

Enabling India's National Solar Mission: Role for Energy Storage, EVs and Demand Response

Presented by

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President & MD, Customized Energy Solutions (India)**

Presented at



CES is at the forefront of competitive electricity markets and emerging technology trends

Headquarter

**Philadelphia,
Pennsylvania**

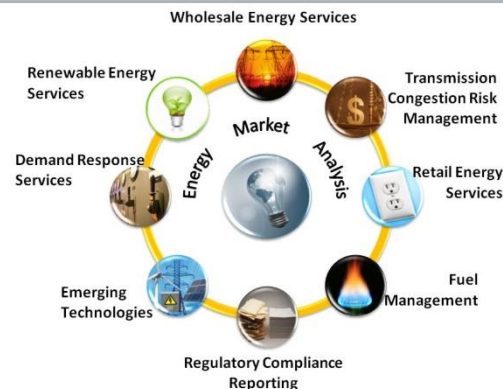


Headcount

150+ Global



Industry orientation



Location

- US regional offices in PJM, NYISO, ISONE, CAISO, MISO, ERCOT & SPP
- India
- Canada
- Japan
- Mexico

Clients

**500+ Clients
Worldwide**



CES services

Consulting

- Feasibility Analysis
- Competitive Assessment
- Interconnection Studies
- Financial Analysis
- StorageIQ : Market Insights
- Project Finance Advisory

Data Acquisition & Scheduling

- Real-time Communication through SecureNet-RT
- UI Management
- Real-time Monitoring for energy and ancillary services
- Web-based reporting

Scheduling and Operations

- Registration / Accreditation
- Portfolio Management
- Bidding Strategies
- SOC management
- Settlements

CES assists clients from concept to market implementation

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

Customized Energy Solutions - Awards

- Inc. 5000 – Ten Time Honoree during 2006- 2016
- Philadelphia 100 Best Places to work: 2001, 2004 – 2012, 2014
- CII Most Innovative Energy Service Award for Tata Power DR Program - 2012
- Energy Storage Association Brad Roberts Award for Outstanding Industry Achievement - 2016
- IPPAI Power Innovation Award – 2016 for creation of India Energy Storage Alliance
- India Smart Grid Forum President's Award – 2018 for accelerating adoption of smart grids in India



CES is proud to have won this award 10 times:
2001, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012



Energy
Storage
Association



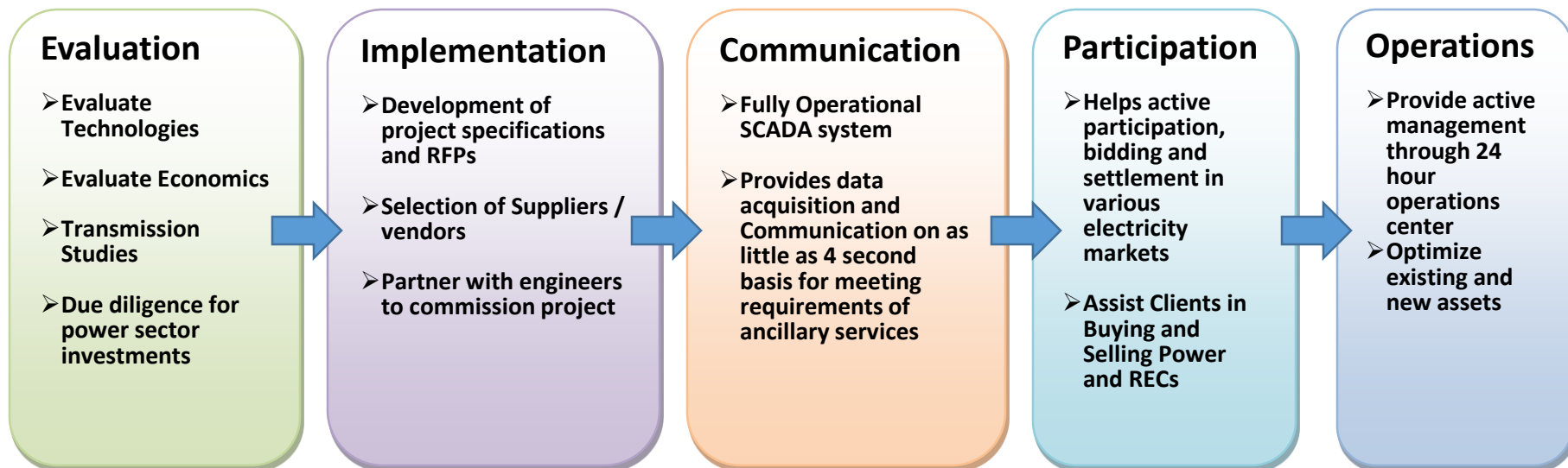
Confederation of
Indian Industry



India Smart Grid Forum

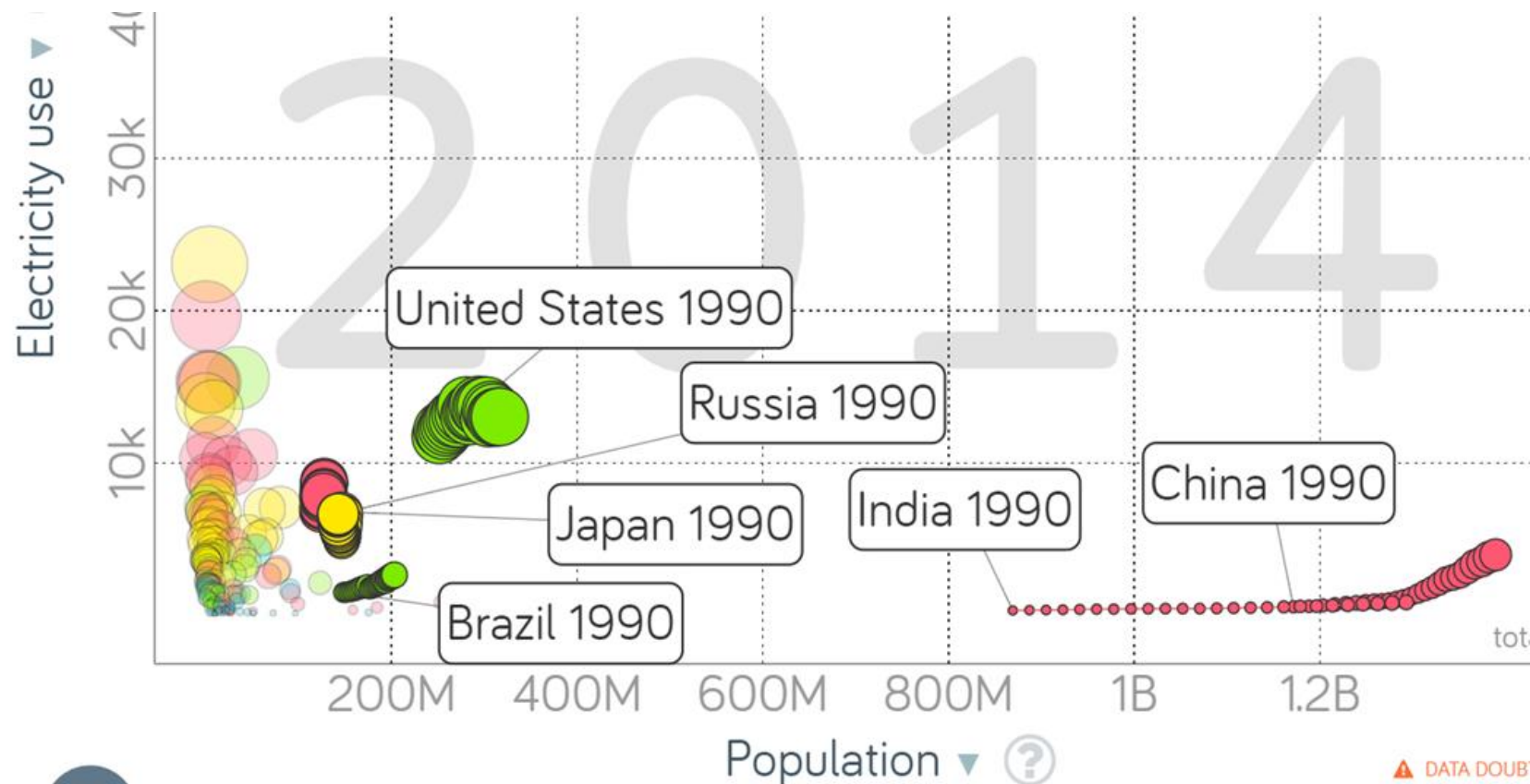
Customized Energy Solutions Provides a Full Suite of Services

Analyze . Simplify. Implement



Energy Scenario in India

India has ~343 GW installed generation capacity with a population of 132 Crores, while China has 1,650 GW capacity and US has 1,065 GW capacity for ~32.5 Crores population

