Energy Storage Forum
21-11-2013

Energy Storage Technology landscape and opportunities in US and India

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IESA India Energy Storage Alliance

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Outline

- Energy Storage Technology landscape
- US Electricity market Overview
  - Applications for energy storage in US
- India's energy infrastructure overview
  - Applications of energy storage in India
  - Introduction to India Energy Storage Alliance
- Q&A

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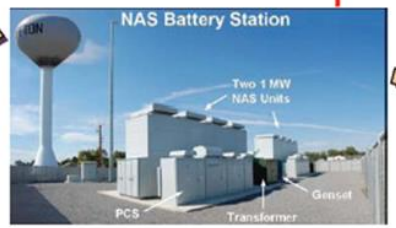
Role of Energy Storage in Modern Grid

Perform Achieve Trade (PAT) mechanism for thermal plants & introduction of ancillary services

Over $26B planned Transmission investments over next 5 years. Also need for transmission optimization with significant wind penetration.

Graphics adapted from an EPRI Presentation by Joe Hughes

Large Central Units



Substation Batteries

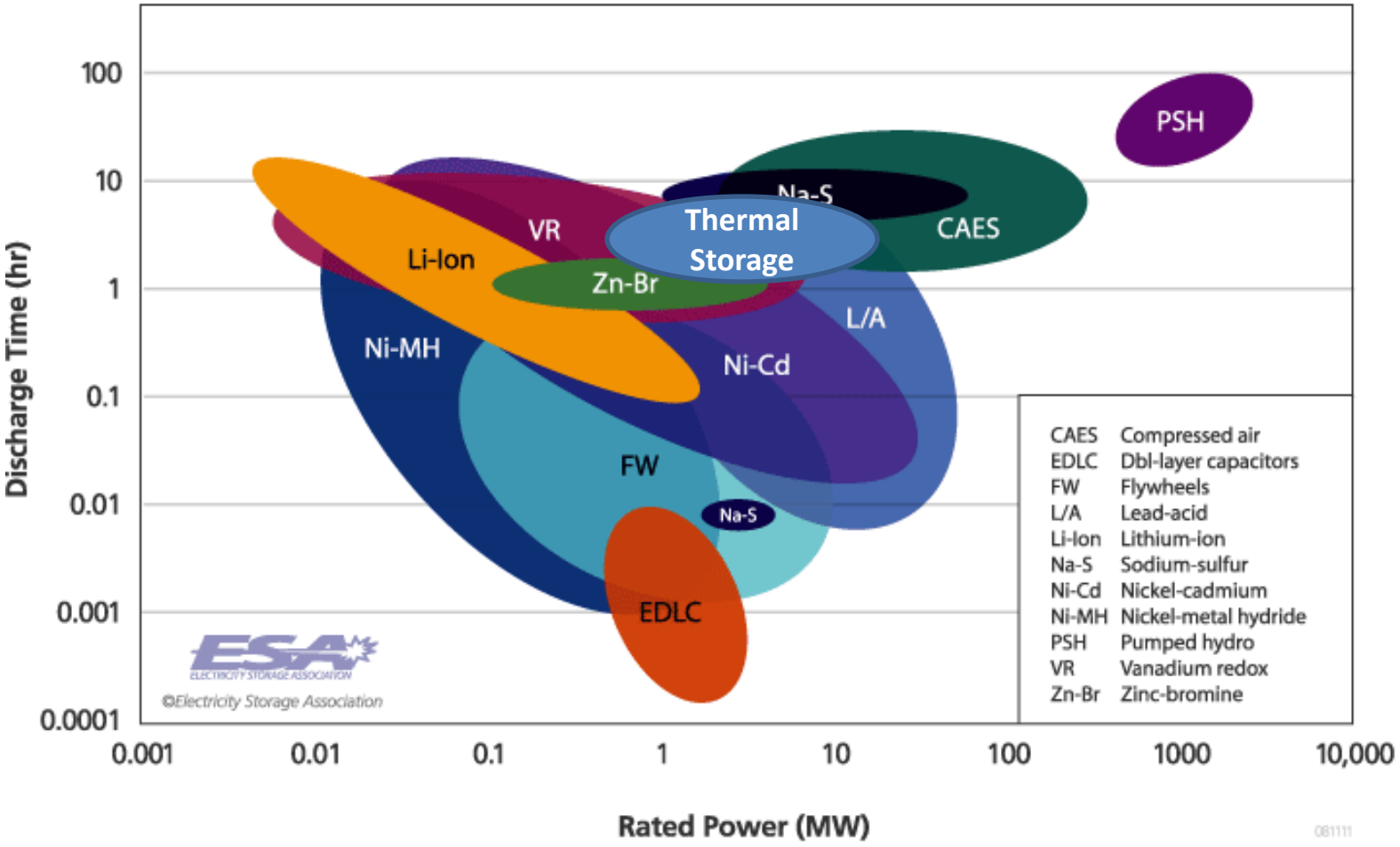
Storage at Gri

Adapted from EPRI & AEP presentation

Commercial & Industrial customers, SEZs / townships, Micro grids for rural electrification etc.

