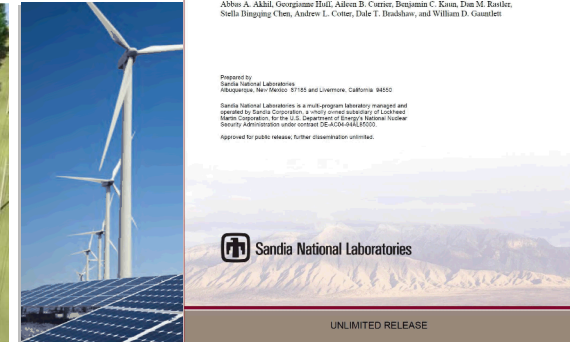


Exceptional service in the national interest



DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA (ESHB)

October 24, 2013
Georgianne Huff



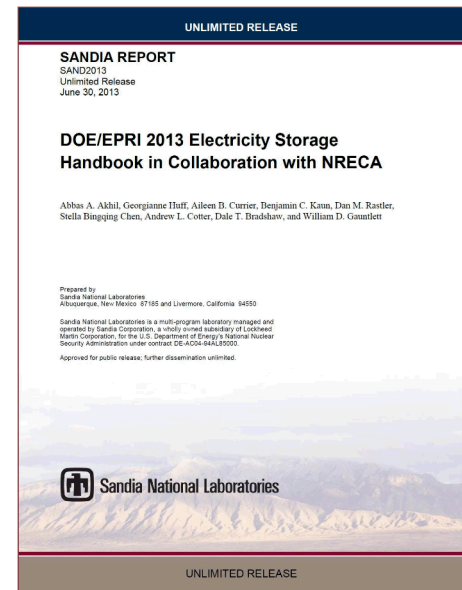
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Thank You for your vision and collaboration

- Dr. Imre Gyuk, Energy Storage Program Manager, U.S. Department of Energy's Office of Electricity
- Haresh Kamath, Electric Power Research Institute
- Robbin K. Christianson, National Rural Electric Cooperative Association
- Energy Storage Handbook Advisory Panel

Co-authors:

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Partnerships and Collaborations

- **DOE** ■ **EPRI** ■ **NRECA**
- Contributed data and perspective
- Large potential readership pool
 - EPRI – 1,000+ organizations
 - NRECA – 900+ members
- Assures consistent cost and technology status