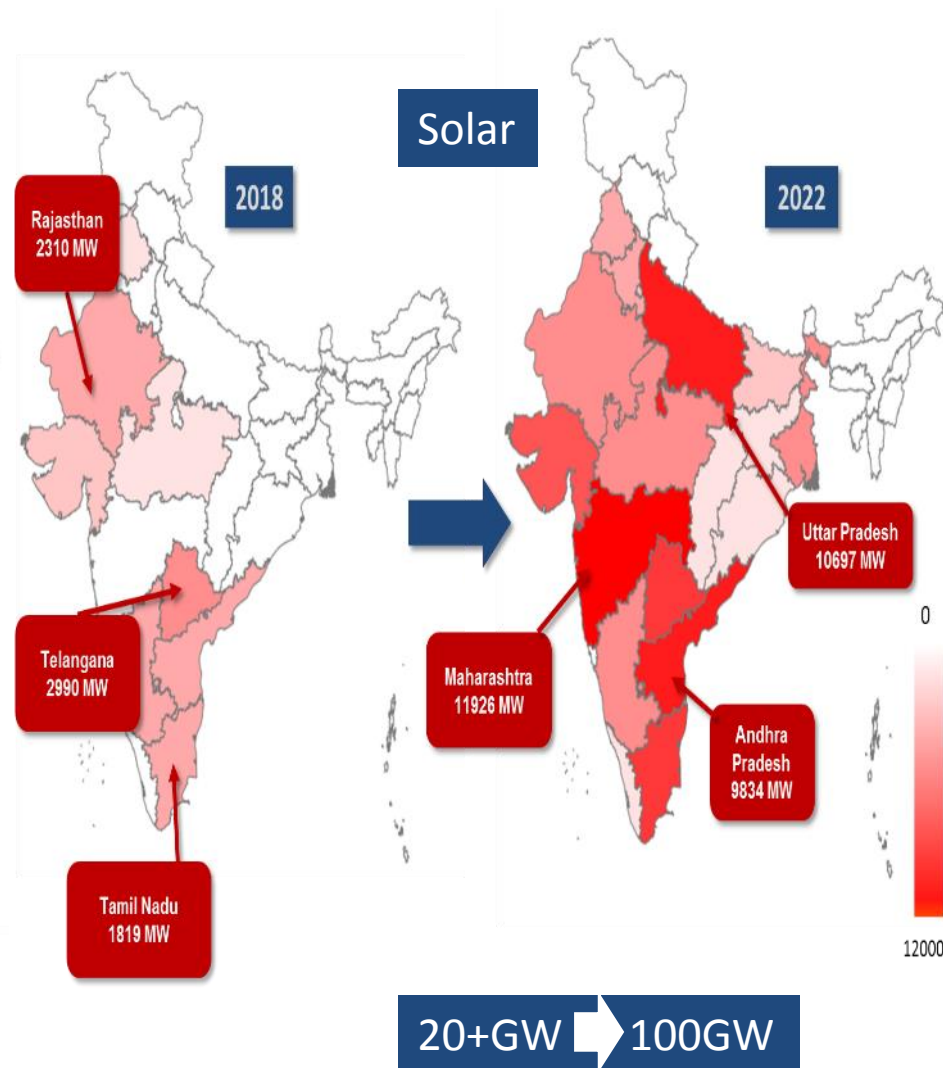
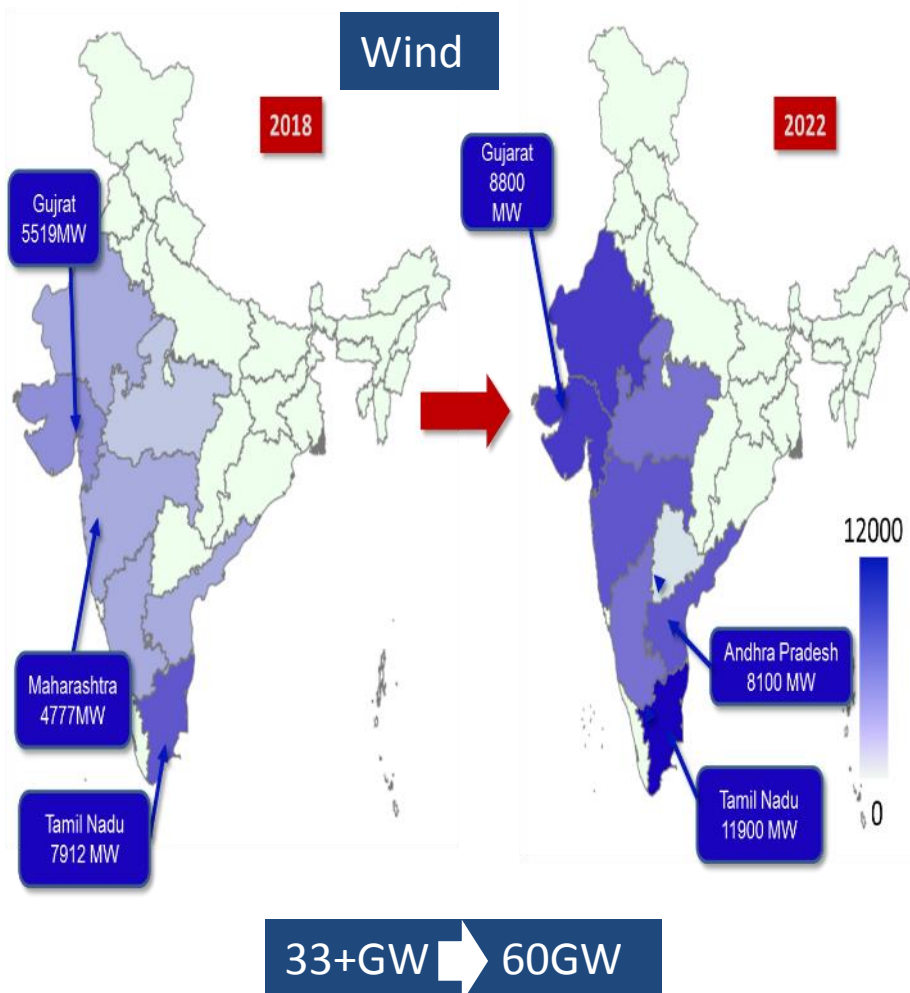


Per Capita Annual Energy Consumption in 2014 (Source: Gapminder.org)

US: 13,000 Japan: 7820, Russia: 6600, China: 3930, Brazil: 2600, India: 800 kWh/Yr

In 2017, India's per capita energy consumption was ~1200 kWh/ yr and MOP expects India's per capita energy consumption to double in the next 6 to 7 years, and then double again after 5 years.

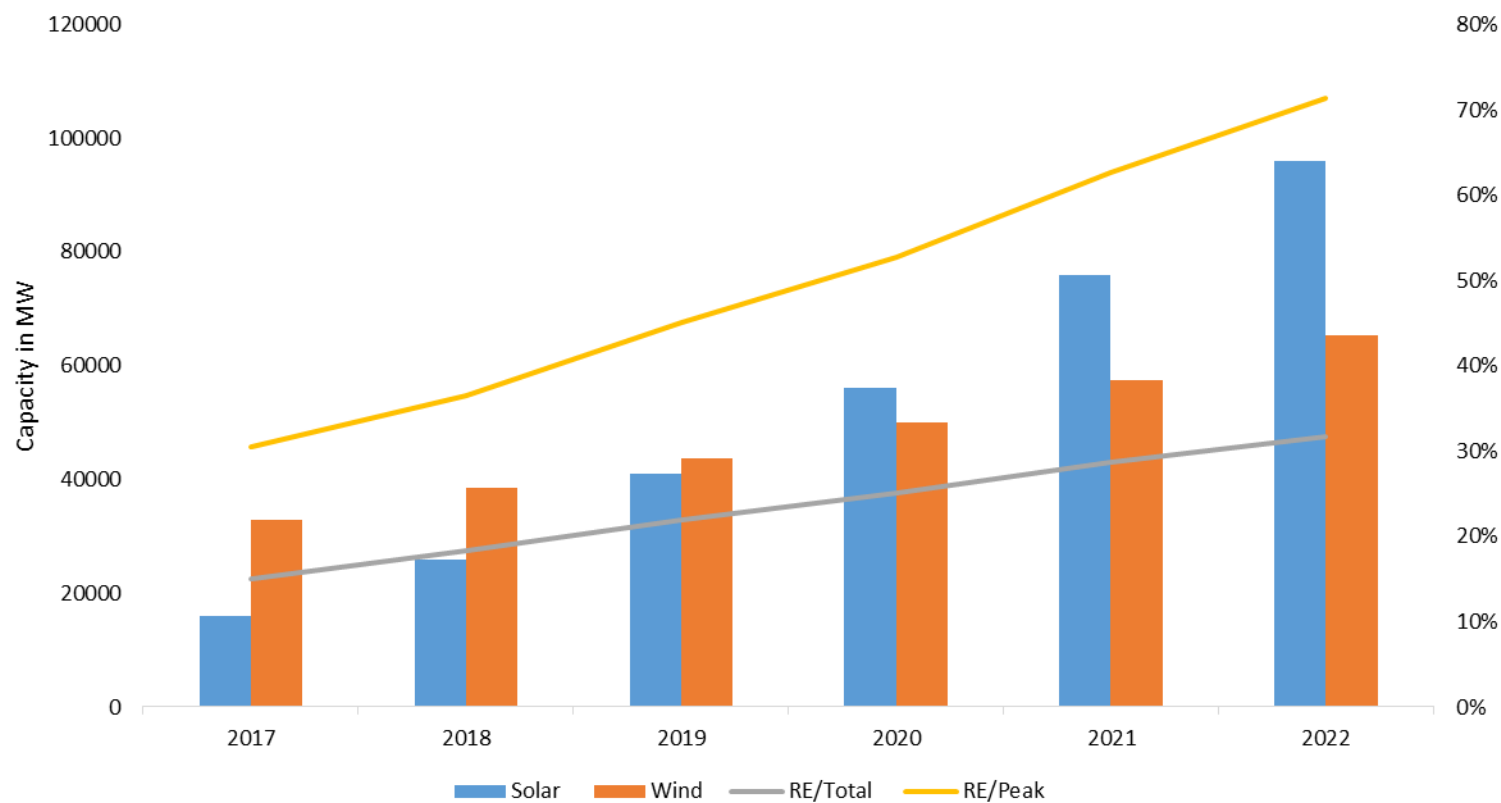
India's RE installations and targets





Evolving Supply Mix in Indian grid

Wind and Solar Cumulative Installed Capacity and %RE penetration (peak demand and capacity wise)

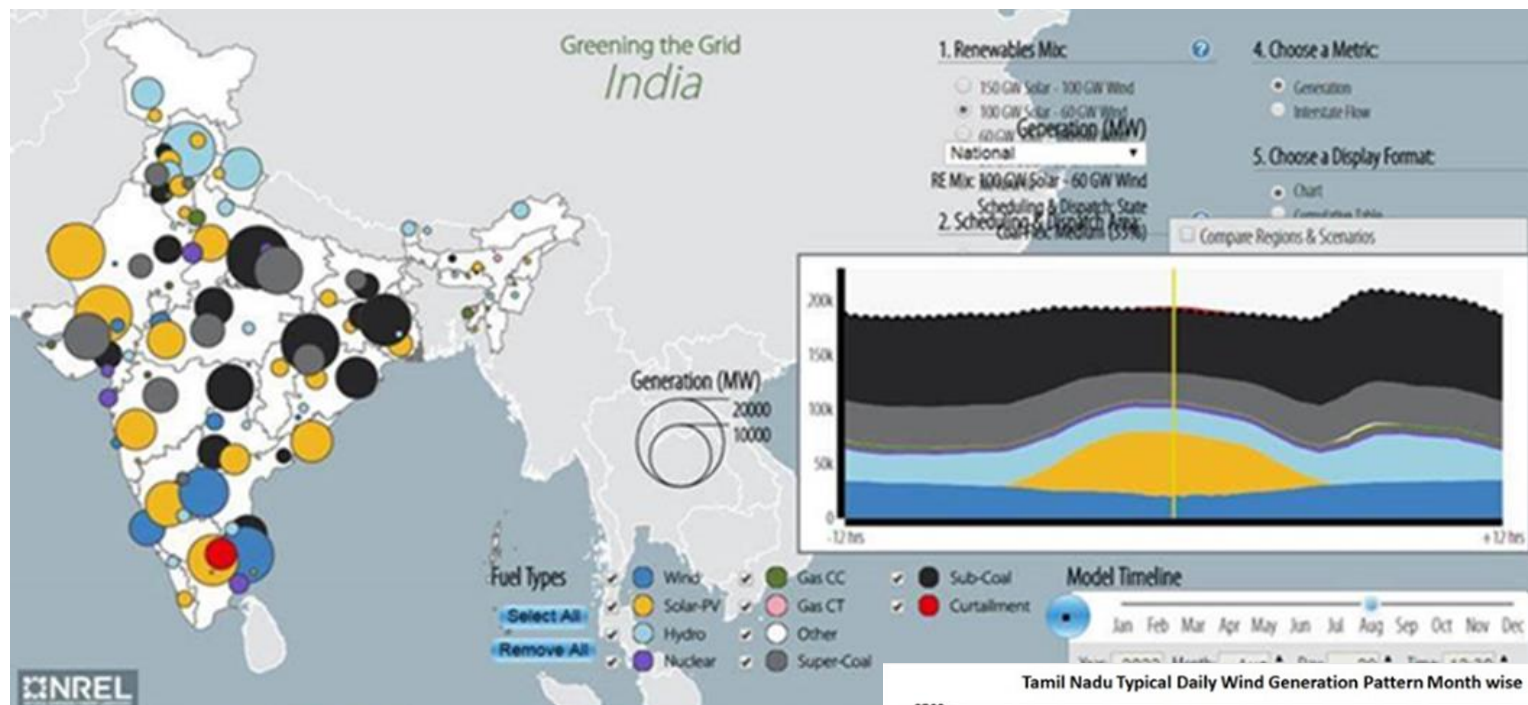


Source: NEP, EPS by CEA and CES analysis

Tremendous addition of wind and solar PV by 2022 to the Indian grid, traditionally designed for fossil fuel based generation, will lead to higher deviations and increased need for more flexible assets



