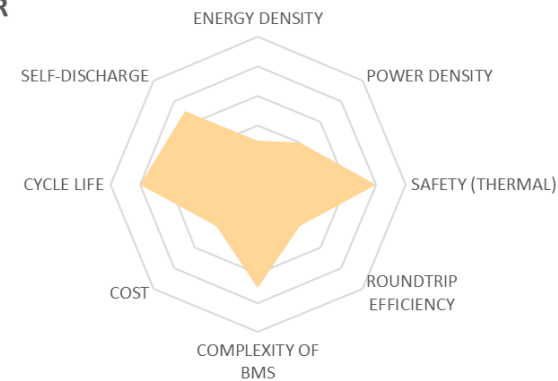
NAS



VRB



ZBR

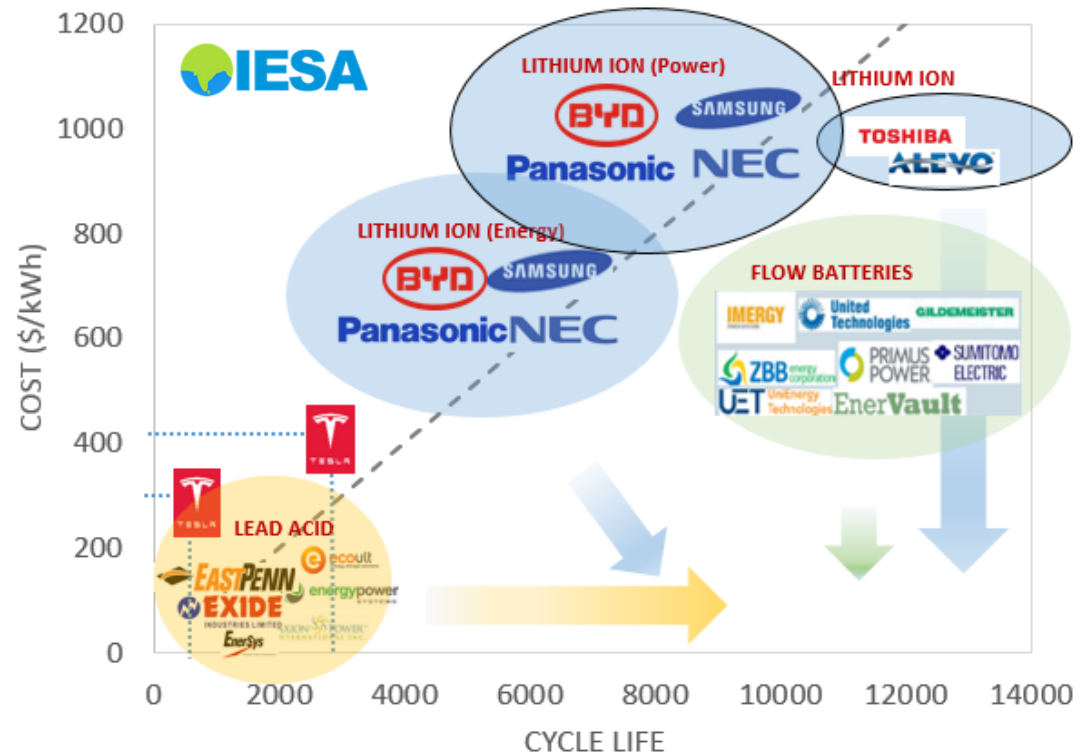


世界的トレンドー貯蔵技術

ENERGY STORAGE performance metrics:

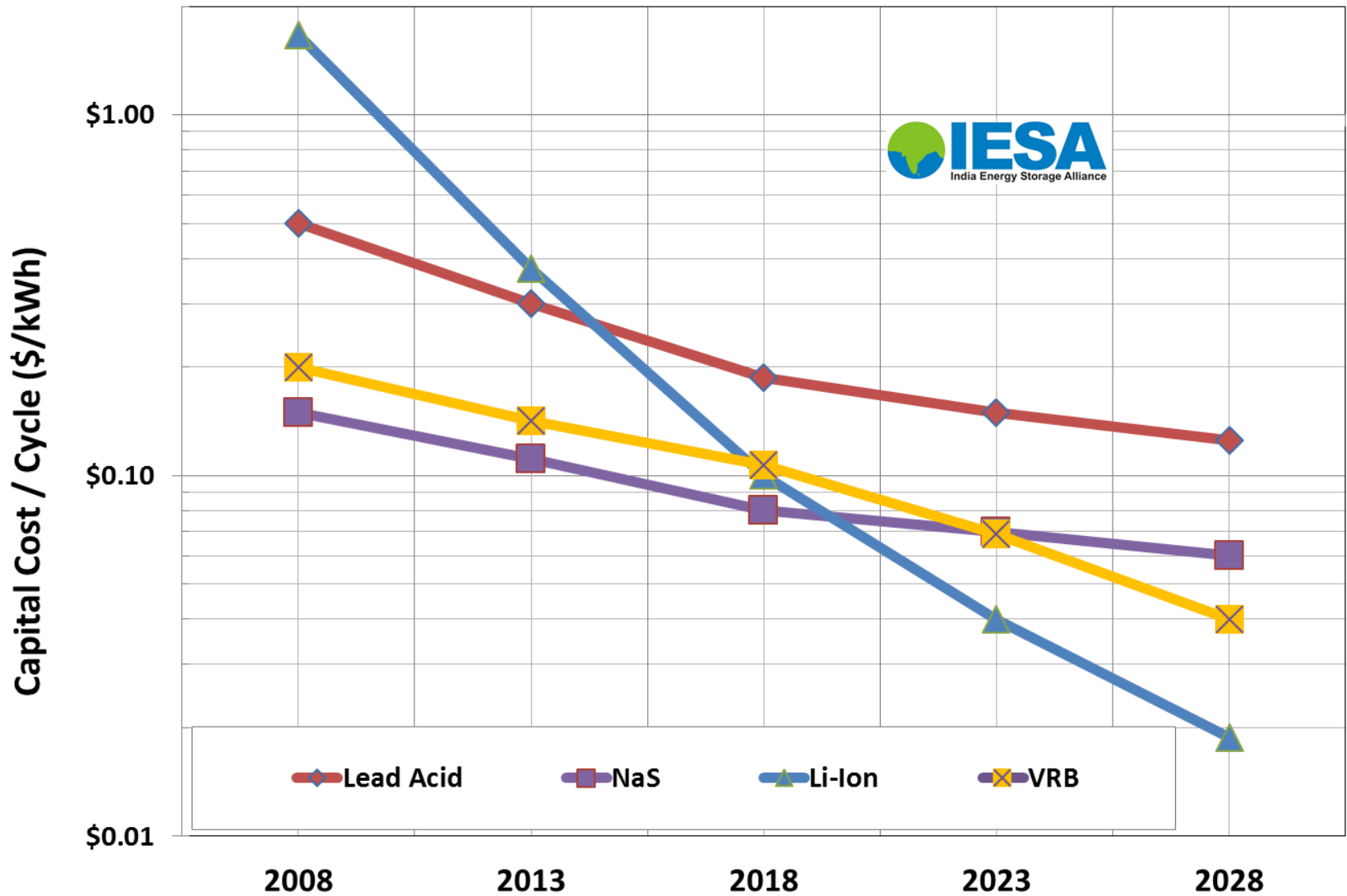
- Capital cost (\$/kWh)
- Cycle life
- Roundtrip Energy Efficiency
- Space footprint
- C-rate (duration)
- Usable SOC range

Lead Acid batteries have been the workhorse for industrial and residential backup and provide lower capital cost solutions, while **Li-Ion & Flow** batteries are emerging as solutions for applications requiring higher cycle life.