www.indiaesa.info

Emergence of Energy Storage Tech

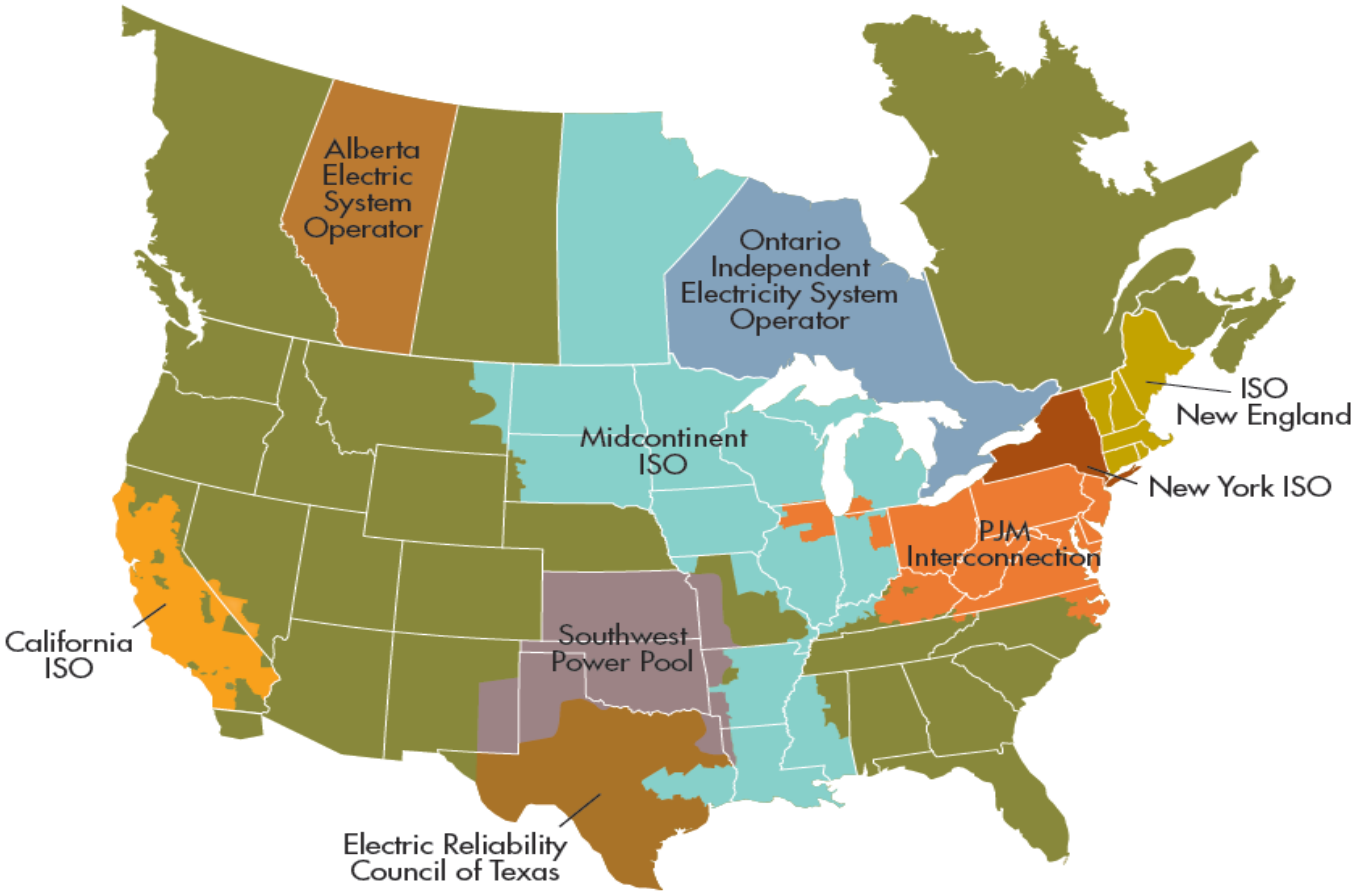


Source: Electricity Storage Association www.electricitystorage.org

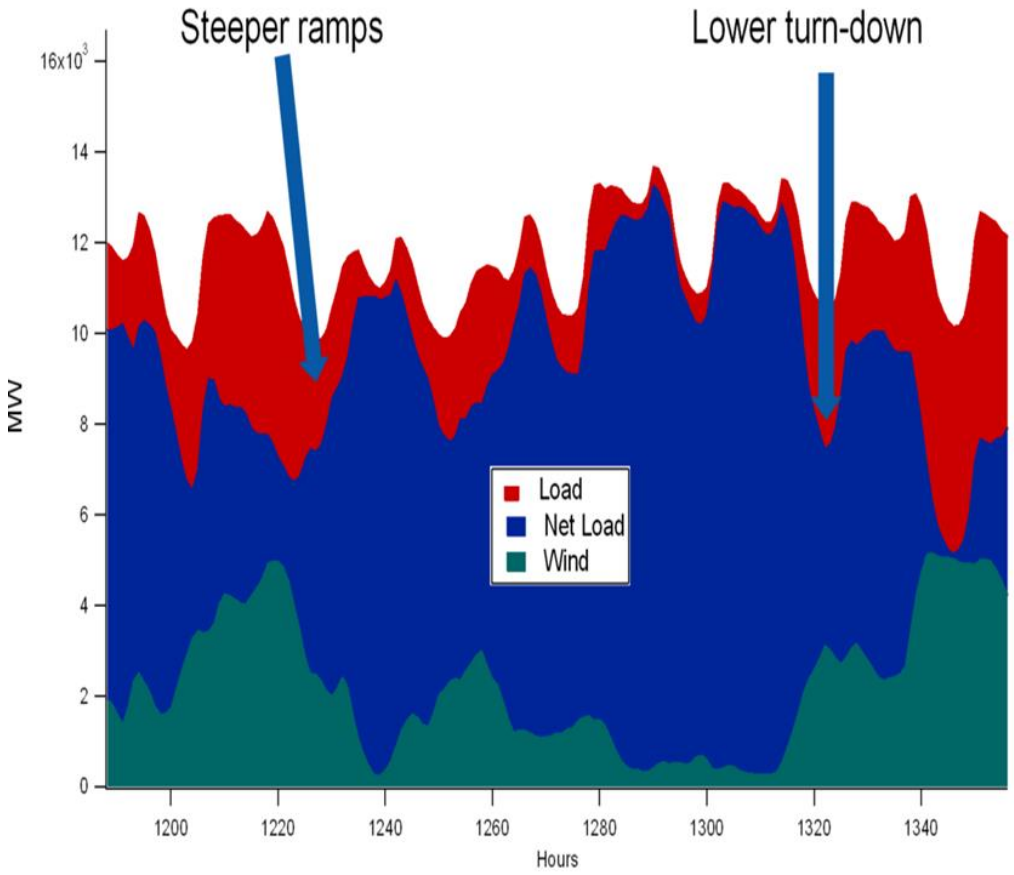
Energy Storage Technology Landscape

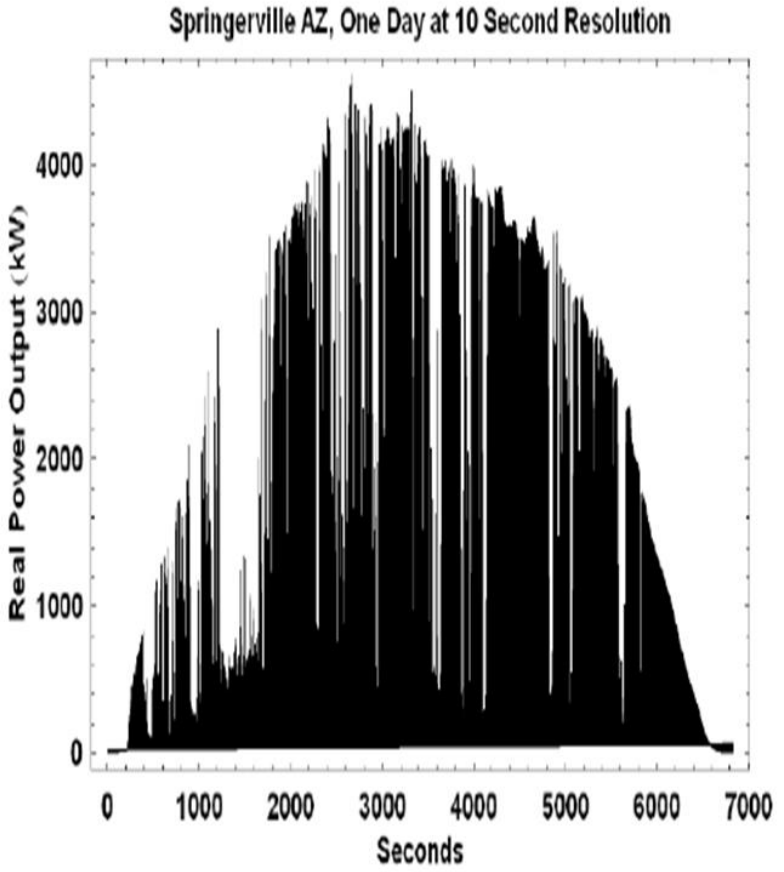
- Compressed Air Energy Storage
  - Dresser Rand, LightSail, SustainX
- Sodium based (NaS, NaNiCl , Na-Ion)
  - NGK, GE, FIAMM, Aquion
- Flow Batteries (VRB/ZBB)
  - Deeya, Gildemeister, UniEnergy, UTC, Prudent
  - ZBB, Premium Power, Primus, RedFlow
- Flywheels
  - Beacon, Temporal Power
- Li-Ion Batteries
  - A123, Altairnano, Electrovaya, Enerdel, Microvast, Panasonic, Samsung, SAFT, Toshiba,

Electricity Markets in North America



Challenges in Renewables Integration





Source: Dr. Michael Milligan NREL / AWEA : Dr. Jay Apt, CMU

Energy Storage Applications

Generation

- **Energy Arbitrage**
- **Ancillary Services**
  - Frequency Regulation
  - Spinning Reserves
  - Supplemental Reserves
  - **NEW** Ramping
- **Capacity**
  - Peak Energy
  - **NEW** Flexibility
- **Reliability**
  - Voltage Support/Reactive Power
  - Black Start
  - Frequency Response

Transmission & Distribution

- **Upgrade deferral**
  - Reduce circuit and line overload
- **Grid resiliency**
  - Outage mitigation
  - Back-up power
- **Voltage support/power quality**
- **Congestion relief**

End-users

- **Reduce Demand Charges**
- **Optimize Retail Rates**
- **Power Quality/UPS**
- **Onsite renewables**

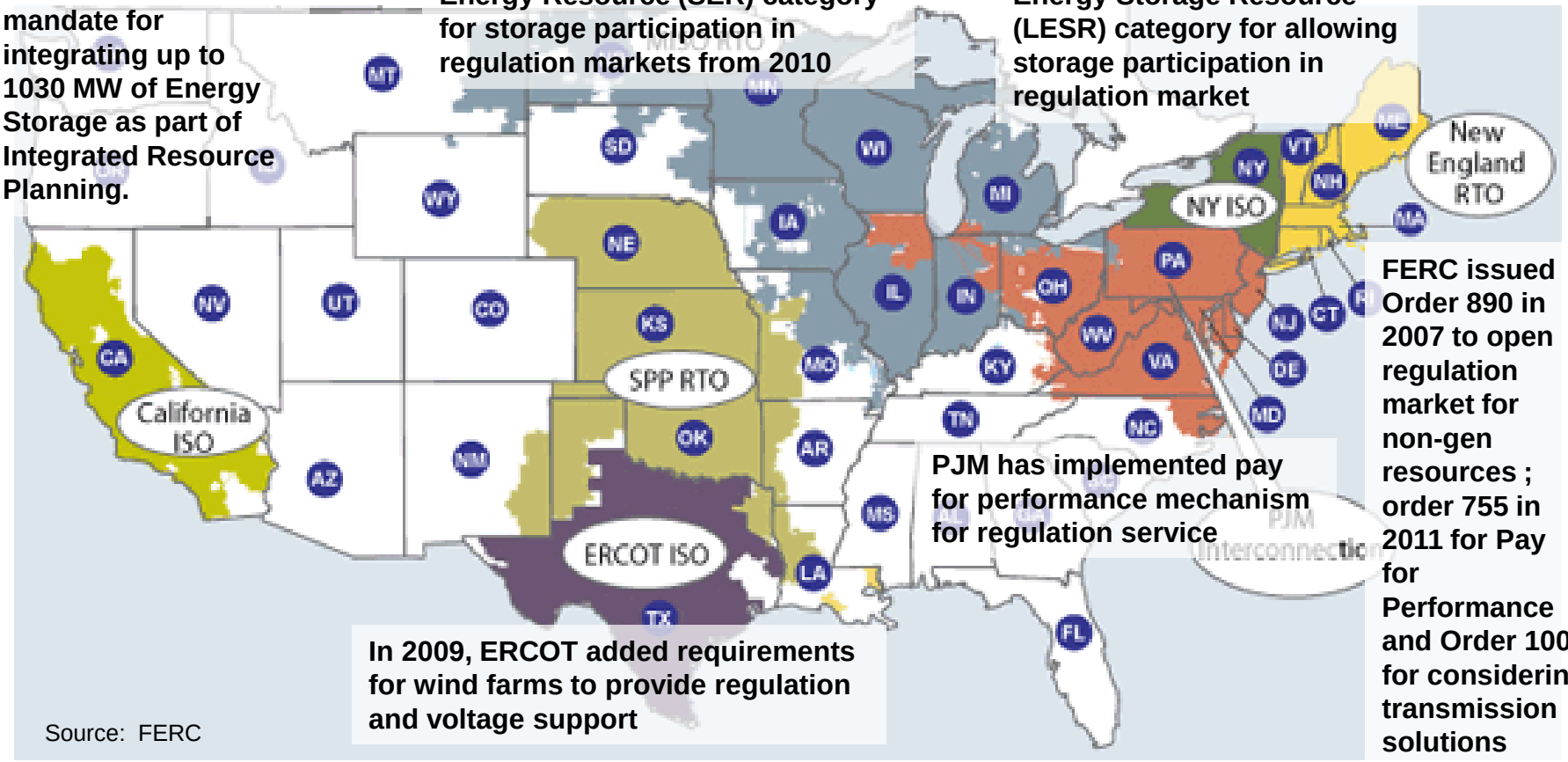
ISO/RTO Markets focused on "Generation" Applications and Demand Response , Utilities focused on "T&D"

US Policy initiatives to integrate energy storage

CA has issued mandate for integrating up to 1030 MW of Energy Storage as part of Integrated Resource Planning.

MISO has created a Stored Energy Resource (SER) category for storage participation in regulation markets from 2010

NYISO has created a Limited Energy Storage Resource (LESR) category for allowing storage participation in regulation market



PJM has implemented pay for performance mechanism for regulation service

In 2009, ERCOT added requirements for wind farms to provide regulation and voltage support

Source: FERC

FERC issued Order 890 in 2007 to open regulation market for non-gen resources ; order 755 in 2011 for Pay for Performance and Order 1000 for considering transmission solutions

US Congress has proposed "Storage Technology of Renewable and Green Energy Act" of 2009 to provide investment tax credits for storage projects.

US Department of Energy:
Smart Grid-Energy Storage Demonstration Projects

Additional R&D funding of over 600 Million $ provided for transformative energy storage technologies through ARPA-e program in past 3 years.