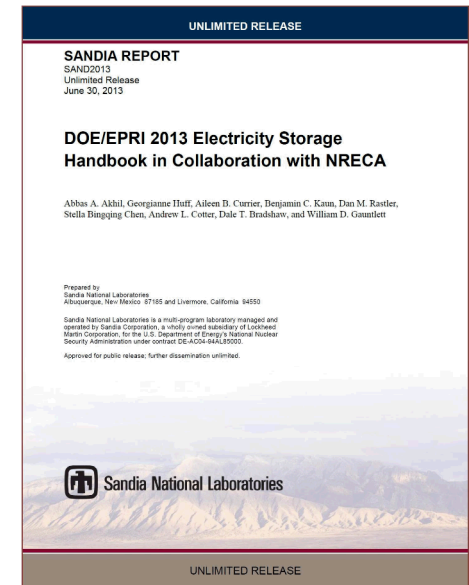
U.S. DEPARTMENT OF
ENERGY



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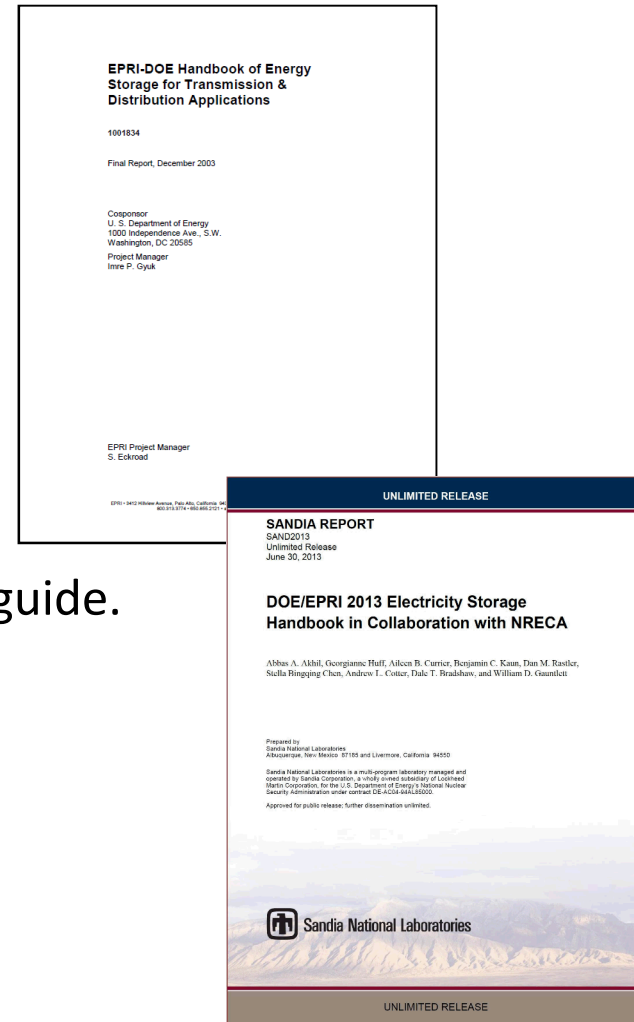


NRECA
A Touchstone Energy® Cooperative



ESHB Background

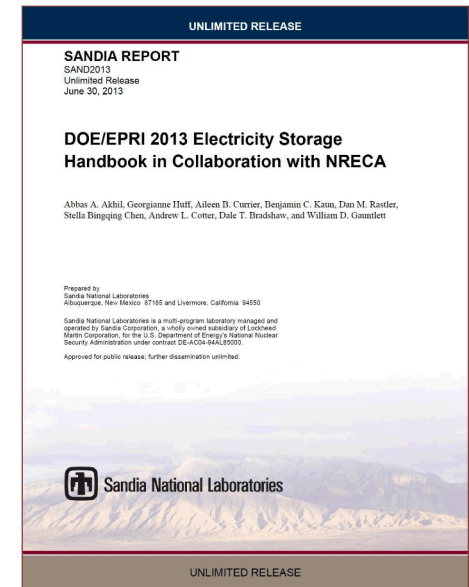
- First edition – Published in 2003
 - Multiple storage applications and technologies
- Current edition published July 3, 2013
 - Hands-on approach and how-to guide
- Fill industry need
 - single resource
 - thorough and comprehensive implementation guide.
 - summarizes storage system costs
 - public domain



ESHB Content

- 4 Chapters and Appendices
 - Storage benefits and services
 - Storage technologies, cost, performance and maturity
 - Methods and tools for evaluating storage
 - Storage system procurement and installation
- Appendices
 - Cost Details
 - Computational tools
 - sample procurement documents
 - interconnection schematics

Handbook ~ 170 pages; Appendices ~ 170 pages



ESHB - Reader-friendly Approach

“Road Maps”

Suggested Guide for Utility and Co-op Engineers/System Planners

- Specific areas of interest
- Engineers/System Planners
- System Vendors and Investors
- Regulators and Policy Makers

What are the relevant use cases for energy storage?

Chapter 1 identifies storage services and functional uses including storage for renewable integration and provides ranges and minimum requirements for storage systems with illustrative examples. The use cases and applications span generation, T&D as well as customer-side applications.

What are the technology options and how can use cases of interest be assessed?

Chapter 2 describes current storage technologies and their high-level performance characteristics, maturity, and costs in \$/kW and \$/kWh. Chapter 4 identifies various technology-assessment tools from preliminary screening to more detailed analysis. Selected tools are described in Appendix A.

What are the costs and important procurement and installation issues?

Chapter 4 presents two different system procurement/ownership options for investor-owned utilities (IOUs) and co-ops. It addresses practical safety, interconnection, warranty, and codes issues to guide successful project completion. Appendix C provides sample Requests for Information (RFIs) and Requests for Quotes (RFQs) that can be modified to suit specific needs and serve as guidelines for system procurement processes. Appendix B gives detailed system and component cost information organized by storage technology. These data were obtained from system vendors for the various technologies currently in use for stationary applications and were used to derive the capital costs in Chapter 2. Appendix D illustrates interconnection configurations for selected storage systems and gives representative interconnection equipment costs. These configurations can be changed to meet more specific site needs as necessary. Appendix C contains a sample specification for cyber security guidance specific to Li-ion battery systems that can serve as a guideline for other storage technology systems.