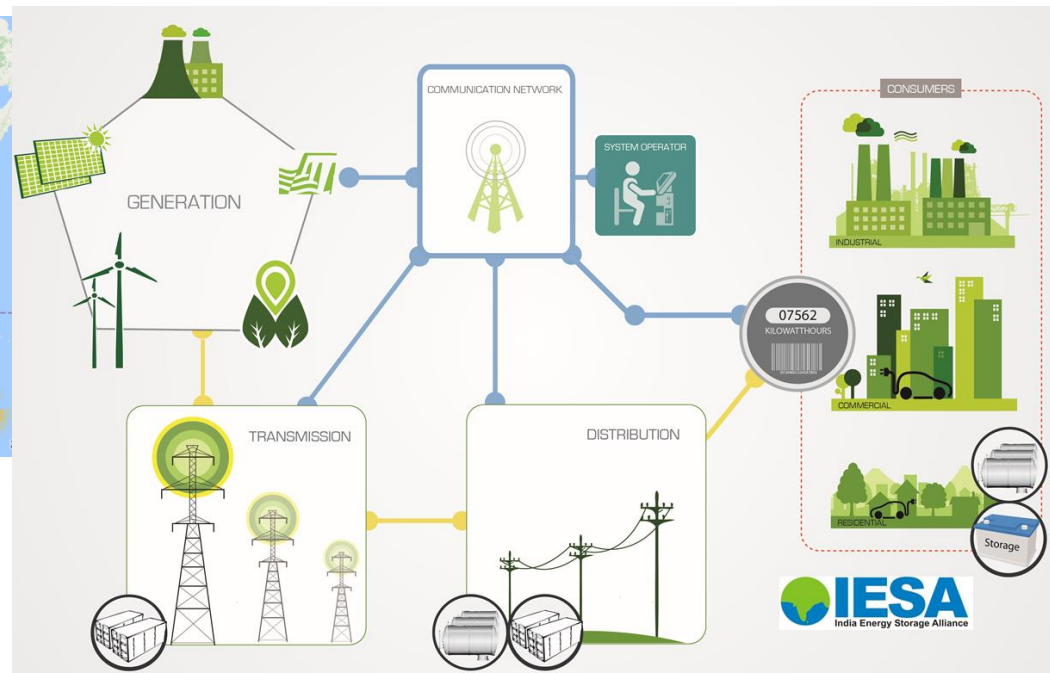


Several companies are now looking at improving the performance/cost ratio by implementing design and materials innovations. Innovations will emerge as game changers where different technologies are competing for similar applications.

資本コスト/サイクル寿命の傾向



スマートグリッドでのエネルギー貯蔵の役割



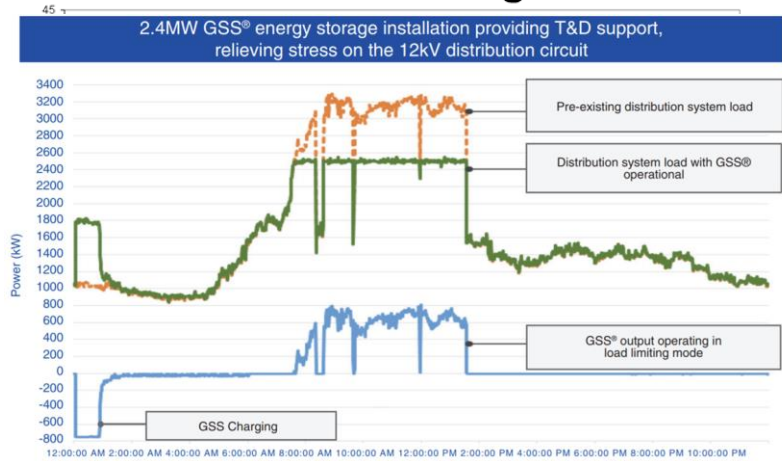
Energy storage could play a key enabling role in every aspect of modern grids including Generation, Transmission, Distribution and at Customer Premise (including electric vehicles).

認められている用途に対する 代表的な設備構成

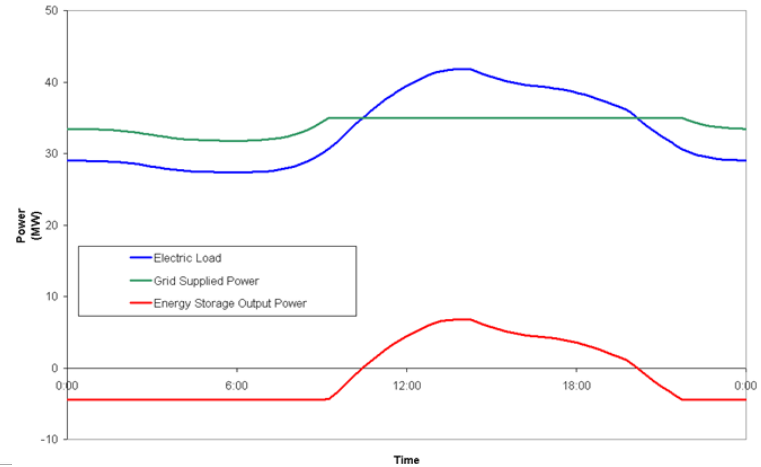
Segments / Applications	Sub Segments	Power Rating	Duration	DOD	Type of cycles	No of cycles / Year
Renewable Energy Integration	Wind Smoothing	1 MW- 20 MW	15 min - 1 h	<60%	Shallow	<18,000
	Wind Firming	1 MW-20 MW	4-6 h	>80%	Deep	<500
	Solar	3 KW-2 MW	3-6 h	>80%	Deep	<350
Load shifting or energy arbitrage	Commercial	10 KW - 2 MW	2-4 h	>80%	Mix	<400
	Industrial	500 KW - 5 MW	2-4 h	>80%	Mix	<400
Off grid applications	Rural Microgrid (households)	1KW - 5 kW	2-8 h	>80%	Mix	<400
	Rural Schools / Hospitals	1 KW - 10 kW	2-8 h	>80%	Mix	<400
	Telecom Towers	2 KW - 5 kW	2-4 h	>80%	Mix	<700
Replacement of DG	Commercial	10 KW - 2 MW	2-4 h	>80%	Mix	<400
	Industrial	500 KW - 5 MW	2-4 h	>80%	Mix	<400
Transmission or Distribution Deferral		1-20 MW	2-6 h	>80%	Mix	<300
Ancillary Services	Frequency Regulation	1 MW- 20 MW	15 min – 1 h	<60%	Shallow	<18,000
Reactive Power Management	Utility / C&I	3 KW - 10 MW	15 min – 1 h	N.A.	N.A.	N.A.

