POWER SYSTEM FLEXIBILITY

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IMPORTANCE OF POWER SYSTEM FLEXIBILITY IN INDIAN GRID

Flexibility is required, as :-

- ***HEAVY PENETRATION OF RENEWABLE (variable) ENERGY.***

  *[In **November 2021**, India had renewable energy capacity of **150 GW** consisting **solar (48.55GW)**, **wind (40.03GW)**, **small hydro power (4.83GW)**, **bio-power (10.62GW)** and **large hydro (46.51GW)**, and the **nuclear (6.78GW)**. India has committed for a goal of **450 GW** renewable energy capacity by **2030**.]*

- ***CONTIGENCIES RELATED TO NETWORK ISSUE:-*** *(transmission bottleneck insides states & limited capacity of inter-state transmission lines).*

- ***POWER QUALITY ISSUES-*** *(a) Harmonics / surges*
  (b) Frequency and voltage fluctuation

  - ***USAGE PATTERN :*** *by the Residential / Commercial / Industrial costumers*

    Demand Response(DR) and Time of Day (ToD) to make demand flexible.

- ***VARIABILITY OF LOAD OR DEMAND*** *– as function of weather , calamity / festivals.*

- ***FREQUENT OUTAGE OF CONVENTIONAL POWER PLANT:-*** *[Electrical/ Mechanical fault, old units]*

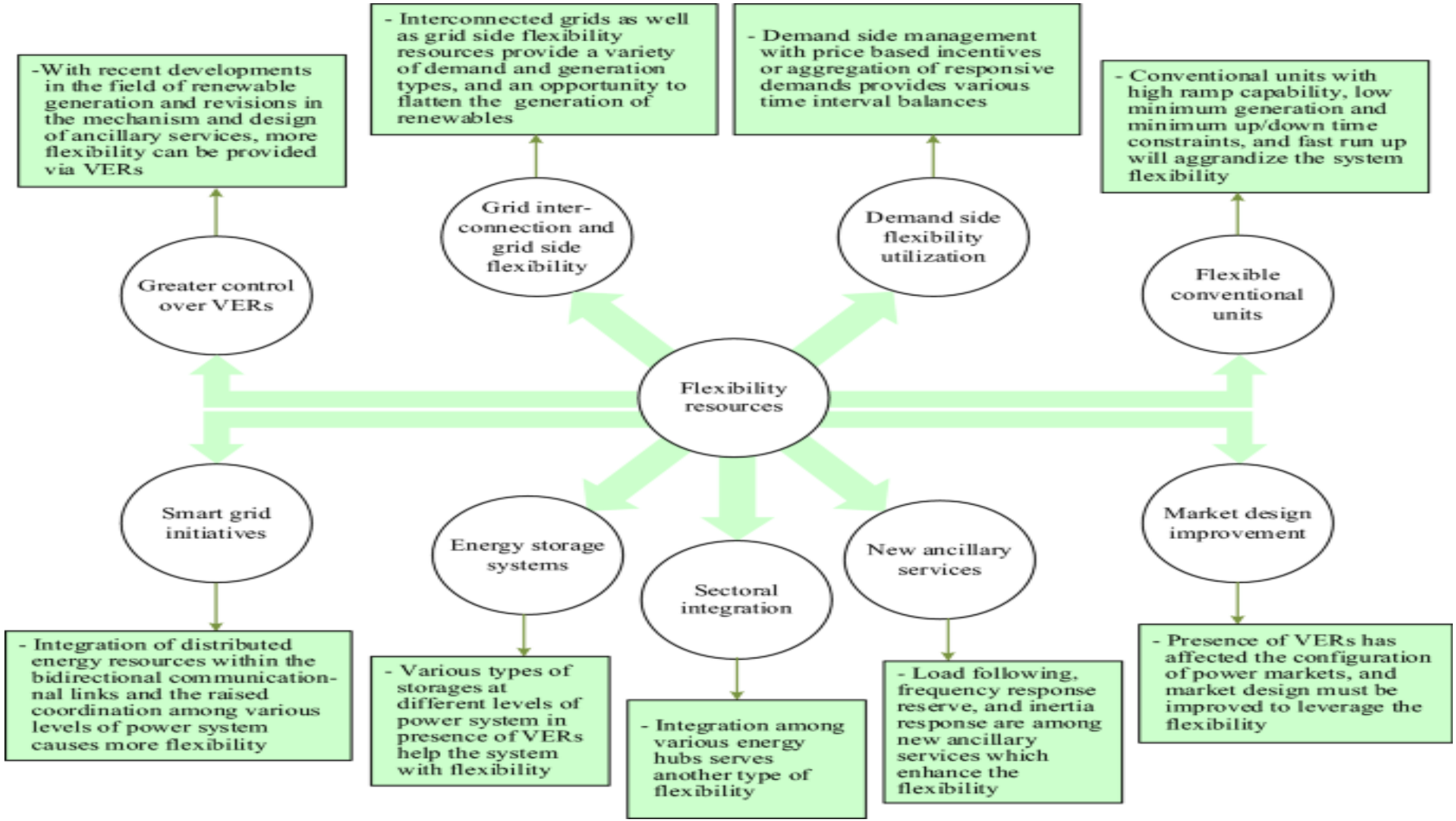
- ***PRESENT LIMITATION OF POWER MARKET DESIGN.***