Major projects include: CAES demonstration (NY and CA), Renewable Integration (CA, TX, NM), Peak Shaving, Community Energy Storage and demonstration of new technologies.

Visit www.energy.gov for additional details.

Storage Application: Frequency Regulation

Conventional Grid

+

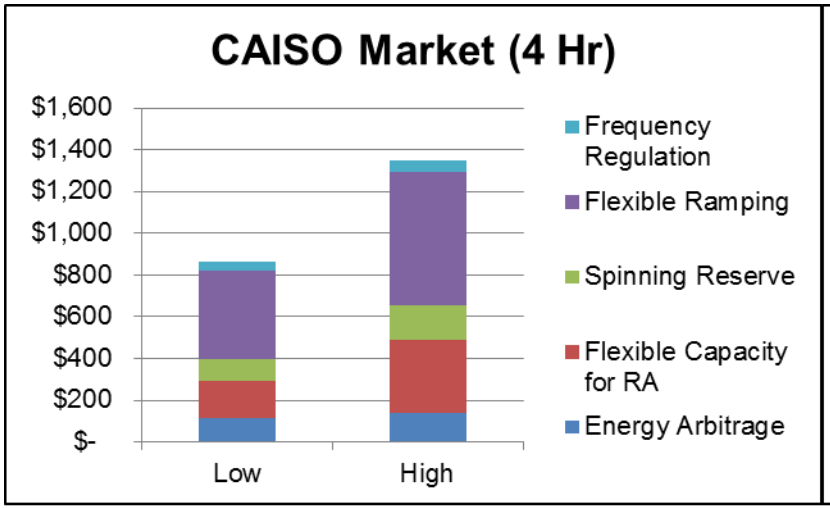
- Manage renewable variation by fossil generators varying output
  - Decreases efficiency
  - Increases fuel consumption
  - Requires more maintenance
  - Increases emissions

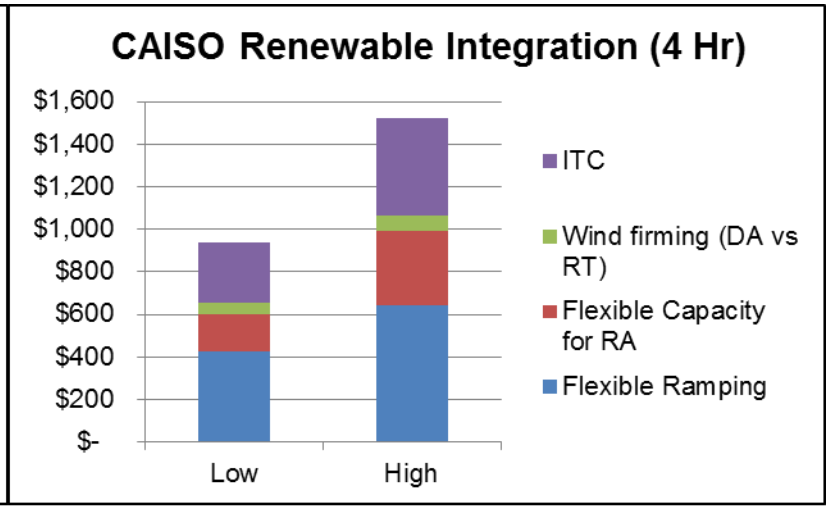
Smarter Solution: Storage

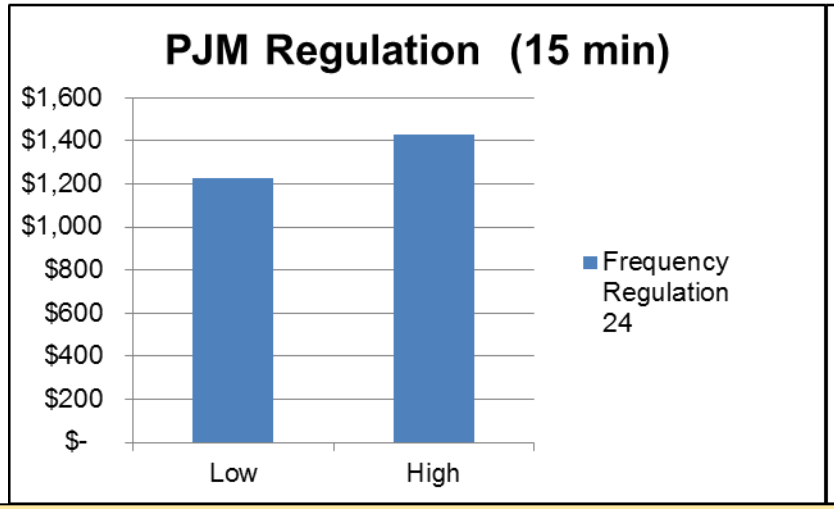
+

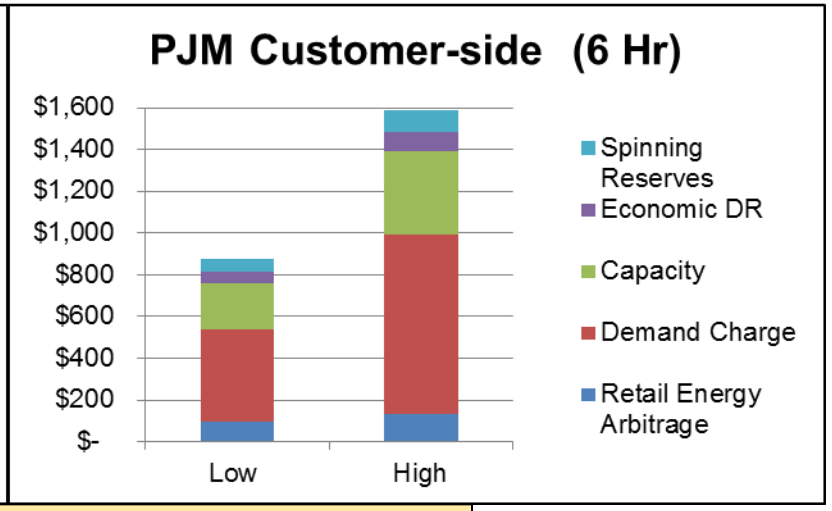
- Store energy when supply exceeds load; inject energy when load exceeds supply
  - High round trip efficiency
  - Low operating cost
  - Near instantaneous response
  - Zero direct emissions
  - Frees up generation capacity

Market Application Examples: Target System Cost per kW in 2018 (10% IRR)



