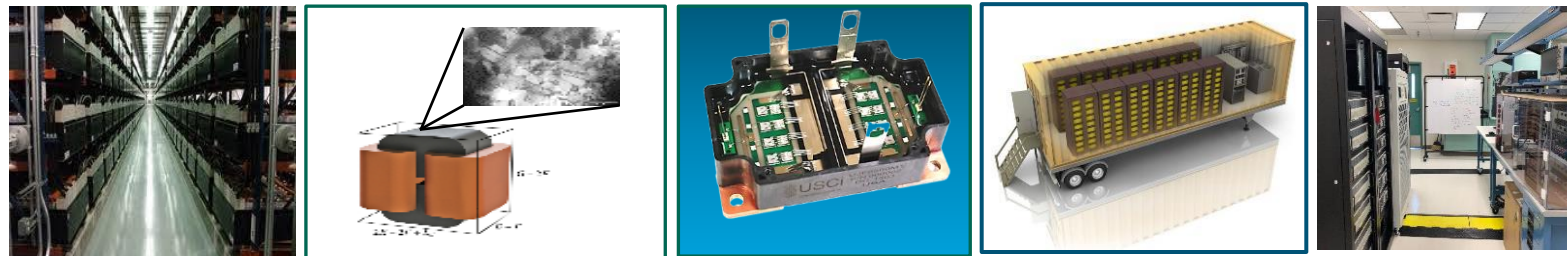


Power Conversion System Reliability and Safety



PRESENTED BY
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ENERGY STORAGE R&D AT SANDIA



BATTERY MATERIALS

Large portfolio of R&D projects related to advanced materials, new battery chemistries, electrolyte materials, and membranes.



CELL & MODULE LEVEL SAFETY

Evaluate safety and performance of electrical energy storage systems down to the module and cell level.



POWER CONVERSION SYSTEMS

Research and development regarding reliability and performance of power electronics and power conversion systems.



SYSTEMS ANALYSIS

Test laboratories evaluate and optimize performance of megawatt-hour class energy storage systems in grid-tied applications.



DEMONSTRATION PROJECTS

Work with industry to develop, install, commission, and operate electrical energy storage systems.



STRATEGIC OUTREACH

Maintain the ESS website and DOE Global Energy Storage Database, organize the annual Peer Review meeting, and host webinars and conferences.



