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Application of Cost-Effective Grid-Scale Battery Storage as an Enabler of Network Integration of Renewable Energy

by

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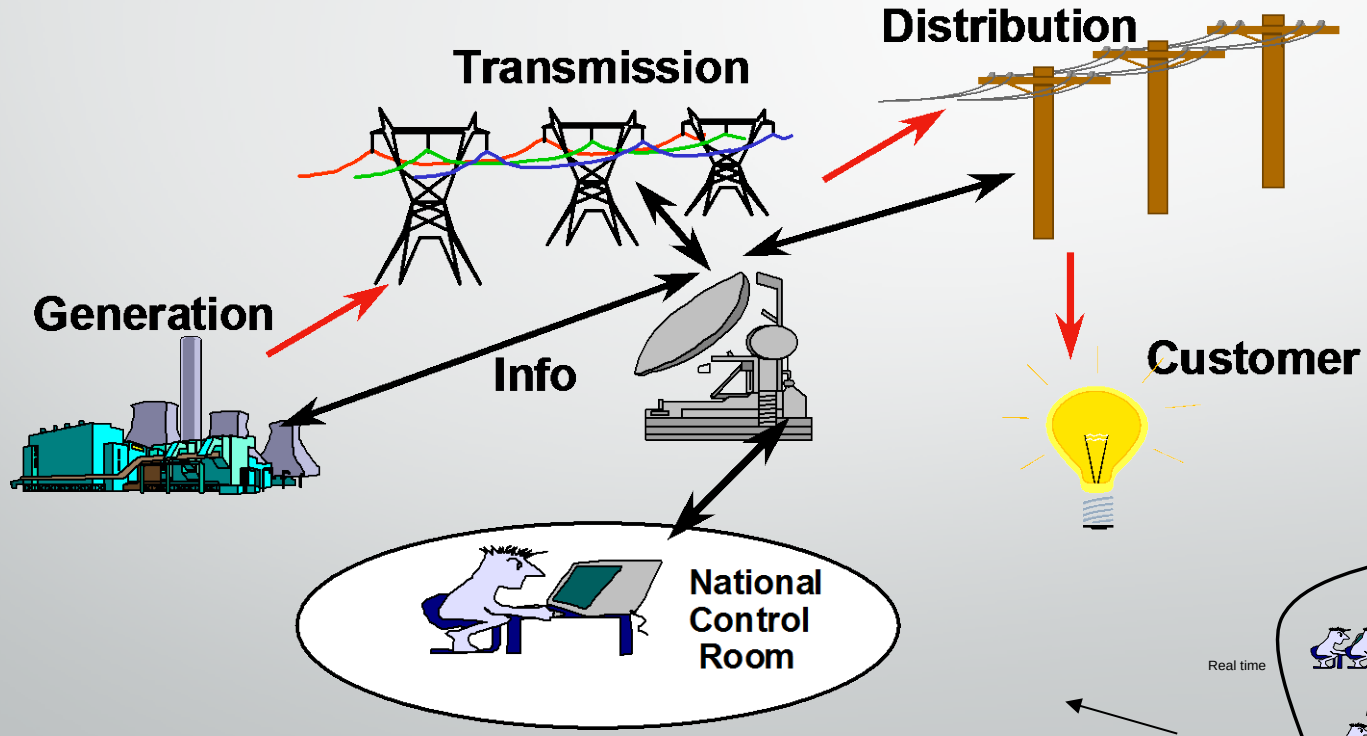
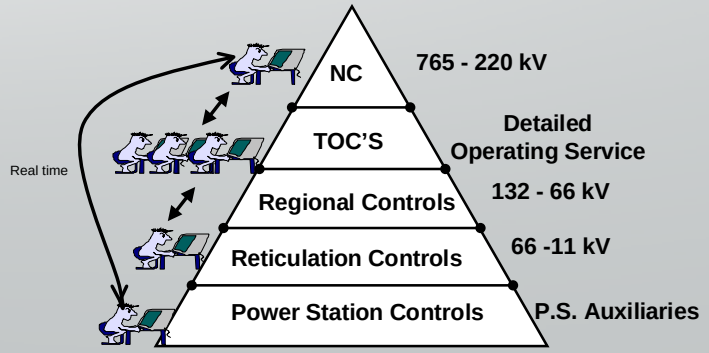
Outline of Presentation

