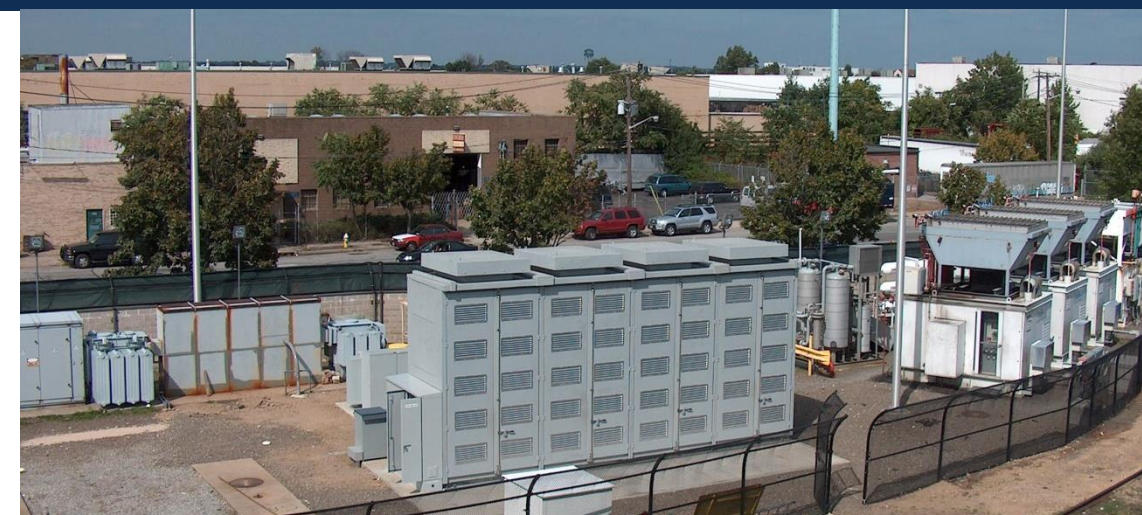
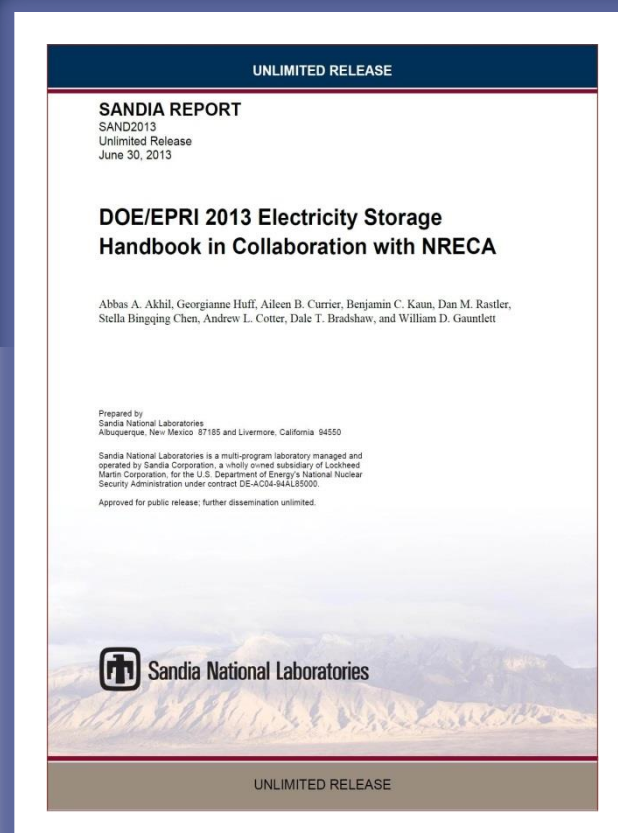


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Update: DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA

September 19, 2014

Georgianne Huff / Abbas Akhil



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Funding and guidance from DOE's **Office of Electricity**
and **Dr. Imre Gyuk, Program Manager of the Electrical**
Energy Storage Program

AND

Haresh Kamath, Electric Power Research Institute (EPRI)

Robbin K. Christianson, National Rural Electric
Cooperative Association (NRECA)

Thank You for your vision and collaboration

Handbook Overview

Why do we need a Storage Handbook?

- Industry needs an unbiased overview of storage technologies, performance metrics, system costs, regulatory issues, codes and standards
- Fast-changing technology, evolving cost targets and regulations

Handbook Overview – Cont'd

Why is it innovative?