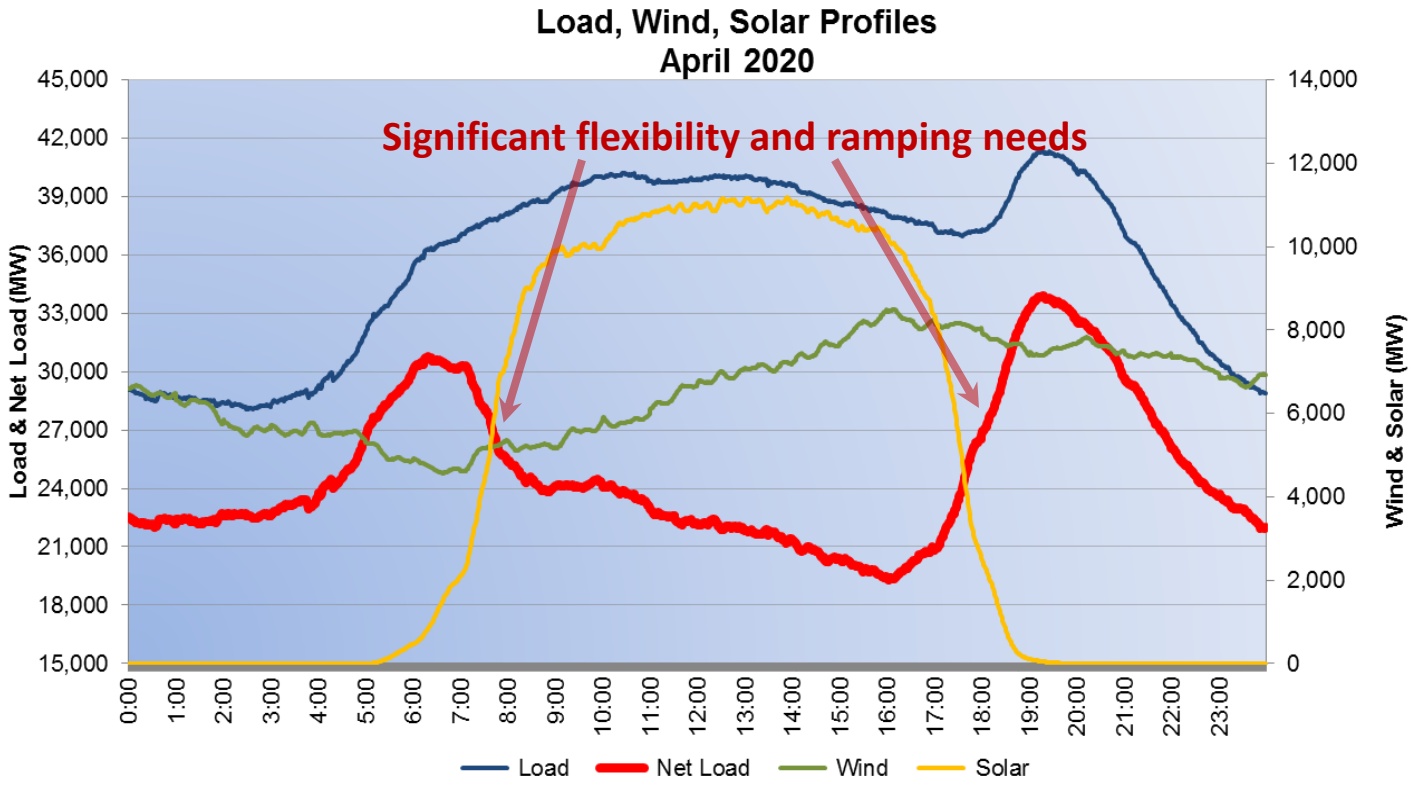






Except frequency regulation, need to stack multiple applications

New Storage Application: Ramping

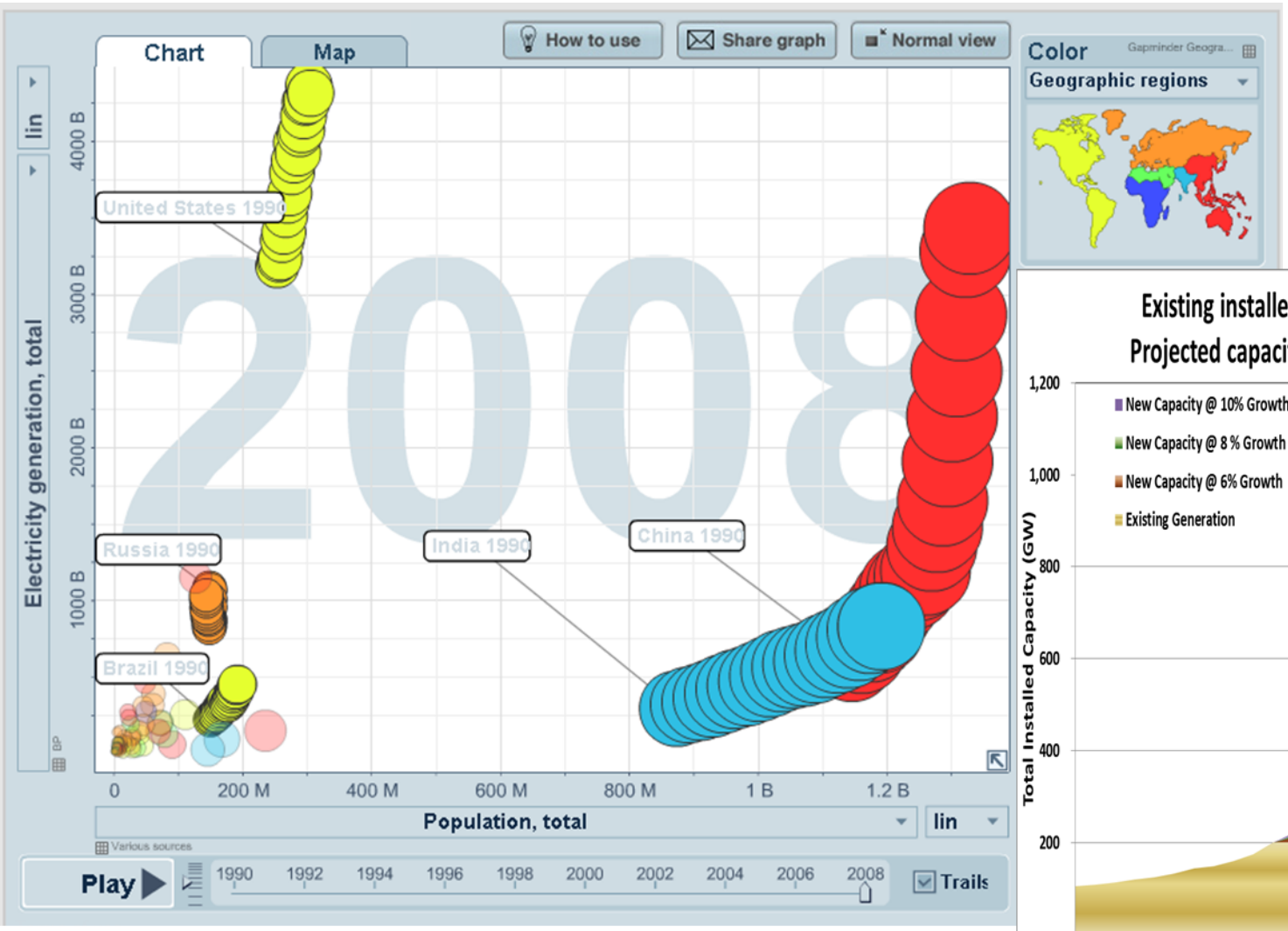


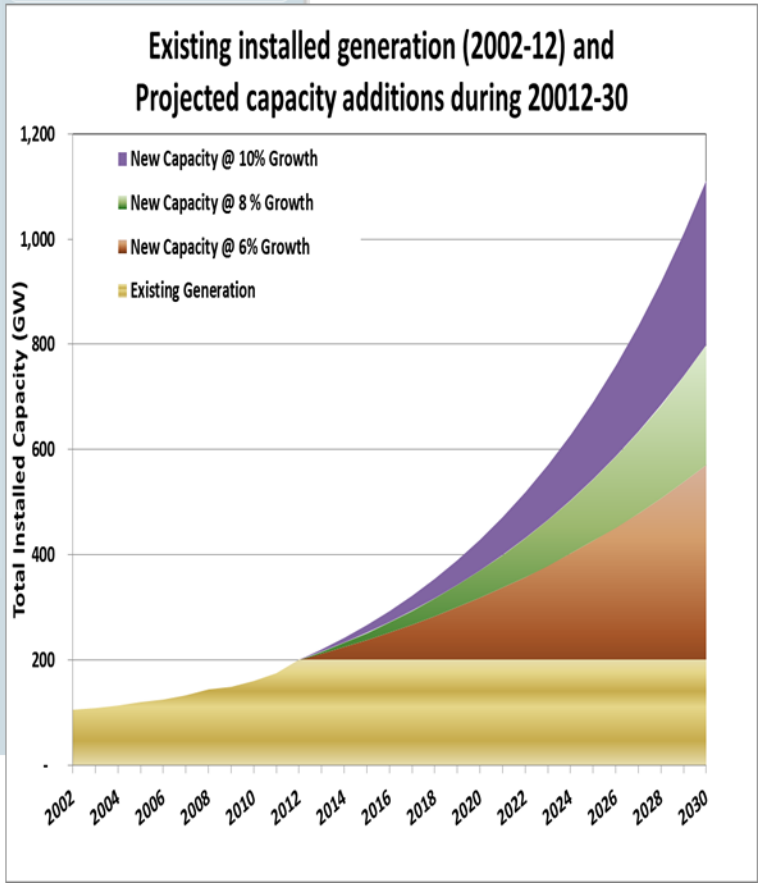
California is creating flexible ramping and flexible capacity products in 2015 to procure needed ramp capability for managing renewables

Factors critical for developing grid scale storage

- Understanding of the market rules & performance requirements
  - Significant variation on rules for storage across the country
  - Duration requirements, dispatch methodologies vary
- Technology selection and optimization of product configuration
- Analysis of potential changes in the supply, demand and transmission systems that can influence revenues and costs
- Operational optimization (e.g. response rate, state-of-charge management) and bidding strategies to maximize profit
- Co-optimizing multiple value streams
  - Except for frequency regulation need multiple value streams
- Site selection and interconnection requirement

India Electricity Generation & Anticipated Installed Capacity Additions





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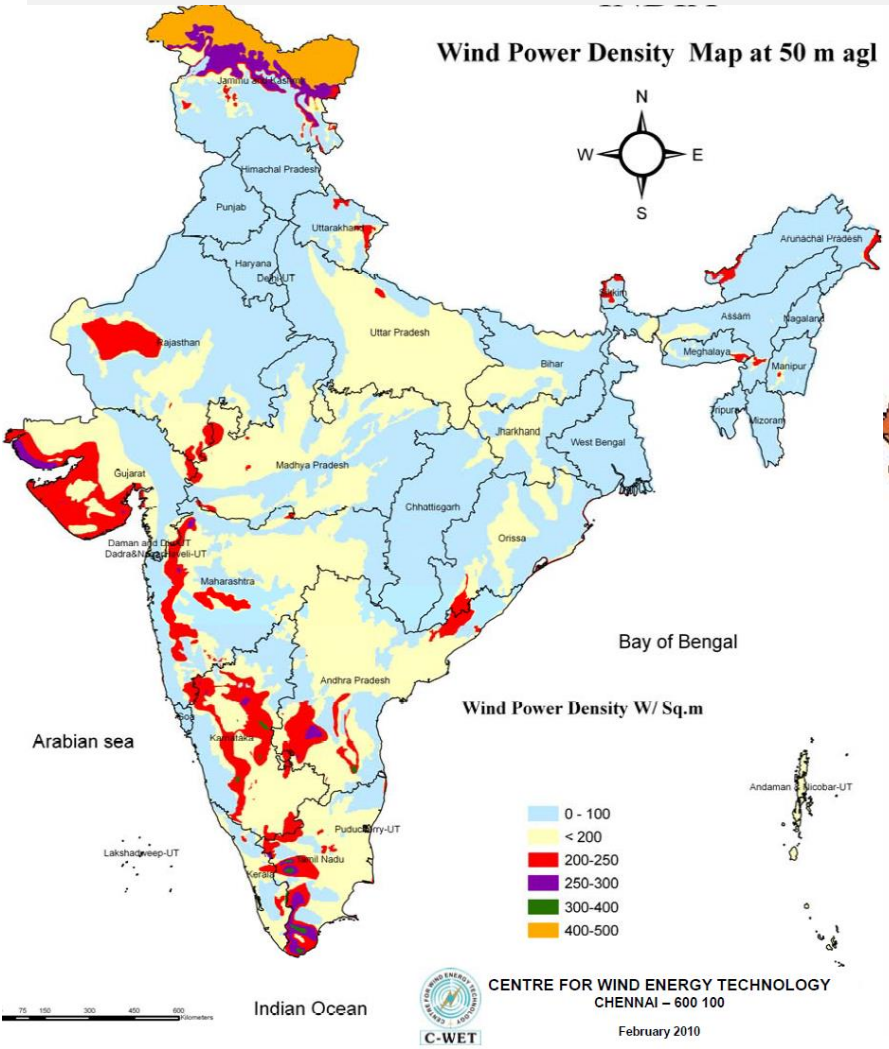
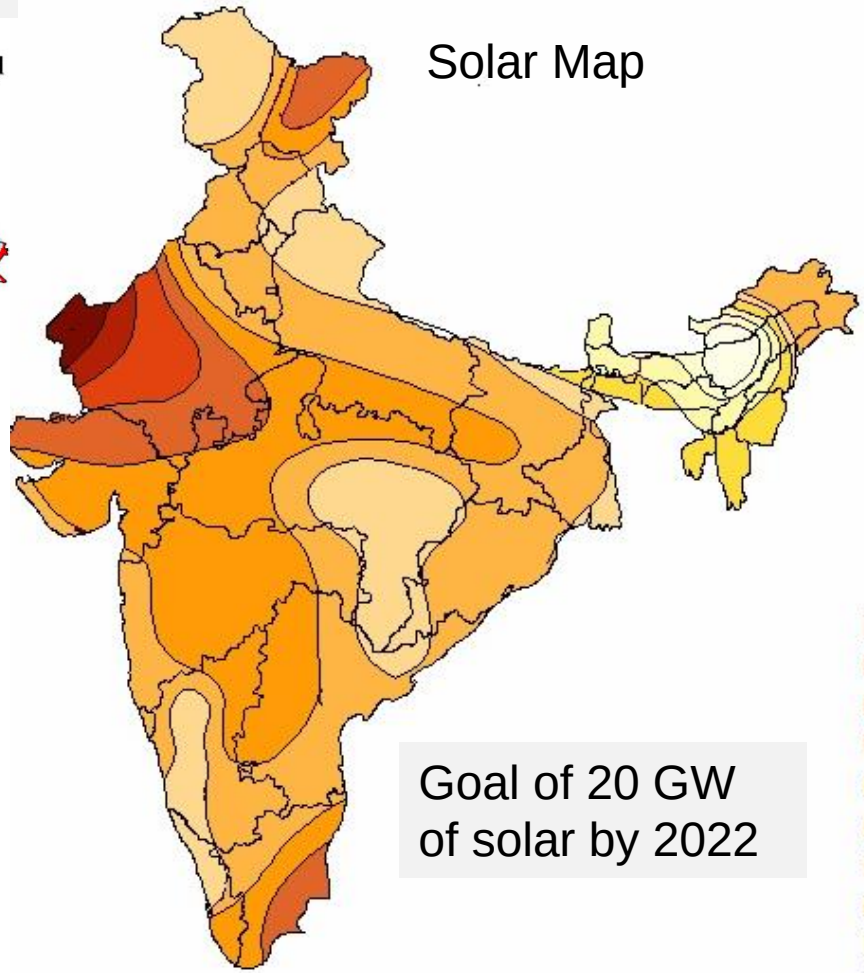
India – Wind and Solar Resource Availability

