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Energy Storage Impacts in Resilience Hubs and Other Critical Infrastructure

An Assessment Guide for Developers and Practitioners

June 2026

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Summary

Battery energy storage systems (BESS) deployed behind the meter at resilience hubs (e.g., schools, libraries, and publicly accessible buildings that provide essential services during power outages) and other critical infrastructure can deliver a wide range of benefits. During normal operations, BESS can provide economic and operational value, including lower energy costs, improved affordability, greater predictability in electricity expenditures, and other energy access and service-quality improvements. During power disruptions, BESS can also provide resilience and security benefits by maintaining energy access and continuity of essential services and reducing outage-related impacts. However, existing evaluation approaches often either focus narrowly on engineering performance (e.g., system operation and availability) or rely on broad socio-economic frameworks that are not well suited for behind-the-meter storage applications. As a result, project developers, utilities, and funders frequently lack consistent approaches for defining project success, quantifying benefits, comparing outcomes across projects, and using evidence to support planning, investment, and long-term deployment decisions.

This report presents a practitioner-oriented impact assessment framework for evaluating the outcomes of behind-the-meter BESS deployed at resilience hubs and critical infrastructure facilities. The framework is designed to support evidence-based decision-making by improving the consistency, transparency, and comparability of outcome estimation across projects. Importantly, the framework and methodology were developed, applied, and refined through an active deployment program, ensuring that the approach is both rigorous and feasible for real-world implementation.

The framework is organized into five iterative components:

- Developing an action plan by defining impact assessment objectives and scope, mapping capacity and resources, determining a timeline, and planning for risks.
- Defining project goals by identifying the issues or challenges the project is intended to address and linking those goals to measurable outcomes.
- Identifying metrics by translating goals and outcomes into measurable indicators and down-selecting to a manageable, documented set.
- Collecting data and measuring outcomes by designing data collection and management plans, implementing data collection under different measurement scenarios, and calculating metrics.
- Reporting and using results by interpreting findings in relation to project goals, applying results to optimize current systems and inform future projects, and communicating outcomes to stakeholders in decision-relevant formats.

The report also provides a structured metric architecture that links technical BESS performance to broader economic, operational, and user-centered outcomes. Metrics are organized into six categories: Economic Benefits, Energy Access, Energy Resilience, Energy Security, Infrastructural Benefits, and Workforce Development. This structure supports balanced evaluation across both normal operating conditions (“blue sky” outcomes such as cost savings and expenditure stability) and disruption events (e.g., avoided outage-related losses and continuity of critical services).

In addition, the report provides practical implementation guidance and supporting toolkits for practitioners and analysts. It specifies multiple evaluation scenarios, including baseline and post-deployment comparisons, post-deployment-only evaluation when counterfactual data are limited, and longitudinal monitoring for tracking performance over time. It also provides guidance on identifying feasible data sources, selecting appropriate measurement approaches, decomposing outcome drivers, and tailoring dissemination to different decision-making audiences. The framework is designed for real-world constraints, including limited staffing capacity, budget limitations, and uneven data availability. When public data are insufficient, primary data are collected through surveys, interviews, and focus groups to capture outcomes not reflected in existing datasets.

Finally, illustrative case studies informed by real projects demonstrate how the methodology can be applied across diverse deployment contexts, including public-serving facilities, institutional sites, and household-scale applications. These examples highlight how the framework can be adapted to different operating conditions, stakeholder priorities, and data environments while maintaining a consistent and defensible evaluation structure.

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During the preparation of this work, the authors used the OpenAI GPT-5 series to improve style, clarity, and grammar. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Acronyms and Abbreviations

BESS	battery energy storage systems
DOE	Department of Energy
EPA	Environmental Protection Agency
ES4RH	Energy Storage for Resiliency Hubs
K	thousand
kWh	kilowatt hours
PNNL	Pacific Northwest National Laboratory

Glossary

Baseline	The pre-deployment condition or measurement used as the reference point for comparison with post-deployment results. Baseline data are important for assessing change attributable to the project.
Battery Energy Storage System (BESS)	A system that stores electricity for later use and discharges it when needed, such as during grid outages or periods of high demand. BESS can support backup power, demand management, and continuity of essential services.
Blue Sky Conditions/ Blue Sky Day Benefits	Normal, non-emergency operating conditions under which a BESS can provide routine benefits, such as improved affordability, more predictable energy costs, peak demand management, or load shifting.
Critical Infrastructure	Facilities or systems whose continued operation is important for maintaining essential services, such as water treatment plants, health care facilities, emergency response centers, and other key service sites.
Critical Services	Services that are prioritized during outages or emergencies, such as communication, refrigeration, water access, first aid, shelter, or basic comfort.
Data Governance	The policies, roles, and procedures that determine how data are collected, stored, accessed, shared, protected, retained, and used during and after the impact assessment process.
Impact Assessment	A structured process used to evaluate whether a project achieved its intended goals and outcomes and to inform future decision-making, planning, and investment.
Impact Assessment Action Plan	A document or planning framework used to organize and execute the impact assessment process for a BESS project. It identifies the assessment's objectives, scope, tasks, milestones, roles, resources, timeline, budget, and risks and serves as a road map for carrying out the assessment effectively.
Impact Assessment Objective	In the context of this document, impact assessment objectives, or simply "objective(s)," mean the objective(s) of the impact assessment task.
Indicator	A measurable sign of progress or change used to evaluate whether a project is achieving its intended goals.
Measurement Scenario	The overall approach used to collect and compare data for a metric, such as two-point-in-time measurement, single-point-in-time measurement, or ongoing/longitudinal monitoring.
Metric	A specific, measurable variable that reflects whether a project is achieving its intended outcomes (e.g., energy cost savings or improved resilience during grid outages).
Ongoing or Longitudinal Monitoring	A measurement approach involving repeated or continuous data collection over time to assess trends, durability, or long-term outcomes.