貯蔵の定常用途

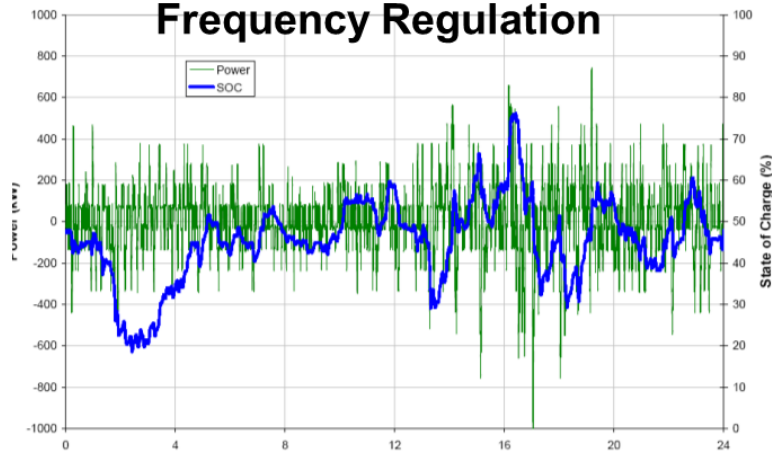
Peak Shaving



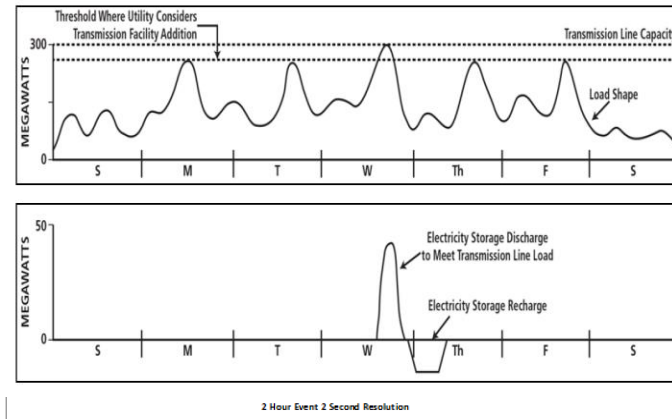
Load Levelling



Frequency Regulation

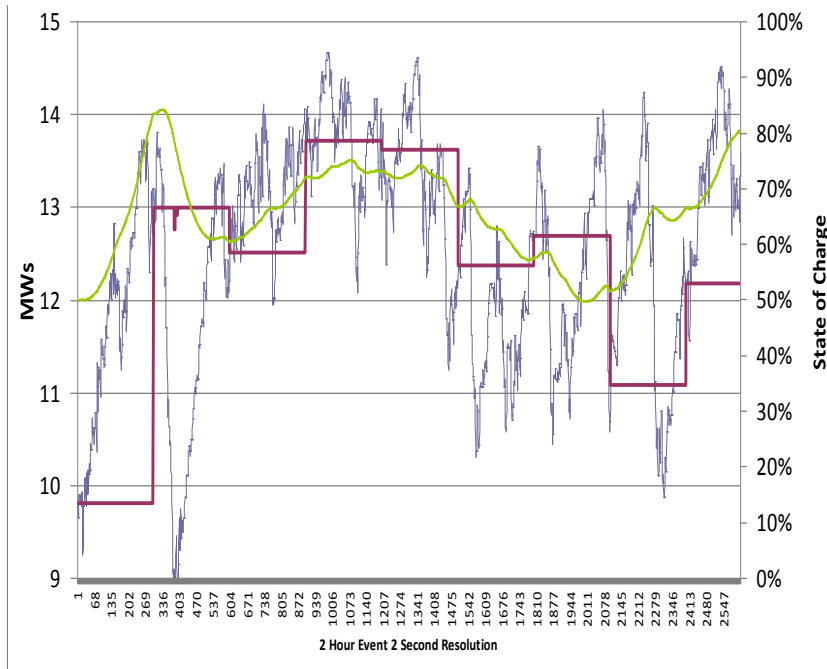


T&D Upgrade Deferral

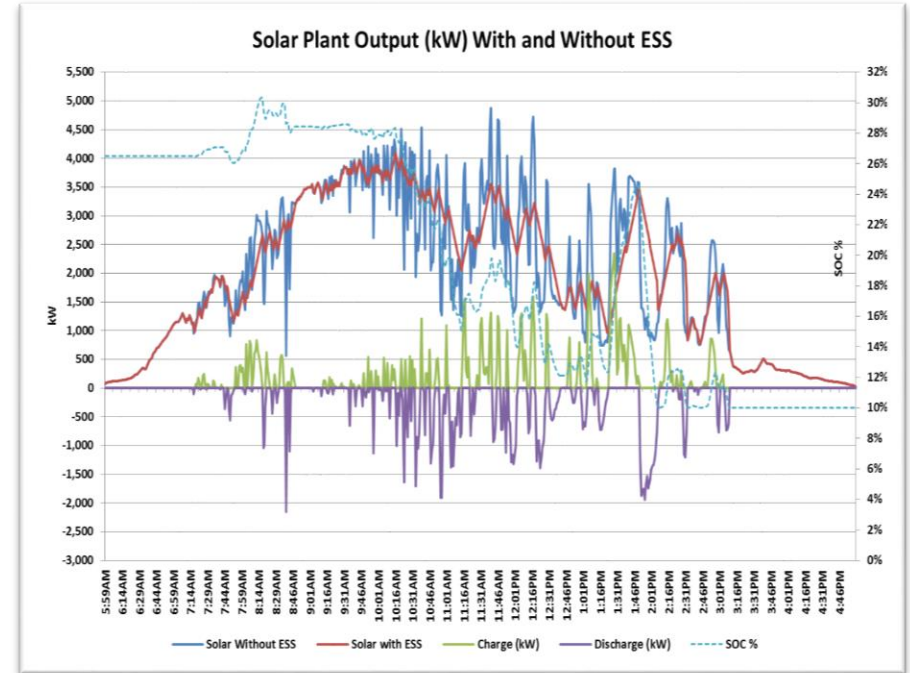


エネルギー貯蔵： 再生可能エネルギーの平準化と スケジューリング及び出力変化率制御

Wind Firming for forecast errors

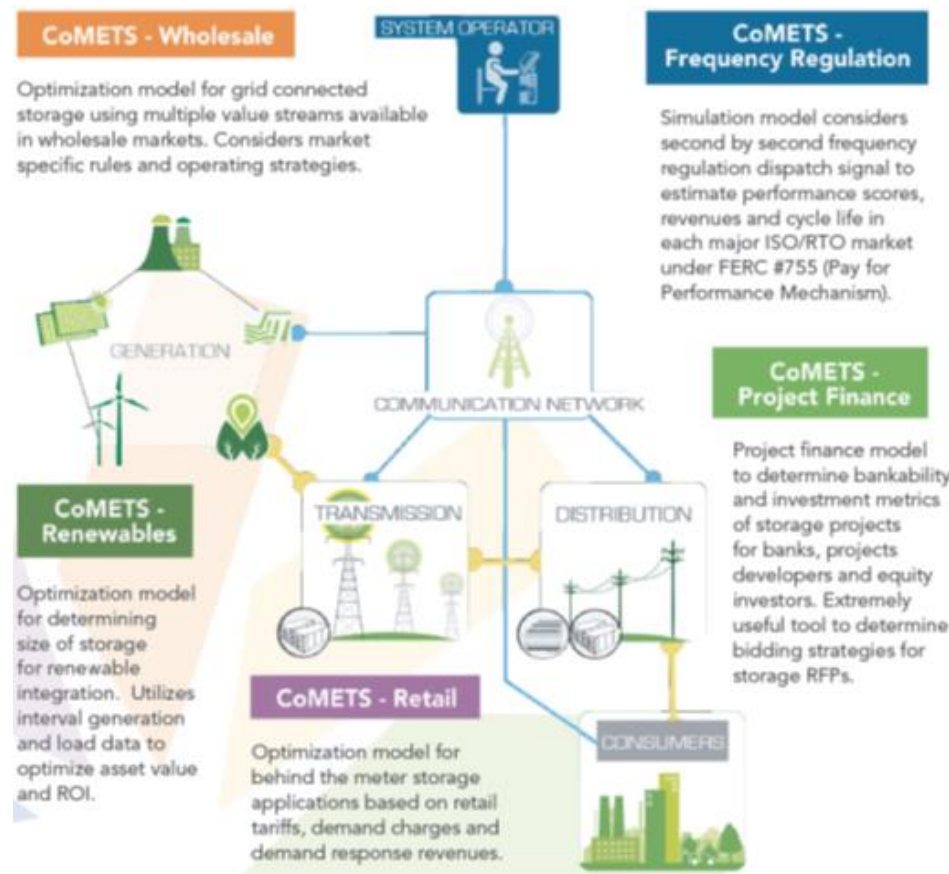


Solar Smoothing for addressing ramps



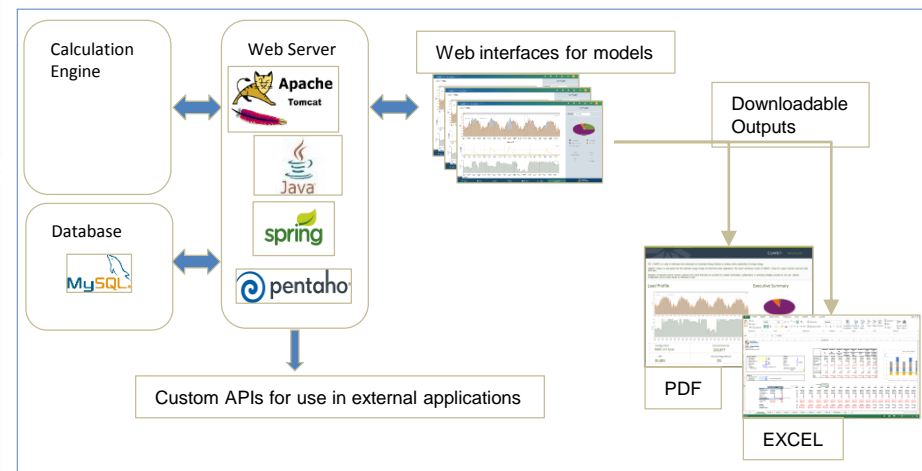
- In January 2017 AES signed a contract in Hawaii for firm solar + storage power at 11 cents / kWh