- Introduction
- Energy storage technologies
- Battery storage system
- Deployment of grid-scale battery storage devices
- Closing Remarks

1.0 Introduction – Electric Power System

- Generation, transmission and distribution of electricity
- Generation ⇨ Demand + Network losses
- System Requirements: Voltage ± 6% ; Frequency ± 1%





Some Challenges in the Electricity Industry

- Electricity Production = Consumption + Network Losses (Instantaneously)
- Fossil-fuels and uranium are depletable sources
- Electricity production from conventional sources involves environmental pollution
- Intermittency in renewable sources (wind, solar-PV)
- Economic challenges (affordable electricity prices)
- Environmental challenges (reduction in GHG emissions)
- Regulatory challenges (government mandate on renewable energy)
- Changing public perception – energy sustainability

Opportunities in the Electricity Industry

Renewable energy (RE):

- RE (such as wind, solar) are non-depletable
- RE can enable energy resource sustainability
- RE can reduce GHG emissions and global warming
- Wind energy tends to be highest at night when load demand is often lowest.
- Large-scale solar is ineffective at night when there is no sunlight

Opportunities in the Electricity Industry

Energy storage (ES):

- ES will enhance the use of RE and assist achieve emission targets
- Enable bulk storage of electrical energy for future dispatch
- Bulk storage can enable curtailment of intermittency
- Unlock a new market in RE with increased penetration in T&D networks
- Catalyze the rapid uptake of rooftop solar PV installations in households
- Demand-side management

Opportunities in the Electricity Industry

Energy storage:

- Energy storage devises can be used supplement smart grid applications where PV, wind, biomass are integrated.
- Used to defer capital investment for augmentation
- Off-grid and isolated grid applications in islands or rural areas
- Provide peaking power and reduce the need for fossil-fuel peaking plant (gas turbines)
- Improvements in power quality and voltage stability and frequency regulation.

"There is a need for extensive practical experience in the implementation and monitoring of grid-scale energy storage devises in electric power grids worldwide."

2.0 Energy Storage Technologies

Classification:

- Mechanical storage
  - Potential energy - pumped hydro storage, compressed air
  - Kinetic energy - flywheels
- Chemical storage – hydrogen energy, thermo-chemical energy (solar cells, fuel cells)
- Electromagnetic energy storage
  - Electrical – capacitors and super-capacitors
  - Magnetic – superconducting magnetic energy storage (SMES)
- Thermal energy storage – cold and heat storage
- Electrochemical energy storage – batteries, flow batteries