Outcome	A measurable change or effect resulting from the project, used to assess whether project goals have been achieved. Outcomes may be technical, economic, operational, or user centered.
Output	The immediate, tangible product of project implementation, such as installed battery capacity, connected equipment, or other completed project components. This is distinct from longer-term outcomes.
Post-deployment	The period after the BESS has been installed and is operational, during which project outcomes are measured and compared against baseline conditions.
Primary Data	Data collected directly for the purpose of the impact assessment, such as surveys, interviews, observations, or facility logs.
Project Goal	In the context of this document, project goals, or simply “goal(s),” mean the overall goals for the battery storage project.
Proxy Metric/Proxy Data	A substitute metric or data source used when the preferred metric or direct data are unavailable. Proxy metrics or data should approximate the concept of interest as closely as possible and be clearly documented.
Resilience Hub	A facility designed to support essential services during outages or emergencies.
Secondary Data	Existing data obtained from other sources, such as utility records, BESS system logs, census data, or public datasets.
Single-Point-in-Time Measurement	A measurement approach based on one post-deployment data collection effort, often using retrospective or recall-based information when baseline data are unavailable.
SMART Framework	A goal-setting framework used to develop objectives or goals that are Specific, Measurable, Achievable, Relevant, and Time-bound.
Stakeholder	An individual or organization with an interest in, responsibility for, or that is affected by the project or its outcomes.
Two-Point-in-Time Measurement	A measurement approach that compares baseline and post-deployment conditions to assess change over time.

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1.0 Introduction

1.1 Background

The Energy Storage for Resiliency Hubs (ES4RH) program aims to strengthen the reliability, resilience, and affordability of the electrical grid by supporting the deployment of advanced, behind-the-meter energy storage systems at critical infrastructure sites. Sponsored by the U.S. Department of Energy (DOE)'s Office of Electricity and implemented by Pacific Northwest National Laboratory (PNNL) and Sandia National Laboratories, the program provides technical assistance and cost-share funding to help organizations—such as local governments, non-profits, and small utilities—design and implement energy storage solutions that maintain essential services during power disruptions.

These facilities, often serving as resilience hubs or key service providers, play an important role during grid outages and extreme events by supporting access to vital services such as reliable energy, communication, refrigeration, basic comfort, first aid, and shelter. In addition, many sites benefit from "blue sky day" operation of these systems through improved affordability and more predictable energy costs. Many sites are also located in areas that experience more frequent outages or grid infrastructure constraints. Integrating battery energy storage systems (BESS) at these sites can reduce reliance on costly alternatives, improve energy independence, ensure continuity of operations, support longer-term energy cost management, and better align energy services with local needs.

A key component of the ES4RH program is evaluating project impacts, with a primary focus on how BESS installations support the infrastructure, facilities, and populations they are intended to serve while also assessing technical performance outputs. Documenting outcomes, such as efforts on operational continuity, energy costs, and the ability of facilities to sustain essential services during disruptions, builds evidence for use cases, operations and management practices, and complementary efforts such as workforce training. This evidence helps maximize system benefits, inform investments and design decisions, and support accountability to stakeholders and funders, for instance, showing a regulated utility that a resilience hub delivers its intended benefits and justifying cost recovery through rates. Impact assessment tools are critical for measuring progress and guiding future deployment strategies.

To support this, PNNL is providing ES4RH participants with the following:

1. Individualized impact assessment support for evaluating project outcomes.
2. This guidebook, which details a practical impact assessment process tailored to BESS projects at resilience hubs and other critical infrastructure.
3. Workshops and technical assistance to build capacity for ongoing impact tracking and use of results.

1.2 Introduction to Battery Energy Storage Systems for Resilience

BESS store electricity during periods of lower demand or lower prices and discharge it when needed, including during grid outages or peak demand periods. These systems convert electrical energy to a stored form and then dispatch it to the grid or directly to loads to maintain power quality and continuity (Datta et al. 2021; Elgqvist 2021; Trevizan et al. 2023).