- It is a hands-on guide and desk reference
- Detailed system cost data; technology updates; storage system ownership and acquisition guidance: has sample RFI and RFP documents

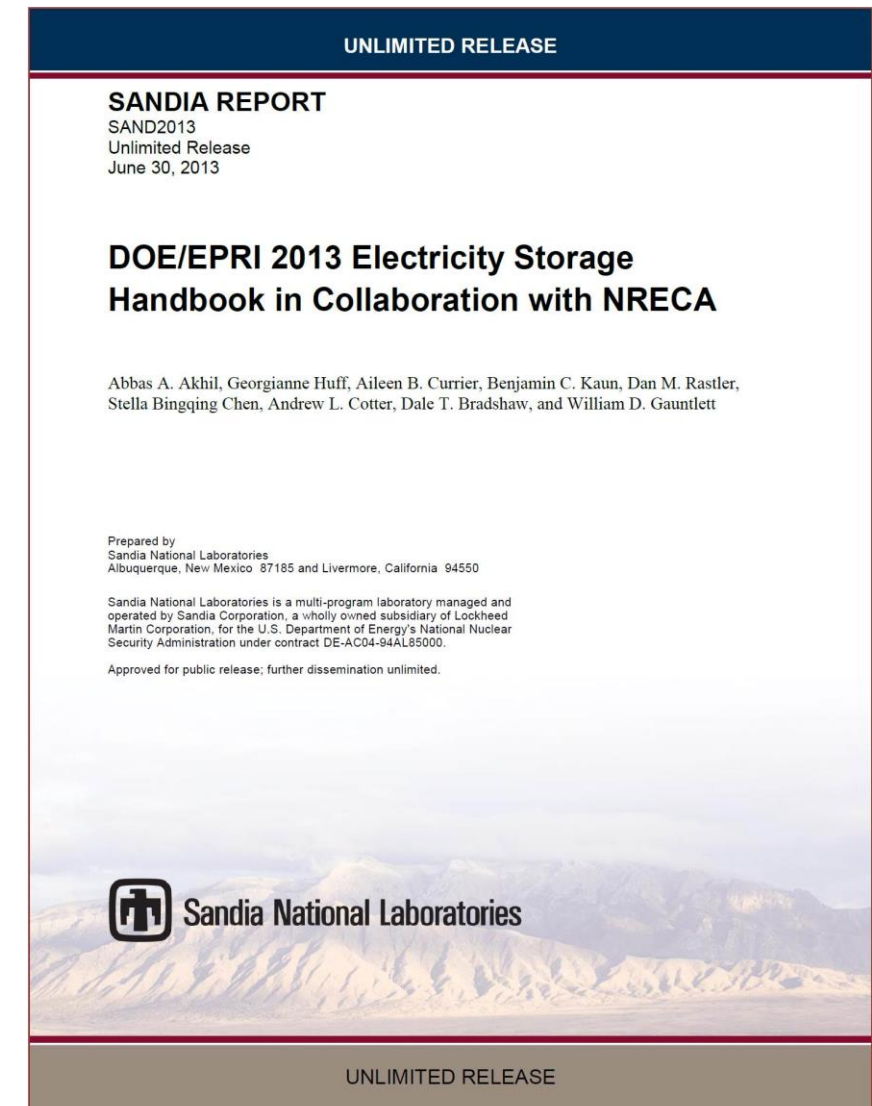
Handbook Development

- **Landmark collaboration** between DOE, EPRI and NRECA – content written jointly
- Different perspectives: EPRI – regulated utility; NRECA – rural co-operative
- Content development guided by an *active* ten-member Advisory Panel representing utilities, system vendors, regulators and industry associations
- Audience is utility and co-operative engineers/decision makers , policy makers, investors and researchers

ESHB Document Format and Availability

- PDF format only, 12 MB file size
- Downloaded over 2,700 times during first month – from US and Overseas servers
- Free download from:

<http://www.sandia.gov/ess/publications/SAND2013-5131.pdf>



ESHB Update – FY14

- Comments and suggestions to be submitted via website <http://www.sandia.gov/ess/handbook.php>
- Suggestions are automatically acknowledged; reviewed for relevance and validity by the authors; contacted again if the suggestion leads to a change in the Handbook content
- Added to the computational tools section based on the findings of the ESA/Navigant report
- Minor corrections, format clarity; graphics cleanup
- Prepare plan for a comprehensive update of the cost database in collaboration with EPRI and NRECA

**ESS**[Home](#)[Overview](#)[+ Events/News](#)[+ Projects](#)[- Publications](#)[> DOE/EPRI 2013
Electricity Storage
Handbook](#)[> DOE Energy
Storage Database](#)[> ES-Select Tool](#)[+ > Technical Reports](#)[> Conference
Archives](#)[+ Business](#)[+ Technology](#)[+ Energy Storage Safety](#)[Associated Sites](#)**DOE/EPRI 2013 Electricity Storage Handbook****About**

The [DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA](#) is a how-to guide for utility and rural cooperative engineers, planners, and decision makers to plan and implement energy storage projects.