19+ GW of wind installed by 2013
Additional 30 GW expected by 2020



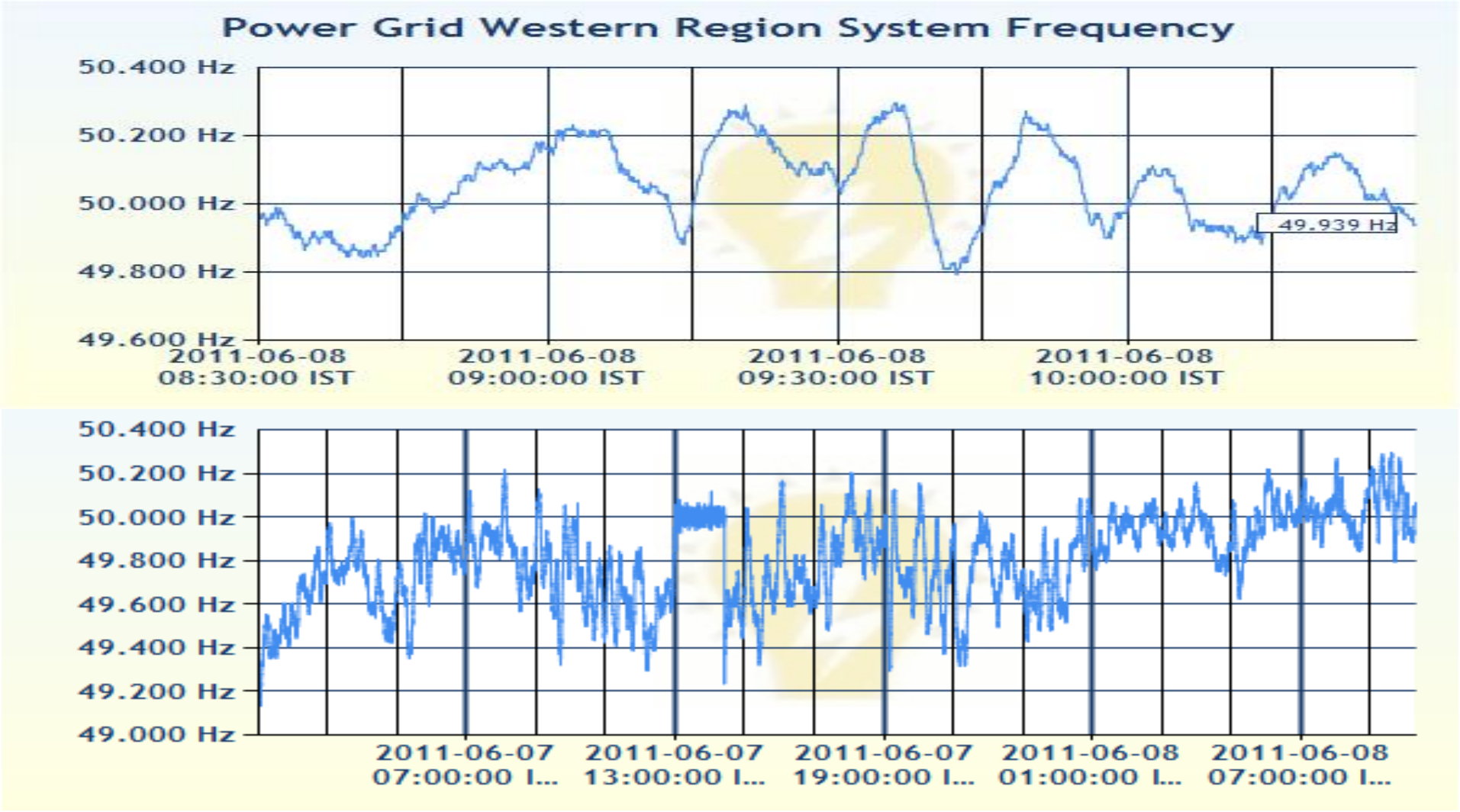
Solar Map



kWh / sq. m
6.6 - 6.4
6.4 - 6.2
6.2 - 6.0
6.0 - 5.8
5.8 - 5.6
5.6 - 5.4
5.4 - 5.2
5.2 - 5.0
5.0 - 4.8
4.8 - 4.6
4.6 - 4.4

Goal of 20 GW
of solar by 2022

India Grid Frequency

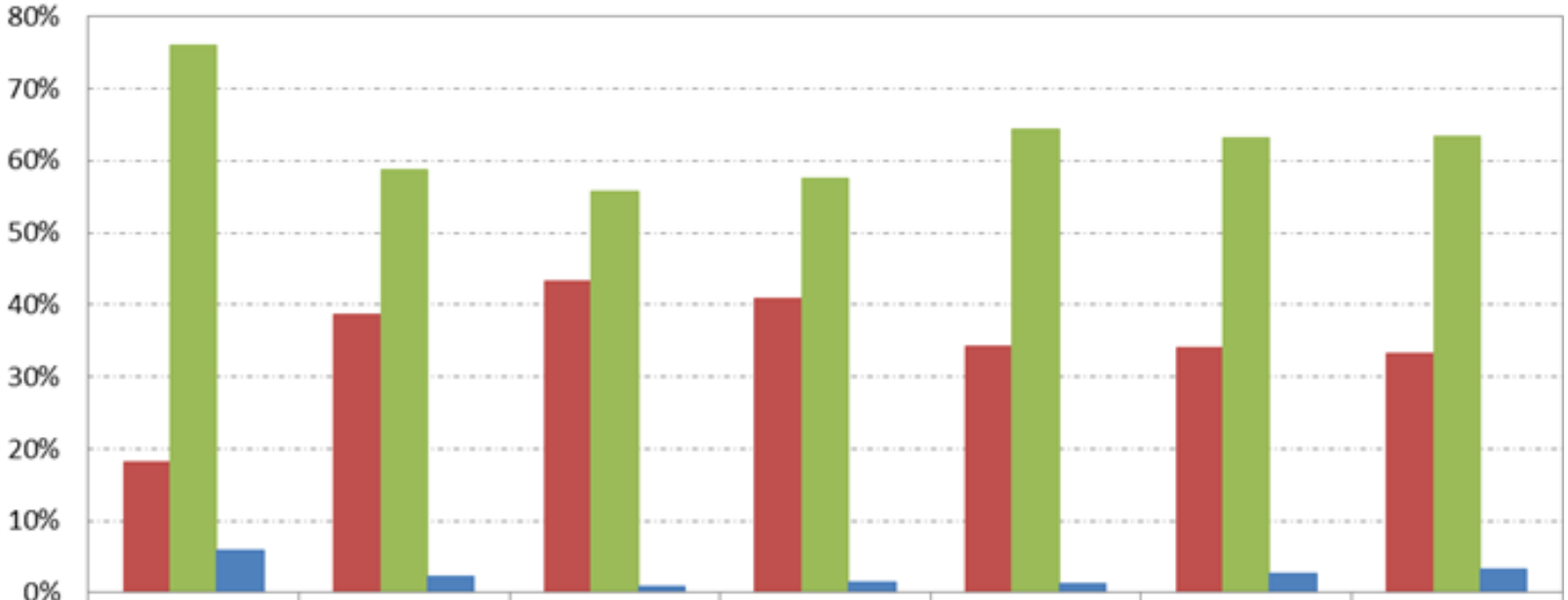


Implementing new Indian Grid Code

- Wind / Solar developers may have to pay financial penalties for deviations of more than ±30% of forecast
- Wind energy generators will be able to fine tune their schedules (based on forecasting) as close as three hours before actual generation.
- The operational frequency band has been further tightened from '50.3 Hz to 49.2 Hz' to '50.2 to 49.5 Hz'.
- This is generating interest in exploring better forecasting as well as integrating storage for wind farms

