Regional Conference on Energy Resilience through
Decentralized Power Plants and Smart Grid Integration

Implementing Decentralized Renewable Energy Projects Integrated With Smart Grids - Challenges and Opportunities

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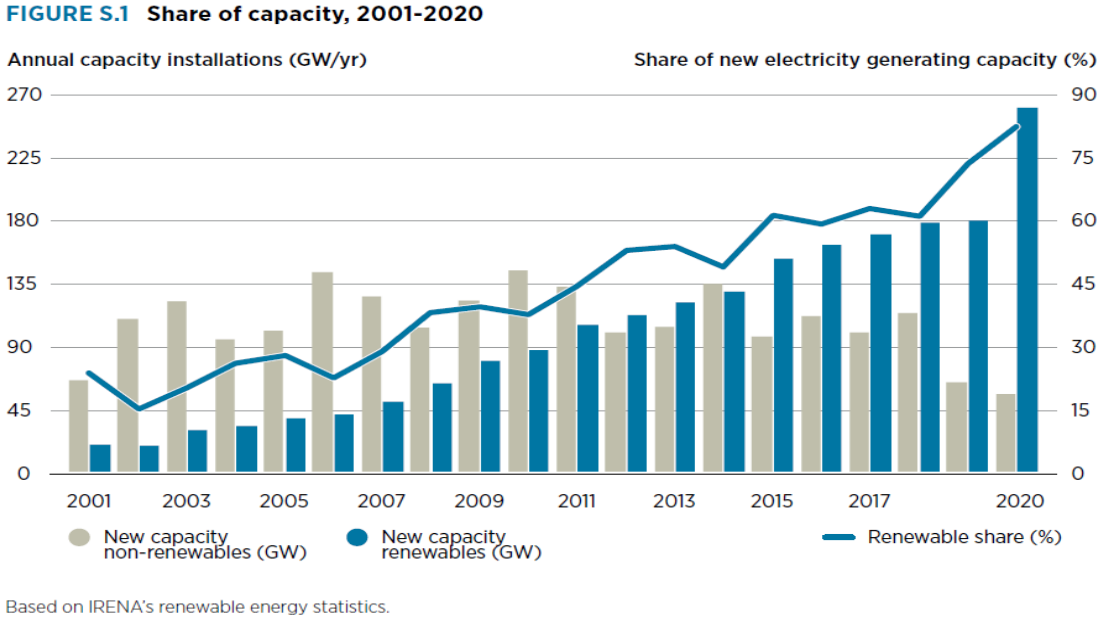
Decarbonizing the Global Energy Sector by 2050

Per IEA estimates, annual addition of 630 GW of Solar and 390 GW of Wind by 2030 is required to achieve the emission reductions needed to limit global temperature rise to 1.5°C

- Solar Energy - *more than TWICE the record highest levels of Solar addition of 280 GW in 2020*
- Wind Capacity - *almost FIVE TIMES the Wind capacity additions in 2020*
- Net Zero by 2050 - *90% of the energy from RE by 2050 – compared to 20% presently; 306 million-tons of Green Hydrogen per year by 2050*
- Estimated US$ 5 trillion annual investment by 2030 onwards
- Global Installed Power Generation Capacity is 7.78 TW of which 2.98



One Terra-Watt (TW) + a year of RE addition to the grid poses serious challenges!

IEA Report - Net Zero by 2050: A Roadmap for the Global Energy Sector:
https://iea.blob.core.windows.net/assets/4719e321-6d3d-41a2-bd6b-461ad2f850a8/NetZeroby2050-ARoadmapfortheGlobalEnergySector.pdf