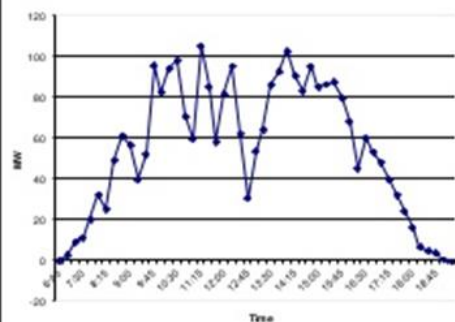
Greening the Grid: Modelling vs Reality



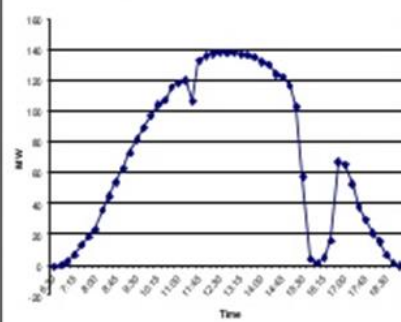
Varying Output:

Sudden Variation in Generation:

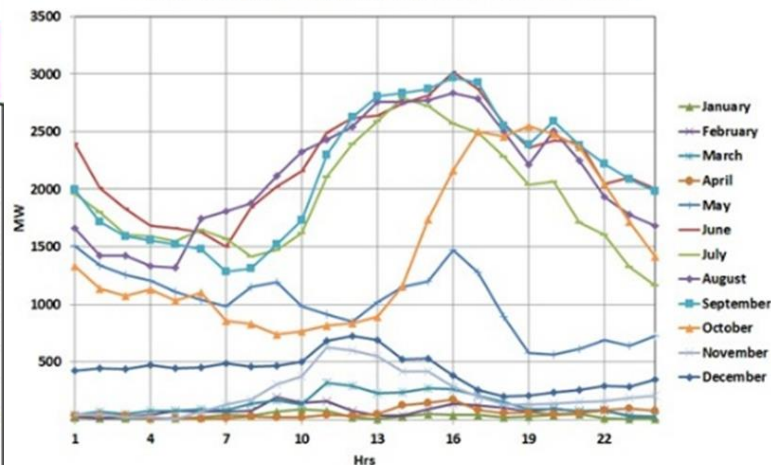
Charanka Solar Generation on 11.04.12



Charanka Generation on 13.04.12

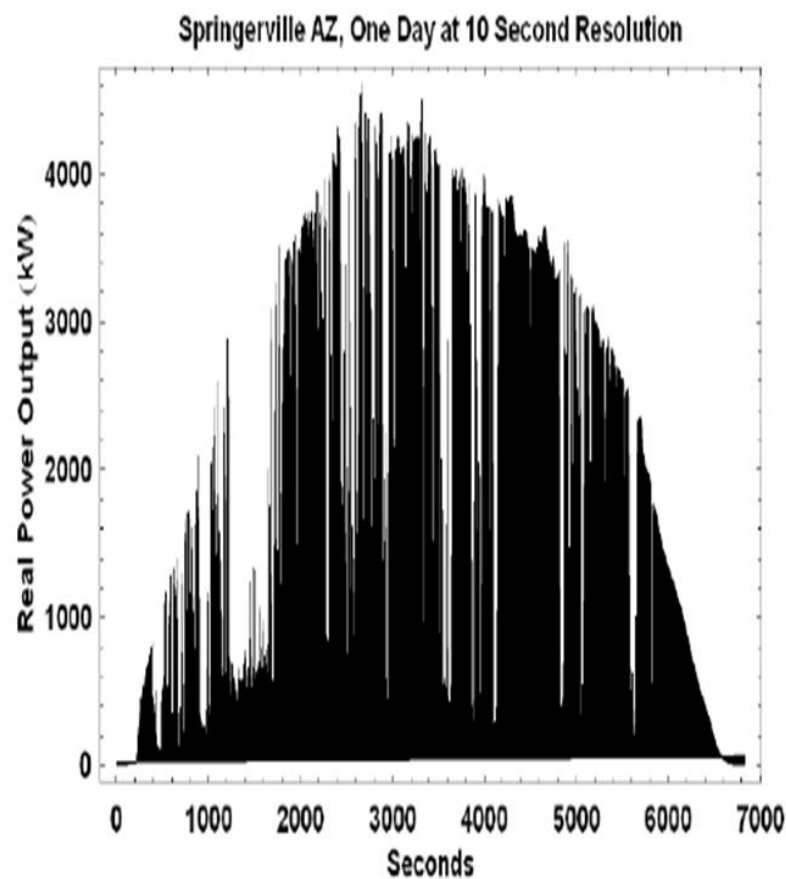
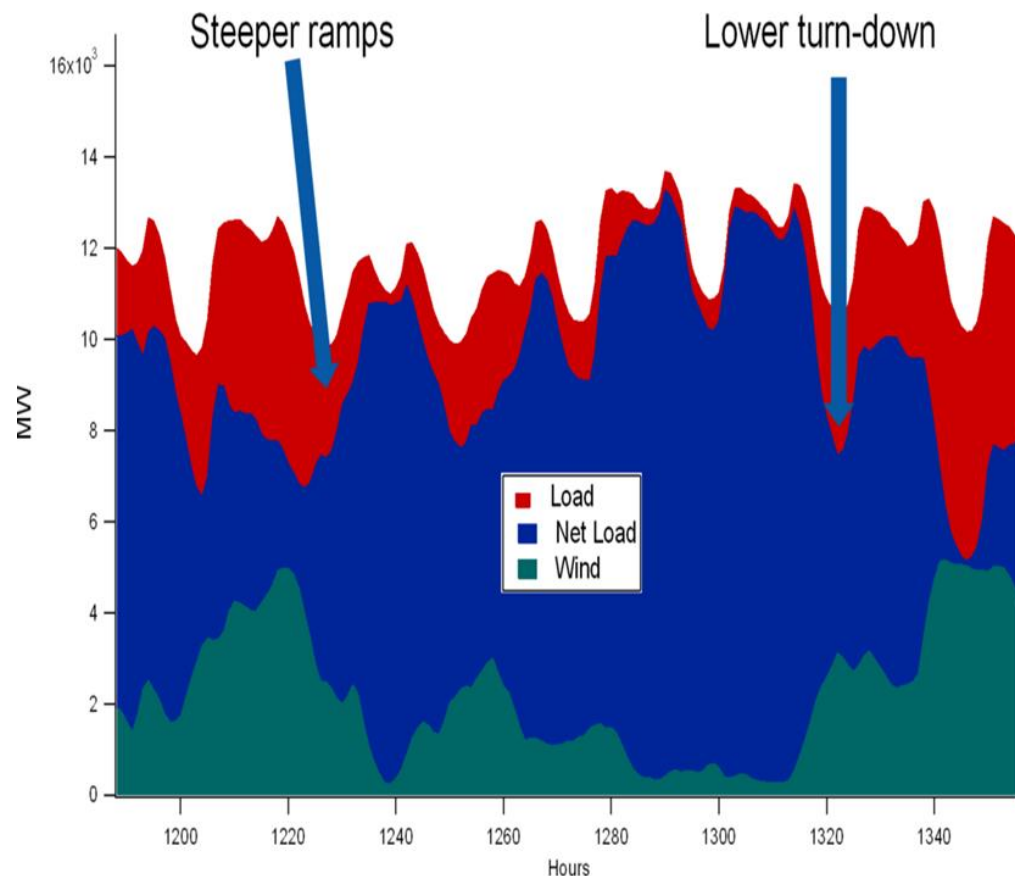


Tamil Nadu Typical Daily Wind Generation Pattern Month wise



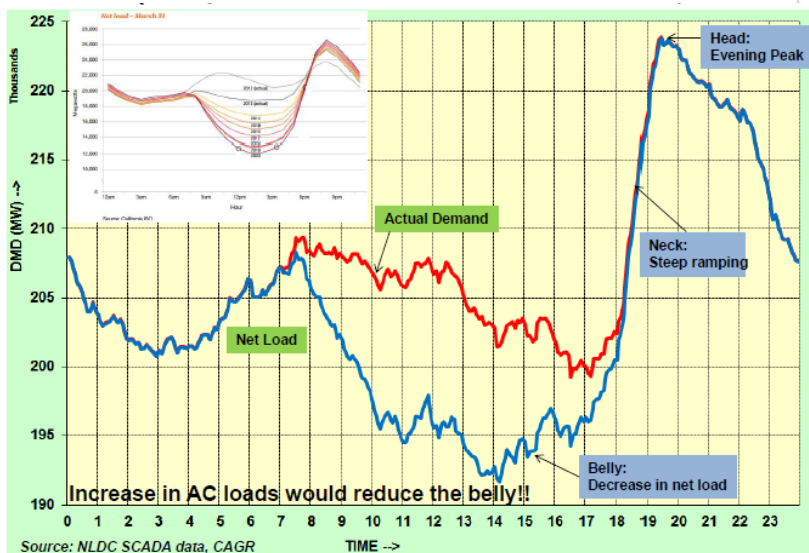


Challenges in renewables integration

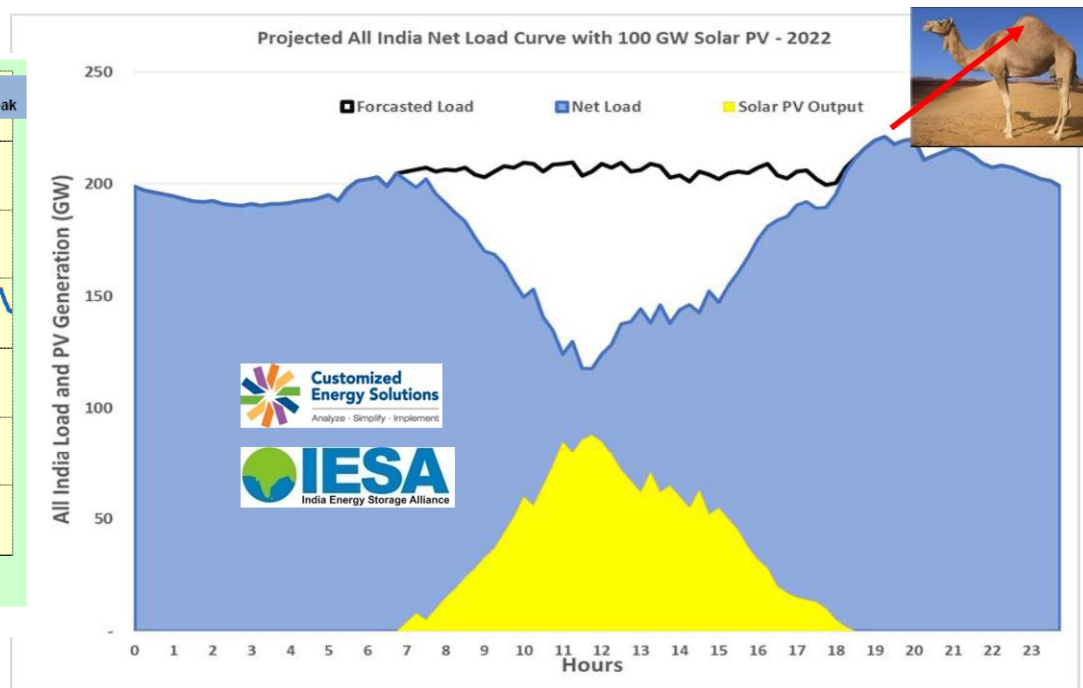


Source: Dr. Michael Milligan NREL / AWEA : Dr. Jay Apt, CMU

Expected India Net Load Curve 2022 (with 100 GW of solar generation)