BESS can:

- Provide backup power during outages.
- Reduce strain on the grid during high-demand periods.
- Improve frequency control and power quality (Baja et al. 2019; Mohanty et al 2024; Walker and Desai 2023).
- Support integration of on-site variable generation.
- Reduce operational costs through peak shaving and load shifting (Datta et al. 2021).

BESS can be deployed at multiple scales. They may serve a single household as part of a nanogrid, support multiple buildings within a microgrid, operate off-grid, or operate at utility scale (ADB 2018; Elgqvist 2021; Mohanty et al. 2024). This flexibility makes them well suited for supporting resilient operations at facilities that provide critical services during emergencies.

1.3 Integrate Energy Storage into Resilience Hubs and Critical Infrastructure

Resilience hubs are public facilities designed to provide essential services during power outages or emergencies; they are often located in schools, libraries, community centers, or other publicly accessible buildings. In addition to emergency shelter, medical care, clean water, and food, these facilities can offer access to communication, refrigeration, heating and cooling, and device charging when the broader grid is unavailable (Baja 2018; Baja et al. 2019; Ciriaco et al. 2022; Elgqvist 2021; Farley et al. 2024; NREL 2018; USDN 2019). Their role is especially important in areas that experience more frequent outages, infrastructure constraints, or disaster risks.

In addition to resilience hubs that serve the public, many critical infrastructure facilities, such as water and wastewater treatment plants, emergency operations centers, and health care facilities, also rely on continuous, reliable power to maintain essential services (Mühlhofer et al. 2023; Xu et al. 2026). At these sites, BESS can help sustain core functions during grid disruptions and reduce the operational and financial risks associated with power interruptions (Xu et al. 2026). Together, resilience hubs and critical infrastructure facilities represent priority applications for energy storage where maintaining service continuity is especially important. During normal (“blue sky”) conditions, BESS can also help manage demand charges, shift consumption away from high-cost periods, and improve the overall affordability and predictability of energy use at these facilities.

Given these dual roles (support during disruptions and operational benefits during normal conditions), BESS-integrated resilience hubs and other critical infrastructure are a key focus of this guide. The impact assessment approach presented in the following sections is designed to capture both technical performance and practical outcomes associated with these installations.

1.4 Understand Impact Assessment and Its Stakeholders

Impact assessment is a structured process used to evaluate whether a project achieves its intended goals (The World Bank 2004; Hobson et al. 2014). In the context of BESS at resilience hubs, impact assessment helps determine the following:

- How well systems perform under real-world conditions.
- What outcomes they deliver (e.g., cost savings, service continuity, reliable backup power).

- How these outcomes support broader resilience outcomes (NREL 2018).

The purpose of impact assessment is to track progress, identify areas for improvement, and generate evidence that supports decision-making and future investment. It also ensures accountability for public funding and enables stakeholders to learn from and improve their efforts (Walker and Desai 2023).

Impact assessments support the following:

- Project teams and facility operators, by providing evidence on what is working well and where adjustments are needed.
- Funders and program sponsors, by demonstrating results and informing decisions about directing future funding, scaling or replicating projects, and identifying high-impact models.
- Planners and technical partners, by supplying data that can be used in future designs, investment decisions, funding applications, and development and resilience strategies.
- Local residents and stakeholders, by gaining a clearer understanding of how energy projects perform and what value they bring locally.

1.5 Address Gaps in Energy Storage Evaluation

Most existing evaluation frameworks either focus primarily on technical performance of energy storage systems (Walker and Desai 2023; Trevizan et al. 2023) or on broader social and economic outcomes of infrastructure and development projects (Ruegg et al. 2014; Hannan et al. 2021; Terrapon-Pfaff et al. 2018; Mohanty et al. 2024). Few tools are explicitly designed to connect both perspectives at the scale of BESS deployed at resilience hubs and other critical infrastructure.

Technical evaluations often emphasize BESS performance indicators such as metered charge/discharge cycles, round-trip efficiency, or system availability (Trevizan et al. 2023; Walker and Desai 2023). While essential, these metrics do not fully capture outcomes such as the ability to maintain critical services during outages, support continuity of operations, or reduce operational risk. Conversely, many established assessment frameworks in development and planning focus on high-level social or economic indicators, with limited guidance specific to distributed energy technologies (Terrapon-Pfaff et al. 2018; Colombo et al. 2018).

This gap can make it difficult for project leaders, impacted parties, and funders to define what success looks like for BESS at resilience hubs; track outcomes using metrics that reflect both technical and practical aims; and communicate results, demonstrate value, and build a case for sustained investment in formats useful to partners, funders, and planners.

This guide addresses that gap by offering a tailored, practical impact assessment approach for BESS projects at resilience hubs and other critical infrastructure. It is designed to be the following:

- Adaptable, so it can be applied to different project types and local contexts.
- Achievable, recognizing constraints in staff time, data access, and analytic resources.
- Balanced, combining technical indicators with outcomes that matter to project stakeholders.