The Handbook also serves as an information resource for investors and venture capitalists, providing the latest developments in technologies and tools to guide their evaluations of energy storage opportunities. It includes a comprehensive database of the cost of current storage systems in a wide variety of electric utility and customer services, along with interconnection schematics. A list of significant past and present energy storage projects is provided for a practical perspective.

The Handbook is jointly sponsored by the U.S. Department of Energy and the Electric Power Research Institute in collaboration with the National Rural Electric Cooperative Association.

Download

The DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA is available for [download \(PDF, 12.3 mb\)](#).

Submit Comments and Questions

Use the form below to contact the DOE/EPRI 2013 Electricity Storage Handbook coordinators now. If you would like to submit supporting materials with your comment, please e-mail them to eshb@sandia.gov

Name:

E-mail (required): e.g., "myname@company.com"

Phone number: including area code.

Subject:

Message:

Handbook location: e.g., page or section

Tools

- > [DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA](#)
- > [PUC Handbook](#)
- > [DOE Global Energy Storage Database](#)
- > [ES-Select Tool](#)

Resources

- > [Safety Codes, Standards, and Regulations](#)
- > [Advanced Energy Storage Device Testing](#)
- > [Electrical Energy Storage Applications and Technologies Conference \(EESAT\)](#)
- > [Energy Storage Technology Advancement Partnership \(ESTAP\) Webinars](#)
- > [Energy Storage Association \(ESA\)](#)
- > [Draft Storage/Stationary Batteries Standards List \(courtesy of UL\)](#)
- > [Energy and Climate \(SNL\)](#)

ESHB Update Plan for FY15

- Engage Advisory Committee with EPRI and NRECA to review FY15 updates
- Content from EPRI Energy Storage Integration Council (ESIC) – *Details on next slide*
- Update Cost Database in collaboration with EPRI and NRECA; format change for cost data for increased clarity
- Update technologies especially flow batteries
- Include cost data for operational systems in California, Hawaii and Alaska

What is ESIC?

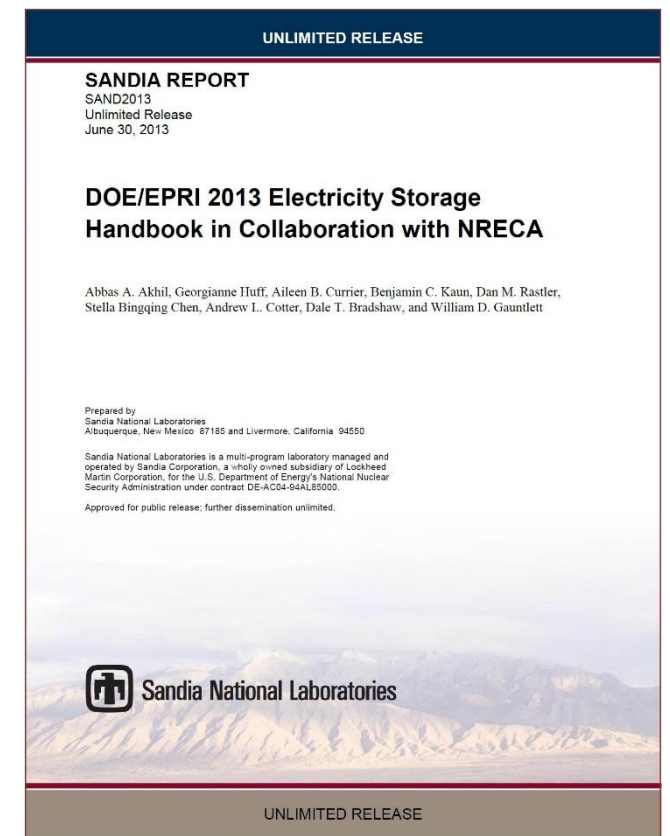
- A public, technical forum led by EPRI to facilitate the availability and integration of safe, reliable, and cost-effective energy storage systems, guided by electric utility needs
- Collaboration between utilities, national labs, regulators, developers
- 5 working groups: planning/operations, procurement, integration
- ESIC will provide significant content guided and reviewed for utility needs