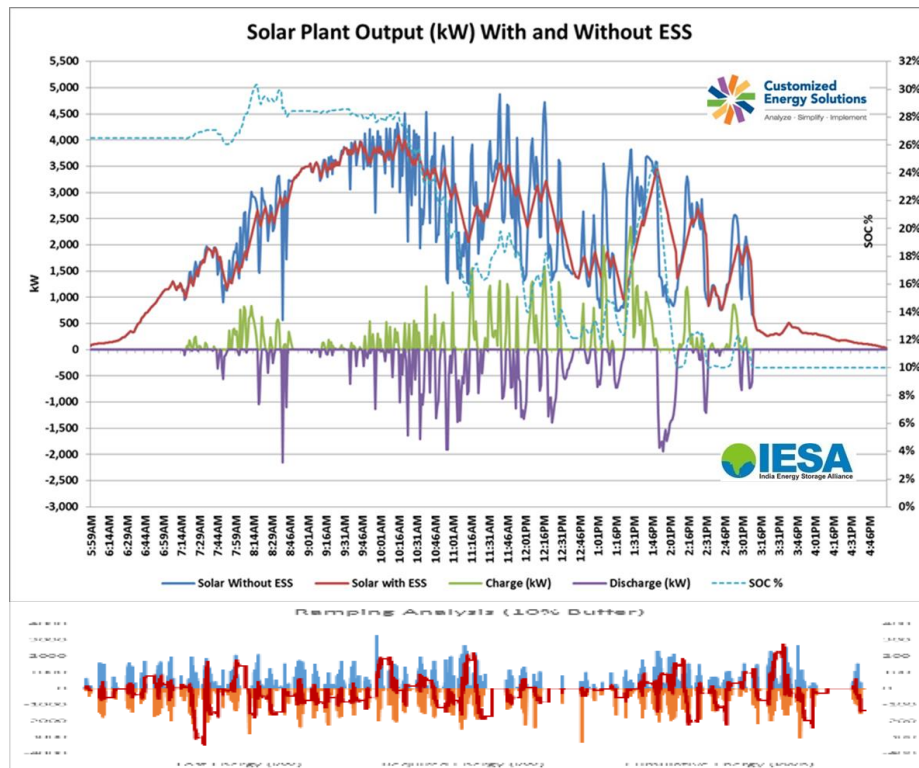


POSOCO's projections for India net load curve with 20 GW solar PV



IESA projections for India net load curve with 100 GW solar PV

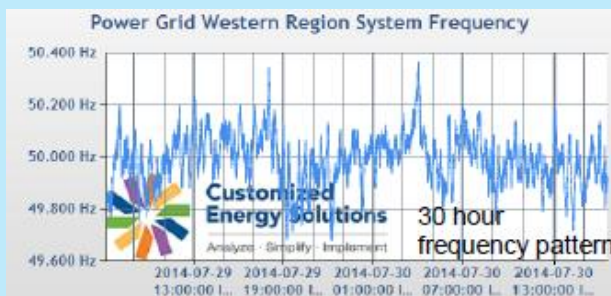
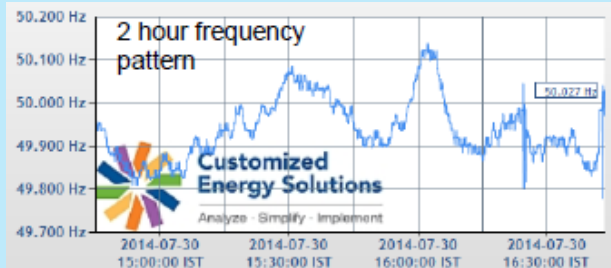
Solar + Storage Case Study on Port Blair, Andaman & Nicobar Island



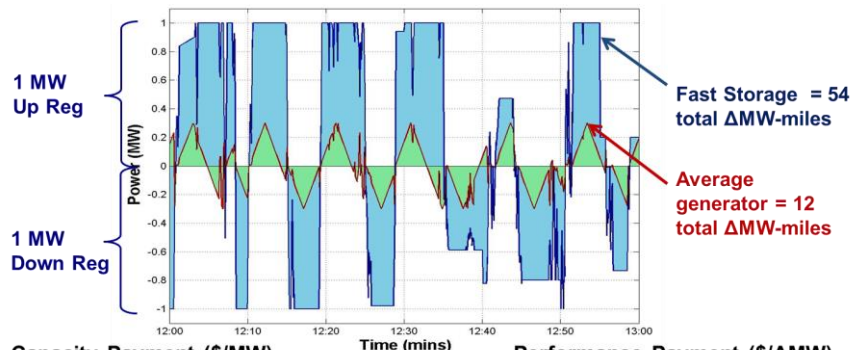
- Solar generation is inherently intermittent and supply may create very large instantaneous ramps.
- The problem will be accentuated in islands like Andaman and Nicobar, where currently diesel generators are used for providing base load as well as balancing service
- MNRE under Greening the Islands program is exploring deployment of 50+ MWh of energy storage with solar PV
- 1st project in this for 20 MW solar + 8 MWh storage is being implemented by NLC.
- There are 5-6 RFPs for additional projects with combined solar + storage capacity of 20 MWh being developed by NTPC and Indian Army

Island is dependent on diesel generators as primary source of electricity and balancing power, where solar variability is a major issue and opportunity for energy storage integration.

Grid Balancing Services: for improving grid power quality for the 21st century smarter grid



FERC Order 755: Pay-for-Performance

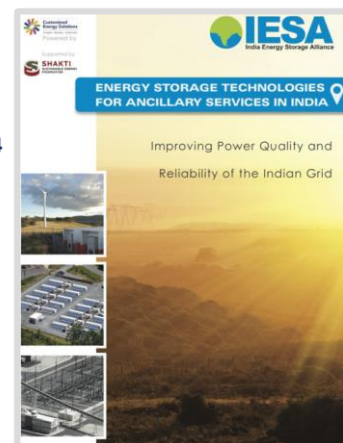


Capacity Payment (\$/MW)

- Amount set-aside (MW)
- Includes Opportunity Cost
- *May be adjusted based on state-of-charge*

Performance Payment (\$/ Δ MW)

- Sum of up and down movement "**mileage**" (Δ MW)
- Adjusted by **accuracy**



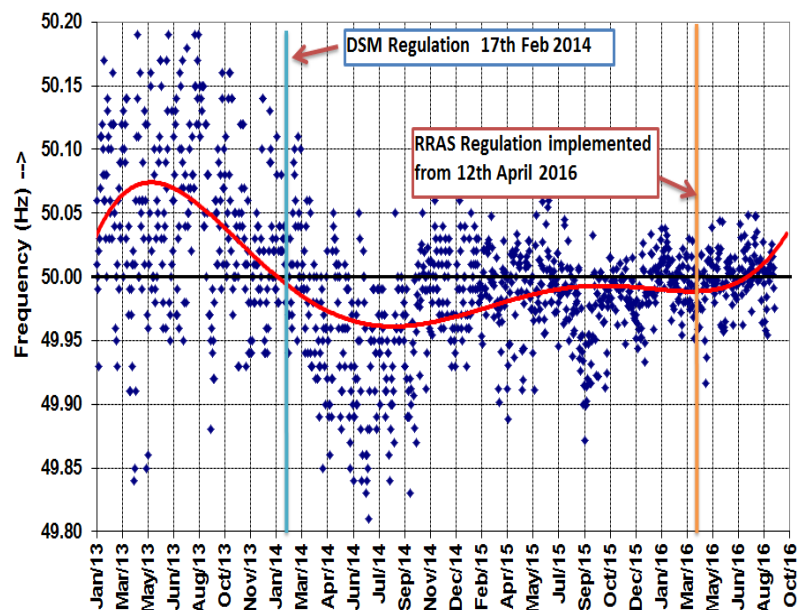
- Consumers have no ability to resolve the grid frequency on their own. In a synchronized grid this has to be managed by grid operators.
- India can address a significant part of the frequency issues by allocation of flexible resources hydro, gas based generation and EES.

IESA is leading efforts for promotion of the ancillary services by actively engaging policy makers, central electricity authority and other key stakeholders. Last year IESA released a report outlining the roadmap for adoption of EES for grid frequency regulation.

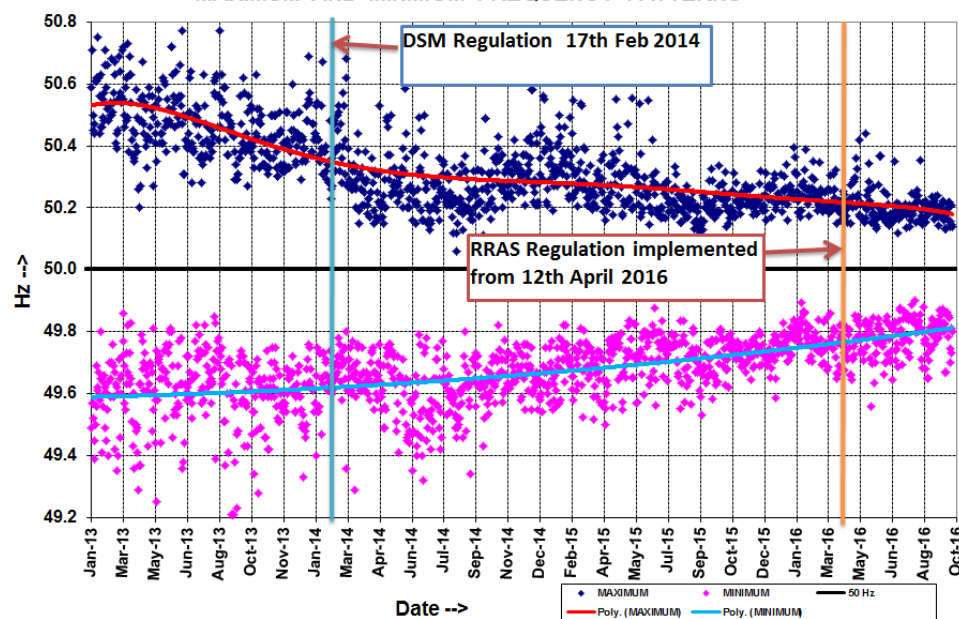
Improved frequency profile of Indian Grid