This approach builds on existing evaluation literature and practitioner experience while modifying and streamlining methods, so they can be implemented by local project teams and their partners.

1.6 Overview of the Impact Assessment Guide

This guide provides a step-by-step framework for planning and carrying out an impact assessment for BESS projects, with examples and case studies drawn from applications at resilience hubs. Its primary audience is project developers, facility operators, local partners, and others directly affected by the BESS project who are responsible for or interested in planning, implementing, and assessing BESS deployments.

The guide offers local planners and stakeholders a process and tools to conduct an impact assessment of a BESS project, strengthening local ownership of project evaluation and building capacity to investigate outcomes and apply insights to improve existing and future projects. A secondary audience includes researchers, funders, regulators, and program managers who may use the framework to interpret results across multiple projects or to inform future initiatives.

This guide is organized around five core components of impact assessment (Figure 1), reflected in Sections 2.0 through 6.0. These components are often carried out iteratively rather than linearly, but together they form a complete framework.

1. **Developing an Action Plan (Section 2.0)**

   Establishes the foundation for the assessment by defining impact assessment objectives and scope, laying out tasks, mapping capacity and resources, determining a timeline, and planning for risks. This component is cross-cutting and supports all others.

2. **Defining Project Goals (Section 3.0)**

   Identifies the issues or challenges the project is intended to address, defines clear project goals, and links those goals to outcomes that can later be measured.

3. **Identifying Metrics (Section 4.0)**

   Translates goals and outcomes into measurable indicators by developing a list of candidate metrics, refining them using practical dimensions and design principles, down-selecting to a manageable set, and documenting the final metrics.

4. **Collecting Data and Measuring Outcomes (Section 5.0)**

   Operationalizes the selected metrics by designing data collection and management plans, identifying data sources, implementing data collection under different measurement scenarios, and calculating metrics to measure outcomes.

5. **Reporting and Using Results (Section 6.0)**

   Interprets metric results in relation to project goals, applies findings to optimize current systems and inform future projects, and communicates outcomes to stakeholders in formats that support decision-making and future planning.

Figure 1. Five Core Components of Impact Assessment

The detailed steps under the Five Core Components of Impact Assessment are outlined in Appendix E.

1.7 How to Use This Guide

Readers can use this guide either sequentially or as a reference for specific stages of an impact assessment. Impact assessment is most effective when considered early in project planning, but much of the work depends on prior project development activities, such as feasibility analysis, system design, and deployment, so the timing and scope of assessment tasks should be aligned with the broader project schedule. Projects in early planning phases may wish to move through the steps in order—starting with defining project goals, then identifying metrics, planning data collection, and finally interpreting and using results. Projects that are already underway can focus on the sections most relevant to their current needs (for example, refining metrics in Section 4.0 or planning reporting in Section 6.0) while referring back to earlier sections as needed. The case study examples throughout the document provide practical templates and ideas that can be adapted to different project contexts.

While the core concepts and methods in this guide can be applied to many types of projects, the examples focus on energy applications, with an emphasis on BESS projects at resilience hubs. A case study is presented alongside the conceptual framework, illustrating how each component of the impact assessment process can be implemented in practice. These examples are anonymized and adapted from real-world participant experiences in the ES4RH program.

The approach has been tested and refined to balance scientific rigor with practicality, supporting evaluation that is defensible while still achievable for local project teams and their partners. Additional tools and resources, including example metrics and data sources, are provided in the appendices to help readers adapt the framework to their own contexts.

2.0 Developing an Action Plan

Developing a comprehensive action plan is the foundation of a successful impact assessment. The action plan translates intent into implementation by defining how the assessment will be conducted, who will carry it out, when activities will occur, and what resources are required.

BESS projects, particularly those designed for resilience hubs and other critical infrastructure, present unique challenges, including extended project timelines and multi-faceted stakeholder demands. These attributes make a strategic and adaptable action plan especially critical for success. While BESS projects may already include action plans for operations, performance, safety, and decommissioning, creating a dedicated impact assessment action plan is equally important to systematically evaluate resilience, economic, infrastructure, workforce, and other outcomes.

An impact assessment action plan should address key elements such as responsible parties, roles, timelines, task allocations, budgets, risks, and other components essential to project execution. This plan can either be integrated into an existing project action plan or developed as a stand-alone document. Additional information, such as required workforce, financial allocations, staff expertise, regulatory timelines, and risk mitigation strategies, should be incorporated to support the assessment's scope and objectives. Ultimately, the action plan serves as a road map, enabling developers, practitioners, and other stakeholders to navigate the impact assessment process effectively and achieve meaningful, actionable insights.

