Grid Energy Storage

Course Number: EE-02-703

PDH: 4

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Module 1: Introduction

Learning Objectives

By the end of this section, you will be able to:

- **Evaluate** the role of Energy Storage Systems (ESS) in modernizing the electrical grid and meeting projected energy demands.
- **Identify** the primary drivers for energy storage deployment, including renewable integration, infrastructure aging, and emergency preparedness.
- **Analyze** the projected economic growth and regulatory landscape surrounding the energy storage industry.

Executive Summary: To meet a projected national demand of 4–5 terawatt-hours by 2050, the U.S. must deploy substantial energy storage to integrate variable renewables, stabilize a transmission system where 70% of lines are over 25 years old, and foster a market projected to reach $19 billion by 2017.

Grid Modernization and Energy Needs

Modernizing the electric grid is essential for handling projected energy needs and addressing climate change. By 2050, the United States is estimated to require between **4 and 5 terawatt-hours** of electricity annually. Planning for this expansion requires balancing economic viability, resiliency, cyber-security, and environmental sustainability.

Energy storage systems (ESS) are critical to meeting these challenges by:

- **Improving Operating Capabilities**: Enhancing grid flexibility and dispatch.
- **Mitigating Infrastructure Investment**: Reducing the need for immediate physical grid expansions.
- **Regulating Power Quality**: Managing the reliability of power from both traditional and variable (renewable) sources.
- **Emergency Preparedness**: Contributing to overall grid resilience and backup power.

Urgency and Regulatory Drivers

The requirement for storage has become a pressing issue, largely driven by state-level mandates and federal interest.

- **California (AB 2514)**: Enacted in 2010, this law required the establishment of procurement targets for 2015 and 2020. In 2013, targets and mechanisms were proposed totaling **1,325 MW** of storage.
- **Federal Legislation**: Two bills, the **STORAGE Act** (S. 1030) and the **MLP Parity Act** (S. 795), were introduced to establish incentives for deployment.

Renewable Energy Integration

Increasing penetration of renewable energy to meet Renewable Portfolio Standards (RPS) is intrinsically linked to energy storage.

- **Smoothing Delivery**: Storage offsets the variability of wind and solar, increasing the value of renewable power.
- **Distributed Generation**: When used with distributed assets, storage provides power-conditioning and enables higher renewable penetration.

Addressing Aging Infrastructure

The U.S. transmission system requires augmentation to maintain performance and security.

Asset Type	Estimated Age Profile
Transmission Lines	70% are 25 years or older
Power Transformers	70% are 25 years or older
Circuit Breakers	60% are more than 30 years old

💡 **Design Tip:** Engineers should consider pre-positioning storage on the load side of transmission constraint points to make the grid more secure, reliable, and responsive. This can reduce line-congestion and line-loss by moving electricity at off-peak times.

Electrification of Transportation

The shift toward electric vehicles (EVs) makes energy storage and vehicle-to-grid integration critical.

- **Secondary Applications**: Focus is growing on "second-life" applications for retired EV batteries in stationary residential or commercial settings.
- **Validation**: Pilot projects, such as Project Plug-IN, are currently validating business models for these commercial storage applications.

DOE Strategic Goals and Economic Impact

The Department of Energy (DOE) facilitates technology discovery and removes deployment barriers to secure U.S. leadership in clean energy.

- **Cost Targets**: The DOE 2011 Strategic Plan aims to reduce energy storage costs by **30% by 2015**.
- **Market Opportunity**: The energy storage industry is poised to grow from $200 million in 2012 to **$19 billion by 2017**.
- **Manufacturing Base**: A strong domestic market fosters a robust manufacturing base, providing export opportunities and supporting energy independence.

Checkpoint Quiz

1. **What is the primary benefit of "smoothing" renewable power with storage?**
   a) It reduces the total amount of energy produced.
   b) It eliminates the need for any frequency regulation.
   c) It increases the value of renewable power by regulating delivery timing and quality.
   d) It prevents the need for any customer-side meters.

Answer: (c). Storage allows intermittent energy sources to be delivered more consistently, increasing their overall value to the grid.

2. **According to DOE estimates, what percentage of U.S. transmission lines are 25 years or older?**
   a) 25%
   b) 50%
   c) 60%
   d) 70%

Answer: (c). DOE estimates indicate that 70% of both transmission lines and power transformers are at least 25 years old.

Module 2: State of Energy Storage in US and Abroad

Learning Objectives

By the end of this section, you will be able to:

- **Analyze** the current distribution of energy storage technologies in the U.S. based on rated power and installation capacity.
- **Evaluate** the impact of federal and state regulatory policies, such as FERC Order 755 and California's AB 2514, on the commercial viability of storage.
- **Compare** international deployment strategies for grid storage across major markets including Japan, China, India, and Europe.

Executive Summary: As of August 2013, the U.S. energy storage market is dominated by pumped hydro at 95% of the 24.6 GW total capacity. While large-scale systems are mature, the industry is transitioning toward a diverse portfolio of batteries and flywheels driven by new regulatory frameworks and international competition.