But significant scope for improvement remains

Pattern of Average Frequency



MAXIMUM AND MINIMUM FREQUENCY PATTERNS



The frequency has remained within the operating band for over 75% of the time
i.e. **over 20% of the time frequency is outside the band.**



Ancillary Services

Technology choice: Environmental Impact

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

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

India's National Mission on Electric Mobility

2010 – SIAM /
MOHI conduct
detailed study

2012 – Final
study report
released

2013 – NMEM
launched.
National Council
for E Mobility
formed

2014 – FAME
Scheme
Rollout

2018-
National EV
Policy

Vehicle / Technology Segment	Potential for xEVs (M units)
Battery Electric Vehicle (BEV) 2W	3.5 to 5
Hybrid Electric Vehicles (4W, Bus, LCV)	1.3 to 1.4
Other BEVs (3W, 4W, Buses, LCV)	0.2 to 0.4
Total	5 to 7

Objective

- Promoting adoption of a range of Electric Mobility solutions for India

Annual Crude Oil savings by 2020

- ~USD 2 billion

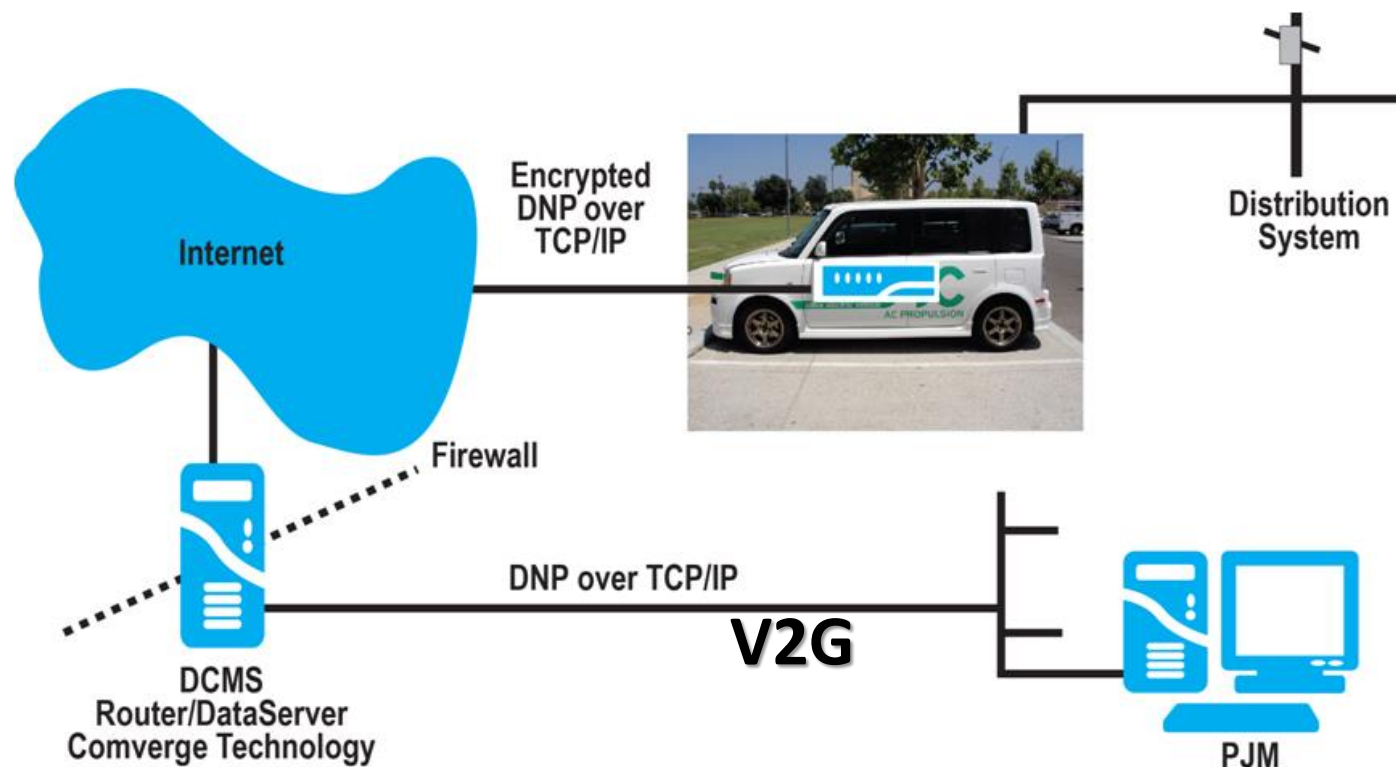
Reduction in CO2 emissions by 2020

- 1.3 – 1.5 %

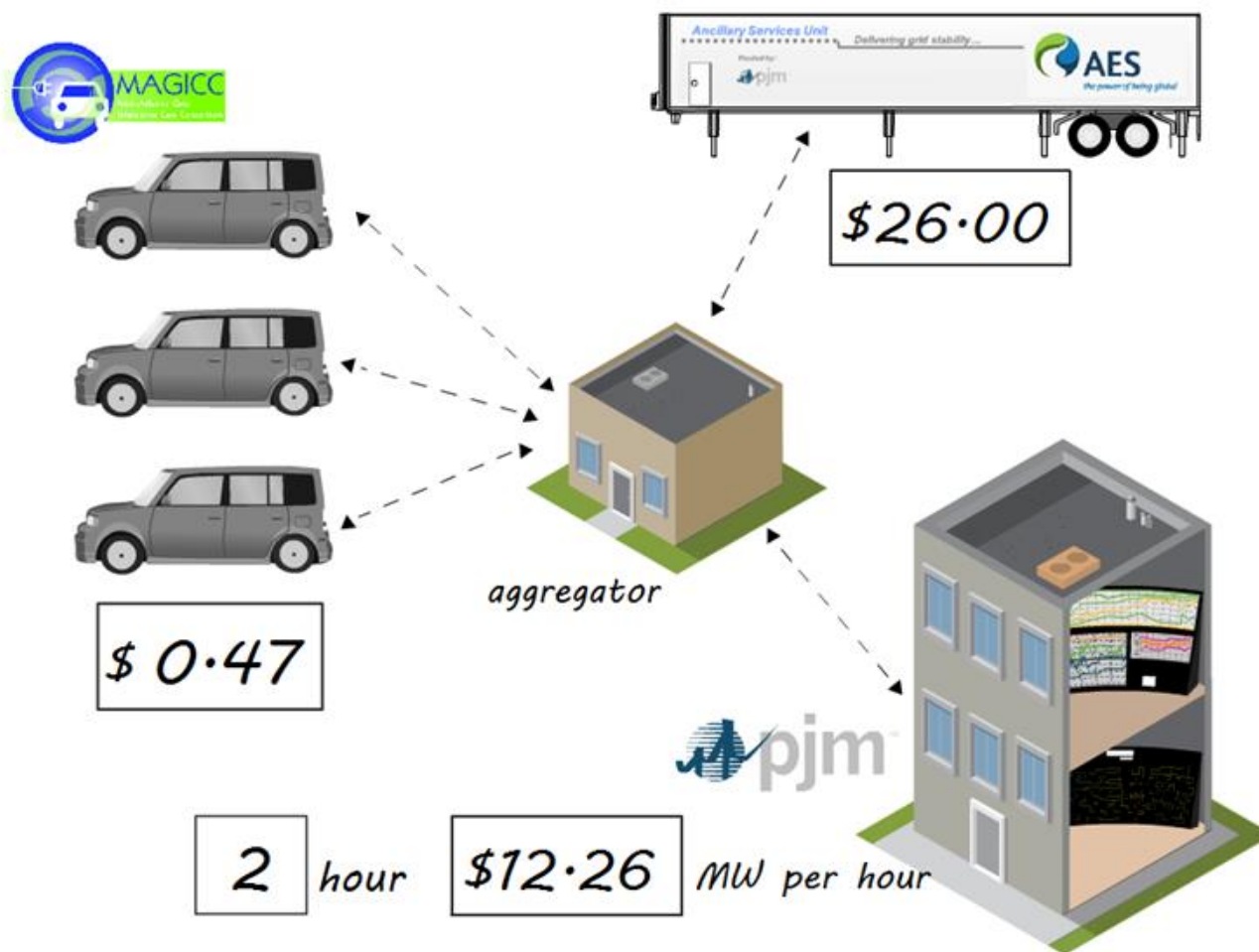




EVs can also become source of ancillary power for grid



PJM – EV participation in Ancillary Mkt



* Data taken from 01/11/10

Essential Elements to make V2G a Reality

- Technology
 - Regulations
 - Willing EV owners, high economic rewards and cooperative battery/vehicle manufactures
-

Technology

Suitability of EV batteries for grid services

- Would using an EV battery for anything but driving reduce the battery life?
- Would the warranty of battery be voided?
- Is there high enough economic incentive for an EV owner to consider V2G participation?

Bi-Directional Chargers/inverters

- On-board Bi-directional charging/discharging system connected to the grid or an intermediary storage
- Adds costs and complexity

Communications

- The vehicle needs on-board communications to respond to signals from the grid.
- The equipment should adhere to communications protocols
- Needs to develop standards for communication protocol

Controls

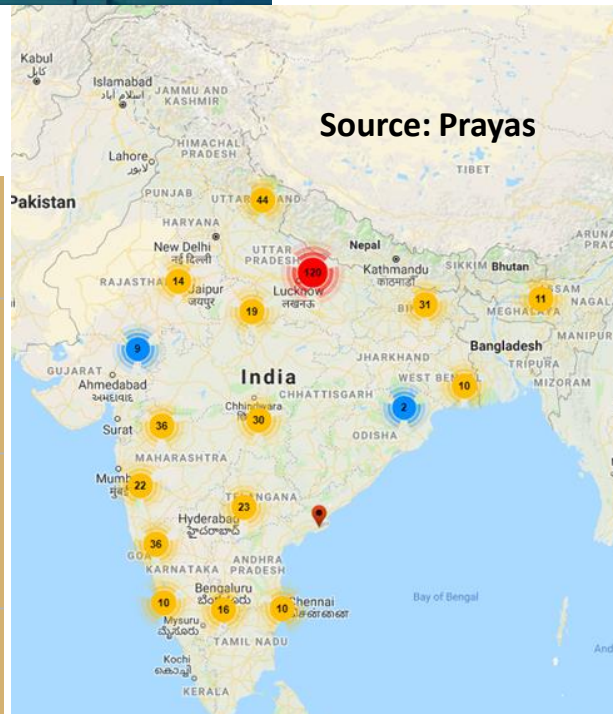
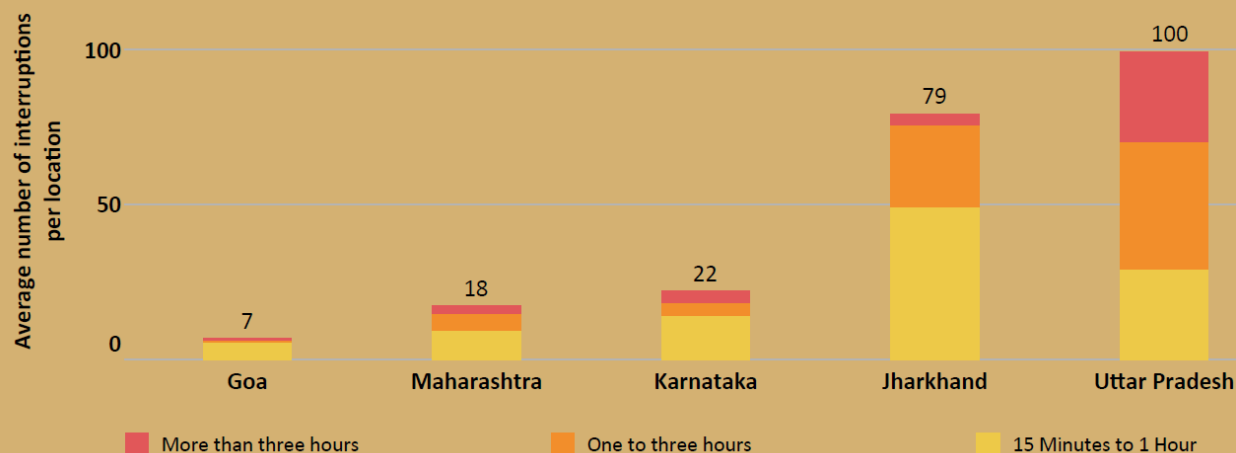
- Algorithms and protocols that ensure that the battery while serving Grid is not rendered useless for the primary of purpose of an EV- Drive.

