ENERGY STORAGE

EXPLORING THE BUSINESS LINK OPPORTUNITY:

TRANSMISSION & CLEAN ENERGY DEVELOPMENT IN THE WEST

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Presented by:
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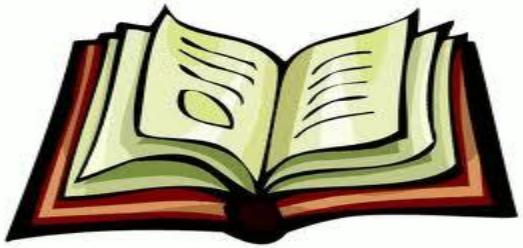
Energy Storage

- What is Energy Storage?
  - Energy storage is like a frozen pizza
  - It is a resource with a capacity of one MW or greater, which is capable of storing energy and may qualify as a mode to supply Ancillary Services. The energy resource can both withdraw energy and inject energy.



Integration of Renewable Energy Sources

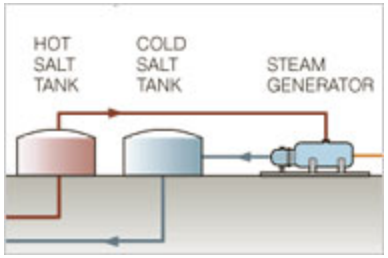
- Benefits of storage for renewable energy sources:
  - Reduce plant capital costs
  - Reduce project financial risk
  - Improve wind/solar power production
  - Reduce O&M expenses
  - Improve reliability
  - Manage peak demand
  - System integration
  - Increase reliability

Energy Storage

- What is Energy Storage good for – a checklist
  - Load leveling
  - Peak shaving
  - Frequency regulation
  - Avoiding grid congestion
  - Enabling price arbitrage
  - Assisting in carbon-free energy delivery

Storage Technologies

- Mechanical
  - Compressed air
  - Flywheel
  - Pumped hydroelectric
- Electric
  - Capacitor
  - Superconductor magnets
- Thermal
  - Molten salt
  - Pumped heat



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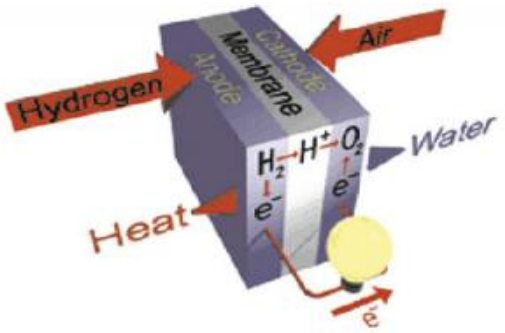
Storage Technologies

- Chemical
  - Lead acid
  - Hydrogen fuel cell
  - Flow batteries
  - Lithium-Ion (Li-Ion)
    - Electric vehicles
  - Nickel Cadmium (Ni-Cd)
  - Nickel Metal Hydride (NiMH)



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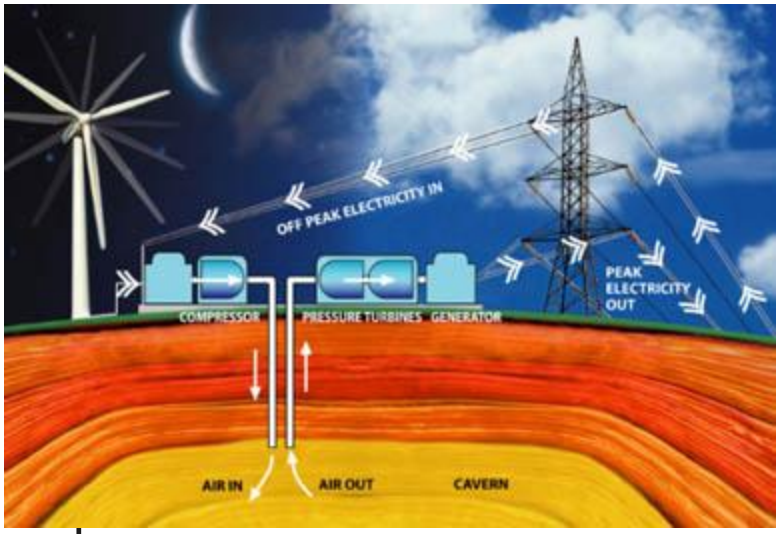
Compressed Air Storage

- Stored in an old mines, salt caverns or geological feature
- Using Natural gas, the air is heated and then it passes through turbines
- Advantages:
  - Lasts longer
  - No toxic materials
  - Low cost of energy/power
  - Easily dispatchable
- Disadvantages:
  - Efficiency varies with power demand
  - Very high pressure raises safety issues
  - Location sensitive
  - Requires heating