- In June 2017, NextEra has signed a contract for smoothing of solar power with storage at less than 4.5 cents / kWh in Arizona, USA

定量分析



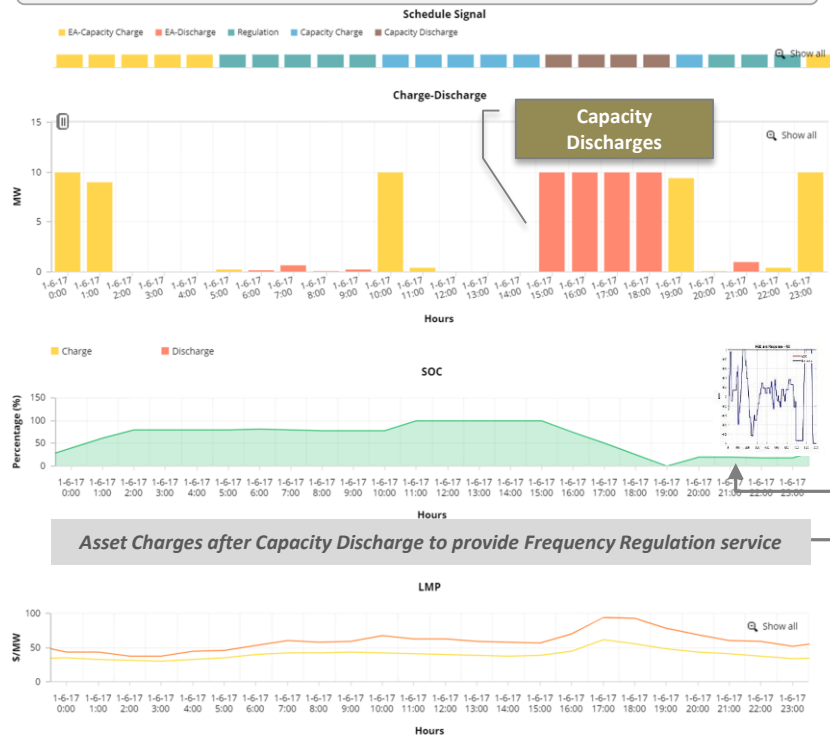
CoMETS (Competitive Markets Evaluation Tools for Storage): CES proposes to utilize its proprietary modeling platform CoMETS to simulate the dispatch of hybrid assets, to perform financial analysis and any other analytics necessary.

Option to create web-based tool that client can utilize to analyze the complete financials of solar – storage hybrid assets in select locations.



ケーススタディー: 給電のサンプル

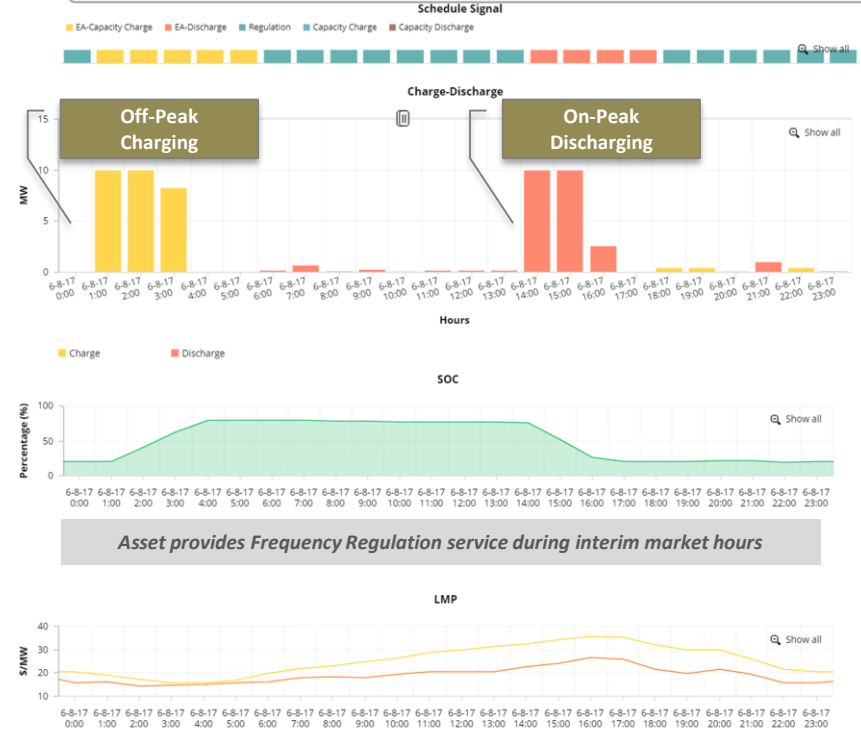
Capacity Discharges - To mitigate System Peak