India – Grid Frequency Analysis

Grid Frequency: Daily Pattern

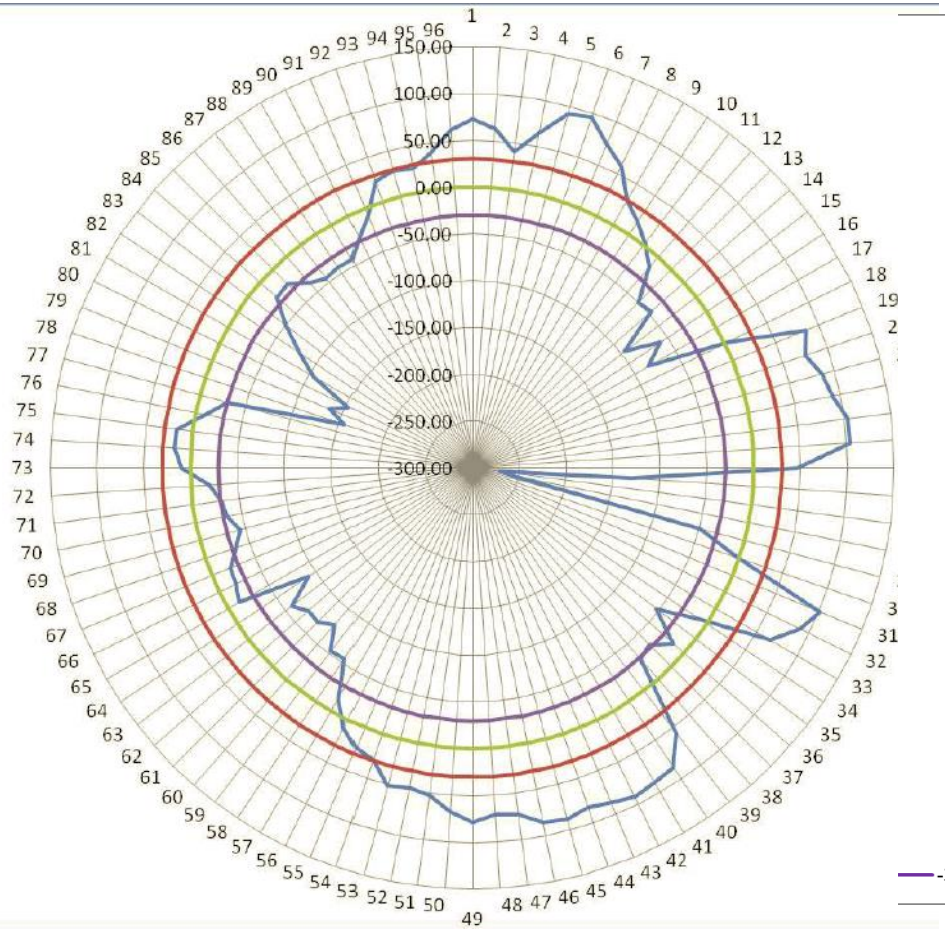


	Sun	Mon	Tue	Wed	Thu	Fri	Sat
less than 49.8 Hz	18%	39%	43%	41%	34%	34%	33%
Between 49.8-50.2 Hz	76%	59%	56%	58%	64%	63%	63%
greater than 50.2 Hz	6%	2%	1%	2%	1%	3%	3%