Key Components of an Action Plan

The development of an action plan for a BESS impact assessment includes the following steps:

- **Define the Impact Assessment Scope and Objectives**: Clearly establish the purpose, objectives, and desired outcomes of the impact assessment.
- **Lay Out Tasks and Milestones**: Identify and detail the individual tasks necessary to achieve the stated impact assessment objectives.
- **Map Capacity and Resources**: Allocate and secure the necessary resources, including funding, workforce, and equipment, and assign responsibilities to specific parties.
- **Determine a Timeline**: Develop a schedule that includes key milestones, deadlines, and checkpoints for the impact assessment, keeping the overarching project milestones in mind.
- **Plan for Risks**: Identify potential risks or challenges that could impede progress and create strategies to address or mitigate them proactively.

Although these components are broadly applicable across evaluation contexts, this guidance emphasizes considerations specific to BESS deployments supporting resilience hubs and critical infrastructure.

2.1 Define Impact Assessment Objectives and Scope

Clearly defined objectives and scope form the foundation of the action plan. Objectives and scope should follow SMART principles (Specific, Measurable, Achievable, Relevant, Time-bound) to ensure the assessment remains focused, feasible, and aligned with stakeholder priorities.

Objective

The objective of an impact assessment outlines why it is being conducted, what it aims to achieve, and the desired outcomes of the evaluation process. Well-defined objectives provide the foundation for structuring tasks and metrics, ensuring alignment with stated project goals while guiding stakeholders' understanding of the assessment's purpose.

Scope

Defining the scope involves outlining the work to be completed as part of the impact assessment and specifying the final deliverables. The scope is shaped by objectives and identifies the activities required to achieve the stated purpose and outcomes effectively. Setting the scope with clarity helps stakeholders stay aligned to expectations and priorities throughout the process.

The case study application at the end of this section offers a practical example of how to define objectives and scope for a BESS impact assessment.

2.2 Lay Out Tasks and Milestones

Once the impact assessment objectives and scope are established, the next step is to identify the tasks required to execute the assessment and align them with appropriate milestones. Task planning should begin with major activities aligned to the impact assessment life cycle, including project goal refinement, metric selection, data source identification, data collection, data analysis, and reporting and dissemination. Establishing milestones at key transition points, such as completion of metric selection, baseline data collection, or draft reporting, helps track progress and maintain alignment with overall project timelines.

Some tasks can be defined at the outset, while others will emerge as metrics and methodologies are refined. For example, once key indicators are selected, additional tasks, such as survey design, instrument testing, or data-sharing agreements, may be required. Because impact assessment is inherently iterative, task planning should remain structured but flexible, with the confirmation of selected metrics and finalized data collection methods serving as an early milestone before full implementation begins. Similarly, the completion of major phases, including data collection and analysis, should be treated as milestones to ensure measurable progress.

Key Considerations for Task Planning and Milestones

Ensure effective task and milestone planning throughout the impact assessment process by doing the following:

- **Account for Iterative Processes:** Not all tasks can be defined in detail at the outset. Build flexibility into the plan and incorporate interim milestones that allow for refinement as evaluation needs and methodologies evolve.
- **Reference Major Project Milestones:** Align assessment tasks with significant project milestones such as operation dates, evaluation periods, or reporting timelines.
- **Prioritize Critical Path Activities:** Tasks that directly support the objectives of the impact assessment (e.g., data collection and analysis) should be carefully defined, linked to milestone checkpoints, and monitored.

- **Ensure Resource Alignment:** Confirm that required resources, such as personnel, budget, and time, are dedicated to completing tasks and achieving associated milestones on schedule.

By carefully laying out tasks and milestones, project teams can maintain an organized approach to assessing the impacts of BESS projects. This iterative and milestone-driven strategy ensures alignment with overarching project goals while remaining adaptable to the dynamic nature of impact evaluations of BESS.

The example tasks outlined in the case study application at the end of this section illustrate activities commonly included in a Scope of Work for an impact assessment. These tasks encompass early planning activities, such as identifying metrics and data sources, as well as data handling and reporting, which are critical to producing the final assessment.

2.3 Map Capacity and Resources

Mapping capacity and resources ensures the assessment is feasible within available constraints. Resource mapping identifies who and what will complete the work. Capacity mapping assesses how much work can realistically be accomplished within available time, expertise, and funding. This step may lead to adjustments in scope or metric selection to align ambition with feasibility (see Section 4.0).

Guiding Questions for Resource and Capacity Mapping

To guide this process, ask the following questions:

- **Who will do the work?**

  Identify internal teams, partners, contractors, and stakeholders who can contribute to the impact assessment process. Ensure roles and responsibilities are clearly defined.

- **How much time is available?**

  Evaluate team availability in relation to their existing workload and project timelines.

- **Who has the knowledge, skills, or willingness to learn?**

  Identify individuals or groups with expertise in data collection, analysis, and reporting. Leverage any gaps as opportunities for partnerships or capacity-building initiatives.