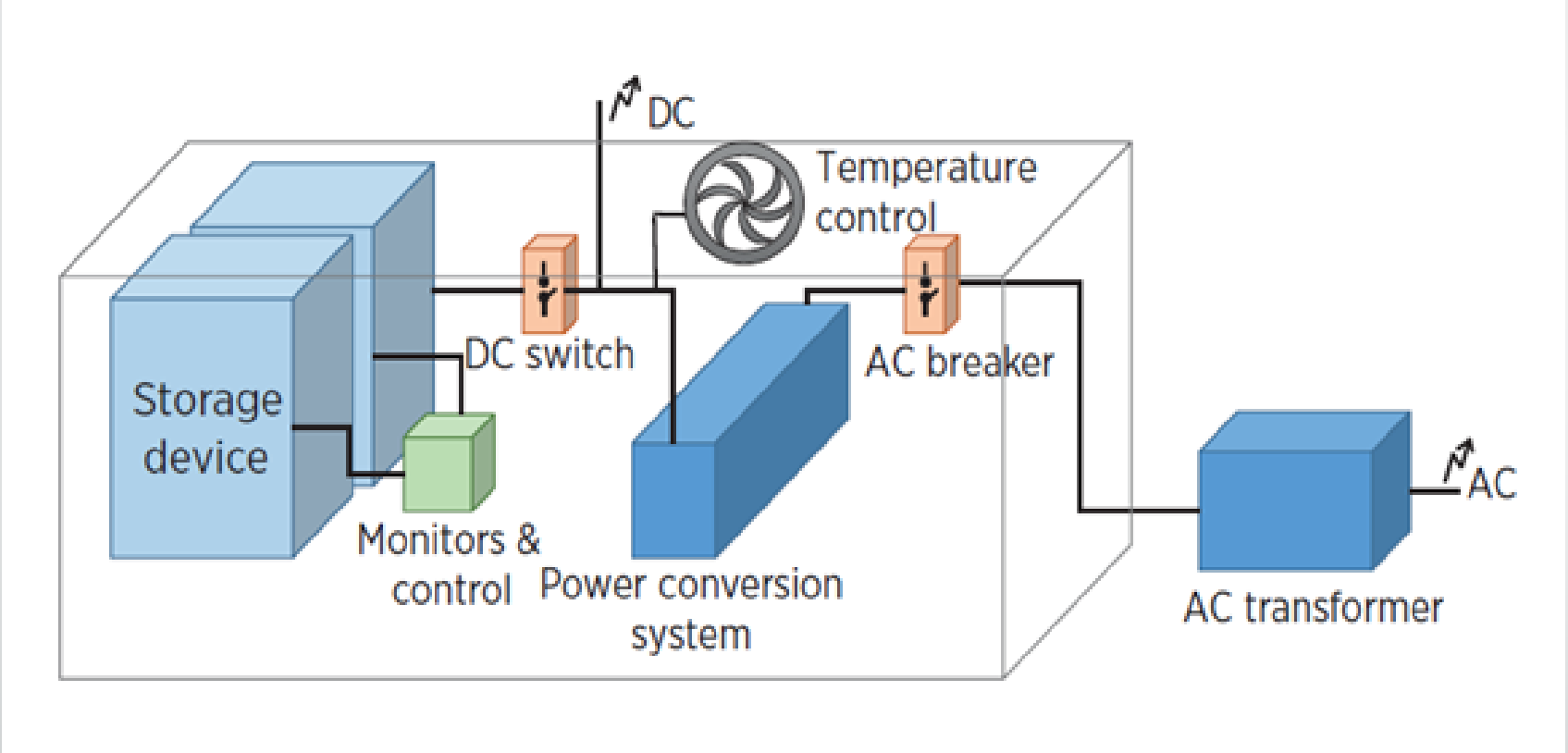
Energy Storage Devices (ESD)

Some key questions and requirements:

- Demonstrate that ESD increase value and provide grid support when required?
- Show that ESD can meet grid standards in terms of safety, quality and reliability.
- For a commercial perspective in deploying ESDs, what are the key drivers, applications and challenges?
- How will the regulatory framework be established? Who can own, operate, and maintain ESDs and define tariff structures?

"The introduction and application of cost-effective grid-scale battery storage will be a game-changer for the distribution and control of electric power."

3.0 Battery Storage System



Components: power conversion systems (bi-directional invertors), monitoring and control systems (charge controller, optimize performance) and battery unit.