Wind Forecasting Errors

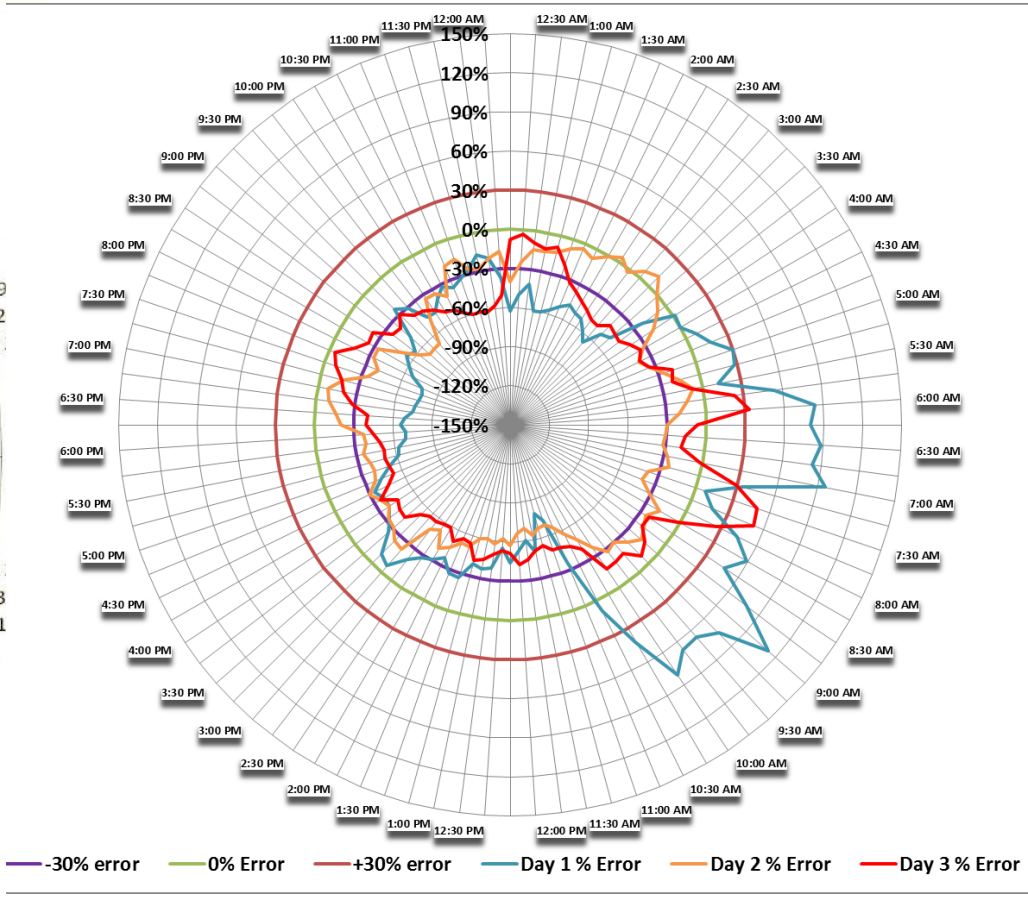
Insights from initial scheduling trials

Gujarat



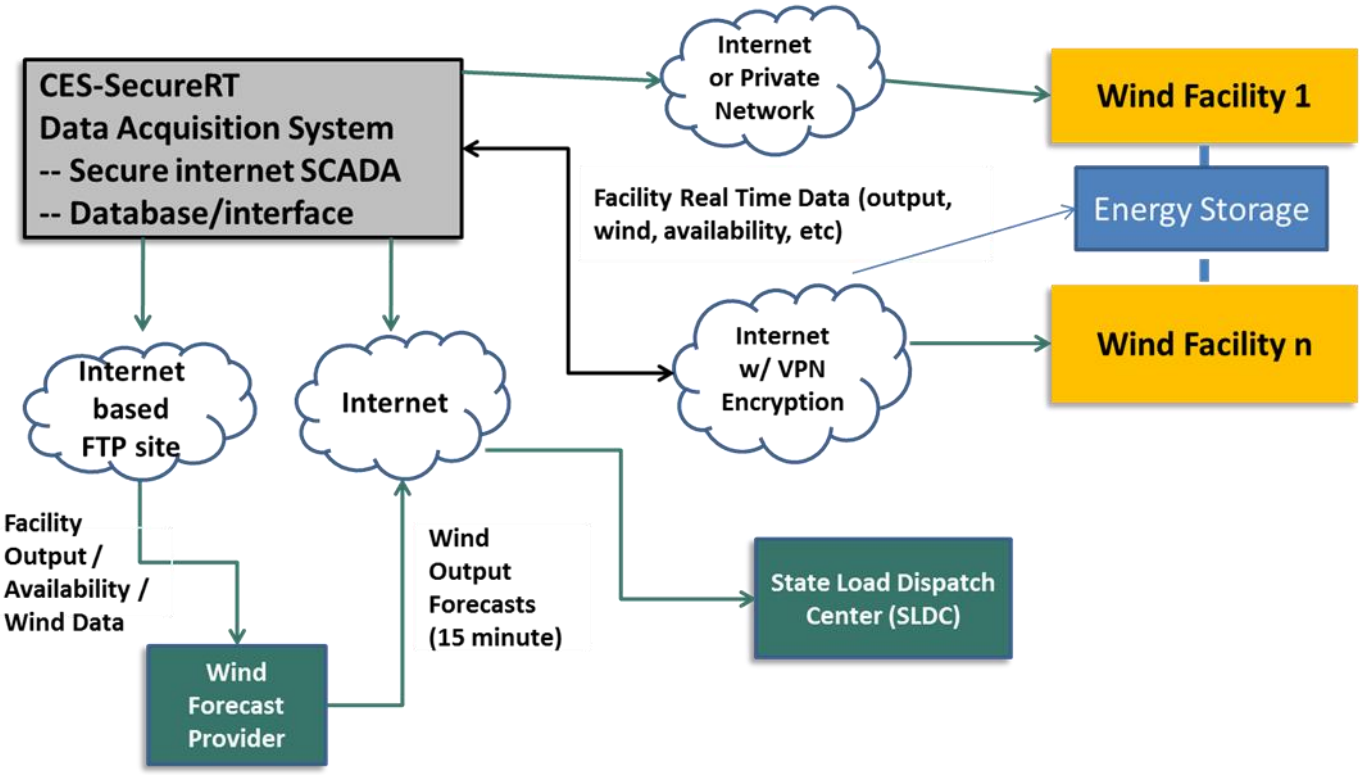
Source: GLDC

Maharashtra



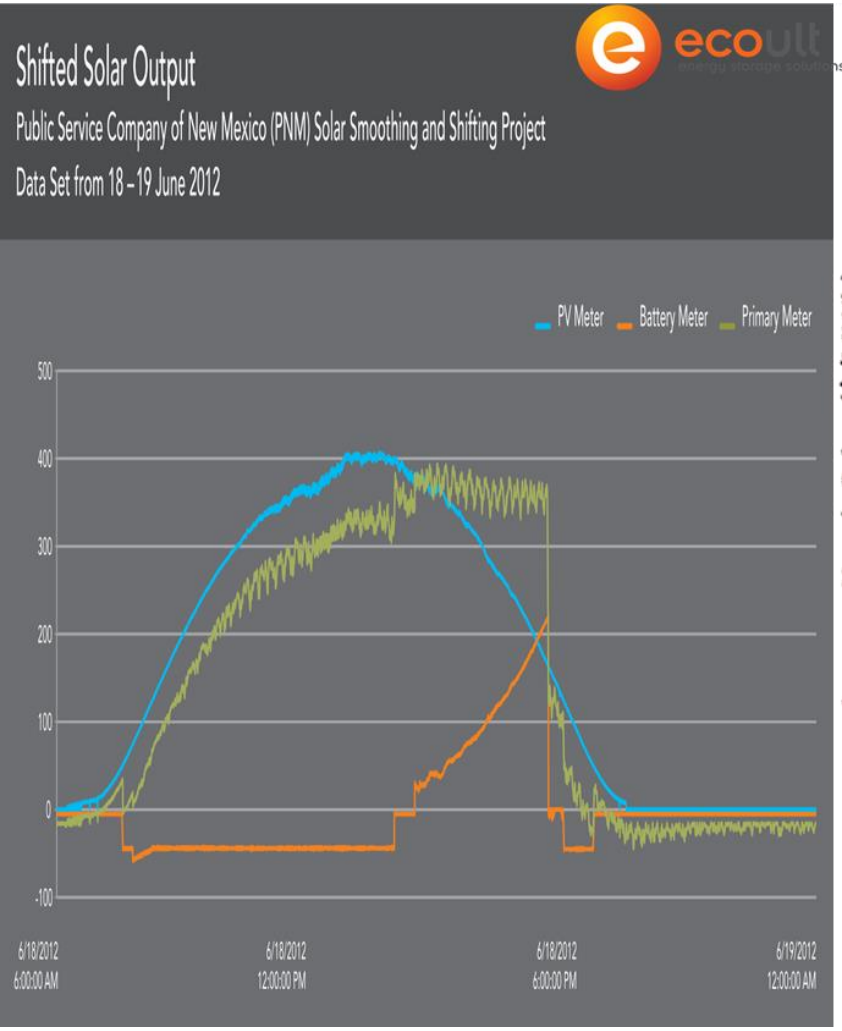
Source: MSLDC

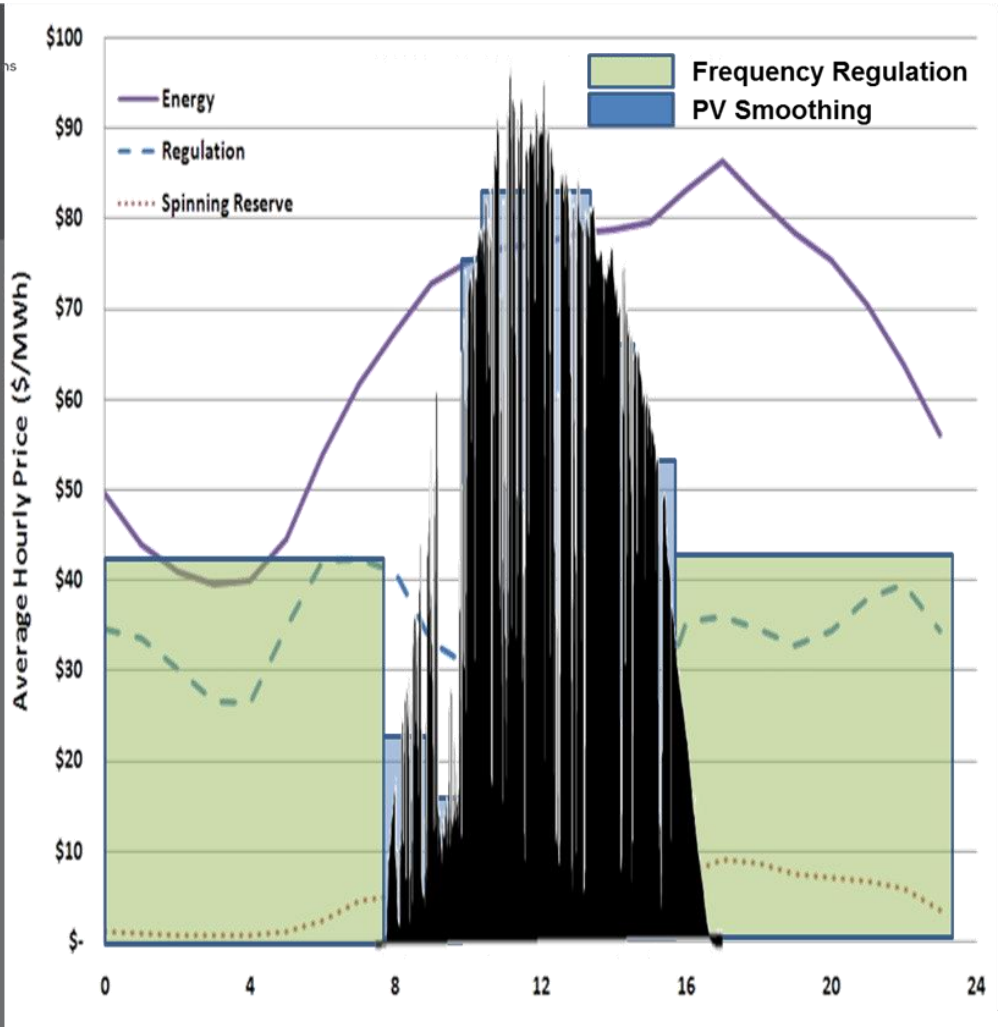
Wind scheduling with Advanced Wind Forecasting and Energy Storage



Customized's Market Operations Center currently actively manages over 3000 MW of generation, energy storage and demand response resources to maximize profits for our clients.

Solar PV – Storage Hybrid Solutions





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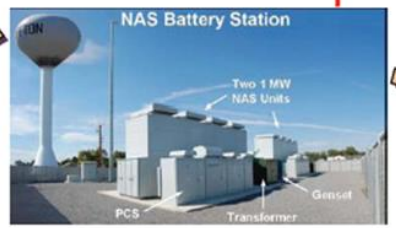

Substation Batteries

Storage at Gri

Adapted from EPRI & AEP presentation

Commercial & Industrial customers, SEZs / townships, Micro grids for rural electrification etc.

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Microgrids and Rural Electrification

- Microgrids can provide power support to off grid or weaker grids by enabling integration of locally available renewable resources and reducing reliance on Diesel Generators
- Rural Electrification Corporation is Nodal Agency under Rajiv Gandhi Rural Electrification Scheme.
  - Under the scheme, 90% capital subsidy is provided by Government of India for overall cost of projects.
- This is generating interest in hybrid renewable + energy storage projects for supplying power to remote villages
- Similar opportunities also exist for commercial & Industrial facilities with weak grid connectivity

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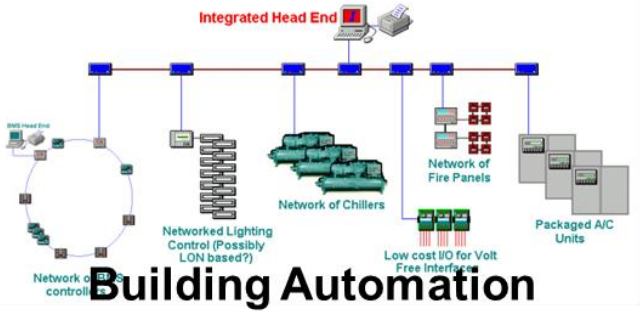
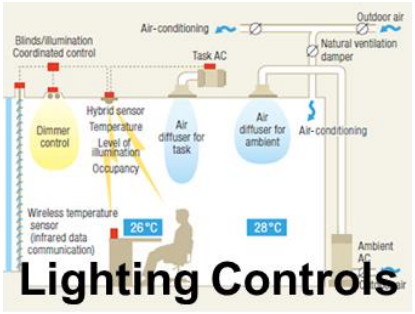
Ultra Modern Townships with 5 – 50 MW of peak demand could drive need for storage in India.

Integrating Energy Efficiency & DR

Thermal Ice Storage



Building Automation



Lighting Controls

Variable Speed Drives

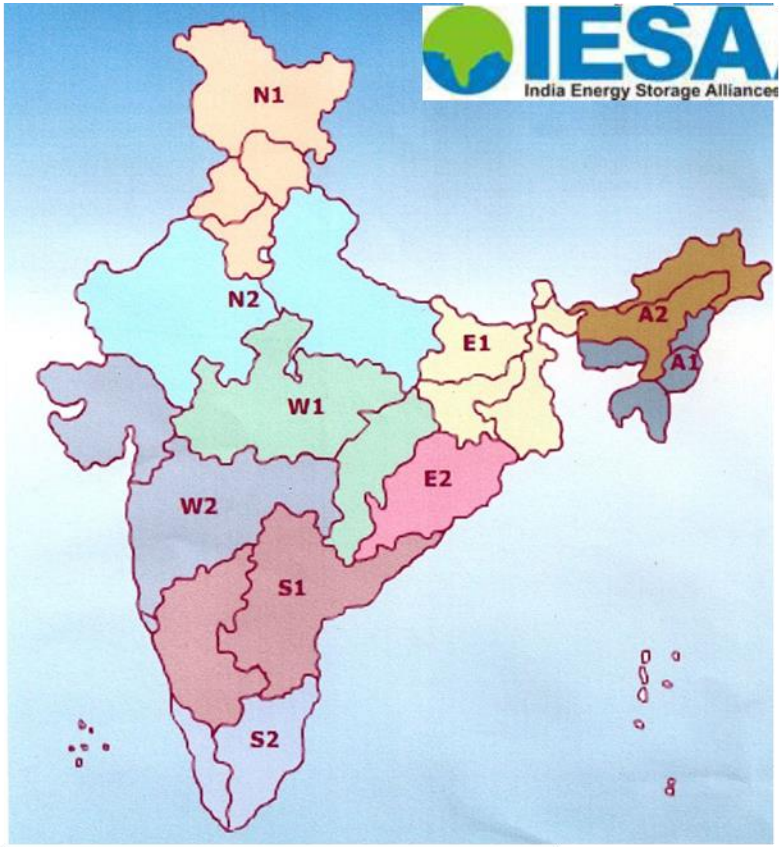
Emergency Generators

Air Compressor System

Energy Efficient Motors

India Energy Storage Alliance

- India Energy Storage Alliance was launched in 2012 to help technology and system integration companies involved in energy storage and microgrids to understand and capture opportunities in thro growing market
- In 2013 launched IESA-Knowledge Partner Network with a goal of addressing energy storage applications in over 10 key sectors of Indian economy
- For more details visit www.indiaesa.info