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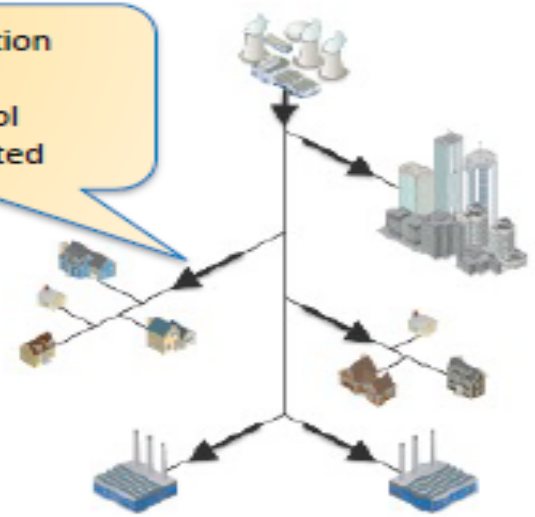
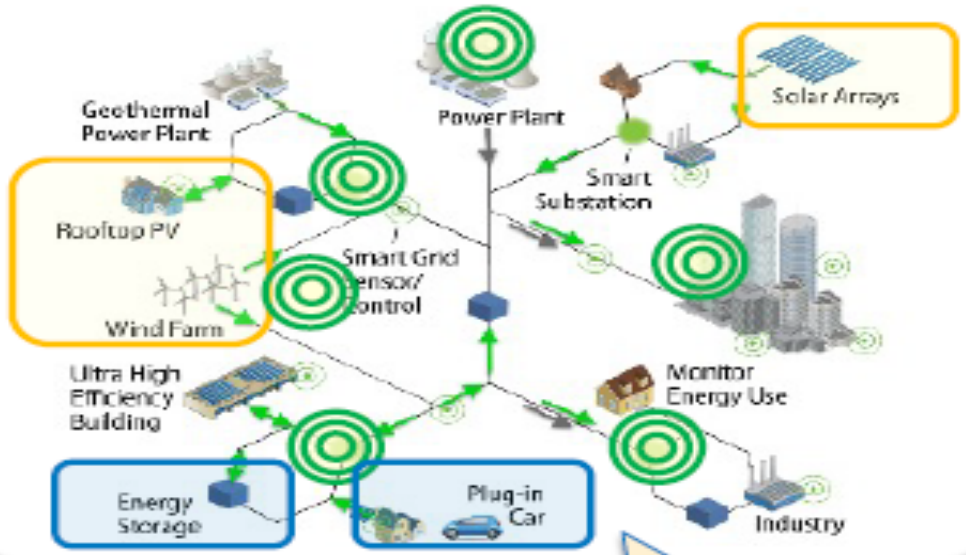
Smart Grids – Key to System Flexibility

Traditional Power System

- Large Generation Systems
- Central Control
- Highly Regulated



Modern Power Systems



Smart Grid Features

- New communications and control capabilities
- New energy technologies and services
- Increasing share of variable distributed energy resources
- Microgrids, energy storage systems, electric vehicles, smart appliances

DIGITALIZATION LEADING TO INCREASED SYSTEM FLEXIBILITY

DRIVERS

- Increased variable generation
- More bi-directional flow at distribution level
- Increased number of smart/active devices
- Evolving institutional environment
- A plethora of DERs

Brief Overview of Indian Power System

- Third largest power system in the world: 403 GW; 300 million customers; 3 million Sq-km in one frequency: ***One Nation – One Grid***
- 168 GW of Renewable Energy
- Last 4 years India added more RE capacity than conventional generation capacity
- 5 Regional Control Centers and a National Control Center
- One of the largest Wide Area Monitoring System (WAMS) on the transmission network

IEA Projections of Indian Power System

(capacities in GW)