ESHB - Reader-friendly Approach

- “Road Maps” at the beginning of the Handbook guide the reader to specific chapters based on their interests
- Engineers/System Planners
- System Vendors and Investors
- Regulators and Policy Makers

ESHB Content

- Handbook organized in 4 Chapters ~170 pages and Appendices
 - Storage benefits and services
 - Storage technologies, cost, performance and maturity
 - Methods and tools for evaluating storage
 - Storage system procurement and installation
- Appendices
 - System cost details
 - Computational tools
 - Sample procurement documents
 - Interconnection schematics



SANDIA REPORT

SAND2013-5131
Unlimited Release
July 2013

DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA

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Sandia National Laboratories

Handbook Roadmaps

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

What are the relevant use cases for electricity 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, transmission and distribution (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 dollars per kilowatt (\$/kW) and dollars per kilowatt hour (\$/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 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 C provides sample Requests for Information (RFIs) and Requests for Proposals (RFPs) that can be modified to suit specific needs and serve as guidelines for system procurement processes.

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 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.

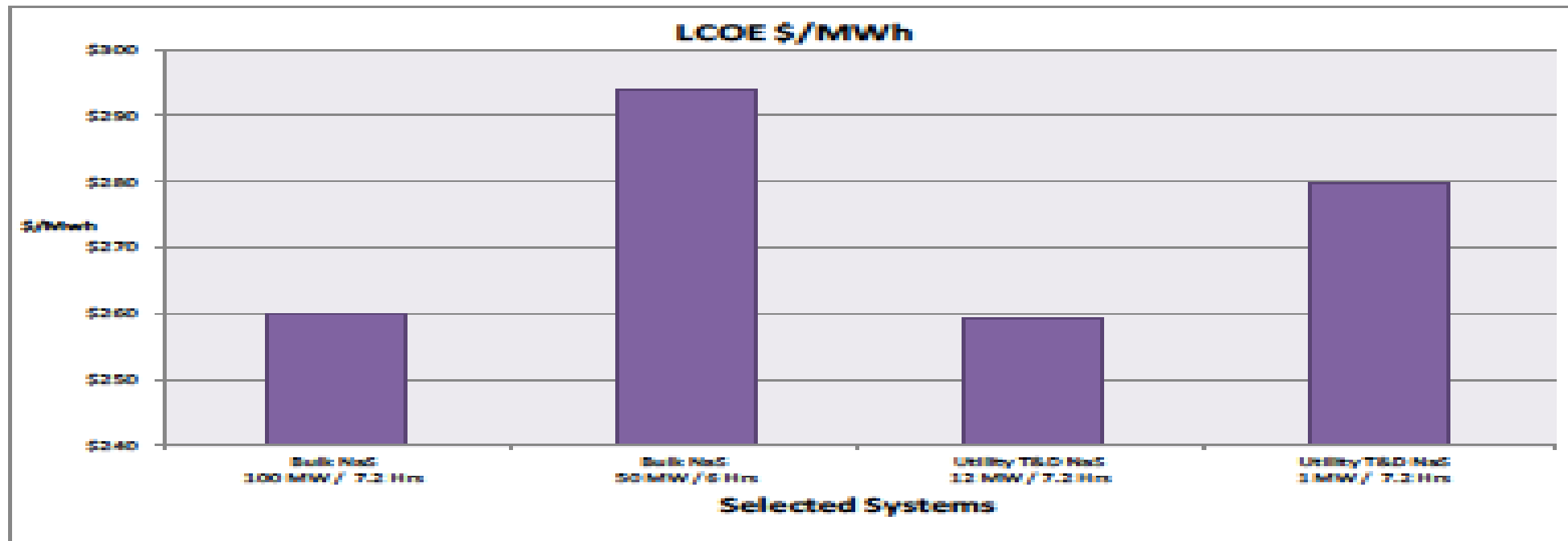


Figure 36. Levelized Cost of Energy in \$/MWh for Different Sodium-sulfur Systems

