Grid Energy Storage

Course Number: EE-02-703

PDH: 4

Approved for: AK, AL, AR, FL, GA, IA, IL, IN, KS, KY, LA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OK, OR, PA, SC, SD, TN, TX, UT, VA, VT, WI, WV, and WY

State Board Approvals

Florida Provider # 0009553 License #868
Indiana Continuing Education Provider #CE21800088
Maryland Approved Provider of Continuing Professional Competency
New Jersey Professional Competency Approval #24GP00025600
North Carolina Approved Sponsor #S-0695
NYSED Sponsor #274

Course Author: Mathew Holstrom

How Our Written Courses Work

This document is the course text. You may review this material at your leisure before or after you purchase the course.
After the course has been purchased, review the technical material and then complete the quiz at your convenience.
A Certificate of Completion is available once you pass the exam (70% or greater).
If a passing grade is not obtained, you may take the quiz as many times as necessary until a passing grade is obtained).
If you have any questions or technical difficulties, please call (508) 298-4787 or email us at admin@PDH Pro.com.

Executive Summary

Modernizing the electric system will help the nation meet the challenge of handling projected energy needs—including addressing climate change by integrating more energy from renewable sources and enhancing efficiency from non-renewable energy processes. Advances to the electric grid must maintain a robust and resilient electricity delivery system, and energy storage can play a significant role in meeting these challenges by improving the operating capabilities of the grid, lowering cost and ensuring high reliability, as well as deferring and reducing infrastructure investments. Finally, energy storage can be instrumental for emergency preparedness because of its ability to provide backup power as well as grid stabilization services.

At present, the U.S. has about 24.6GW (approx. 2.3% of total electric production capacity) of grid storage, 95% of which is pumped storage hydro. Europe and Japan have notably higher fractions of grid storage. Pursuit of a clean energy future is motivating significantly increased storage development efforts in Europe and Asia, as well as the U.S.

Energy storage technologies—such as pumped hydro, compressed air energy storage, various types of batteries, flywheels, electrochemical capacitors, etc., provide for multiple applications: energy management, backup power, load leveling, frequency regulation, voltage support, and grid stabilization. Importantly, not every type of storage is suitable for every type of application, motivating the need for a portfolio strategy for energy storage technology.

There are four *challenges* related to the widespread deployment of energy storage: cost competitive energy storage technologies (including manufacturing and grid integration), validated reliability & safety, equitable regulatory environment, and industry acceptance. Issues that are being explored in this paper focus on reducing system costs through targeted application of science and engineering research and development for new storage concepts, materials, components and systems (including manufacturability and standardization). Developers should consider technical risk mitigation, for controlling the uncertainties at the early stage of deployment so that cost estimates and operational practices can develop based upon well-grounded and fully understood data. Ongoing research and development, from fundamental science of energy storage mechanisms to the early-stage development of platform technologies should also be considered in support of these challenges. Industrial standards for grid storage are in their infancy. Industry acceptance could also gain ground when we reduce the uncertainty surrounding how storage technology is used, and monetized, at scale. Ultimately, it will be the experience and real-world use of storage that will provide the confidence and desire to expand installed storage.

The expansion of the electricity system can be accelerated by the widespread deployment of energy storage, since storage can be a critical component of grid stability and resiliency. ***The future for energy storage in the U.S. should address the following issues: energy storage technologies should be cost competitive (unsubsidized) with other technologies providing similar services; energy storage should be recognized for its value in providing multiple benefits simultaneously; and ultimately, storage technology should seamlessly integrate with existing systems and sub-systems leading to its ubiquitous deployment***.

In reviewing the barriers and challenges, and the future for energy storage, a strategy that would address these issues should comprise three broad outcome-oriented goals:

1. Energy storage should be a broadly deployable asset for enhancing renewable penetration – specifically to enable storage deployment at high levels of new renewable generation
2. Energy storage should be available to industry and regulators as an effective option to resolve issues of grid resiliency and reliability
3. Energy storage should be a well-accepted contributor to realization of smart-grid benefits – specifically enabling confident deployment of electric transportation and optimal utilization of demand-side assets.

To realize these outcomes, the principal challenges to focus on are:

- **Cost competitive energy storage technology** - Achievement of this goal requires attention to factors such as life-cycle cost and performance (round-trip efficiency, energy density, cycle life, capacity fade, etc.) for energy storage technology as deployed. It is expected that early deployments will be in high value applications, but that long term success requires both cost reduction and the capacity to realize revenue for all grid services storage provides.
- **Validated reliability and safety** - Validation of the safety, reliability, and performance of energy storage is essential for user confidence.
- **Equitable regulatory environment** – Value propositions for grid storage depend on reducing institutional and regulatory hurdles to levels comparable with those of other grid resources.