- ***PRESENT MODELLING.- scheduling / forecasting***

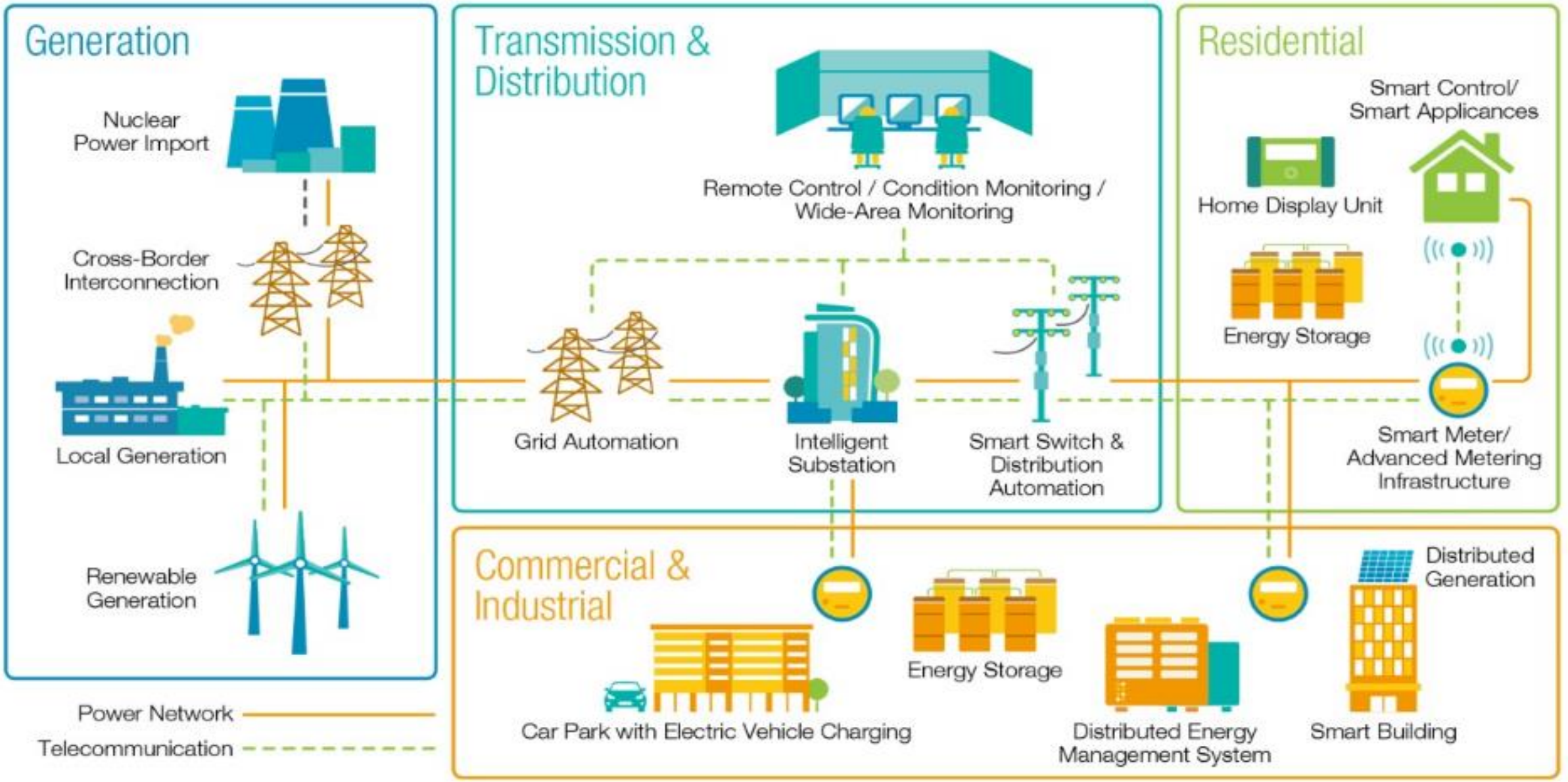
Solution for Power System Flexibility:-

- Flexibility of resource : Addition of smart grids, inclusion of RE, DER (distributed energy resources like small generation unit, Battery etc in distribution side.)
- Proper System flexibility assessment.
- Finding the problems and barriers of electricity markets.
- System planning and operation requirements.
- Supporting Market design evolutions.
- Spinning reserves (frequency responsive)
- Automatic generation control (AGC)
- Short dispatch intervals.
- Load following (flexi-ramp)
- Frequency response reserve
- Inertia response.

A summary of flexibility resources :-



SMART GRID – *has a smart role in Power System Flexibility.*



DEMAND RESPONSE:- *(balancing supply and demand)*

TYPEs of DR :-

- ***Emergency Demand Response*** is used to mitigate the potential for blackouts or brownouts during times when demand threatens to exceed supply resources. This typically occurs on days of extreme hot or cold temperatures when heating and cooling systems are causing greater demand on the grid.
- ***Economic Demand Response*** is employed by utilities to avoid the significantly higher costs of producing energy during peak demand times of the day that is associated with ramping up "peaking" power plants to meet higher than expected demand.
- ***Ancillary Service Demand Response*** is used to support the transmission of electricity to loads in a manner consistent with reliability requirements that are imposed on utility companies by industry regulators.

Demand Response Strategies:-

- ***Direct Load Control*** demand response events involve the remote interruption of customers' energy usage, in which power distributors cycle loads like heating, cooling, elevators, washing etc. on and off at varying time intervals during peak hours of the day.