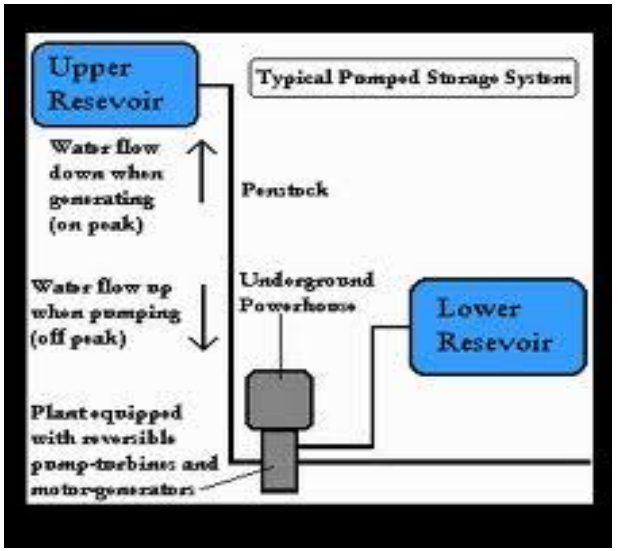


Flywheels Storage

- Energy is stored by accelerating a rotor to a very high rate of speed
- Advantages:
  - Equipment has a long life (rated for 20+ years)
  - Easy to measure -- energy is stored via speed
  - Uses benign materials
  - Up to 85% efficient
  - High Energy Density
  - Quick charge and discharge
- Disadvantages:
  - Limited storage time –
    - Typically only hours
  - Large mass rotating at high speed raises safety issues

Pumped Hydro Storage

- Pumps water to a high storage reservoir during low demand
- Hydroelectric dam with a large reservoir can be operated during peak demand
- Approximately 75-80% efficient
- Advantages:
  - Quickly dispatchable
  - Good for various applications
  - Lower cost of energy
  - Can store large amounts of energy
- Disadvantages:
  - Location sensitive
  - Initial costs vary

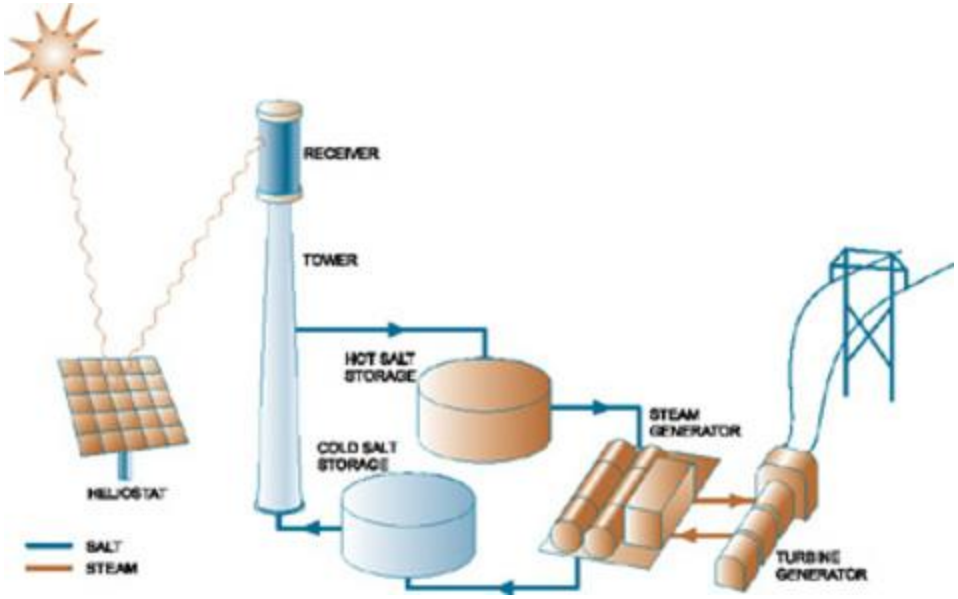


Electrochemical Capacitors Storage

- Similar to batteries in that they have two electrodes immersed in an electrolyte and separated by a porous separator
- Advantages:
  - Electric charge is not through a chemical reaction
  - Wide-ranging capabilities
- Disadvantages:
  - High cost
  - Operational issues
  - Reliability needs to be improved

Thermal Storage

- Molten Salt
  - Liquid salt is solar heated
  - Stored and Insulated
  - Used to superheat water
- – Advantages:
  - Highly efficient
  - Provides cheap energy
  - Can be stored for up to a week
- – Disadvantages:
  - Requires large containers
  - System is complex
  - Needs warm, humid climate