"Grid-scale battery storage – greater flexibility, control and utilization of electrical power"

Battery Storage System – Drivers and Applications

Some key drivers and applications of grid-scale battery storage systems:

- Increased RE usage
- Increasing network costs and poor utilization of assets
- Increasing need for reliable backup power
- Peaking power
- Demand side management
- Tariff changes
- Arbitrage

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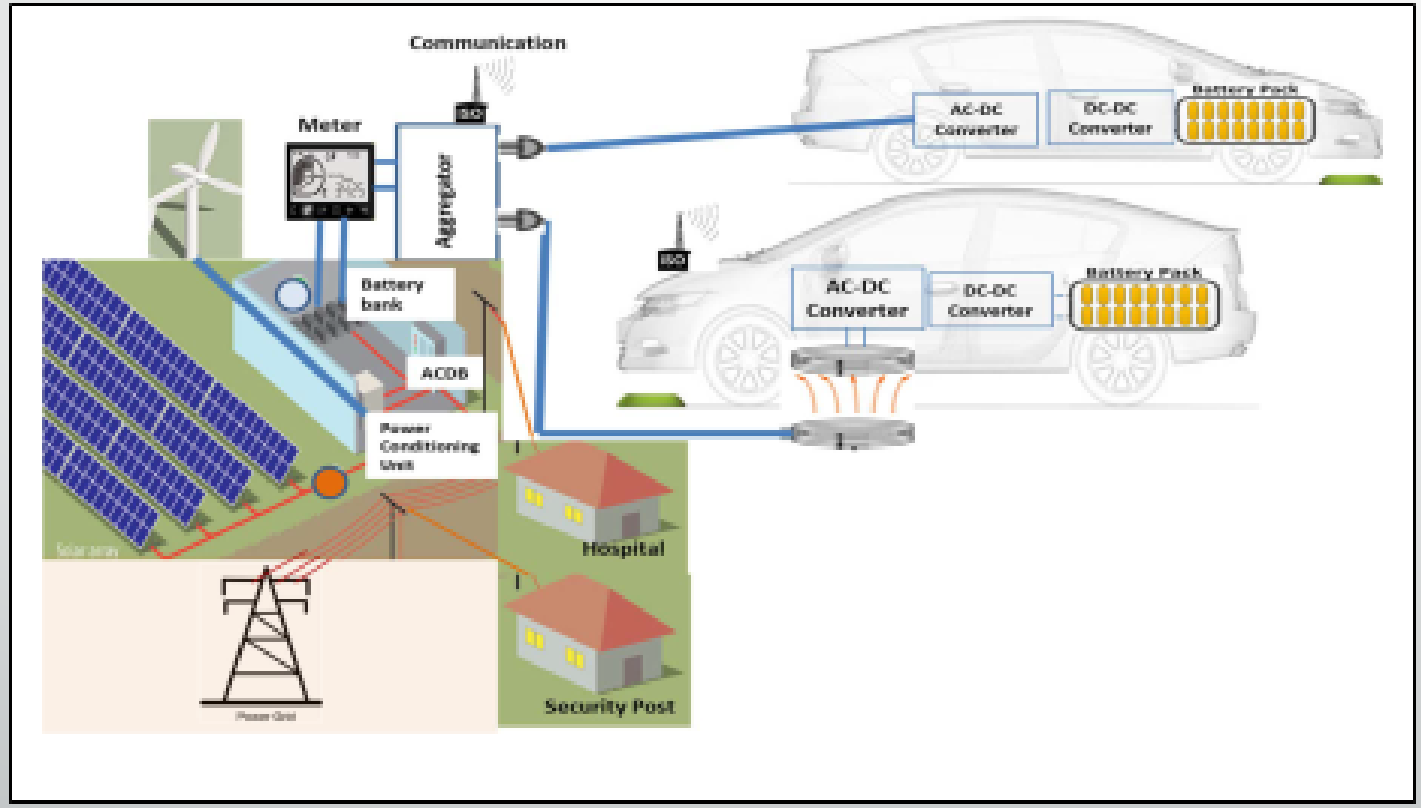
- Power quality
- Off-grid or isolated grid applications
- Increased use of Electric vehicles (EVs)