- ***Dynamic Pricing*** uses variable electricity rates to encourage customers' voluntary curtailment during demand response events. Utilities use a variety of pricing schemes including peak time rebates, critical peak pricing, and time of use rates to curtail usage.

Demand Response Technologies

- ***End-User Interfaces*** –Communication with consumers about an event, including information about energy usage and pricing with smart grid. Consumers need to acknowledge their participation in the program.
- ***Load Control Devices*** – Utilities use a number of different tools to actually cycle systems like heating and cooling on and off during demand response events. Load control switches enable direct remote control over AC units or heating systems. Smart thermostats allow utilities to adjust temperature settings remotely.
- ***AMI*** –AMI (Advance Metering Infrastructure) is increasingly being used with demand response, because it enables both utilities and end-users to have more robust data about loads, energy usage and electricity pricing.
- **SCADA, OMS, DMS**-

ENERGY STORAGE SYSTEM(ESS):- *A solution to Power System Flexibility*

TYPES OF ESS(Energy Storage System):-

1. PHS(Pumped Hydrolectric Storage)
2. BESS(Bettary Energy Storage Stystem)
3. Super Capacitor.
4. CASE(Compressed Air Energy Storage)
5. FES (Fly-wheel Energy Storage)
6. Thermal Energy Storage (Cryogenic hydrogen storage & Hydrides(solid hydrogen)

Roles of ESS:-

1. Balancing of Power
2. Grid stabilization & Grid operational support i.e; frequency regulation services, contingency reserves, voltage support and black start etc.
3. Power quality and reliability.
4. Load shifting / Peak shaving.