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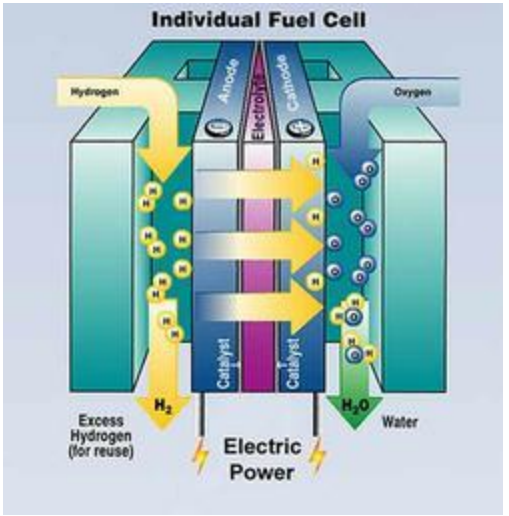
Hydrogen Fuel Cell Storage

- Converts the chemical energy from a fuel into electricity through a chemical reaction with oxygen or another oxidizing agent
- Advantages:
  - Uses waste thermal energy from nuclear power
  - Quickly dispatchable
- Disadvantages:
  - High cost
  - Short life
  - Complex
  - Cannot tolerate freezing temperatures
  - High pressure storage of flammable gas

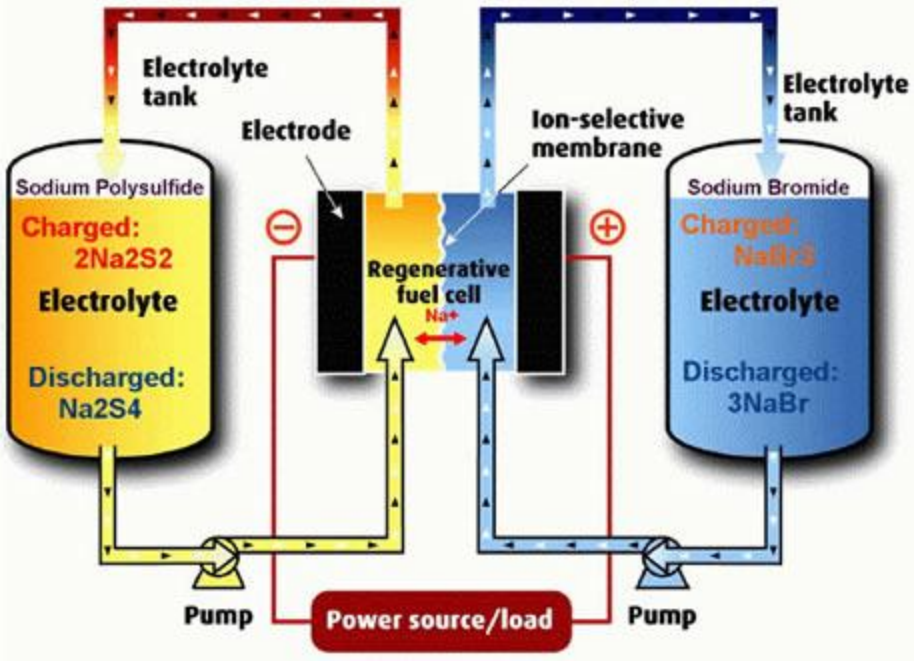


Electrochemical Batteries Storage

- Sodium Sulfur, Lead Acid, Nickel Metal-Hydride, Lithium-Ion
- Used for peak shaving
- Advantages:
  - – Mobile
  - – Modular (power/energy)
  - – High efficiency 80-95%
- Disadvantages:
  - – High cost of some
  - – Life span issues
  - – Toxic materials

Flow Battery Storage

- Flow batteries are store and release energy through a reversible electrochemical reaction between two electrolytes
- Advantages:
  - Inexpensive
  - Scalable
  - Good response time
  - Long-term storage
- Disadvantages:
  - Some toxic materials
  - It's a relatively complex system
  - Maintenance issues (leaks, membrane)