- **What resources are available?**

  Assess the budget, data sources, tools, and equipment necessary to support the desired scope of the impact assessment.

- **What gaps exist?**

  Given available resources identified through the questions above, do any gaps remain and how will they be addressed?

Leveraging Partnerships Effectively

Strategic partnerships can expand capacity and improve rigor.

- **External Partnerships:** Engage universities, federal agencies, non-profits, or contractors who may already be collecting relevant data or creating metrics. Shared data or reporting efforts enhance efficiency and reduce duplication.
- **Local Resources:** Utilize relationships with local organizations, municipalities, or community groups to support public engagement activities or assist with data collection.
- **Technical Expert:** Engage appropriate experts or leverage partnerships to strengthen analytical or statistical expertise for evaluation tasks.

Formalizing roles through agreements or contracts improves accountability and clarity.

Stakeholder Engagement

Stakeholder engagement is critical throughout the impact assessment process. Involving stakeholders early and often ensures that the assessment reflects local priorities and is rooted in real-world needs. Stakeholders may include project leaders, impacted individuals, and project supporters such as funders, government representatives, civic organizations, and community groups. By defining each stakeholder's role (e.g., providing data, reviewing feedback, communicating results), teams can better align stakeholder contributions with the project's goals.

Engagement activities, such as interviews, focus groups, local resident meetings, or listening sessions, inform the assessment process, enabling it to better consider stakeholder capacity, priorities, and perspectives. Early and frequent engagement helps prioritize outcomes to track, supports alignment with stakeholder expectations, and helps address community concerns early, encouraging trust and transparency. In addition, stakeholder feedback (including outside of formal surveys and engagement activities) should be documented and used when interpreting impact assessment results.

Additional resources for mapping capacity are listed in Appendix A.

2.4 Determine a Timeline

Determining an appropriate timeline is an essential part of developing an impact assessment action plan. A well-defined and flexible timeline ensures that tasks and milestones align with project goals while accommodating the constraints and challenges inherent to BESS projects, including extended deployment schedules. Timelines also serve as a critical framework for tracking progress, comparing results before and after deployment, and adapting to unforeseen changes.

Key Considerations for Creating a Timeline

When creating the timeline for an impact assessment, consider the following key points:

- **Baseline and Post-deployment Measurement:** Establish a timeline that accommodates comparisons of baseline metrics (pre-deployment) against post-deployment metrics. This is central to evaluating the impacts of BESS. In some cases, depending on the metric and data collection method, an abbreviated timeline may be an option, with data collection occurring only at one point in time, post-deployment. This is discussed further in Section 5.0.

- **Seasonality and Variability:** Where relevant, collecting up to 12 months of data before and after deployment can account for seasonal variation. This will help ensure the calculated BESS impacts are not because of fluctuations in data or processes that may vary seasonally such as outdoor temperature and seasonal programming. The appropriate duration depends on assessment objectives and data availability.
- **Short- and Long-term Impacts:** Shorter tracking periods may be sufficient for capturing immediate impacts, whereas longer periods may be necessary for capturing multi-year impacts and measuring sustained outcomes.
- **Alignment and Flexibility:** Anchor milestones to operational dates and reporting deadlines and incorporate buffer time to address deployment or data delays.

Selected metrics and data collection methodologies are key factors that influence the timeline. As these elements are identified, the timeline may need to be revisited and updated to reflect new realities. Build in buffer periods to account for schedule shifts.

The case study application at the end of this section illustrates a practical timeline for organizing key tasks and milestones within an impact assessment framework.

2.5 Plan for Risks

Risk planning strengthens the resilience and credibility of the impact assessment. Anticipating challenges early enables mitigation strategies that preserve timelines and data quality outcomes.

Common Risks and Mitigation Strategies

- **Stakeholder Fatigue:** Maintain regular communication and clarify expectations.
- **Regulatory or Funding Changes:** Monitor policy shifts and develop contingency plans.
- **Budget Constraints:** Prioritize critical tasks and adjust scope if necessary.
- **Technical Delays:** Build timeline buffers and coordinate with deployment teams.
- **Data Limitations:** Identify alternative data sources or proxy metrics.
- **Inter-Team Dependencies:** Establish clear communication channels and milestone tracking.

Incorporating Flexibility and Adaptability

Flexibility is a defining characteristic of effective impact assessment planning. When data access changes, deployment schedules shift, or stakeholder priorities evolve, the action plan should be updated accordingly. Adaptive planning ensures the assessment remains relevant, rigorous, and aligned with project goals, even under uncertainty.

Case Study Application: Comprehensive Planning Framework

This case study application illustrates one approach to developing a comprehensive impact assessment action plan for BESS projects. By integrating objectives, scope, key tasks, milestones, and timeline, this example offers a practical road map for aligning all aspects of impact assessment planning with project goals and desired outcomes (see Figure 2).