How have public utility commissions (PUCs) treated storage and what are the regulatory drivers for storage?

Appendix E provides a comprehensive review of PUC cases where storage was included and their outcomes. Chapter 4 summarizes enacted and pending Federal Energy Regulatory Commission (FERC) and State regulatory initiatives that promote storage.

Which trade associations are promoting storage and what are the venues for networking in this community?

Chapter 4 identifies those industry groups and not-for-profit conferences that provide networking opportunities with system vendors, technology developers, and other utilities that use or are considering storage, as well as a window into Federal and State programs that promote storage deployment.

ESHB Content Highlights – Chapter 1

- Chapter describes and illustrates services that storage provides to the grid
 - Storage System Size Range; Target Discharge Duration; Min. Cycles/Year

Table 1. Electric Grid Energy Storage Services Presented in This Handbook

Bulk Energy Services	
	Electric Energy Time-Shift (Arbitrage)
	Electric Supply Capacity
Ancillary Services	
	Regulation
	Spinning, Non-Spinning and Supplemental Reserves
	Voltage Support
	Black Start
	Other Related Uses
Transmission Infrastructure Services	
	Transmission Upgrade Deferral
	Transmission Congestion Relief
Distribution Infrastructure Services	
	Distribution Upgrade Deferral
	Voltage Support
Customer Energy Management Services	
	Power Quality
	Power Reliability
	Retail Electric Energy Time-Shift
	Demand Charge Management

ESHB Content Highlights – Chapter 2

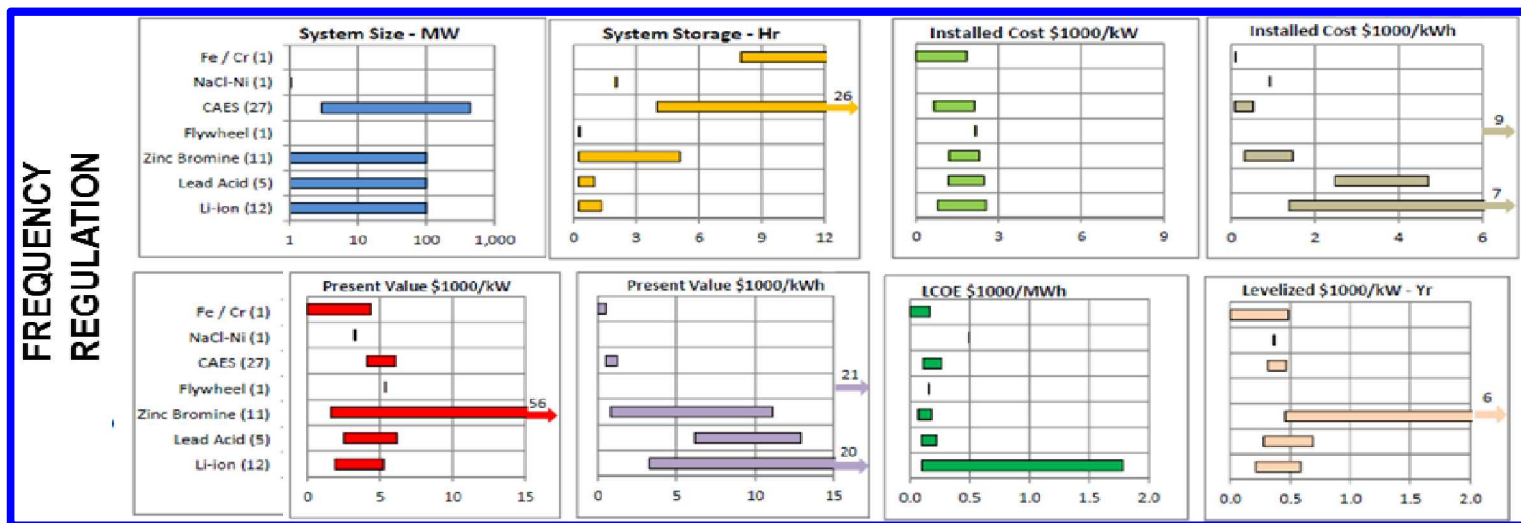
- Reviews currently available and emerging electricity storage technologies
 - Snapshot of the status
 - Trends in deployment
 - “Technology Dashboards”
 - Estimates of life-cycle costs