GRID ANALYTICS

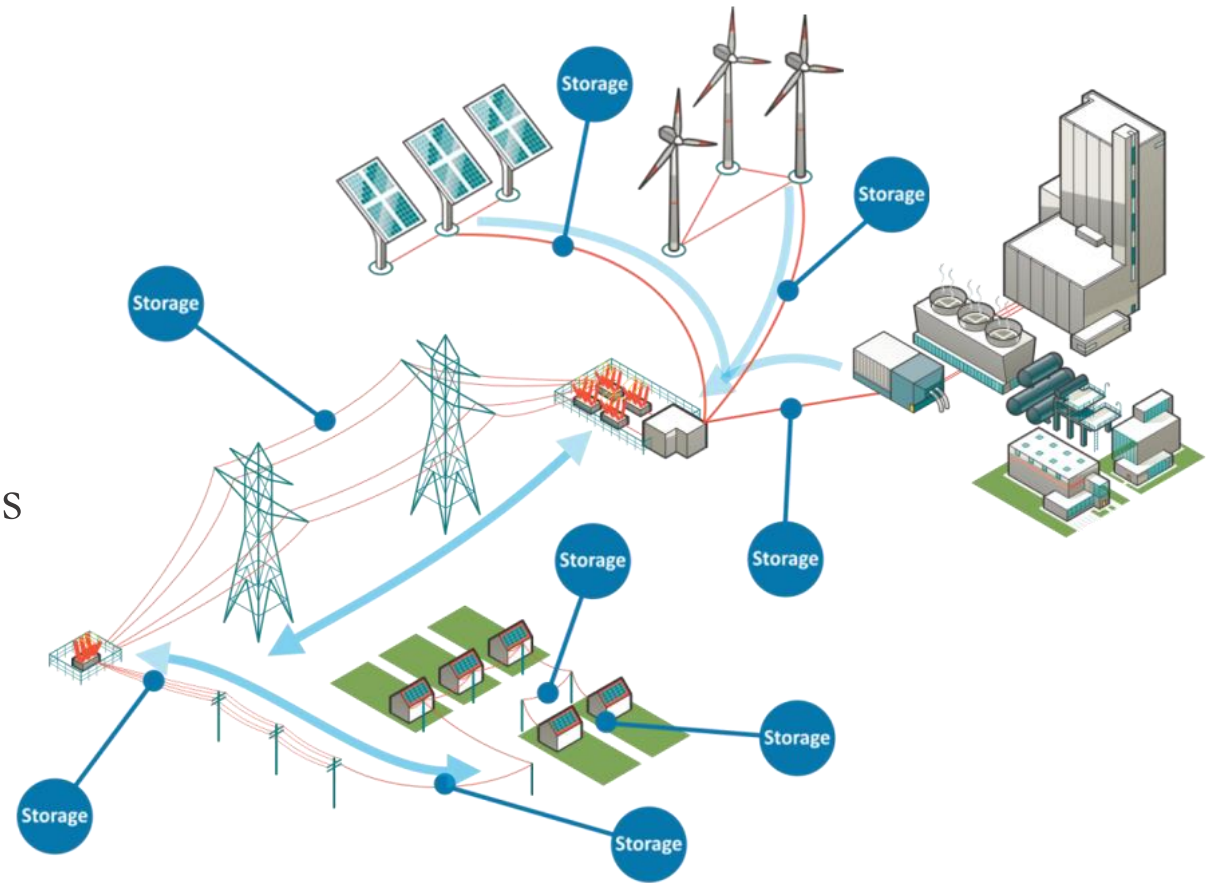
Analytical tools model electric grids and microgrids, perform system optimization, plan efficient utilization and optimization of DER on the grid, and understand ROI of energy storage.

Wide ranging R&D covering energy storage technologies with applications in the grid, transportation, and stationary storage

BENEFITS OF ELECTRICITY STORAGE



- Maintain quality power and reliability
- Provide customer services — cost control, flexibility, and convenience
- Improve T&D stability
- Enhance asset utilization and defer upgrades
- Increase the value of variable renewable generation



BATTERY ENERGY STORAGE SYSTEM ELEMENTS



Battery Storage	Battery Management System (BMS)	Power Control System (PCS)	Energy Management System (EMS)	Site Management System (SMS)	Balance of Plant
• Modules • Racks • \$/KWh	• Battery Management & BESS Protection	• Bi-directional Inverter • Inverter control • Interconnection / Switchgear • \$/KW	• Charge / Discharge • Load Management • Ramp rate control • Grid Stability • Monitoring • \$ / ESS	• Distributed Energy Resources (DER) control • Synchronization • Islanding and microgrid control • \$ / microgrid	• Transformer/ POC switchgear • BESS container • Climate control • <u>Fire protection</u> • Construction and Permitting • \$ / project