Capacity Savings

Frequency Regulation

Energy Arbitrage + Frequency Regulation

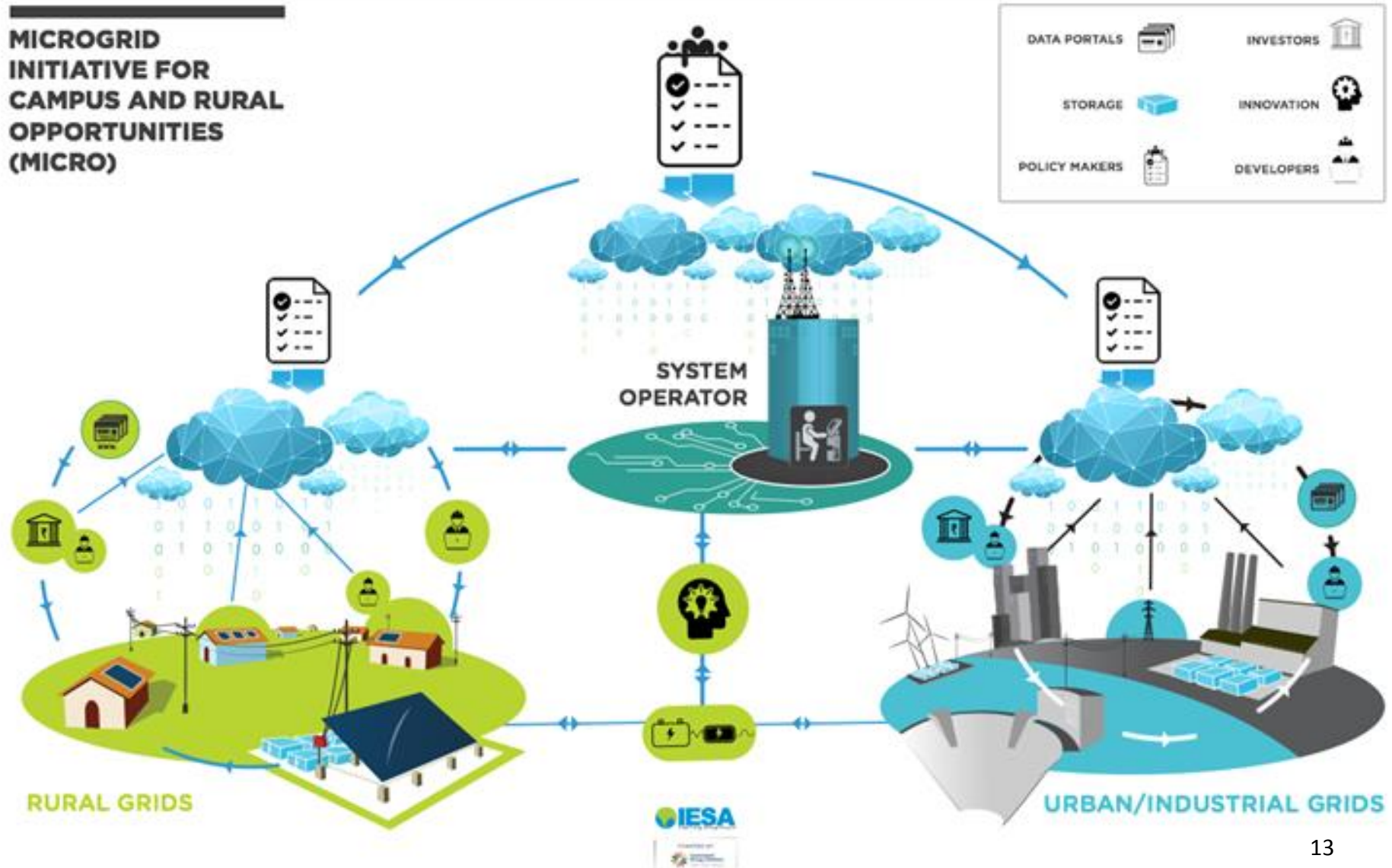


Transmission Savings

Energy Arbitrage

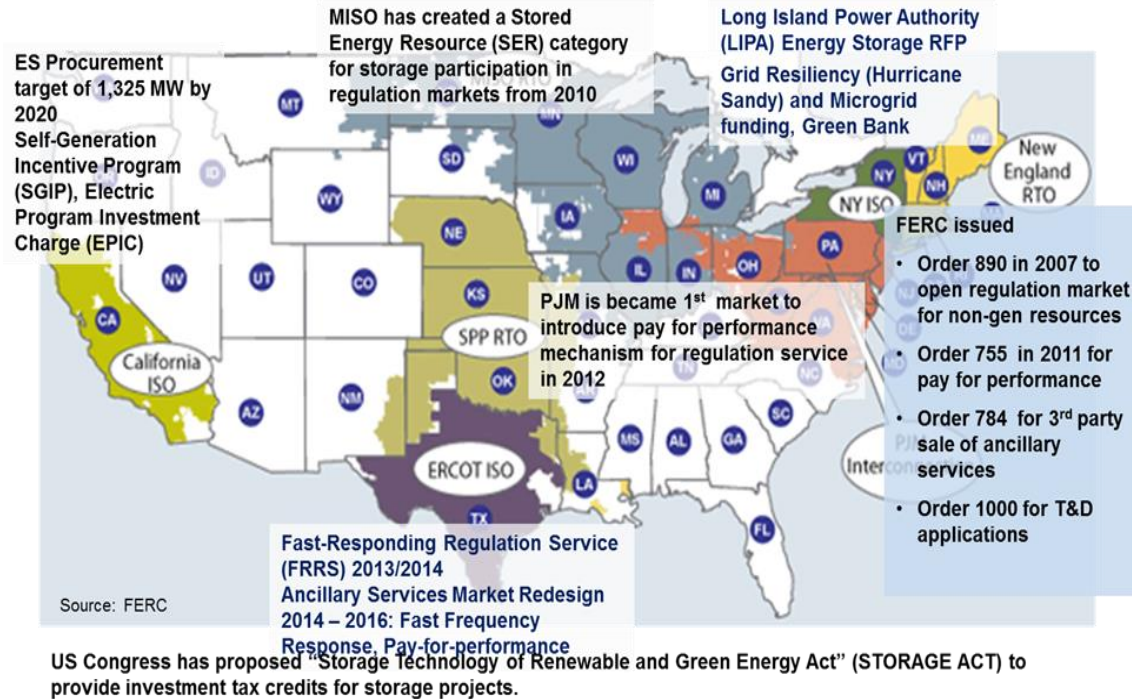
キャンパス及び村落部のマイクログリッド

MICROGRID INITIATIVE FOR CAMPUS AND RURAL OPPORTUNITIES (MICRO)