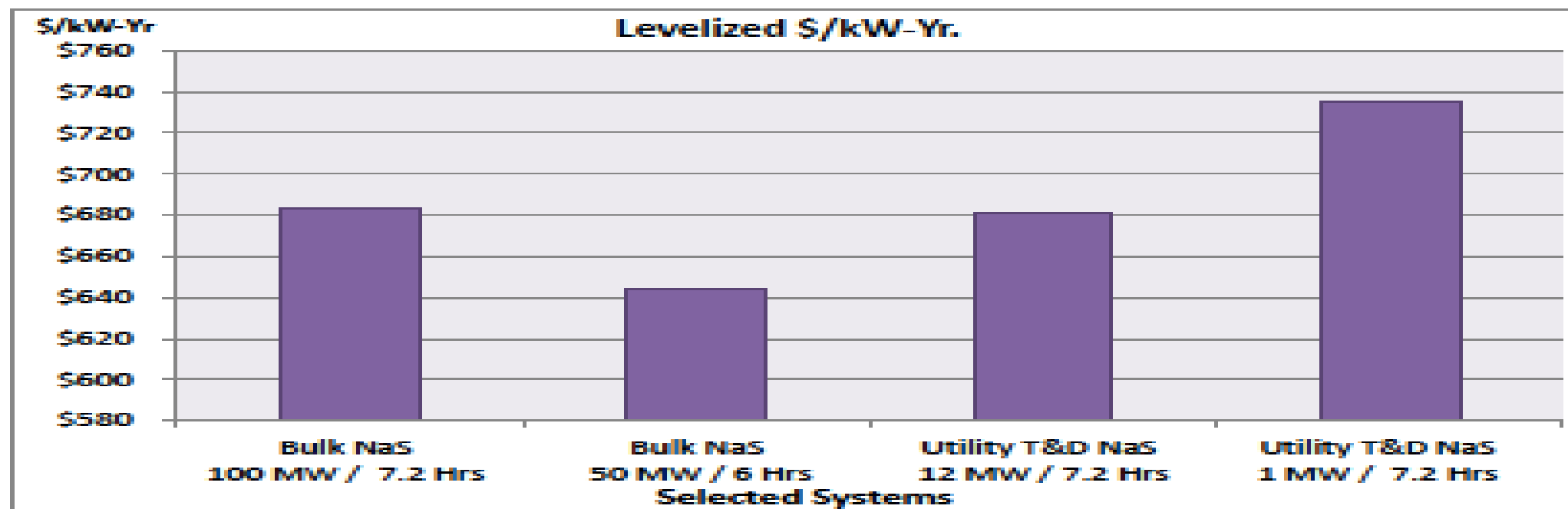


Figure 37. Levelized Costs of Capacity \$/kW-yr for Different Sodium-sulfur Systems

Additional Sodium-Sulfur Battery Resources

1. [Program on Technology Innovation: Long Island Bus NaS Battery Energy Storage System](#), EPRI ID 1013248, EPRI, Palo Alto, CA, EPRI ID 1013248, March 2006.



Figure 113. Steps in Electricity Storage Evaluation

(Source: EPRI)

3.2.1 Step 1a: Grid Opportunity/Solution Concepts (“What Electricity Storage Can Do”)

Figure 114 illustrates Step 1a.

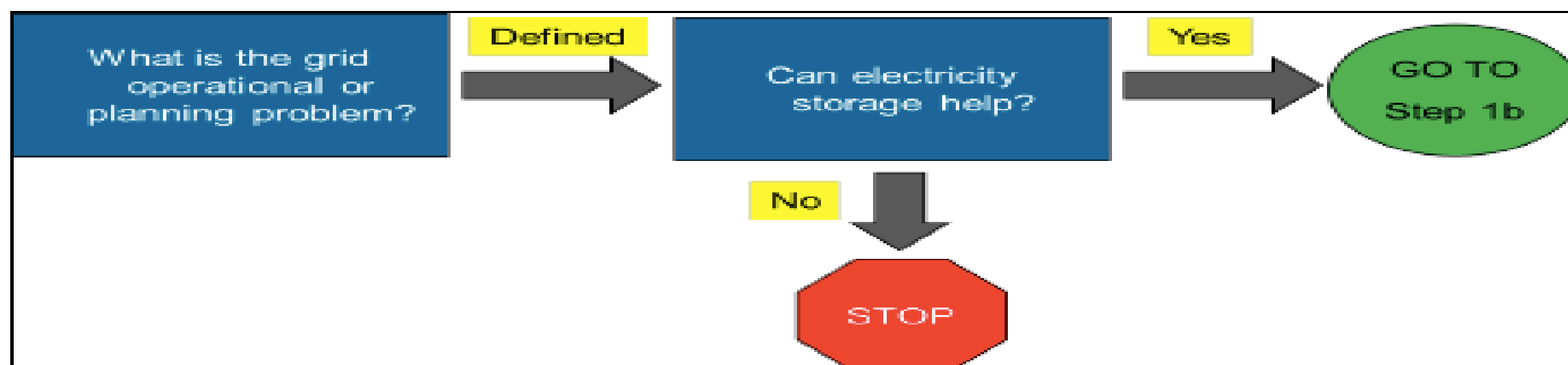


Figure 114. Decision Diagram for Step 1a: Opportunity/Solution Concepts

(Source: EPRI)

3.2.1.1 What Is the Grid Operational or Planning Problem?

Grid operational or planning problems can be anything from a congested transmission line, a sharp load peak, an outage, voltage deviation caused by increased penetration of renewable resources, etc. Some of the services that help relieve those issues are formally categorized in ancillary services and can be procured through markets. Others are site-specific issues that require a unique solution.