- **Industry acceptance** – Industry adoption requires that they have confidence storage will deploy as expected, and deliver as predicted and promised.

The US DOE is addressing these challenges in the following ways:

Challenge/Goal	Strategy Summary
Cost competitive energy storage technology	• Targeted scientific investigation of fundamental materials, transport processes, and phenomena enabling discovery of new or enhanced storage technologies with increased performance • Materials and systems engineering research to resolve key technology cost and performance challenges of known and emerging storage technologies (including manufacturing) • Seeded technology innovation of new storage concepts • Development of storage technology cost models to guide R&D and assist innovators • Resolution of grid benefits of energy storage to guide technology development and facilitate market penetration
Validated reliability and safety	• R&D programs focused on degradation and failure mechanisms and their mitigation, and accelerated life testing • Development of standard testing protocols and independent testing of prototypic storage devices under accepted utility use cases • Track, document, and make available performance of installed storage systems
Equitable Regulatory Environment	• Collaborative public-private sector characterization and evaluation of grid benefits of storage • Exploration of technology-neutral mechanisms for monetizing grid services provided by storage • Development of industry and regulatory agency-accepted standards for siting, grid integration, procurement, and performance evaluation
Industry acceptance	• Collaborative, co-funded field trials and demonstrations enabling accumulation of experience and evaluation of performance – especially for facilitating renewable integration and enhanced grid resilience • Adaptation of industry-accepted planning and operational tools to accommodate energy storage • Development of storage system design tools for multiple grid services

1.0 Introduction

Modernizing the electric grid will help the nation meet the challenge of handling projected energy needs—including addressing climate change by relying on more energy from renewable sources—in the coming decades, while maintaining a robust and resilient electricity delivery system. By some estimates, the United States will need somewhere between 4 and 5 tera watt-hours of electricity annually by 2050.[2] Those planning and implementing grid expansion to meet this increased electric load face growing challenges in balancing economic and commercial viability, resiliency, cyber-security, and impacts to carbon emissions and environmental sustainability. Energy storage systems (ESS) will play a significant role in meeting these challenges by improving the operating capabilities of the grid as well as mitigating infrastructure investments. ESS can address issues with the timing, transmission, and dispatch of electricity, while also regulating the quality and reliability of the power generated by traditional and variable sources of power. ESS can also contribute to emergency preparedness. Modernizing the grid will require a substantial deployment of energy storage. In the past few years, the urgency of energy storage requirements has become a greater, more pressing issue that is expected to continue growing over the next decade:

- California enacted a law in October 2010 ***requiring*** the California Public Utilities Commission (CPUC) to establish appropriate 2015 and 2020 ***energy storage procurement targets for California load serving entities, if cost effective and commercially viable by October 2013*** (AB 2514). In February 2013, the CPUC determined that Southern California Edison must procure 50 MW of energy storage capacity by 2021 in Los Angeles area. Additionally, in June 2013, the CPUC proposed storage procurement targets and mechanisms totaling 1,325 MW of storage. Other States are looking to the example that California is setting, and Congress has introduced two bills that establish incentives for storage deployment.[3]
- The increasing penetration of renewable energy on the grid ***to meet renewable portfolio standards*** (RPS) may be linked with greater deployment of energy storage. Storage can "smooth" the delivery of power generated from wind and solar technologies, in effect, increasing the value of renewable power. Additionally, when energy storage is used with ***distributed generation***, it can improve the reliability of those assets by providing power-conditioning value, and enables increased renewable penetration to help contribute to meeting state RPS.

[2] For a table of several such estimates, see Hostick, D.; Belzer, D.B.; Hadley, S.W.; Markel, T.; Marnay, C.; Kintner-Meyer, M. (2012). End-Use Electricity Demand. Vol. 3 of Renewable Electricity Futures Study. NREL/TP-6A20- 52409-3. Golden, CO: National Renewable Energy Laboratory.

[3] The bills before congress are S. 1030 (STORAGE Act) and S. 795 (MLP Parity Act). Details on the California bill (AB 2514) can be found on the CPUC website: http://www.cpuc.ca.gov/PUC/energy/electric/storage.htm