Regulations

- Demand Response rules
 - Tariff that reimburse the vehicle owner for service to the grid.
 - ISO/RTO/utility rules on EV participation as power generation
 - Will require aggregating several EVs to meet the minimum size required to participate in the ancillary services market.
 - V2G market thus needs an aggregators, just like the one needed for demand response to reduce transaction costs and be an intermediary between grid and the EV
-

While significant improvements are taking place in overall generation availability and grid expansion, microgrids can help in improving the power quality and reliability.

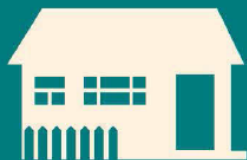
Supply Quality in Rural Areas - December 2017



ESMI Locations Receiving Entire Six Hours of evening supply



80%
Mega Cities



56%
Other Cities



10%
Rural Areas

In May 2017

65%

ESMI locations experienced outages for more than 15 hours

36%

ESMI locations experienced more than 30 interruptions, each greater than 15 min

27%

ESMI locations experienced average daily outage of 30 min or more during evening hours

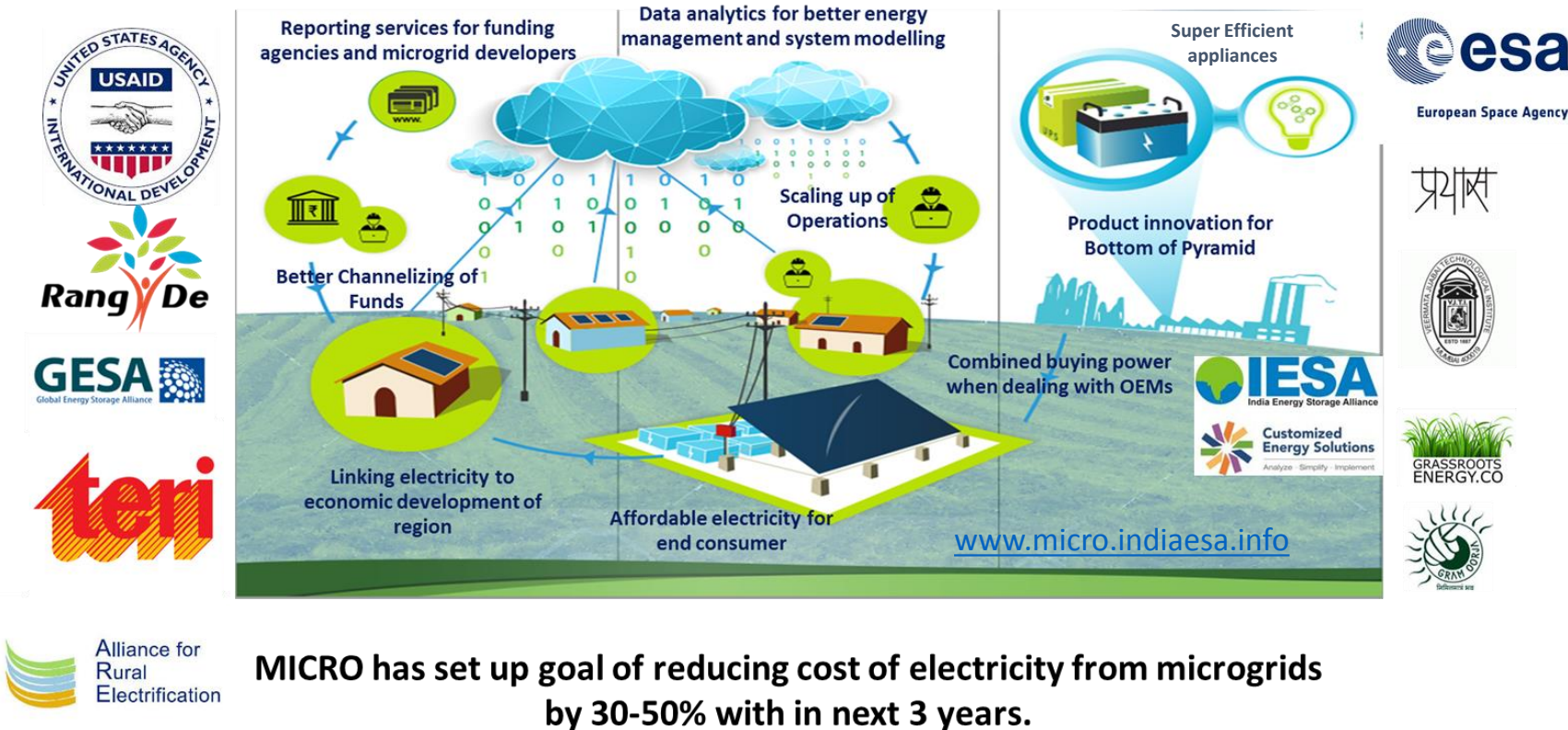
In December 2017

55%

33%

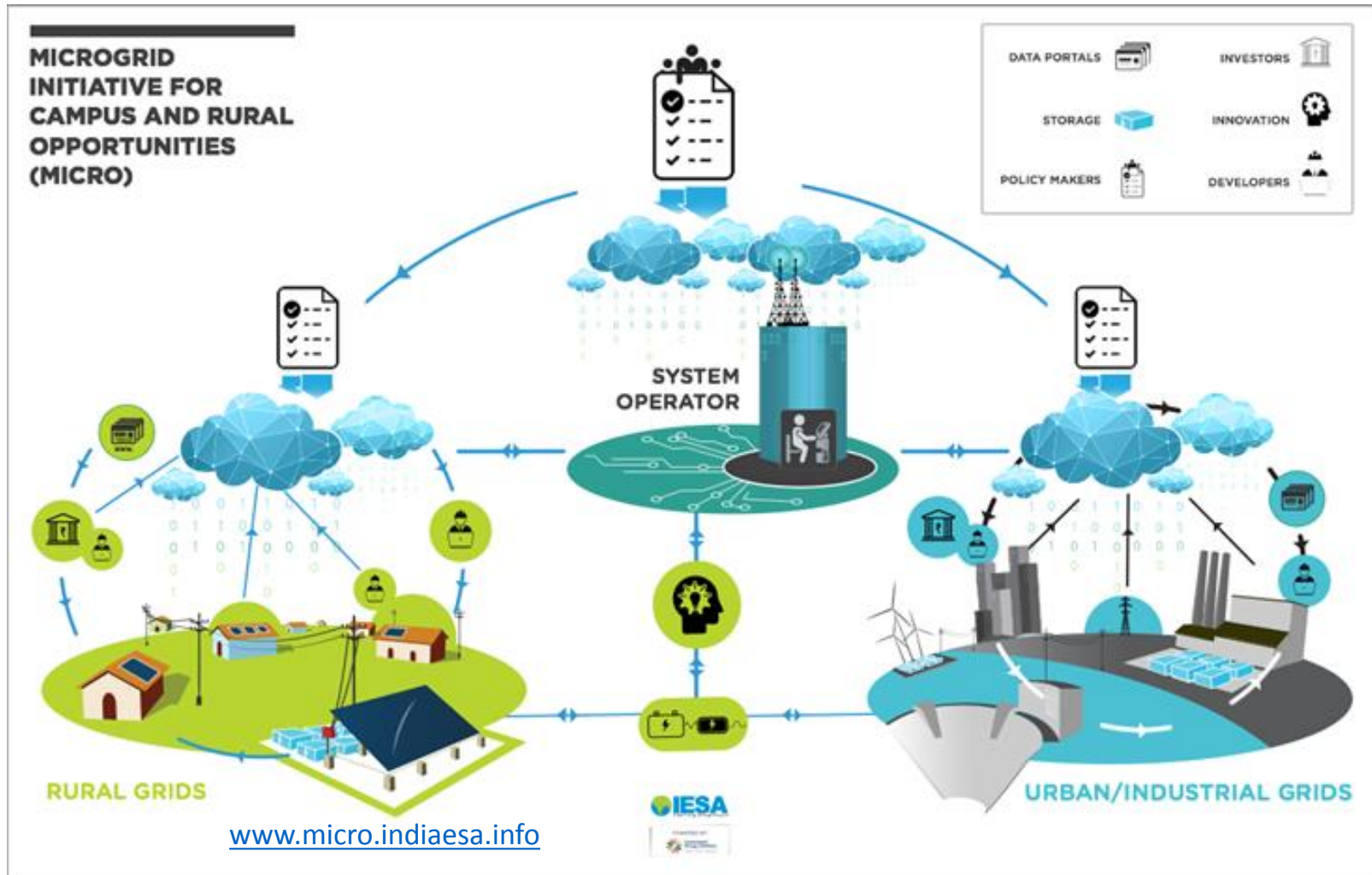
30%

Microgrid Initiative for Campus & Rural Opportunities (MICRO) – Phase 1





Campus & Rural Opportunities (MICRO)



The evolving policy framework for adoption of energy storage in India

ENERGY STORAGE



MAKE IN INDIA



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

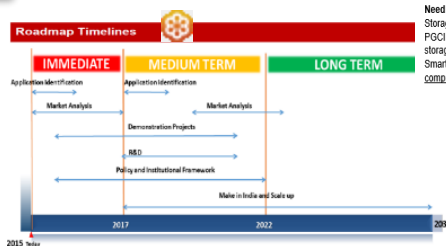
IESA recommendations for encouraging advanced Energy Storage Technology manufacturing in India

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 Firming, 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 KW), Gujarat GIFT RFP 40 MW storage, NTPC 20 MW solar – storage project in Andaman, SEC'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.