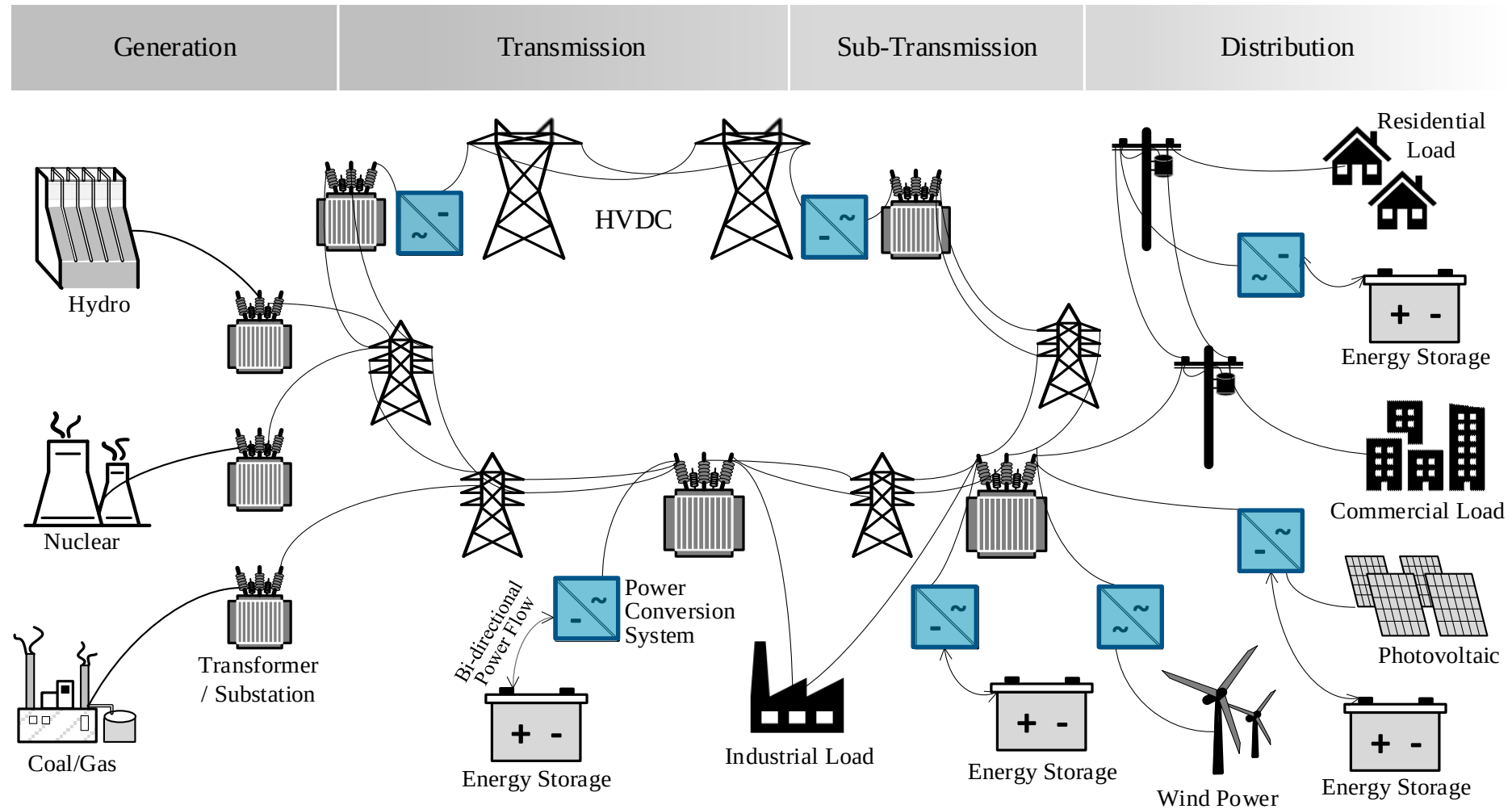
NOTE: Important to have single entity responsible for the ESS integration.

THE EXPANDING ROLE OF POWER ELECTRONICS

Power electronics provides two critical services

- Efficient conversion between disparate forms of electricity
- Unprecedented control over the flow of energy

Power electronics are the most potent tools at our disposal for modernizing transmission, distribution, and utilization.



ENERGY STORAGE SYSTEM COMPONENTS

- Power conversion systems (PCS), sometimes referred to and used interchangeably as power electronics, are a key enabling technology for energy storage.
- In a grid-tied energy storage system, the PCS controls the power supplied to and absorbed from the grid, simultaneously optimizing energy storage device performance and maintaining grid stability.
- There are multiple types of energy storage technologies, and each has their own characteristics and control parameters that must be managed by the PCS.
- An energy storage installation may be tasked with a variety of different grid support services; the PCS is responsible for controlling the flow of energy to meet the requirements of the intended grid support application.
- The major electrical components of a PCS are semiconductor switches, magnetic devices such as inductors and transformers, capacitors, and a controller.

