IEEE SA
STANDARDS ASSOCIATION

INDUSTRY CONNECTIONS
WHITE PAPER

IEEE



IEEE INDUSTRY CONNECTIONS ACTIVITY

MOBILE AND TRANSPORTABLE ENERGY STORAGE SYSTEMS: BUSINESS CASE AND BENCHMARK ANALYSIS

Authored by

Farid Katiraei

ICA Chair, Innoversa Mobile Solutions

Shadi Chuangpishit

ICA Vice Chair, Quanta Technology, LLC

Samaneh Morovati

ICA Secretary, Quanta Technology, LLC

Documents
Document Sharing Hub

Full document details: IEEE Mobile and Transportable Energy Storage Systems: Business Case and Benchmark Analysis

TRADEMARKS AND DISCLAIMERS

IEEE believes the information in this publication is accurate as of its publication date; such information is subject to change without notice. IEEE is not responsible for any inadvertent errors.

The ideas and proposals in this specification are the respective author's views and do not represent the views of the affiliated organization.

ACKNOWLEDGMENTS

Special thanks are given to the following contributors and reviewers of this paper:

Shahab Afshar, *North Carolina Electric Cooperatives*

Alexandre Nassif, *Pacific Northwest National Laboratory*

Swaroop Guggilam, *Electric Power Research Institute (EPRI)*

Mark Siira, *Power Innovation*

Kyle Brazell, *National Grid*

Jerron M. Lloyd, *Dominion Energy*

Yi Liu, *Contemporary Amperex Technology Co., Limited* (CATL)

The Institute of Electrical and Electronics Engineers, Inc. 3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2024 by The Institute of Electrical and Electronics Engineers, Inc.

All rights reserved. 15 November 2024. Printed in the United States of America.

PDF: STDVA27457 979-8-8557-1419-7

IEEE is a registered trademark in the U. S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated. All other trademarks are the property of the respective trademark owners.

IEEE prohibits discrimination, harassment, and bullying. For more information, visit http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html.

No part of this publication may be reproduced in any form, in an electronic retrieval system, or otherwise, without the prior written permission of the publisher.

Find IEEE standards and standards-related product listings at: http://standards.ieee.org.

Copyright © 2024 IEEE. All rights reserved.

Documents
Document Sharing Hub

Full document details: IEEE Mobile and Transportable Energy Storage Systems: Business Case and Benchmark Analysis

NOTICE AND DISCLAIMER OF LIABILITY CONCERNING THE USE OF IEEE SA INDUSTRY CONNECTIONS DOCUMENTS

This IEEE Standards Association ("IEEE SA") Industry Connections publication ("Work") is not a consensus standard document. Specifically, this document is NOT AN IEEE STANDARD. Information contained in this Work has been created by, or obtained from, sources believed to be reliable, and reviewed by members of the IEEE SA Industry Connections activity that produced this Work. IEEE and the IEEE SA Industry Connections activity members expressly disclaim all warranties (express, implied, and statutory) related to this Work, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; quality, accuracy, effectiveness, currency, or completeness of the Work or content within the Work. In addition, IEEE and the IEEE SA Industry Connections activity members disclaim any and all conditions relating to: results; and workmanlike effort. This IEEE SA Industry Connections document is supplied "AS IS" and "WITH ALL FAULTS."

Although the IEEE SA Industry Connections activity members who have created this Work believe that the information and guidance given in this Work serve as an enhancement to users, all persons must rely upon their own skill and judgment when making use of it. IN NO EVENT SHALL IEEE OR IEEE SA INDUSTRY CONNECTIONS ACTIVITY MEMBERS BE LIABLE FOR ANY ERRORS OR OMISSIONS OR DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS WORK, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Further, information contained in this Work may be protected by intellectual property rights held by third parties or organizations, and the use of this information may require the user to negotiate with any such rights holders in order to legally acquire the rights to do so, and such rights holders may refuse to grant such rights. Attention is also called to the possibility that implementation of any or all of this Work may require use of subject matter covered by patent rights. By publication of this Work, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. The IEEE is not responsible for identifying patent rights for which a license may be required, or for conducting inquiries into the legal validity or scope of patents claims. Users are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. No commitment to grant licenses under patent rights on a reasonable or non-discriminatory basis has been sought or received from any rights holder. The policies and procedures under which this document was created can be viewed at http://standards.ieee.org/about/sasb/iccom/.

This Work is published with the understanding that IEEE and the ICCom members are supplying information through this Work, not attempting to render engineering or other professional services. If such services are required, the assistance of an appropriate professional should be sought. IEEE is not responsible for the statements and opinions advanced in this Work.