Large Scale Grid Integration of Renewable Energy Sources - Way Forward



Central Electricity Authority
November 2013



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



MNRE Expert Committee for National Energy Storage Mission

3. The composition of the Committee is as under:-

Secretary, MNRE	Chairman
Additional Secretary, MNRE	Member
Member, (Planning), Central Electricity Authority	Member
Joint Secretary (Smart Grid), Ministry of Power	Member
Adviser (Energy) , NITI Aayog	Member
Representative from Department of Heavy Industry	Member
Representative from Ministry of Environment, Forests and Climate Change	Member
Representative of Council of Scientific and Industrial Research	Member
Representative from ISRO	Member
Representative from CERC	Member
Representative from CII and FICCI	Member
Representatives from the C-WET/ NISE	Member
President – India Smart Grid Forum	Member
Representative from Indian Wind /Solar Association	Member
Executive Director, Indian Energy Storage Alliance	Member
Adviser (Energy Storage), MNRE	Member-Secretary

Key focus areas

- Energy storage for large scale RE at transmission level
- On-site energy storage integration at distribution level
- Rural micro-grids
- Storage component in EV plans

Objectives

- To strive towards leadership in the energy storage sector by creating an enabling policy and regulatory framework that encourages deployment, innovation and further cost reduction through multiple strategies.
- To clearly signal the Government Of India's strong and long-term commitment to the importance and need for energy storage in India;
- To facilitate market led technology deployment at scale across multiple applications and multiple geographies, while gaining valuable technology, policy and regulatory experience;
- To facilitate setting up of large scale integrated electric storage and electric vehicle manufacturing clusters that can also cover manufacturing of components and associated power electronics.
- To provide for job creation in manufacturing, project deployment value chain and associated skill development/training; and
- To set up a national portal of storage projects including regular monitoring of performance, costs, manufacturing etc., aspects that are crucial for knowledge sharing and dissemination.

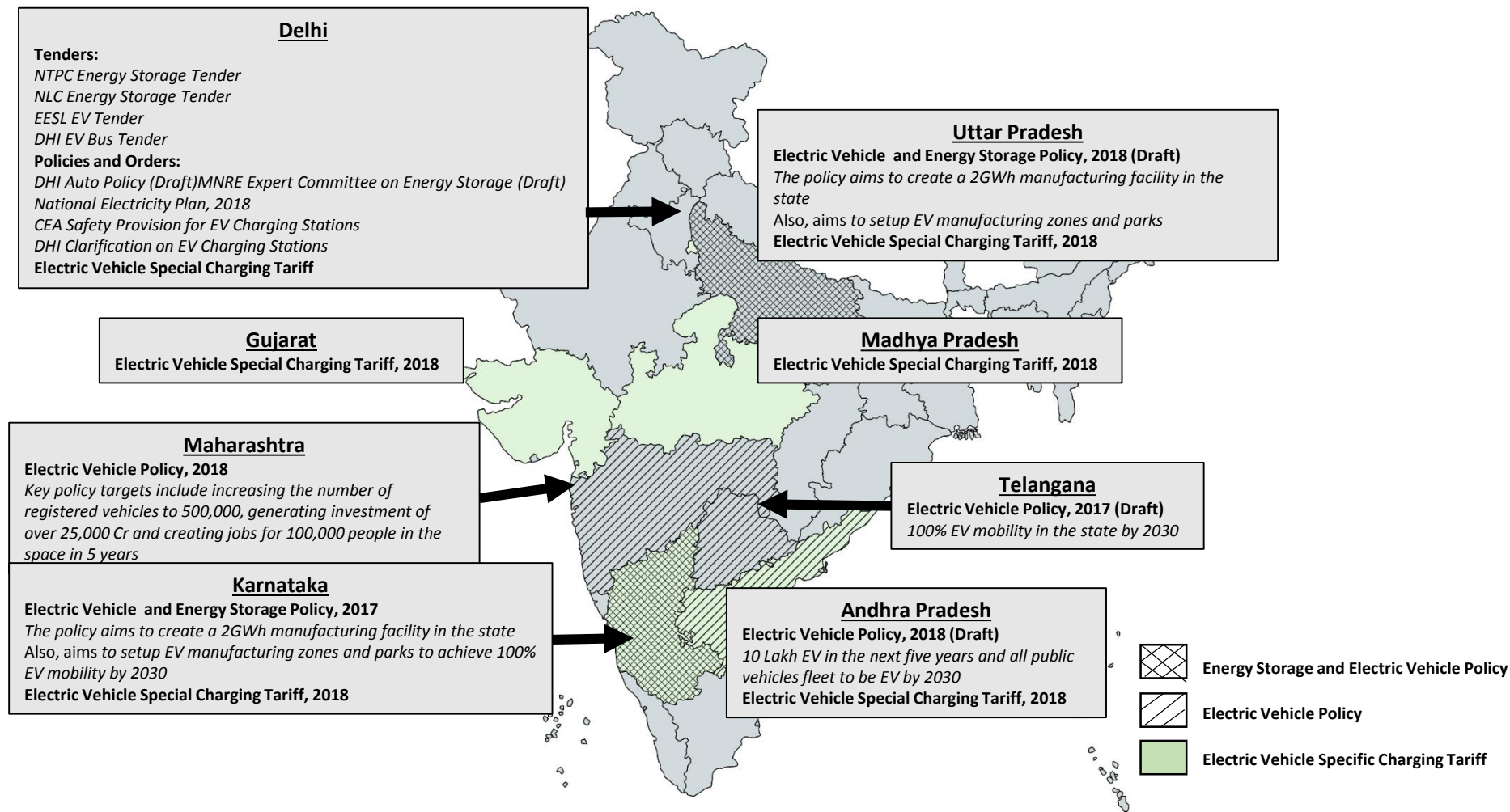
First phase (2018-2022)

- The first phase will focus on applications, wherein energy storage can immediately play a cost effective role, like in the case of integrating storage with
 - diesel generators to minimize diesel consumption
 - providing ancillary services to the grid
 - demand creation in various sectors / applications through mechanism for providing appropriate incentives for various large scale / aggregated storage projects.
- It is also vital to build confidence among stakeholders by deploying market based projects at scale and gain valuable technology, regulatory and policy experience in the coming 2-3 years in preparation for a potential large-scale proliferation of storage systems as they become even more cost-competitive.

Energy storage applications

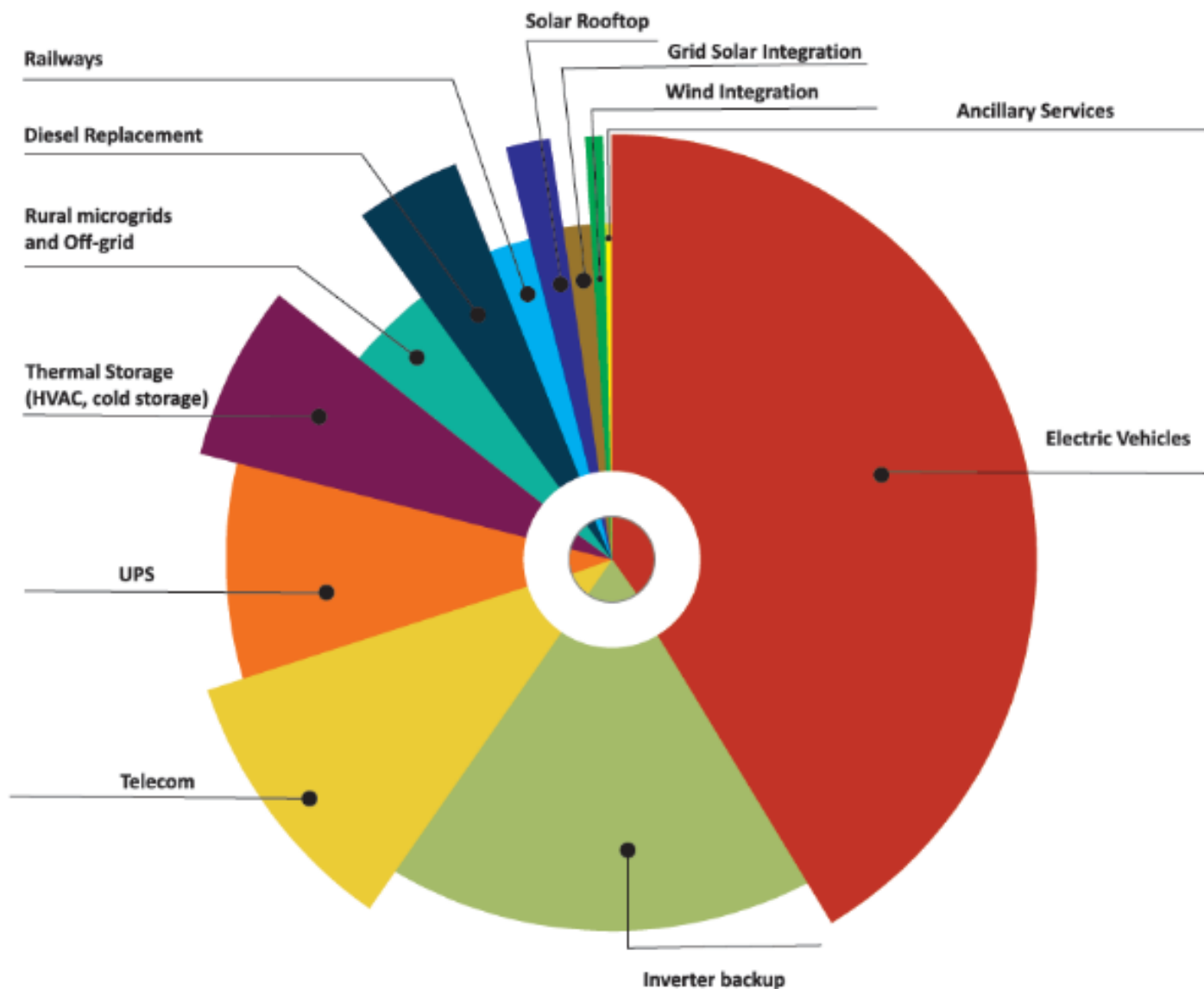
- 3.1 *To reliably increase the share of renewable energy*
- 3.2 *To rapidly enable the electrification of transport*
- 3.3 *To increase the electricity grid's (transmission and distribution) capacity and resiliency, power supply reliability, quality*
- 3.4 *To allow greater autonomy and choice for consumers, furthering competition*
- 3.5 *Micro grids and remote energy consumption*
- 3.6 Allow reduction in diesel consumption for backup power:
- 3.7 Reduce air-conditioning or process heating related to peak load requirement using thermal energy storage:
- 3.8 To facilitate setting up a National Watchdog Agency to oversee the Cyber Security

Current status of energy storage and EV Policies





Policy/Regulation	Expected by	Key Agency
Energy Storage Mission	July 2018	MNRE
National Energy Policy	July 2018	NITI Aayog
National EV Policy	Ongoing	NITI Aayog
Regulations on ancillary services	Dec 2018	CERC
State level EV policies	Ongoing	Multiple
Tenders for RE with energy storage	Ongoing	SECI/NTPC
Rationalization of taxes and duties	Ongoing	MoF/GST council



As per the latest Energy Storage India market overview report by IESA, the energy storage potential between now and 2025 will be around 300GWh.