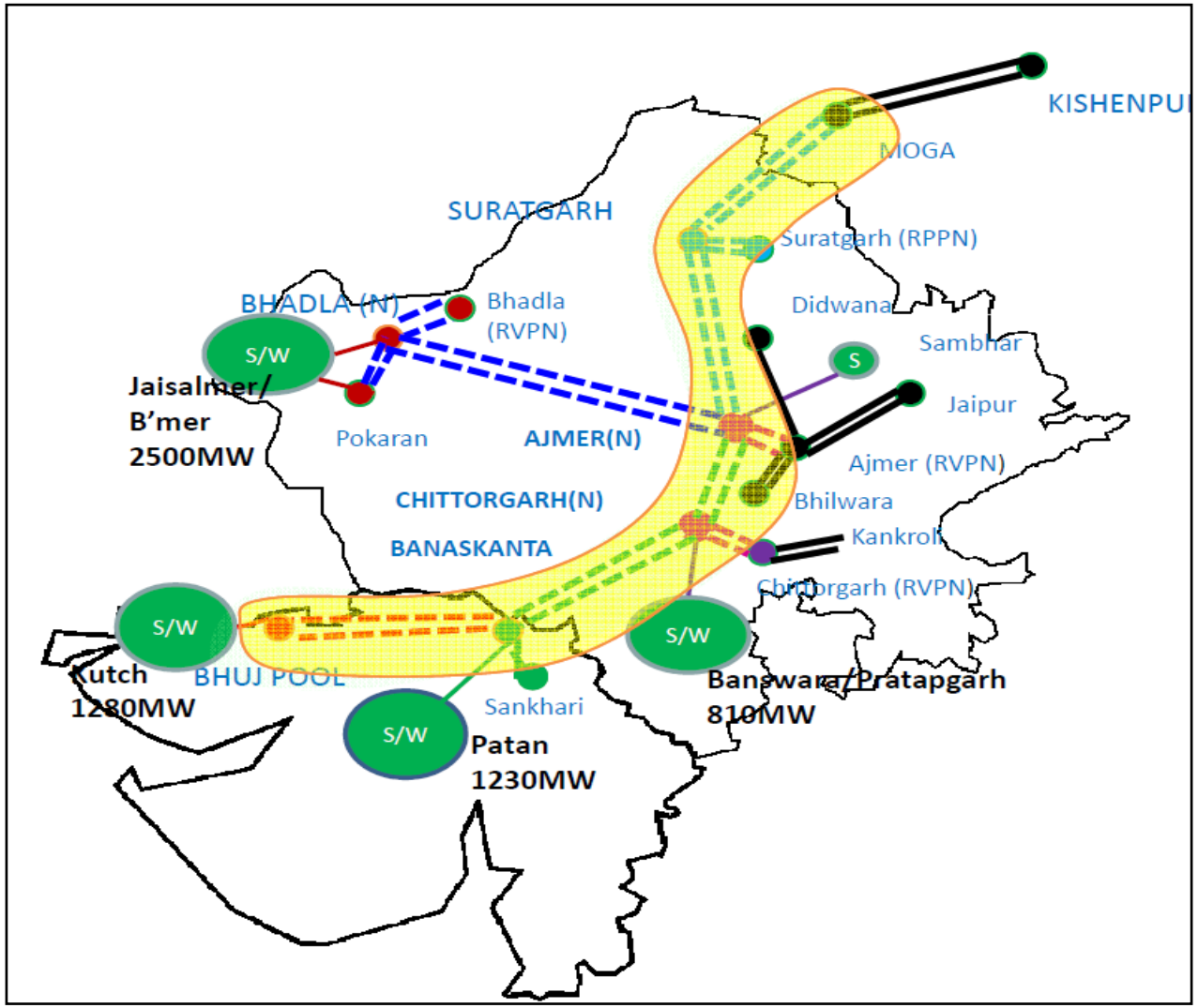
	2030	2040
Solar	207	622
Wind	119	219
Other RE	19	28
Other Sources	444	597
Battery Storage	34	118
Total	823	1584
Flexibility Requirement	-	**±85%** **(50% ramp-up and 35% backdown**

On 05 April 2020, Indian Power system demonstrated 25% flexibility; but 85% flexibility on a daily basis is very different paradigm