Objective:

The primary objective of this impact assessment is to evaluate whether stated project goals for BESS deployment were achieved. Specifically, it aims to inform project developers, owners, and stakeholders about both immediate and sustained impacts of the system, providing insight into adjustments needed when outcomes fall short or validating successes that support replication of the project design.

Secondary objectives include engaging stakeholders to foster transparency, accountability, and trust; publicly sharing project outcomes; and supporting future marketing and grant-seeking efforts.

Scope:

The scope of the impact assessment is to collect and analyze data that informs stakeholders about project outcomes and alignment with stated goals. This includes collecting baseline and post-deployment data, processing metrics, and producing a comprehensive report at the conclusion of the evaluation period. The scope is adapted to align with available resources, capacities, timelines, and area needs.

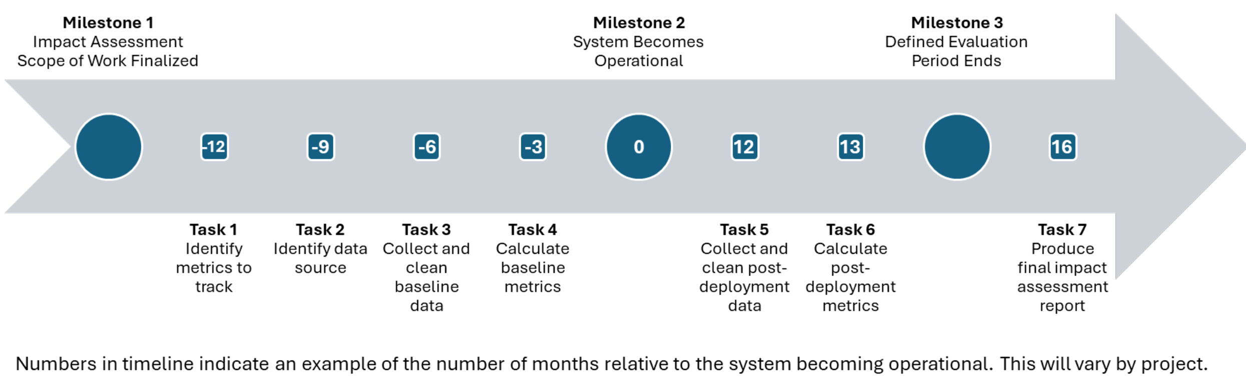

Figure 2. Example Milestone and Task Timeline

3.0 Defining Project Goals

Defining project goals is a foundational step in conducting an impact assessment. Project goals are typically identified in the planning and feasibility study phase of the project, to support the decision to invest and construct the BESS. Prior to constructing the project, it is important to clearly define the following:

1. The stakeholders' issues or challenges the project aims to address.
2. The project goals that describe what the project intends to achieve in response to those issues.
3. The project outcomes that will be tracked to assess progress toward project goals and inform the scope of the impact assessment.

These elements establish a logical pathway, from needs to project intent, and set the foundation for identifying metrics, measuring outcomes, and reporting results in later steps. Section 3.0 can guide the development and documentation of project goals during the planning and feasibility stage of the project, or, if undertaking this exercise later in the project life cycle, Section 3.0 can ensure that project goals are documented in a way that is useful for the impact assessment. If this exercise occurs later in the project life cycle, there may be a potential need to reframe existing project goals, so they are measurable for impact assessment.

3.1 Identify Local Issues and Challenges

The first step in defining meaningful project goals is identifying the issues and challenges facing stakeholders. These challenges provide necessary context for why the project is needed and ensure project design and evaluation are grounded in real-world perspectives.

Examples of challenges include frequent power outages that disrupt essential services, high peak demand charges that create cash flow challenges for residents or facilities, or unreliable energy access that undermines resilience during emergencies. These issues may be identified through existing data, prior studies, local plans, stakeholder engagement, or direct feedback from residents.

A clear understanding of these challenges helps define what the project aims to change and provides the foundation for collaboratively setting project goals with stakeholders. Clear articulation of issues ensures that project goals are focused, actionable, and aligned with priorities, while also creating opportunities to identify and address questions or concerns early. This supports smoother implementation and enables subsequent impact assessment efforts to demonstrate meaningful change.

3.2 Define Clear Project Goals

Project goals articulate what the project intends to achieve in response to identified issues. These goals should be developed collaboratively with local residents and stakeholders to ensure alignment with their priorities, expectations, and lived experiences.

Different use cases, including the following examples, support different goals, and projects may define goals that are specific to the needs of the application:

- A wastewater treatment plant may prioritize operational resilience or uninterrupted access to treated water.
- Residential homes may aim to increase energy affordability or access to refrigeration.
- Resilience hubs may define goals related to maintaining critical services such as heating, cooling, or communication during grid outages.

Project goals are often shaped by internal stakeholder and developer discussions, external funder or regulatory requirements, or a combination of both. To ensure their clarity and usefulness, project teams may follow the SMART framework, which emphasizes goals that are Specific, Measurable, Achievable, Relevant, and Time-bound.