Table 6. Technology Dashboard: Compressed Air Energy Storage

Technology Development Status	1 st Generation - Mature 2 nd Generation - Demonstration	Commercial offer possible System to be verified by demonstration unit
Confidence of Cost Estimate	C	Based on preliminary designs Owners' costs and site-specific costs not included; these costs can be significant. First-time-engineering costs can be significant.
Accuracy Range	C	-20% to +25%
Operating Field Units	2 nd Generation - None	Two of first-generation type
Process Contingency	15%	Key components and controls need to be verified for second-generation systems.
Project Contingency	10%	Plant costs will vary depending upon underground site geology.

ESHB Storage System Costs

- System vendors supplied information on total installed cost for pre-specified systems:
 - Large systems for bulk storage
 - Mid-size systems for spinning reserve and frequency regulation
 - Smaller systems for commercial/industrial and residential
- Costs summarized in \$/kW and \$/kWh
- Mini-strip charts are visual representation of costs:



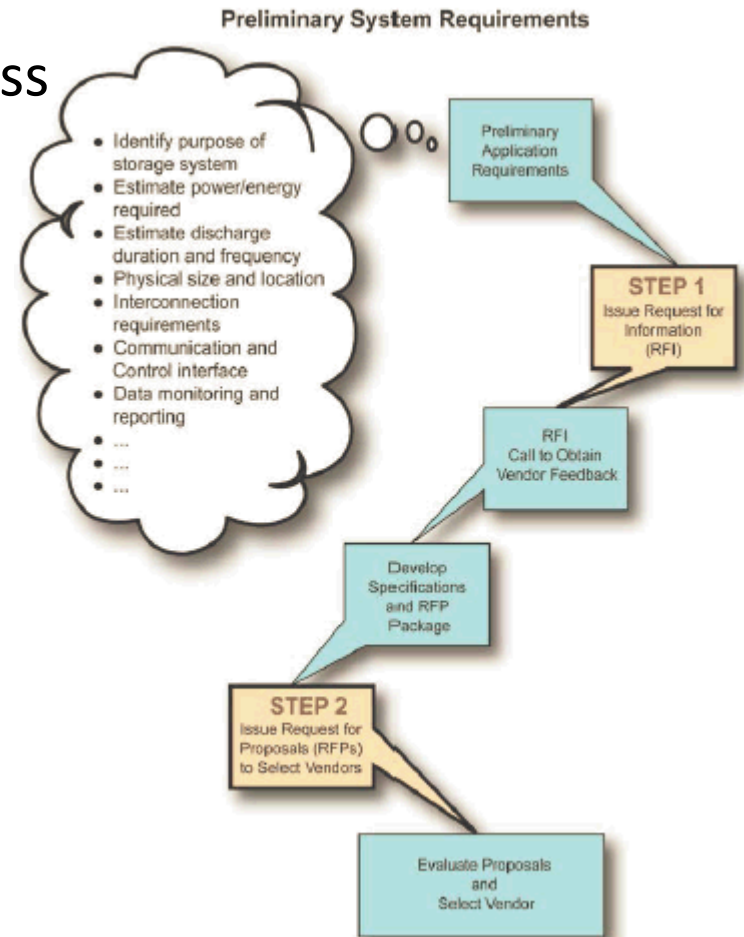
ESHB Content Highlights – Chapter 3

- Methodology for assessing value storage provides grid
- Various computational tools to evaluate and quantify
 - Screening Level – technology selection, high-level application-specific economic comparisons
 - Financial Tools – More detailed, production-cost based models
 - Engineering Tools – Perform stability analysis, sizing of the storage system and location in the grid



