Electrical Energy Storage

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Course Author: Mathew Holstrom

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CONTENTS

INTRODUCTION

Publication of the Electricity Storage Course (Course) is funded through Dr. Imre Gyuk, U.S. Department of Energy (DOE) and Haresh Kamath, Electric Power Research Institute (EPRI) in collaboration with the National Rural Electric Cooperative Association (NRECA). Development of the Course's content was guided by a ten-member Advisory Panel representing system vendors, electric utilities, regulators, and trade associations.[1]

The Course includes discussion of stationary energy storage systems that use batteries, flywheels, compressed air energy storage (CAES), and pumped hydropower and excludes thermal, hydrogen, and other forms of energy storage that could also support the grid, such as plug-in electric vehicles (PEVs) or electric vehicles (EVs). Both DOE and EPRI have separate programs which support PEVs and EVs.

This edition of the Course builds primarily upon the *EPRI-DOE Handbook of Energy Storage for Transmission and Distribution Applications,* released in December 2003, a landmark collaboration between EPRI and DOE. The first Course presented a broad perspective on the potential of energy storage in the national grid, comparative storage technology and benefits assessments, and a review of ten different storage technologies in 14 transmission and distribution (T&D) categories.

This edition of the Course is a how-to guide for electric systems engineers/planners, energy storage system vendors, and investors to aid in the selection, procurement, installation, and/or operation of stationary energy storage systems in today's electric grid. Various perspectives of grid electricity storage are presented for different stakeholders: generators and system operators, load-serving entities (LSEs) with various ownership structures, and customers. The Course includes a review of the current status of technical, financial, regulatory, and ownership issues that impact energy storage adoption, primarily with a U.S.-centric focus. Much of the material presented in this edition of the Course has been condensed and updated from existing reports from Sandia National Laboratories (SNL), EPRI, NRECA, other national laboratories, and industry sources published from the mid-1980s to the present. This edition presents updated information on storage technologies and their benefits in an operational and regulatory environment and recognizes energy storage as a grid component in further detail than the 2003 Course.

[1] The advisory panel members are Eva Gardow, FirstEnergy; Steve Willard, Public Service Company of New Mexico; Naum Pinsky, Southern California Edison; Rick Winter, UniEnergy Technologies; Mike Jacobs, Xtreme Power; Kimberly Pargoff, A123; Pramod Kulkarni, Customized Energy Solutions; Chet Sandberg (representing Electricity Storage Association); Janice Lin, California Energy Storage Association; and Ali Nourai, DNV-KEMA.

OUTLINE

This Course is organized into four chapters and appendices. Roadmaps are provided at the end of this section to aid in navigation of the Course.

Chapter 1: Electricity Storage Services and Benefits

The first chapter reviews 14 services and functional uses, including electricity storage services to the grid, ancillary services, grid system services and functional uses, end user/utility customer functional services and renewables integration that electricity storage provides to the grid as a generation, transmission and distribution (T&D), and customer-side resource. The chapter also provides a brief review of simultaneous use of electricity storage for multiple applications (stacked).

Chapter 2: Electricity Storage Technologies: Cost, Performance, Maturity

The second chapter presents the principles of operation for pumped hydro and Compressed Air Energy Storage (CAES) and the electrochemistry for a family of currently available battery technologies. Each technology section also includes capital and levelized cost of energy (LCOE) charts based on the responses of a first-of-a-kind, comprehensive survey of more than 40 storage vendors. An appendix to this chapter provides further detail on the component and system cost for each technology to provide select grid services, including representative schematics for each service.

Chapter 3: Methods/Tools for Evaluating Electricity Storage

The third chapter discusses screening-level and advanced production cost, electric stability, and financial tools that can be used to evaluate the impact of electricity storage in the grid. An appendix to this chapter provides a summary of specific evaluation tools currently available.

Chapter 4: Storage Systems Procurement and Installation

The final chapter provides an overview of procurement options based on approaches used both in the past and for current projects. Sections in this chapter address purchasing options, safety, interconnection and communication, warranty, and disposal issues. Further details on noteworthy past and present storage projects and a worldwide storage project database initiated by the DOE are presented in a related appendix.

References and Appendices

A glossary of select terms and an extensive reference database of reports published by DOE, EPRI, NRECA, and industry sources are among the supporting appendices provided at the end of the Course. References for material in the text are provided in footnotes.

Course Roadmaps

This Course addresses the what, why, and how of electricity energy storage for grid and stand-alone applications. It is intended for use by an audience that falls broadly into three groups:

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