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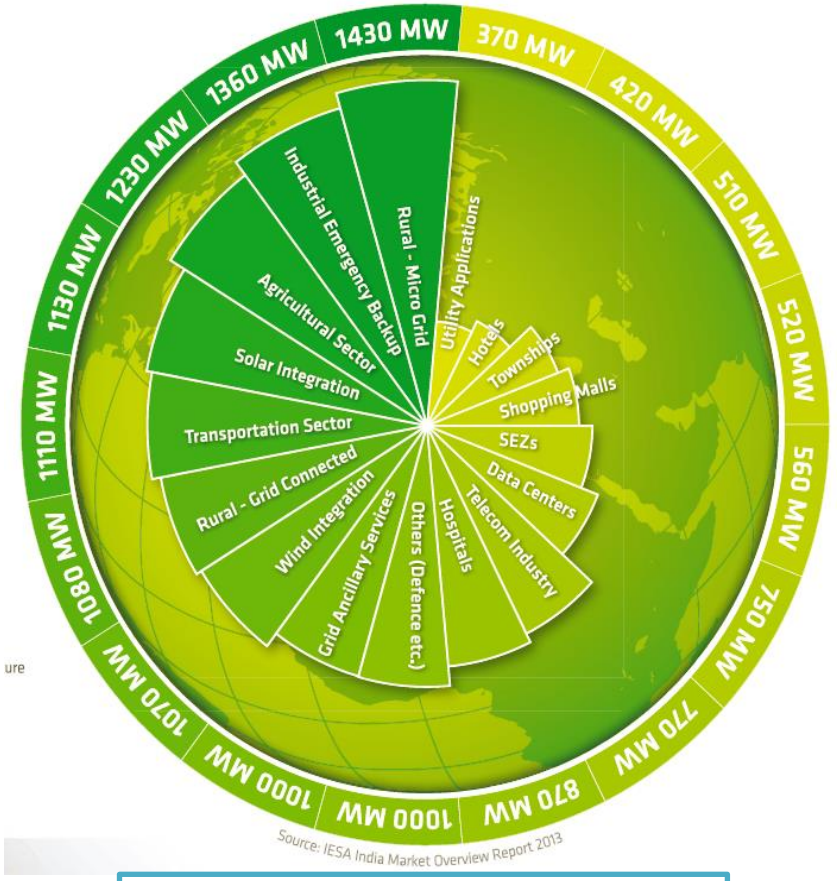
MaRS

Indian Market Opportunities

- Need to find solution for reducing diesel consumption for over 700K telecom towers
- Plans to integrated 30 GW of wind & 20 GW of solar by 2020
- National Electric Mobility Mission has goal of 6-7 Million electric vehicles with a funding of $2.5 Billion by 2020
- India needs to provide access to electricity to over 400 million people currently without access to electricity



Source: IESA India Market Overview Report 2013

15-20 GW by 2020

Key Activities

- Leading energy storage evaluation efforts and related policy initiatives
  - Chairperson of Working group on Renewable Integration, Microgrids and Energy Storage for Maharashtra Electricity Regulatory Commission
  - Member, National taskforce on Renewable Integration for CEA and Ministry of Power
  - Associate member of India Smart Grid Forum
- Launched the 1st energy storage market assessment for India that identified potential of over 15 GW by 2020
- Organized 2 technical tours for building partnerships for storage technologies in India
- Will host the 1st international energy storage and microgrid exhibition in India from 4th -6th December in Mumbai. www.esiexpo.in

IESA Technical Study Tours (2012 & 2013)

The 2012 Tech Tour saw participation from 8 international delegates and over 80 Indian entities.

2nd IESA technical tour was hosted in April 2013 and witnessed participation from 10 international delegates and over 150 Indian participants.

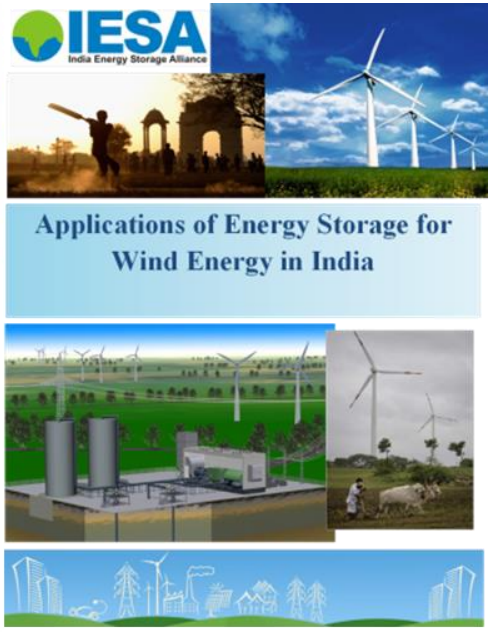
For more information please visit us at www.indiaesa.info

Market Research

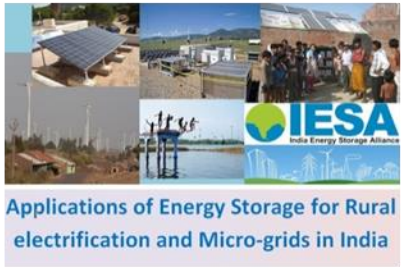
- As part of its market analysis and research on opportunities related to Energy Storage applications in India IESA has released the following reports

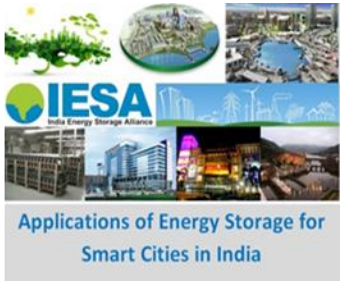
The first-of-its-kind assessment of ESS market potential in India. The report covers analysis and research on the growth of power sector in India and drivers for ESS in India. The report explores the potential applications of ESS by customer segments and provides market potential for each application till 2020. Applications or customer segments considered:

- *Solar integration*
- *Telecom*
- *Transmission Deferral*
- *Back-up power*
- *Emergency power*
- *Transportation*
- *Wind integration*
- *Rural electrification*
- *Ancillary Services*
- *Industrial Applications*
- *Agricultural*
- *Data Centers*



- IESA will be releasing the following reports in the coming months.





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ENERGY STORAGE INDIA

1ST INTERNATIONAL CONFERENCE & EXHIBITION ON ENERGY STORAGE & MICROGRIDS IN INDIA

04 - 06 December 2013

Nehru Centre, Mumbai, India

IESA estimates Market to grow to 15-20 GW by 2020.

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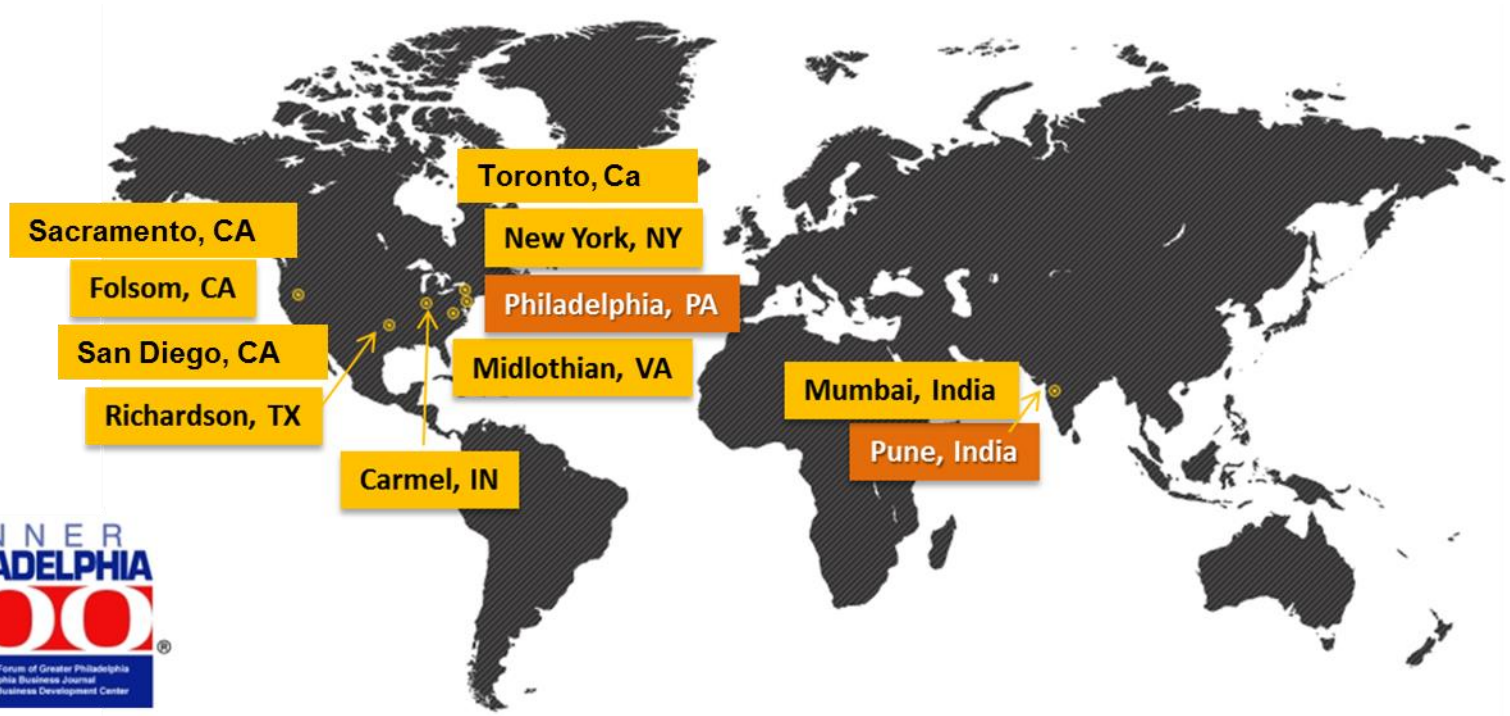
Messe Düsseldorf India

Mars & C-IBC members can receive 20% discount as strategic partner for IESA & ESI..!!

Summary

- Both US and India presents large opportunities for energy storage technologies for integration in grid
- We need fundamental policy reforms as well as better implementation mechanisms for existing policies to avoid recurrence of such event in future
- Emerging technologies including advanced controls, energy storage and Demand Response can provide the required technical solutions for coping with similar challenges in new future.
- Need industry to come together to address policy barriers and educate potential customers for enabling fast adoption of these technologies.
- This can be achieved through active participation in ESA and IESA in USA and India.

Contact US



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