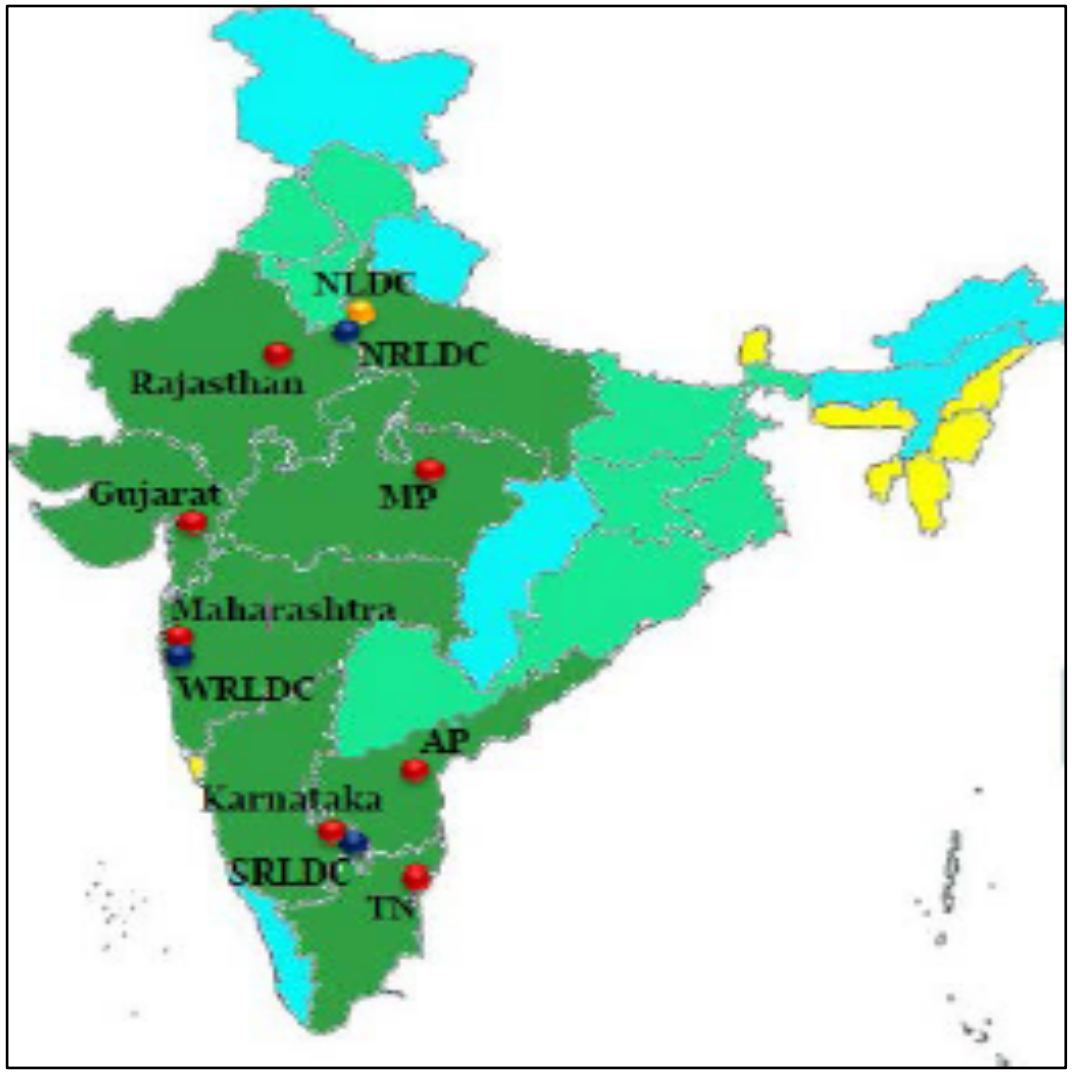
India’s Approach on RE Integration

Green Corridors	Renewable Energy Monitoring Centers (REMC)	Smart Grids	Flexibility in Demand and Generation
Energy Storage Systems (ESS)	Electric Vehicle - Grid Integration	Distributed Energy Resources (DER) and Smart Inverters – IEEE 1547: 2018	Grid Interactive Buildings and Campuses – Smart Microgrids