V2G stands for “vehicle to grid

- **Electric vehicle batteries are by far the most cost-efficient form of energy storage.**
- It is a smart energy **Dynamic Load Management (DLM)**
- **For Grid :- solution to grid congestion**
- **For real estate: -**Vehicle-to-grid helps balance out electricity demand and avoid any unnecessary costs for building an electricity system.

POWER MARKET

(Last updated on Dec, 17 2021)

ADVANTAGE INDIA

Growing Demand

- India ranked sixth in the list of countries to make significant investment in clean energy by allotting US$ 90 billion in between 2010-H22019.
- Growing population along with increasing electrification and per-capita usage will provide further impetus. Power consumption is estimated to reach 1,894.7 TWh in 2022.

Attractive Opportunities

- Under the Union Budget 2021-22, the government allocated Rs. 305,984 crore (US$ 42 billion) for a revamped, reforms-based and result-linked new power distribution sector scheme over the next five years.
- In June 2019, Government launched US$ 5 billion of transmission-line tenders in phases to reach 175 GW target by 2022.

Policy Support

- 100% FDI allowed in the power sector has boosted FDI inflow in this sector.
- Schemes such as Deen Dayal Upadhyay Gram Jyoti Yojana (DDUGJY) and Integrated Power Development Scheme (IPDS) are expected to augment electrification across the country.

Higher investments

- As per the National Infrastructure Pipeline 2019-25, energy sector projects accounted for the highest share (24%) out of the total expected capital expenditure of Rs. 111 lakh crore (US$ 1.4 trillion).
- Total FDI inflow in the power sector reached US$ 15.36 billion between April 2000 and June 2021.

Note: *FDI - Foreign Direct Investment, TWh - Terawatt-Hour, GW- Gigawatt*

(IBEF Report)

Grid Interactive Buildings & Campus:-

GRID INTERACTIVE **BUILDINGS :-**

- Building end uses can be dynamically managed to help meet grid needs and minimize electricity system costs, while meeting occupant comfort and productivity requirements;
- Technologies such as rooftop photovoltaics (PV), battery and thermal energy storage, combined heat and power, electric vehicle charging stations, and other DERs can be co-optimized with flexible building loads to provide greater value to both utility customers and the electricity system; and
- The value of energy efficiency, demand flexibility, and services provided by other behind-the-meter DERs(distributed energy resources) can vary by location, time of day, season, and year.

GRID SERVICES FOR BUILDING:-

- Heating, Ventilation, and Air Conditioning (HVAC).
- Water Heating; Appliances; and Refrigeration.
- Lighting and Electronics.
- Windows and Opaque Envelope.
- Whole-Building Controls, Sensors, Modeling.

Policy support required in term of flexibility options

- ***RE generation forecasting with role and responsibility of each stake holder***
- ***Introduction of ancillary services –*** To counter extreme weather conditions, generating unit or transmission line outages, Trend of load met, congestion in the grid, frequency variation etc.
- ***Spot Power market***
- ***Pump mode hydro station***
- ***Development of Renewable Energy Management Center (REMC)***
- ***Installation of Energy Storage Technology***

- ***Solution :-***
  - *DIVERSIFYING THE LOCATION OF RE.*
  - *HYBRID RE GENERATION – to compensate the generation like solar in day time and wind at night.*
  - *Integrating with ESS (Energy Storage System) & EV (Electric Vehicle)*
  - *CHANGING MARKET DESIGN / OPERATIONAL PRACTICE (consumer side)*
  - *REGULATORY / POLICY / MARKET FRAME WORK.*
  - *Use of FACTS (Flexible AC Transmission) devices / dump load*