蓄電が米国では連邦レベルで優先事項である

- FERC started storage proceeding in 2016
- Since 2016, every US ISO/RTO has had an active stakeholder process addressing energy storage
- Also since 2016, all ISOs/RTOs have had newer technology storage projects in their interconnection queues
- In January 2017, FERC issued Policy Statement clarifying storage resources can receive both cost- and market- based rate recovery



- In February 2018, FERC issued landmark Order 841, “Electric Storage Participation in Markets Operated by RTOs and ISOs,” to enable full wholesale market participation
- FERC also issued Order 845, “Reform of Generator Interconnection Procedures and Agreements,” which improves opportunities for co-located projects
- There have also been several legislative bills that support energy storage, including through tax credits and RD&D

積極的な州のエネルギー貯蔵

California

- 1,325 MW of energy storage by the year 2020 to be procured biennially; 500 MWs more for Distributed.
- Multiple RFPs, and market dynamics have led to procurement of 1,620 MWs of new California storage capacity from 2010 to 2018, of which 420 MWs are on line.
- In addition, November 2018 California regulators approved four PG&E projects, totaling 567.5 megawatts/2,270 megawatt-hours. Includes 300 MW/1200 MWh project to meet capacity shortages .
- Municipal and community utility groups RFPs expected for Energy Storage (Ancillary Services, Capacity, Energy) for multiple uses.
- California’s Integrated Resource Plan expects additional 2000 MW of storage by 2030 to manage the grid.

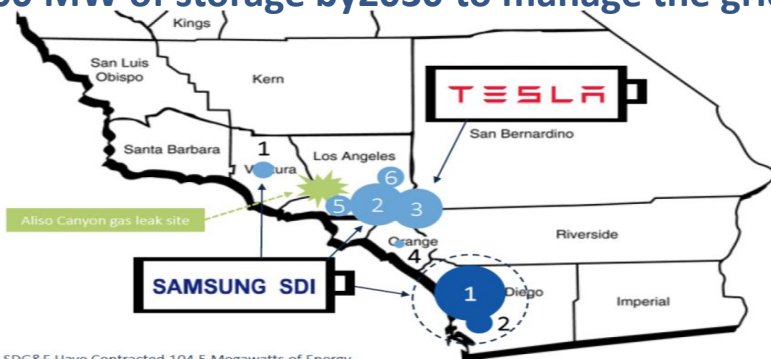
Energy Storage Procurement Targets (in MW)

Storage Grid Domain (Point of Interconnection)	2014	2016	2018	2020	Total
Southern California Edison					
Transmission	50	65	85	110	310
Distribution	30	40	50	65	185
Customer	10	15	25	35	85
Subtotal SCE	90	120	160	210	580
Pacific Gas and Electric					
Transmission	50	65	85	110	310
Distribution	30	40	50	65	185
Customer	10	15	25	35	85
Subtotal PG&E	90	120	160	210	580
San Diego Gas & Electric					
Transmission	10	15	22	33	80
Distribution	7	10	15	23	55
Customer	3	5	8	14	30
Subtotal SDG&E	20	30	45	70	165
Total - all 3 utilities	200	270	365	490	1,325

Source: GTM

In Sept 2017, CPUC rejected the approval of the Elwood Peaker Plant in favor of solar plus storage

Solar and Storage determined more cost effective



SCE and SDG&E Have Contracted 104.5 Megawatts of Energy Storage As Part of Aliso Canyon Procurement

エネルギー貯蔵活動を行っている州の増加


NEW YORK

- Energy Storage Deployment Program
 - Targets **3 GW of storage** by 2030 to support 50% renewables Clean Energy Standard
 - \$310 million “market bridge incentive” + \$40 million for solar + storage projects
- NYISO DER Roadmap and Energy Storage Integration – Integrating distributed resources and storage
- NY Reforming the Energy Vision (REV) – Grid modernization to be “distributed system platform”
- Clean Energy Fund, Green Bank, and more!

MASSACHUSETTS

- Energy Storage Initiative (ESI), launched with *State of Charge* Report in 2016
- Clean Energy Legislation created the market with storage procurement targets (first 200 MWh by 2020 then 1,000 MWh by 2025)
- Grants for Energy Storage: \$20M announced in December 2017, supporting 26 projects and 85MW
- Incentive for Solar plus Storage program – ~6% of initial solar applications (~130 MW)

CES | StorageIQ



Customized Energy Solutions
Analyze · Simplify · Implement

May 2017 – NYISO (NYISO, NY PSC, NY SERDA)

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Market Highlights from May 1 - 31, 2017

NYISO Activity

- **Energy Storage Integration** – At the May 5th Market Issues Working Group (MIWG), NYISO provided stakeholders with an update on its proposal to better integrate grid scale energy storage (front of meter) efficiently into multiple wholesale markets through two separate tracks: Energy Storage Integration and Energy Storage Optimization. NYISO also identified the other projects it is working on related to energy storage, specifically calling out the projects related to the DER Roadmap and the Integrating Public Policy effort. NYISO is looking for feedback on the Energy Storage Integration proposal and bidding parameters (included in [this presentation](#)) to be sent before the end of June to Daniel Noriega, dnoriega@nyiso.com.
 - *Energy storage stakeholders should comment on the proposed bidding parameters by the end of June.*
- **2018 Project Prioritization Process** – At the May 22nd Budget and Priorities Working Group (BPWG), NYISO provided an update on the 2018 Project Prioritization Process. This meeting marked the conclusion of the Identification Phase and the beginning of the Prioritization Phase. Energy Storage Integration and Optimization, which was approved with significant stakeholder support in 2017’s prioritization process, is back for reprioritization along with several other relevant projects.
 - *This year, Energy Storage Integration and Optimization is once again up for voting, so storage stakeholders should rally Market Participants to vote on it again for 2018. Integrating Public Policy also requires votes to move to the third phase that will look at future resource mixes—including storage but it is less directly important for storage stakeholders to support.*
- **DER Roadmap** – The focus of the May 23rd MIWG presentation on DER shifted to the next concept, Monitoring and Control / Measurement and Verification. NYISO’s starting point for evaluating DER metering requirements is to apply the existing requirements to these resources and investigate through a Meter Data Study if and / or whether existing metering requirements could / should be applied to DER. Feedback may be sent to DER_Feedback@nyiso.com.
 - *NYISO is attempting to strike a balance between what it and the Transmission Owners view as the data needed to reliably manage the system vs. not creating undue barriers to entry for DERs. Currently the frequency of meter data transfers and the number of communication connections are significant points of concern for DER Market Participants.*
- **DER Pilot Program** – At the May 5th MIWG meeting, NYISO provided an overview of the Pilot Program framework it is establishing to test new distributed energy technologies. The pilots will not receive any compensation from NYISO and will not directly participate in the markets. The Pilot Program project is back for prioritization in the 2018 Prioritization Process.
- **NYISO 2017 State of the Market (SOM) Report** – NYISO’s Market Monitor published its 2016 SOM Report, [here](#), on May 10th.