Current State of Energy Storage in the U.S.

The Department of Energy (DOE) maintains an interactive database providing a snapshot of storage deployments worldwide.

Capacity and Technology Mix

- **Total Capacity**: The U.S. has 202 storage system deployments with a cumulative operational capability of 24.6 GW.
- **Pumped Hydro**: Accounts for 95% (23.4 GW) of the total, favored for its large unit sizes and utility-sector history.
- **Emerging Technologies**: The remaining 5% includes thermal storage (36% of non-hydro), compressed air (35%), batteries (26%), and flywheels (3%).

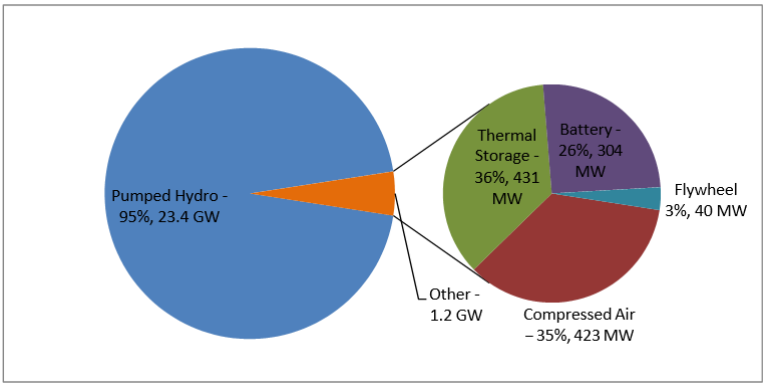

Figure 1 – Rated Power of US Grid Storage projects (includes announced projects)

Installation Sizes

- Deployment sizes range from residential-scale systems (10 kW or below) to large utility systems exceeding 1 MW.
- Systems 10 kW or below are likely undercounted in current reporting.

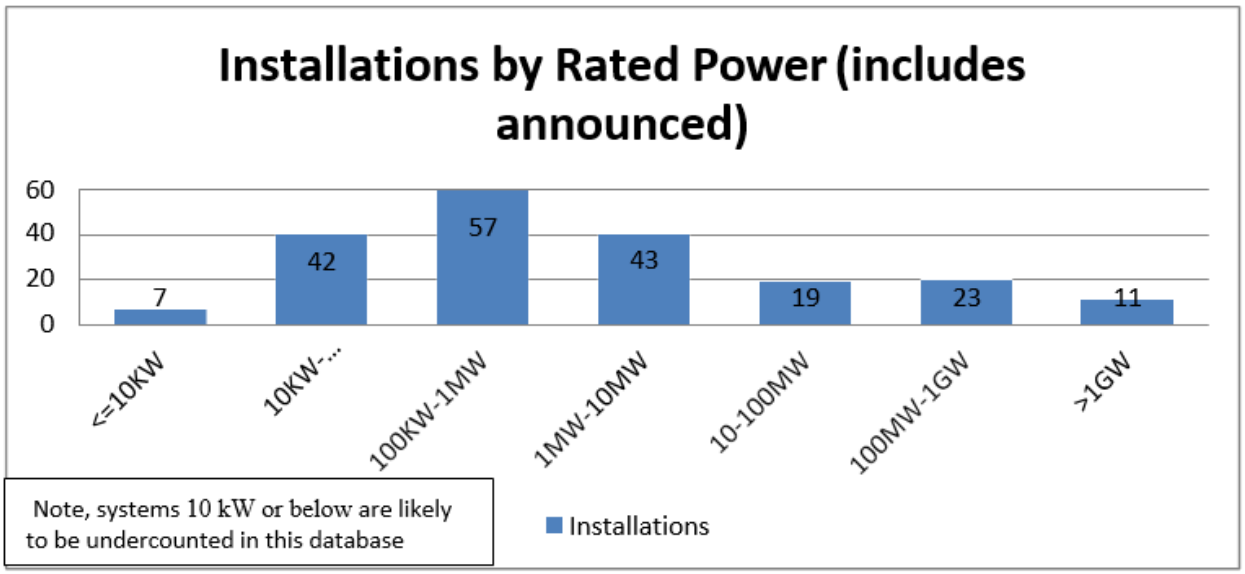

Figure 2 – Number of US installations, grouped by capacity

Regulatory Environment and Oversight

Regulatory policies provide the essential framework for the business case and economics of storage.

Jurisdictional Roles

- **FERC**: Regulates interstate transactions.
- **Public Utility Commissions (PUCs)**: Regulate state-level operations, rate structures, and capacity acquisition.
- **Independent System Operators (ISOs)**: Provide oversight of transmission and generation in specific regions.

Key Policy Drivers

- **FERC Order 755**: Structures payments and sets contracts for frequency regulation.
- **Regional Adoption**: PJM, MISO, CAISO, and NYISO have adopted Order 755, with ISO-NE scheduled for January 2014.

Purchase this course to see the remainder of the technical materials.