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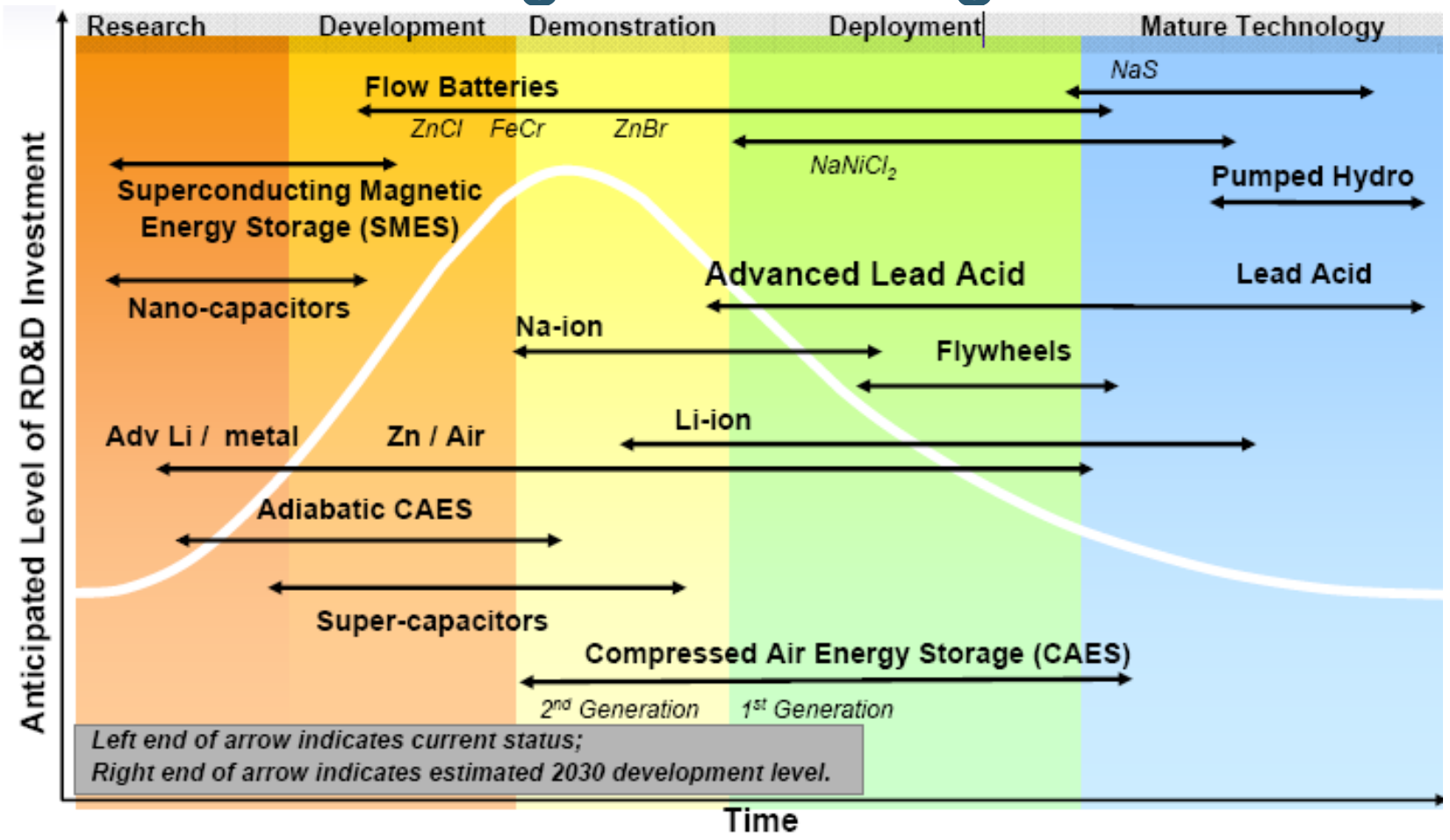
Status of Storage Technologies



Source: Electric Power Research Institute:

Storage Benefits For Transmission/Distribution

- ISO Markets
  - Provide regulation and/or spinning reserve services
  - Price arbitrage

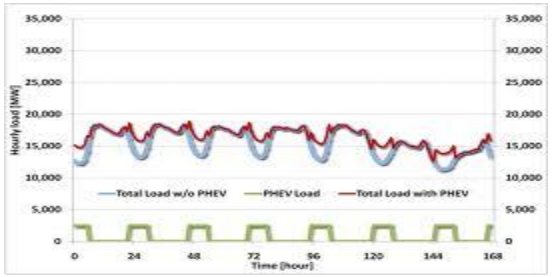
- System
  - Respond to local and system capacity issues
- Transmission
  - Provide VAR support
  - Reduce transmission congestion
  - Defer transmission investments
  - Integrate renewable energy

Storage Benefits, cont.

- Distribution
  - Provide voltage support
  - Defer distribution investment
  - Reduce distribution losses
- End-user
  - Provide power quality services
  - Enhance reliability
  - Enable shifting of demand
  - Support electric vehicle transportation

Are PEVs the Future for Storage?