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エネルギー貯蔵活動を行っている州....

- **ARIZONA** – Regulators pushing clean energy plans to include storage
- **COLORADO** - Legislation for grid-connected and customer-sited storage
- **HAWAII** - Interconnection rules updates, multiple storage policies to support 100% renewables goals
- **MARYLAND** – Launched a storage tax credit program; completed state storage study
- **MINNESOTA** - Grid Interconnection rules
- **NEVADA** - Commission begins implementation of first of several 2017 energy bills;
- **NEW JERSEY** - Signal of storage interest with New Jersey target bill (600 MW of storage capacity by energy year 2021 and 2,000 MW by energy year 2030.)
- **NEW MEXICO** - IRP rules to include storage
- **NORTH CAROLINA** - Governor approves comprehensive energy bill, including storage study
- **OREGON** – Mandate, and PGE and Pacific Power issue Storage Evaluation Plans; bill introduced to examine grid tech impacts
- **TEXAS** – PUCT proceeding on storage ownership and contracting
- **WASHINGTON** – Moving utilities toward including storage in resource planning

インドにおけるエネルギー貯蔵の採用のための政策枠組みの変遷

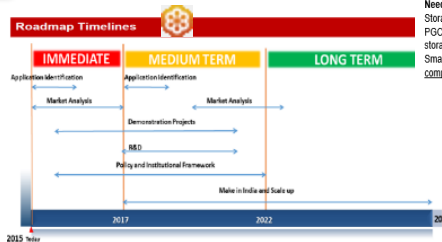
ENERGY STORAGE



Large Scale Grid Integration of Renewable Energy Sources - Way Forward



Central Electricity Authority
November 2013



IESA recommendations for encouraging advanced Energy Storage Technology manufacturing in India

Context: With comprehensive power sector reforms, electrification of villages, generation and transmission capacity addition, reduction in energy deficit, opening up of ancillary services market and installation of large scale renewable power generation, the Energy sector in India is in its inflexion point for transformational growth. With ambitious targets of installing 100 GW of solar and 60 GW of wind by 2022, and becoming 100% electric vehicle nation by 2030, Energy Storage technologies has strategic importance for India's energy security and clean energy future.

Market Size: The total energy storage market between 2015 and 2022, in India is estimated by India Energy Storage Alliance (IESA) is close to 70 GW and 200 GWh. Out of 70 GW, over 35 GW of demand is expected from newer applications like wind and solar integration, frequency regulation, peak management, T&D deferral, diesel replacement and electric vehicles.

Applications: Energy Storage applications include Electric Vehicles, e-rickshaws, Backup Power, Telecom Towers, Renewable Integration, Frequency regulations, Ancillary Services, RE shifting or RE Firing, Forecasting & Scheduling, RE Smoothing, Ramp Rate Control, Optimizing Transmission Utilization, Captive RE Optimization & Demand Charge management, Distributed RE & Micro grids, Micro grids & Off grids, Peak Management, T & D Deferral, Agricultural applications etc.,

Need for Comprehensive Policy: With various ministries / PSUs piloting and announcing Energy Storage demonstration projects and roadmaps such as MNRE Energy Storage Demonstration EOI, PGCIL - Pilot Project in Puducherry (3 projects of 250 KWh - 500 KWh), Gujarat GIFT RFP 40 MW storage, NTPC 20 MW solar - storage project in Andaman, SECI's 1MWh Project in HP and National Smart Grid Mission, MNRE Energy Storage Mission Plan etc., the need for a holistic review and comprehensive policy on Energy storage is imminent.



INDIA ENERGY STORAGE ALLIANCE (IESA)'S VISION IS TO MAKE INDIA THE GLOBAL HUB OF MANUFACTURING FOR ENERGY STORAGE TECHNOLOGIES.

SUBMITTED A PAPER TO NITI AAYOG ON ADVANCED ENERGY STORAGE MANUFACTURING POLICY FOR INDIA

CEA report on large scale RE integration
Nov, 2013

Taskforce for RE integration by CEA and MOP created with participation of IESA
2013-14

IESA hosts IRENA workshop for Electricity Storage: Technologies, supporting RE
Dec 2014

IESA releases report on the role of energy storage for providing ancillary services in India
Dec 2014

MNRE & USAID release Roadmap for Launch of a National Energy Storage Mission
May 2015

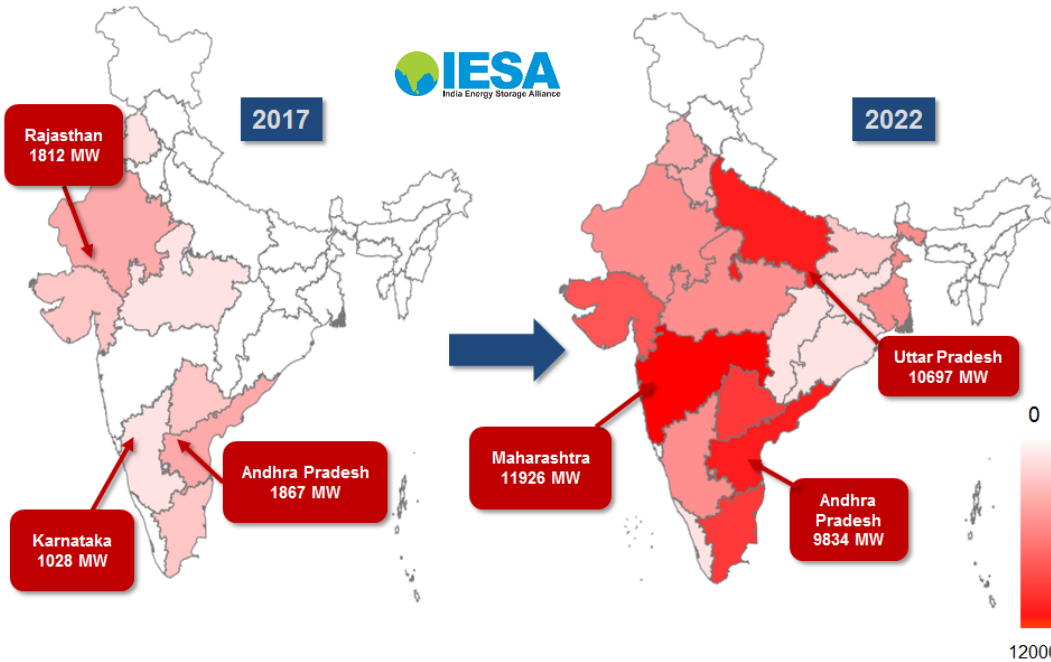
CERC issues Roadmap to operationalise Reserves in the country
Oct 2015

IESA submits recommendations to NITI Aayog for encouraging advanced EST manufacturing in India
May 2016