CHAPTER 4. STORAGE SYSTEMS PROCUREMENT AND INSTALLATION

4.1 Using Business Models for Storage Systems

Storage services for the grid can be acquired through several business models, as shown in Figure 122. These business models range from contracting for services only without owning the storage system to outright purchase. The specific option chosen depends on the varying needs and preferences of the owner. This chapter provides broad guidelines for acquiring electricity storage systems using different options.

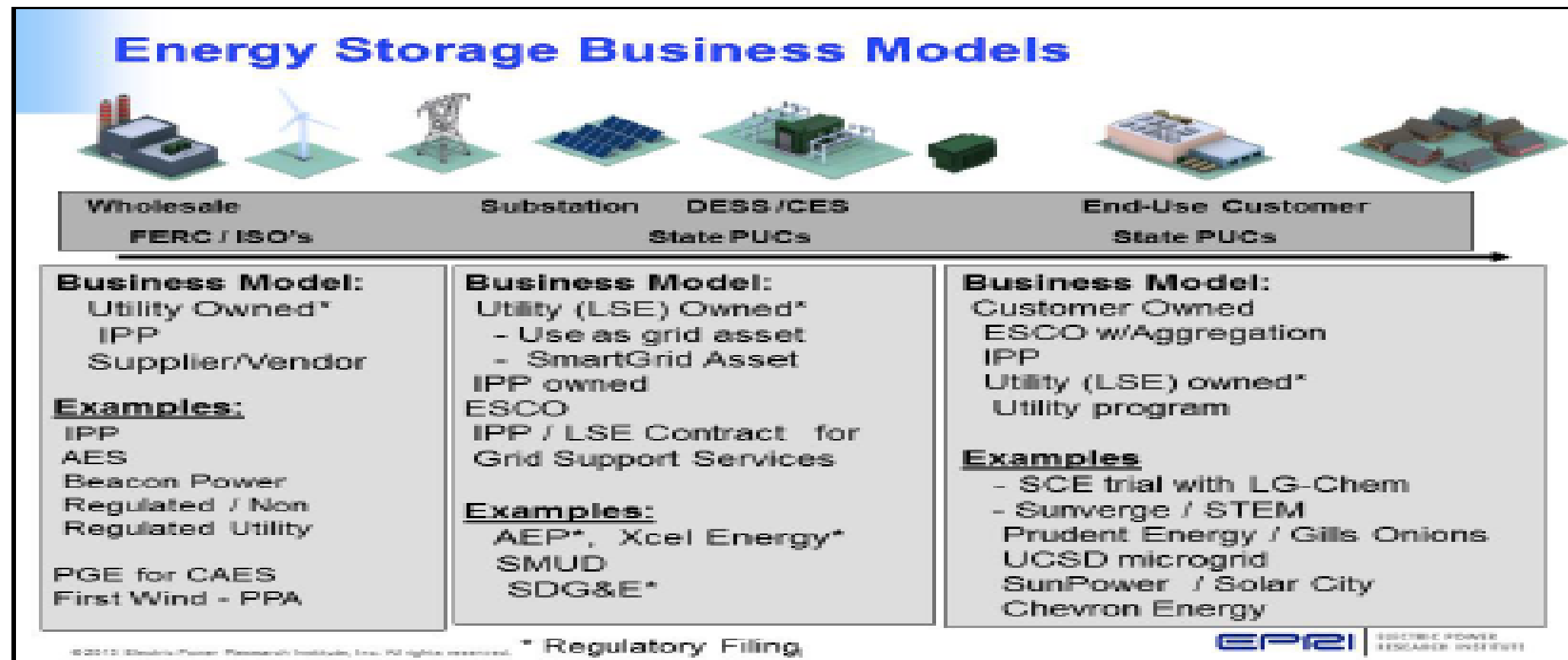


Figure 122. Business Models for Storage Systems
(Source: EPRI)

4.1.1 Third-party Ownership

In this option the storage system is owned, operated, and maintained by a third party who provides specific storage services according to a contractual arrangement. This process is very similar to fossil generating stations' independent power producer agreements. The key terms for fossil plants under such an operating agreement, typically of 20 to 25 years duration, generally include:

REVIEW OF SELECTED TOOLS

A.1 Technology Screening: ES-Select

The ES-Select™ Tool aims to improve the understanding of different electrical energy storage technologies and assess the feasibility for intended applications in a simple, visually comparative form. This tool treats the uncertainties in technical and financial parameters as statistical distributions.