ESHB Content Highlights – Chapter 4

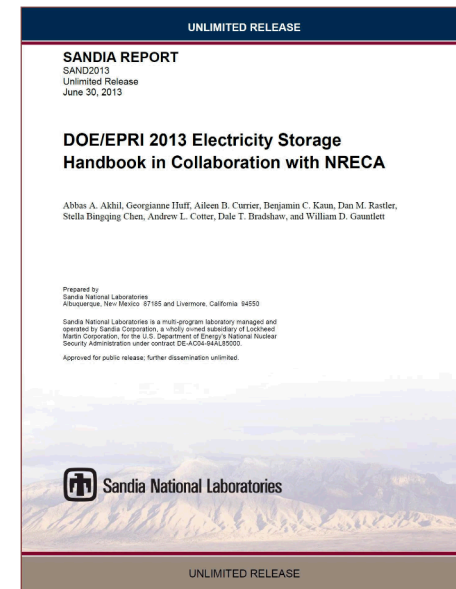
- Specification and procurement process
- RFI – RFP process for acquisition
 - Sample RFI and RFP's
- Interconnection issues
 - front end interface
 - integration into utility network management



source: Sandia National Laboratories

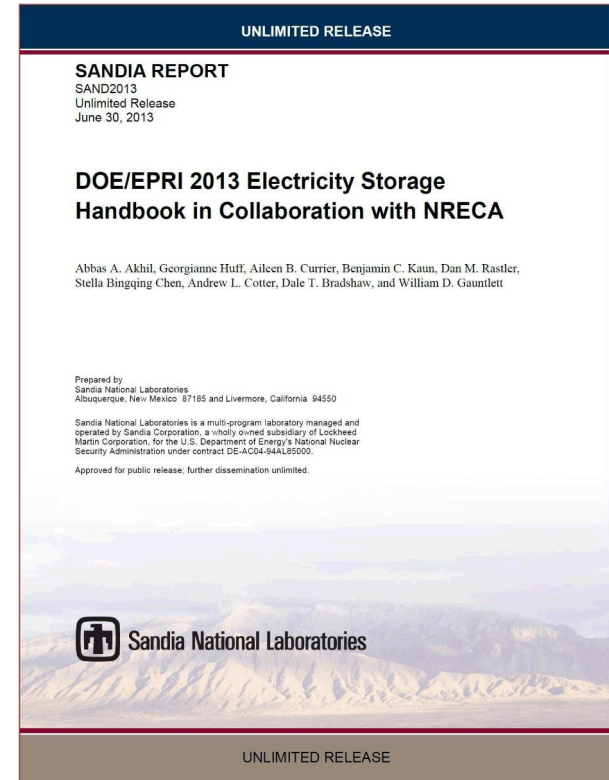
ESHB Content Highlights – Appendices

- Glossary
 - Computational tools
 - Storage system costs
 - Procurement process
-
- Interconnected Costs and Schematics
 - Regulatory framework
 - Test Facilities
 - Past and present noteworthy projects
 - DOE International Energy Storage Database:
www.energystorageexchange.org



ESHB Document Format and Availability

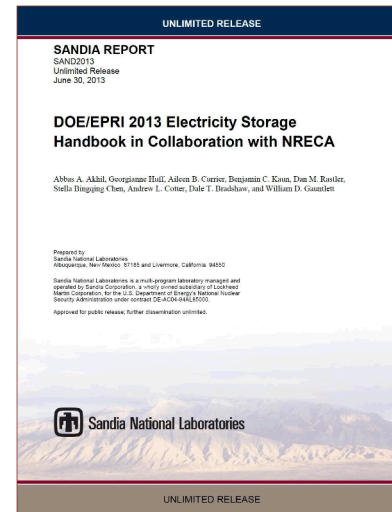
- Available PDF only
- 12 MB
- <http://www.sandia.gov/ess/>
(in tool box on right)



ESHB Summary/Conclusions

- Complete re-write published July 3, 2013
- Impact to the industry
 - Highly cited document
 - Down loaded 2700+ first month
 - Successful partnership between EPRI, NRECA, DOE and SNL
- Living Document

<http://www.sandia.gov/ess/>



ESHB Future Tasks

FY 14

- Setup Input/Revision Process
 - Comments, inquiries, corrections, and suggestions submitted via website www.sandia.gov/ess/
- Minor updates to 2013 edition of the Electricity Storage Handbook
- Project plan for comprehensive update to Cost Database

FY 15

- Update Cost Database

Dr. Gyuk - Thank you for your continued support



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Questions??

Thank You...