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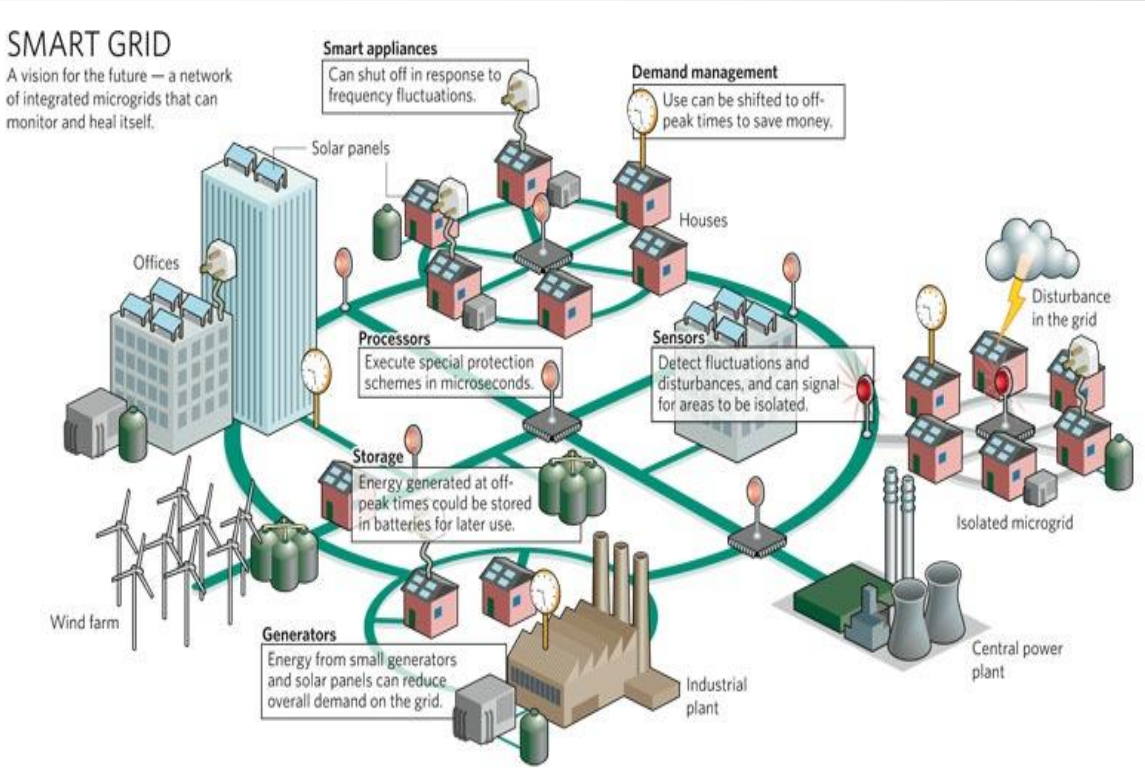
- **Smart Cities – Intelligent Systems**
  - SMART Grids - Grid integration of RE using smart technologies/innovation for smart cities
  - Smart Infrastructure, Smart Transportation Systems
  - Smart Business Enterprises and Entrepreneurship
  - Smart Buildings, Smart Health Care, Smart Water
  - Smart Education and Smart Technologies



4.0 Deployment of Grid-scale Battery Storage Devices

Some key challenges:

- High initial investment cost for battery storage system
- Safety concerns for batteries being used in large-scale
- Non-standardization
- Grid interconnection barriers and excess capacity
- Recycling and environmental issues
- Temperature of batteries in storage and weather extremes
- Lack of clear business case and value proposition – low oil and gas prices and commodity cycles.
- Inadequate policies or incentives to promote wide-scale use.

Closing Remarks

Grid-scale Energy Storage Systems:

- Enabler of the re-invention and modernization of the electric power grid
- Enable renewables and electric vehicles interact with the bulk electric systems
- Enable distributed energy sources (microgrids, demand response)
- Improve grid reliability
- Provide capital deferral in new investment

Thank you