Copyright © 2024 IEEE. All rights reserved.
Documents
Document Sharing Hub
Full document details: IEEE Mobile and Transportable Energy Storage Systems: Business Case and Benchmark Analysis

TABLE OF CONTENTS

ABSTRACT 5

1. DEFINITIONS 6

2. INTRODUCTION 7

3. BUSINESS CASE FRAMEWORK 8

4. USE CASES AND STACKING 10

4.1. UTILITY USE CASES & STACKING 11
4.1.1. BENCHMARK 1: NON-WIRE ALTERNATIVE FOR UPGRADE DEFERRAL AND LOAD RELIEF 11
4.1.2. BENCHMARK 2: RELIABILITY & RESILIENCY 13
4.1.3. BENCHMARK 3: MAINTENANCE OUTAGE MANAGEMENT 14
4.1.4. BENCHMARK 4: DEMAND CHARGE REDUCTION FOR LOCATIONAL PEAKS 15
4.2. NON-UTILITY USE CASE & STACKING 16

5. COST BENEFIT ANALYSIS 17

5.1. COST COMPONENTS 18
5.1.1. UPFRONT COSTS 18
5.1.2. OPERATION AND MAINTENANCE COSTS 20
5.2.QUANTIFIABLE BENEFITS & SAVINGS 22
5.3. SOFT BENEFITS 22

6. CONCLUSION 24

7. REFERENCES 25

Documents
Document Sharing Hub

Full document details: IEEE Mobile and Transportable Energy Storage Systems: Business Case and Benchmark Analysis

MOBILE AND TRANSPORTABLE ENERGY STORAGE SYSTEMS: BUSINESS CASE AND BENCHMARK ANALYSIS

ABSTRACT

In recent years, the energy industry has witnessed heightened demand for reliability and resilience of energy supply. At the same time, the regulatory and environmental push towards decarbonization and electrification highlights the need for cleaner energy supply alternatives. Growing challenges to improve the reliability and resilience of power systems are driven by the increasing frequency of widespread outages caused by climate change.

Portable fossil fuel-based generators, as a traditional method, have been widely used across the industry for backup power, outage management, peak shaving, emergency response, or simply in off-grid areas. Meanwhile, other alternatives are being investigated and deployed as a replacement for conventional gensets that also satisfy the clean supply requirements and regulatory/environmental considerations.

An innovative approach to conventional portable and emergency gensets involves the use of mobile energy storage systems (MESS) and transportable energy storage systems (TESS), offering clean and noise-free alternative solutions. While enhancing grid reliability and resilience remains a critical objective in MESS/TESS deployment, it is equally important to assess the business use cases and cost-effectiveness of these alternative approaches compared to conventional solutions, such as using diesel or gas generators. This paper delves into the business use cases of using mobile ESS and provides benchmark examples, both for utility and non-utility sectors, to illustrate the application of MESS/TESS in sustaining the reliability and resilience of energy supply. In addition, a high-level cost-benefit analysis framework is presented, which outlines the potential financial considerations for the widespread adoption of these solutions in various industry sectors.

Copyright © 2024 IEEE. All rights reserved.

Documents
Document Sharing Hub

Full document details: IEEE Mobile and Transportable Energy Storage Systems: Business Case and Benchmark Analysis

1. DEFINITIONS

The following is a list of definitions for phrases used in this study:

- **Energy storage system (ESS):** Commercially available technology that is capable of absorbing energy, storing it for a period of time, and thereafter dispatching the energy in response to an external control input according to some predefined control function [1].[1]
- **Mobile energy storage system (MESS):** A mobile energy storage system is a type of ESS with flexible connection points packaged for frequent relocations. They are generally installed on mobile transportation vehicles, such as trailers. Its primary purpose is to supply power on a temporary basis [2], [3].
- **Transportable energy storage system (TESS):** A transportable energy storage system is a type of ESS that has flexible connection points and is generally packaged for relocation and installed on mobile transportation vehicles, such as skids. Its primary purpose is to supply power on a semi-permanent basis [2], [3].
- **Portable energy storage system:** Any energy storage system capable of being moved and utilized as a temporary source of power [4].
- **Energy capacity:** The energy available for transfer to the ESS, usually expressed in kilowatt-hours [1].
- **Business Decision:** The process of evaluating the business value for an investment/project (in comparison to any alternatives) and making a final decision on business future activities.
- **Special Circumstances:** These may be events or local needs that create high urgency for the deployment of temporary power, necessitating the use of mobile energy storage. These may override the normal business decision criteria.
- **Soft Benefits:** Non-quantifiable benefits that are not directly driving the business decision but impacting indirectly.

[1] Numbers in brackets correspond to the sources listed in Section 7.