ES-Select™ was created by KEMA in collaboration with Sandia National Laboratories. It is licensed for public use.

A sample screen capture from ES-Select™ Tool is shown in Figure A-1 (below).

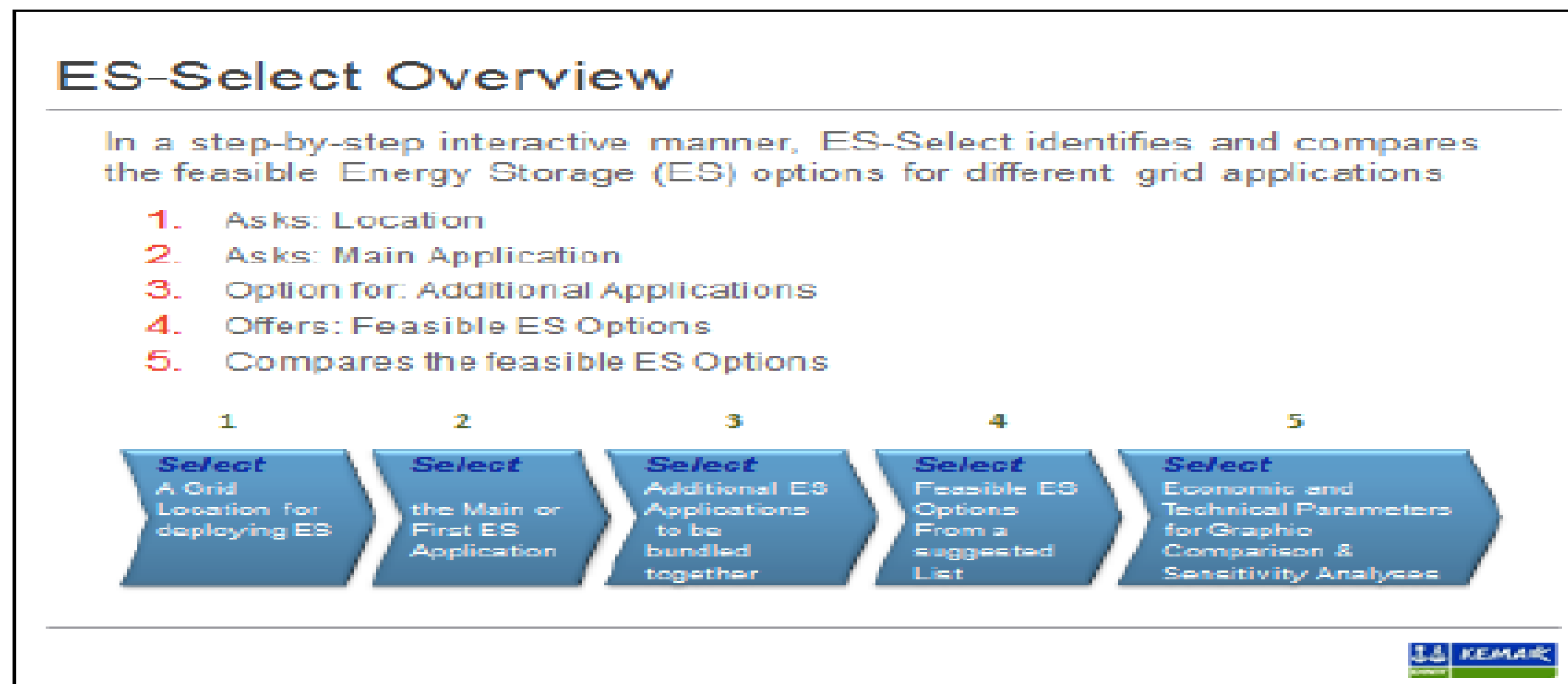


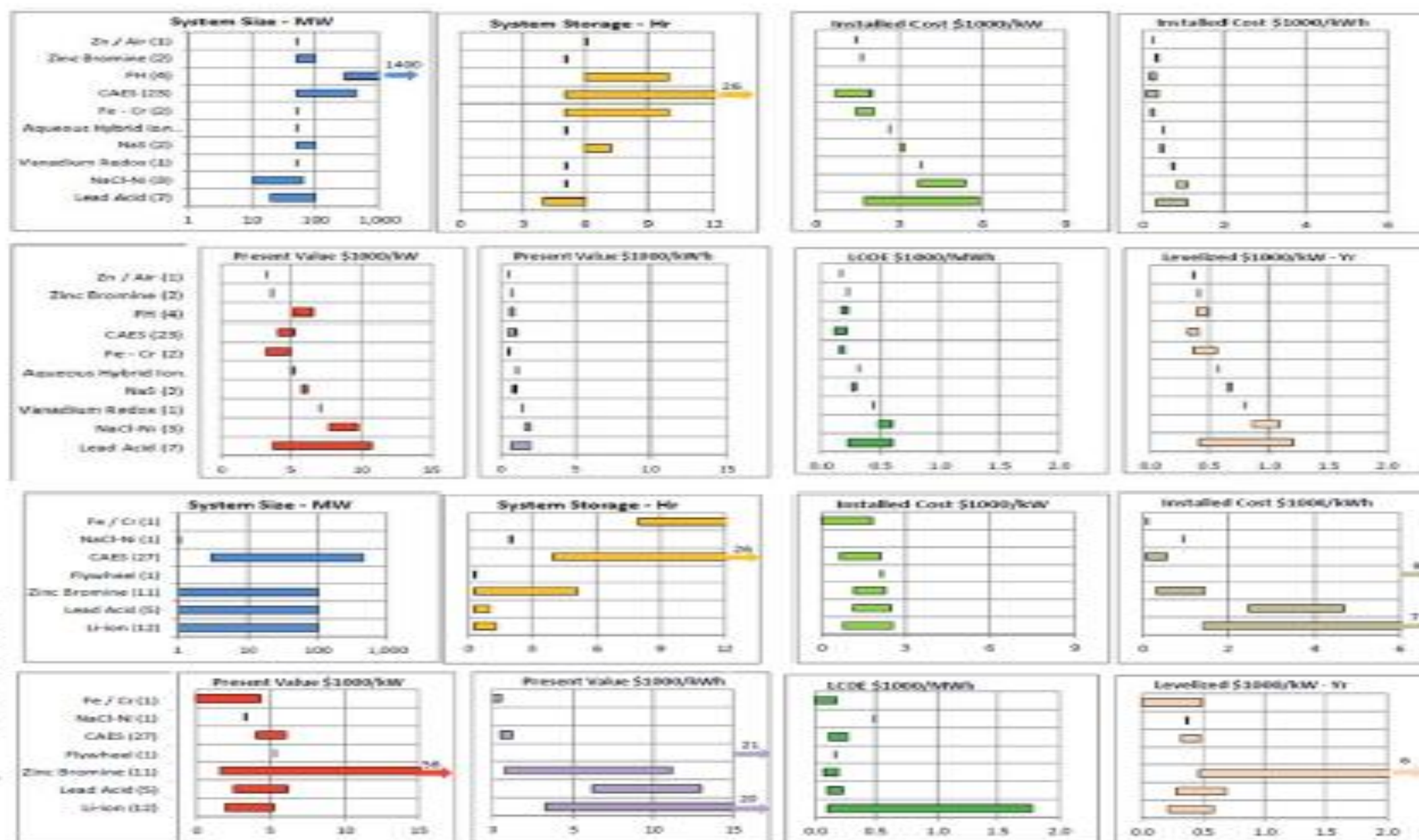
Figure A-1: ES-Select Overview

ES-Select is designed to work with the uncertainties of storage and applications characteristics, costs, and benefits and provides answers in reasonable ranges. It applies the Monte Carlo analysis to choose randomly hundreds of possible values within the provided ranges of input parameters to calculate the range of possible answers. In this educational/screening tool, simplicity is more important than precision. This decision support tool is made for the initial screening purpose. Most facts are still unknown to the user, but some decisions must be made based on what is known at this point.

B.4 Technology Cost Tables

The following mini-charts are organized by service and summarize the detailed information in the tables for each technology which are shown in the sections that follow.

BULK STORAGE



ESHB Summary and Accomplishments

- Published July 3, 2013 - PDF, 12 MB
- Benefit to industry
 - Highly cited document: down loaded 2700+ in first month
 - DOE partnered successfully with EPRI and NRECA to produce a valuable reference source for the industry
- Living Document – ongoing updates, suggestions from readers and content refinements

Thank You to the DOE OE and especially
Dr. Imre Gyuk for his dedication and
support to the ES industry and Sandia's
ES Program.

Questions?

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Thank You...