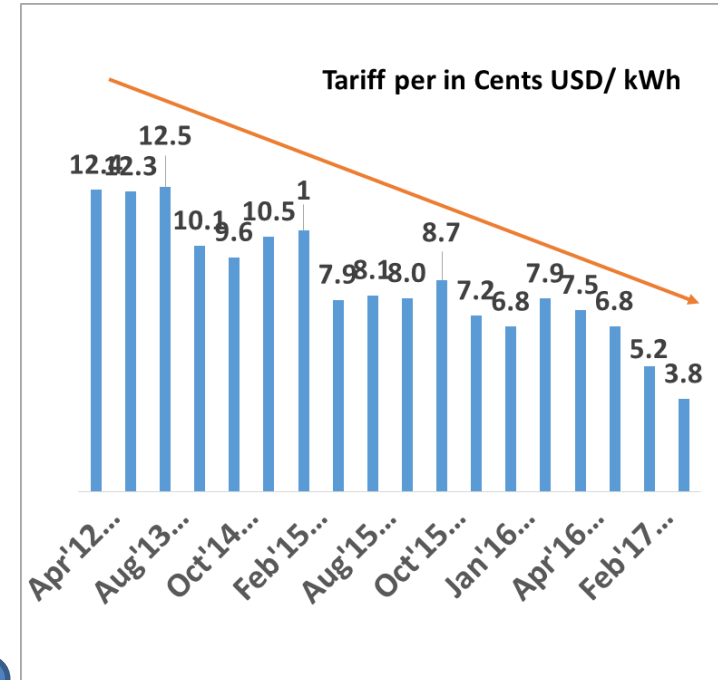
POSOCO's half year implementation report of Reserve Regulation Ancillary Services
Apr-Nov 2016

Worked with DIPP, NITI Aayog and IEEMA on Make in India Opportunity for Energy Storage

インドにおける太陽光発電の成長

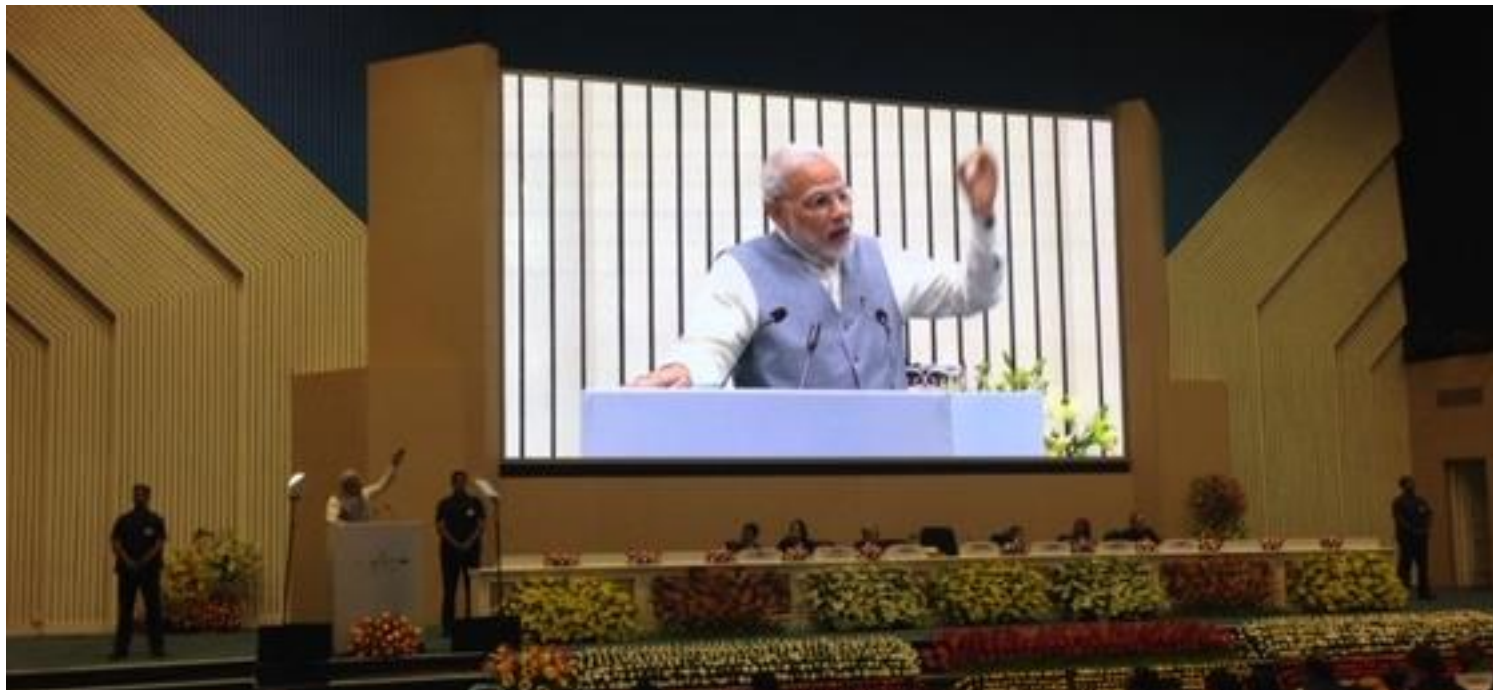


Solar Tariff Trends over past 5 Years



- India's cumulative installed capacity is nearly 13.5 GW
 - Capacity addition in the FY17 was over 5GW
 - Targeted capacity addition for FY 18 is 10GW

エネルギー貯蔵の喫緊の必要性： モディ首相閣下、2018年10月2日



Inaugurating the first assembly of International Solar Alliance, Prime Minister Narendra Modi said **“Under the National Energy Storage mission, the government is focusing on demand creation, indigenous manufacturing, innovation and energy storage,”**

India's National Mission for Transformative Mobility and Battery Manufacturing



A Phased-Manufacturing Program (“PMP”) for Batteries is Proposed by NITI Aayog to develop an export-Competitive cell & battery Manufacturing Ecosystem of 50 GWh + by 2023

India is looking for technology partnership and investments from Japan for the battery & EV supply chain manufacturing.

Capability for	INDIA		
	2020	2022	2024
Raw Material Processing	✗	✗	✓
Separator Manufacturing	✗	✗	✓
Cathode Manufacturing	✗	✓	✓
Electrolyte Manufacturing	✗	✓	✓
Anode Manufacturing	✗	✓	✓
Cell Manufacturing	✗	✓	✓
Pack Manufacturing	✓	✓	✓
Value Chain Captured	<20%	~60%-80%	100%

結 論

- ✓従来型のみならず再生可能エネルギーの資源の最適化、及び電力網のレジリエンスの改善の両方の目的で、エネルギー貯蔵技術が必要である。
- ✓太陽光＋蓄電はすでにディーゼルに対してコスト競争力があり、今日にも大規模展開を開始できる。
- ✓そのようなハイブリッドプロジェクトで今後1年～1年半以内にグリッドパリティに達するため、太陽光＋蓄電が成長を後押しするものと予想される。
- ✓日本企業にとって研究開発、製造及び輸出に関する協力の素晴らしい機会がある。



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