Copyright © 2024 IEEE. All rights reserved.
Documents Document Sharing Hub
Full document details: IEEE Mobile and Transportable Energy Storage Systems: Business Case and Benchmark Analysis

2. INTRODUCTION

Given the extensive outages attributed to recent climate changes and aging infrastructure, the importance of outage mitigation and reducing minimum time to repair for fast recovery has become increasingly crucial. More frequent and severe weather events are straining system operations and post-outage recovery times. The rise in greenhouse gas emissions, particularly from the energy and transportation industry across various economic sectors, including the use of diesel and gas generators in the power industry, has intensified the need for clean and sustainable energy resources.

Traditionally, mobile diesel/gas generators have served as reliable power sources during systems outages (due to system faults, maintenance, or infrastructure upgrades). They offer the flexibility required for restoring power to critical customers. However, the increasing demand for cleaner energy sources and enhanced operational flexibility during outages has created the need to explore alternative solutions.

The availability of mobile and transportable energy storage systems (MESS and TESS) as cleaner alternatives to diesel/gas generators has primarily been limited to very small sizes, which were insufficient to meet the power demands of industrial or commercial customers or to serve multiple customers on a feeder or service transformer in a reliable and scalable manner. However, with the advancement of energy storage technology, there are currently MESS and TESS units available with increased energy capacity for utility and commercial/industrial applications [5].

While stationary energy storage system (SESS) is already deployed as a clean alternative solution replacing diesel/gas generators in certain applications, due to the flexibility of a mobile/transportable ESS, they can be best utilized for emergency response and outage management in certain rural applications and use cases to act as a replacement for mobile diesel generators or use in conjunction for reducing the diesel fuel and runtime in use. The mobile ESS is deployed for temporary power supply from a few hours' duration up to multiple weeks or months. This results in packaging in smaller sizes (up to a couple of MWhs per unit) for improved convenience and reduced logistics/permitting requirements during frequent relocations. On the other hand, the transportable ESS is typically larger in size compared to the Mobile ESS, which can be mounted on a skid or trailer and remain in a location for an extended period of time (from multiple months to years).

Given the potential benefits of MESS and TESS, a more detailed investigation of business use cases and the potential for stacking applications should be conducted for both utility and non-utility customers' usage. Both solutions offer quantifiable and non-quantifiable (soft) benefits. MESS can provide cost-effective long-term

Copyright © 2024 IEEE. All rights reserved.
Documents
Document Sharing Hub
Full document details: IEEE Mobile and Transportable Energy Storage Systems: Business Case and Benchmark Analysis

solutions for the utilities and Generation and Transmission (G&T) cooperatives. TESS, with an extended operational schedule (seasonal schedule), holds the potential to support market capacity engagements for both utilities and commercial/industrial customers.

This white paper discusses different use cases associated with MESS and TESS and how stacking the use cases is an essential contributor to a solid business case for MESS/TESS. A business case framework is presented for formulating the costs, savings, and soft benefits associated with the technology, its implementation and operation. The white paper also provides benchmark examples for both utility and non-utility applications.

3. BUSINESS CASE FRAMEWORK

The technologies discussed within this white paper (MESS and TESS) are utilized or envisioned to be utilized for certain use cases, driven by industry needs for more flexible and cleaner options of power supply during system outages or in the absence of proper power infrastructure. The main use cases for MESS/TESS are outage recovery (during scheduled maintenance or weather-related events), temporary power supply, and seasonal load management. The key aspect of technology deployment at a broader scale is its financial justification for the owners and decision-makers.

In this section, a business case framework has been proposed to lay out the project/solution objectives, identify business opportunities and risks associated with it, determine the costs and benefits, and compare it with other alternatives. The purpose of a business case is to access and evaluate a project/solution from a business and financial perspective and support the decision-makers.

As illustrated in FIGURE 1, the proposed business case framework consists of the following three main blocks:

- Use case characterization, which identifies the objectives and use cases for the solution. Benefits and costs may be derived from either a single use case and/or from multiple use cases by incorporating a value-stacking approach, as shown in FIGURE 1.
- Benefit-cost analysis (BCA), which identifies the associated costs, benefits, and savings. The framework incorporates both monetary (hard) benefits and non-monetary (soft) benefits that are essential for making a business decision.
- Quantification, which translates all the information into a numerical value. The monetary/financial analysis is performed based on the cost/benefit calculations according to unit utilization throughout the year (either from one use case only or stacking of use cases). The non-monetary analysis is performed

Copyright © 2024 IEEE. All rights reserved.
Documents Document Sharing Hub
Full document details: IEEE Mobile and Transportable Energy Storage Systems: Business Case and Benchmark Analysis