- The Obama administration has established a goal of one million Plug-in Electric Vehicles (PEVs) on the road within five years



- With more PEVs on the road, and an increase in demand, the utility industry has begun to respond
- Utilities are looking at PEVs as a source of energy storage, particularly school buses
- Many utilities have begun to set PEV rates that promote off-peak charging through price incentives

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Plug-in Electric Vehicle Storage

- PEV storage impacts to the electric grid, especially to the distribution system (e.g., transformers)
- Impacts charging patterns and behavior
- Vehicle to grid (V2G) services:
  - – Contingency reserve
  - – Frequency regulation
  - – Dispersed energy storage
- Vehicle to home (V2H) services
  - Backup power
  - Demand response (load shifting)
  - Storage for renewable energy
- Impacts electricity prices
- Impacts on emissions

Storage Project Development Considerations

- Efficiency
- Dispatchability
  - Response time
- Cost
  - Cost of power
  - Cost of energy
- Storage time
  - Hours, days, weeks, seasonal
- Location specific
- Life/durability

Storage Project Development Considerations, Cont.

- What kind of energy storage is feasible and cost-effective? Most popular are:
  - Pumped hydro
  - CAES (compressed air energy storage)
  - Batteries
    - Flow batteries
    - Li-ion and lead acid
  - Flywheels

- Interconnection of the storage facility to the transmission/distribution system

Storage Project Development Considerations, Cont.

- PPA with a storage provider
- Making the investment
  - Financing
  - If owing the facility:

    is the facility an asset for the distribution system?

- Regulatory rate treatment
  - FERC
  - State
  - Is it generation/transmission (Ancillary Services)?
  - ISO/RTO integration
  - Support for wind and solar generation

Energy Storage Policy Landscape

- Investment tax credit for energy storage is pending in Congress (S.1764)
- Federal and State regulators are working on policies, rules and regulations to encourage the development of energy storage
  - Federal and State energy storage policies should spur development of new energy storage projects
- Independent system operators are looking at policies to encourage energy storage as Ancillary Services

Energy Storage Issues For Regulators

- How to classify energy storage
  - Is it “generation” or “transmission?”
- Cost recovery
  - How to allow cost recovery of storage, which provides multiple benefits across the generation, transmission and distribution value chain
- How to remove any barriers of entry for the economic development of energy storage
- FERC Chairman Jon Wellinghoff:

“FERC is charged with promoting storage under the 2005 Energy Policy Act…FERC needs to remove barriers to storage… and…needs rate structures that allow storage to provide all functions.”

Energy Storage in the Wholesale Market

- **NYISO**
  - FERC approved new market rules for Limited Energy Storage Resources to provide regulation in May, 2009
- **ISO-NE**
  - Operating a pilot program for alternative technologies, including energy storage, to provide regulation
- **PJM**
  - Implemented a frequency-based signal for energy storage resources in March, 2009, allow resources to self-manage energy and capacity
- **MISO**
  - Recognizes energy storage as different from generation and demand response, but still considering products that would support storage applications
- **CAISO**
  - Proposals are pending similar to the NYISO
- **ERCOT**
  - Exploring feasibility of Energy Storage Pilot Project

Summary

- Electricity is the most useful and abundant energy supply.
- Historically, electricity had to be produced when it was needed and had to be used as soon as it was produced.
- New technologies have emerged that enable electricity to be stored. This has made electricity production and use much more flexible.
- While many of energy storage technologies are developing, others that have been around for years, are becoming more cost-effective.
- Energy storage will improve utilization of power facilities, reduce transmission congestion, facilitate the integration of renewable energy resources, and prevent losses from unreliable power.

Questions?

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Mr. Stosser is an energy attorney with 30 years of experience in many aspects of the energy industry, from traditional energy - natural gas, oil and power - to renewable and alternative energy and clean tech. His practice includes project development and finance of renewable and alternative energy projects, including solar, wind, energy storage and distributed generation; state and federal regulatory matters; and legislation.

Mr. Stosser was formerly with Ardour Capital Investments, LLC, an investment bank focused solely on the renewable energy sector and projects, where he served as Senior Vice President in banking and served as the company's General Counsel. Mr. Stosser has worked with clean tech companies and projects, including fuel cells and other distributed generation, including, batteries, as well as wind, solar, biofuels, green buildings, reusable plastics, biomass, geothermal, and coal gasification.

Prior to his position with Ardour, Mr. Stosser was co-chair of the energy practice at Heller Ehrman, LLP and founding partner and managing partner of that firm's Washington DC office. He formerly served as Assistant General Counsel for Rulemaking and Environmental Law at the Federal Energy Regulatory Commission.