Green Energy Corridor Project – India



Renewable Energy Monitoring Centers in India



Energy Storage Systems for RE Integration

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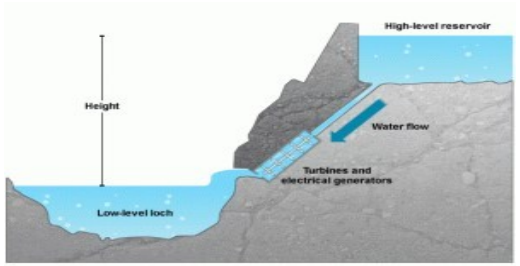
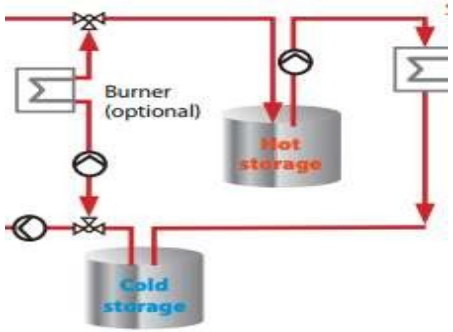
Hydro pumped storage



- Mature technology
- Lowest cost
- Geographical limitations
- Life >50 years

Thermal storage

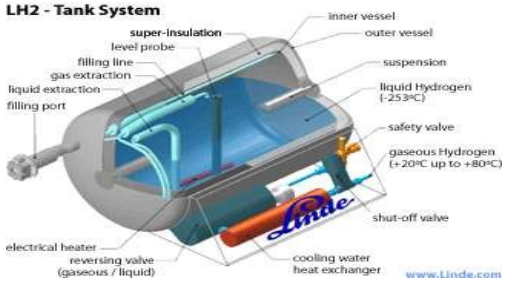


- Emerging energy storage
- Long time (more no. of hours)
- Used onsite
- Life >25-30 years

Batteries

- Faster to deploy
- 90% cost reduction in last ten years
- Modular and easy to deploy at any location
- Fast response for frequency support
- Life is 7-10 years

Hydrogen



- Limited maturity
- High potential
- High potential (power to X)
- High cost

Batteries have emerged as the most viable option for ESS for Grid Applications

Distributed Energy Resources and Smart Inverters - IEEE 1547

- Power electronics that offer many additional features for control and grid support than first generation inverters
- **Smart inverter** functions offer 'Grid Support' features to help utilities
- The goal is to maximize the amount of inverter based DERs on the grid
- Utilities need all DERs to be 'Grid Friendly', and support voltage & frequency
- Some functions from IEEE 1547-2018 may be deployed using off-the-shelf inverters that are not UL 1741SA-listed (VRT, FRT)

IEEE 1547-2003

- Shall NOT actively regulate voltage
- Shall trip on abnormal voltage/frequency

IEEE 1547a-2014 (Amendment 1)

- May actively regulate voltage
- May ride through abnormal voltage/frequency
- May provide frequency response (frequency-droop)

IEEE 1547-2018

- Shall be capable of actively regulating voltage
- Shall ride through abnormal voltage/frequency
- Shall be capable of frequency response
- May provide inertial response

Vehicle Grid Integration (VGI)

Grid Integrated Vehicles at University of Delaware, USA, participating in Ancillary Services Market offering Frequency Response

Approach to Build Grid Flexibility

- **Build Battery Energy Storage System (BESS)** at Solar and Wind Farms
- **Replace Diesel Generator (DG) sets with BESS**: ***ISGF White Paper on DG Replacement with Lithium-Ion Batteries in Commercial Buildings – www.indiasmartgrid.org***
- **Promote Vehicle-Grid Integration**
- **Promote Smart Microgrids**
- **Promote GW-scale Electrolysers for Green Hydrogen**
- **Mandate District Cooling System (DCS) with Thermal Storage**: ***ISGF White Paper on Sustainable Air Conditioning with District Cooling Systems***
- **Promote Electric Cooking:** ***ISGF White Paper on Electric Cooking***
- **Introduce Time of Use (ToU) Tariff for Electricity** ***ISGF Report on Design of Robust Time of Use (ToU) Framework for Electricity Tariff in Gujarat***
- **Create Dynamic Electricity Markets:** Encourage RE Buyers Associations, Promote Peer – to – Peer (P2P) Trading of Green Electricity ***ISGF implemented two pilot projects (Lucknow and Delhi) on P2P trading of solar RTPV energy amongst prosumers and consumers on a blockchain platform***

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Thank You

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