India Energy Storage Alliance (IESA)

- IESA was launched in 2012 by CES to help technology and system integration companies involved in energy storage and microgrids to understand and capture opportunities in this growing market
- In 2013 launched IESA-Knowledge Partner Network with a goal of addressing energy storage applications in over 10 key sectors
- In 2016 created IESA leadership Council to help companies to play strategic leadership in developing IESA roadmap.
- For more details, visit www.indiaesa.info

IESA Members



IESA Initiatives

- Inputs for NITI Ayog for energy storage manufacturing policy:
 - Inputs to CERC, CEA, MNRE and MOP for energy storage policy framework:
 - Energy Storage Standards Roadmap:
 - MICRO - Microgrid Initiative for Campus and Rural Opportunities:
 - MOVE - Electric Vehicles initiative & annual EV conference with ICAT
 - Utility working group:
 - CES-Global Energy Storage Index: <http://gesi.indiaesa.info/>
 - India Energy Storage Database: <http://iesdb.indiaesa.info/>
 - IESA Energy Storage Hotline (1-800-123-3519):
 - IESA Skill development initiative
 - Energy Storage and Microgrid focused incubator at VJTI, Mumbai
-

IESA Approach for driving Industry – Academic Collaboration



LABSCALE TO COMMERCIALIZATION

- Prototyping of developed material or design innovations
- Gathering input from industry and policy makers on needs for next generation solutions

INTERNSHIPS

- Exchange students for pursuing research projects in India
- Actively engaging with Indian partners (manufacturers, policy makers and researchers) for understanding needs and opportunities in India



FUNDING OPPORTUNITIES

- Global Innovation and Technology Alliance (GITA). India collaboration with UK, Spain, Israel, Taiwan, Korea, Finland and Canada
- USAID funding for addressing Energy, Environment and Global Climate Change concerns

ACCELERATOR

In order to promote fast growth in the energy storage domain an accelerator has been planned.

Researchers with innovative technologies can avail the benefits of fabrication, prototyping and industrial testing of their lab-scale setups

Active engagement with key members from the industry who can act as mentors to guide young and enthusiastic researchers and also assist with commercialization.

Research Groups currently part of IESA- Knowledge Partner Network



Innovation possibilities are limitless in energy storage. They could be at a materials, design, controls, packaging or system level. Some ideas for general improvement trends are presented in the next few slides. More IDEAS are always welcome!

India focused Funding Opportunities

- GITA funding for cooperation on Industrial R&D (Funding amount 1.5 cr for 3 years) – Indian counterpart – Department of Science and Technology (DST)
 - India-Israel
 - India-Finland
 - India-UK
 - India-Spain
 - India-South Korea
 - India-Taiwan
- ASEAN – India Science and Technology Development Fund
- Atal Incubation Centers as part of Atal Innovation Mission by Niti Aayog
- UI-ASSIST: US-INDIA COLLABORATIVE FOR SMART DISTRIBUTION SYSTEM WITH STORAGE
- Technology Acquisition and Development Fund (TADF) under Department of Industrial Policy and Promotion (DIPP) has funding available for Green Manufacturing
 - Direct Funding Support for Technology Acquisition
 - Indirect Funding Support through Patent Pools
 - Subsidy for manufacturing water conservation/Pollution control equipment
 - Incentives for Energy, Environment and Water Audits
 - Incentives for construction of green buildings
 - Subsidy for implementing waste water treatment facilities

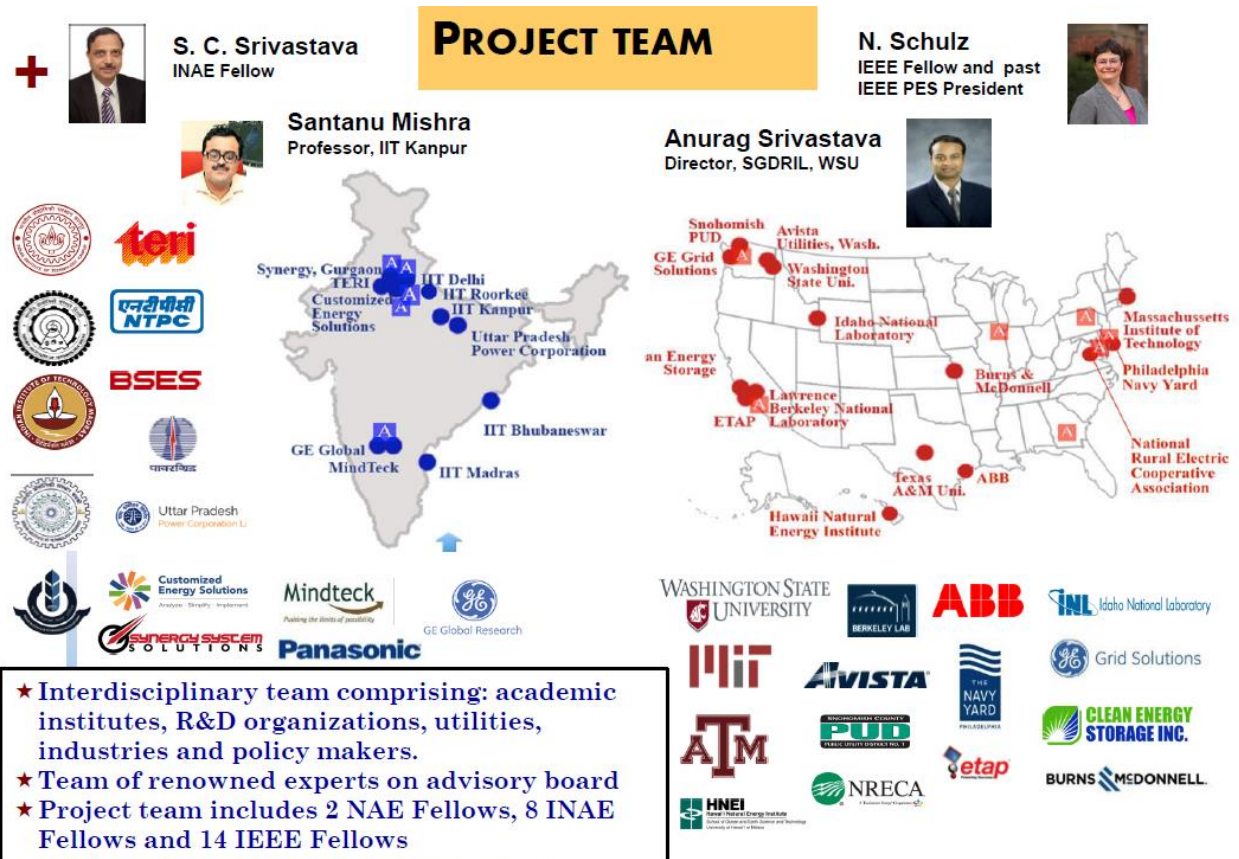


INFLUENTIAL INDIANS IN ENERGY STORAGE & MICROGRIDS

US-India collAborative for smart diStribution System wltH Storage

Part of **Indo-U.S. Joint Clean Energy Research and Development Center (JCERDC)** by funding new research in two areas critical to improving the reliability, flexibility and efficiency of the electricity delivery system - **Smart Grids and Energy Storage.**

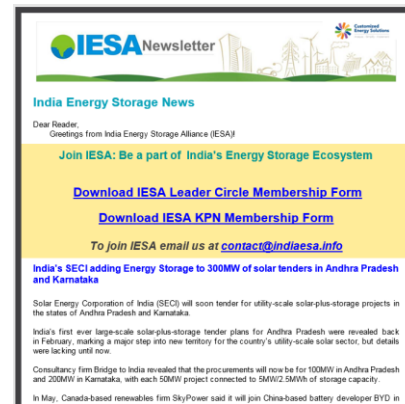
The program will be administered in India by the bilateral Indo-U.S. Science and Technology Forum (IUSSTF) and in the U.S. by the Department of Energy.



Stay informed about India opportunities

Subscribe to free IESA newsletter or download the quarterly magazine Emerging Technology News at www.indiaesa.info

Members also get access to RFPs / Tenders in members only section



IESA-KPN Information Bulletin

IESA - Newsletter

IESA – Project/Tender Alert

IESA – Policy Update



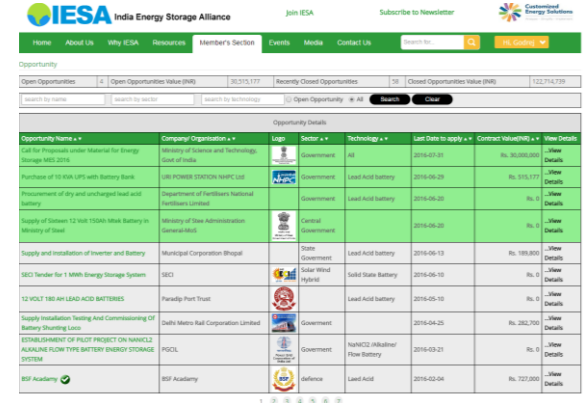
IESA – Resource Section

IESA – Industry News

▼ 2016

▼ October

- Hero MotoCorp To Invest Up To ₹ 205 Crore In Ather Energy
- Mahindra launches new electric car 'e2oPlus'
- NTPC plans 50MW solar with battery storage on Indian islands
- Changing mobility: Ashok Leyland and DHL bet on electric vehicles



Open Opportunities	Open Opportunities Value (INR)	Recently Closed Opportunities	Closed Opportunities Value (INR)
1	12,174,177	0	12,174,177

Opportunity Name	Company / Organization	Logo	Sector	Technology	Last Date to apply	Contract Value (INR)	View Details
4 th International Conference and Exhibition on Energy Storage & Microgrids in India	Department of Science and Technology, Govt of India		Government	AS	2016-03-01	Rs. 30,00,00,000	View Details
Purchase of 10 MW LFP with Battery Bank	LSR POWER SYSTEMS PRIVATE LTD		Government	Lead Acid Battery	2016-06-28	Rs. 10,11,17,171	View Details
Procurement of dry and uncharged lead acid battery	Department of Fisheries National Fisheries Limited		Government	Lead Acid Battery	2016-06-20	Rs. -	View Details
Supply of Station 12 Volt 100Ah VRLA Battery in Ministry of Steel	Ministry of Steel Administration General Staff		Central Government	Lead Acid Battery	2016-06-20	Rs. -	View Details
Supply and installation of Inverter and Battery	Municipal Corporation Bhagal		State Government	Lead Acid Battery	2016-06-13	Rs. 1,89,80,000	View Details
SECI Tender for 1 MWh Energy Storage System	SECI		Solar Wind Hybrid	Solid State Battery	2016-06-10	Rs. -	View Details
12 VOLT 180 AH LEAD ACID BATTERIES	Paradip Port Trust		Government	Lead Acid Battery	2016-05-10	Rs. -	View Details
Supply Installation Testing And Commissioning Of Battery Storage Unit	Dash Metro Rail Corporation Limited		Government	NA/NC2 /Inverter/ Flow Battery	2016-04-25	Rs. 202,70,000	View Details
ESTABLISHMENT OF PILOT PROJECT ON NANOLINE ALKALINE FLOW TYPE BATTERY ENERGY STORAGE SYSTEM	PGCIL		Government	NA/NC2 /Inverter/ Flow Battery	2016-03-21	Rs. -	View Details
BSF Academy	BSF Academy		Defence	Lead Acid	2016-03-04	Rs. 1,02,00,000	View Details

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