> **Example Project Goal**
>
> "Reduce the average monthly utility bill by 15 percent for 25 participating households within 12 months of BESS commissioning." This goal aligns with the SMART criteria: It is Specific (targets bill reduction for 25 households), Measurable (15 percent reduction in utility bills), Achievable (through BESS-enabled cost savings), Relevant (supports energy affordability), and Time-bound (within 12 months of commissioning).
>
> Clearly articulated project goals serve as reference points for the rest of the entire impact assessment process. They guide the identification of meaningful outcomes, the selection of metrics, and the evaluation of success.

3.3 Link Project Goals to Outcomes and Measurement

Once project goals are defined, they establish a foundation for identifying project outcomes and selecting appropriate metrics to track progress. Outcomes represent the measurable changes or effects resulting from the project, ultimately indicating whether, and to what extent, the project goals have been achieved.

Project outputs, the immediate, tangible products of implementation (e.g., installed battery capacity or physical infrastructure), can provide initial evidence of progress. However, the impact assessment ultimately focuses on outcomes, which capture the longer-term effects such as reduced electricity bills, improved energy reliability, enhanced resilience, and increased service continuity.

Measurable outcomes provide evidence of project performance and are essential for learning, accountability, and reporting. These outcomes should focus on long-term changes, such as improved energy reliability, reduced outages, or enhanced grid stability, and can include both quantitative data (e.g., number of outages prevented) and qualitative data (e.g., local resident feedback and perceptions of improved reliability).

When linking project outputs to outcomes, challenges may arise, such as the absence of baseline data or difficulties in establishing causality. Selecting a small number of meaningful outcomes aligned with project goals simplifies measurement and increases the usefulness of the assessment. Subsequent sections in this guide provide further guidance on selecting metrics (Section 4.0) and measuring outcomes (Section 5.0).

Case Study Examples: Aligning Challenges, Project Goals, and Desired Outcomes

The examples in Table 1 demonstrate how identified project challenges inform clearly defined goals and corresponding desired outcomes. Challenges describe the underlying need, goals state what the project intends to accomplish, and outcomes reflect the anticipated changes resulting from implementation.

Table 1. Project Challenges, Goals, and Associated Desired Outcomes

Challenges	Project Goal Examples	Outcomes
School A is seeking to reduce rising electricity costs that strain its operating budget and limit resources available for core educational needs. The school currently relies heavily on grid electricity, including during high-cost peak demand periods, resulting in elevated annual utility expenditures. To address these challenges, the school is considering the installation of on-site generation paired with battery energy storage to better manage energy use and costs.	By December 2026, reduce the school's annual electricity costs by at least 20% by installing and operating on-site generation paired with battery energy storage to offset grid electricity use during high-cost demand periods.	• Reduced electricity expenditures for the school • Lower reliance on grid electricity during peak demand periods • Increased use of energy generated on-site • Improved financial stability for school operations
Storm-related power outages pose an ongoing threat to Organization B, particularly during severe weather events such as thunderstorms, hurricanes, and other natural hazards. These disruptions can leave residents without access to electricity for extended periods, compromising safety, health, and access to essential services. Currently, Organization B lacks a dedicated facility equipped to provide reliable power and critical support during emergency scenarios. As a result, there is a clear need for a resilience hub to support local residents during outages and other extreme weather events.	By December 2026, design, construct, and operationalize a resilience hub capable of serving 25–35 local residents during emergency events, including prolonged power outages. The hub will provide reliable backup power and access to essential services to enhance preparedness and response capacity.	• Reduced vulnerability during extreme weather events that result in power outages • Increased access to a local resilience hub during emergency scenarios • Improved continuity of critical services for local residents during grid disruptions • Strengthened overall emergency preparedness and resilience

4.0 Identifying Metrics

Metrics are critical tools for measuring a project's outcomes. In this guide, the term "metric" refers to a specific, measurable variable that reflects whether a project is achieving its intended outcomes (e.g., energy cost savings or improved resilience during grid outages). Carefully selected metrics go beyond measuring technical performance; they also capture broader targets such as affordability, energy access, and resilience.

Metrics are essential for identifying gaps between planned outcomes and actual results, supporting decision-making and enabling adaptive planning. They provide stakeholders, funders, and project teams with actionable insights to track progress and refine implementation strategies. This section focuses on how to select metrics that are meaningful, measurable, and aligned with project goals and local priorities.

When carefully selected, metrics answer the core evaluation question, "Is the project creating the kind of impact it set out to achieve?"

4.1 Develop a List of Potential Metrics

The first step in identifying metrics is developing a preliminary list based on project goals and outcomes, as discussed in Section 3.0. This process ensures that metrics align with the project's unique challenges, purpose, and stakeholder priorities.

4.1.1 Translate Project Goals into Measurable Metrics

Start by reviewing the project's goals and outcomes, then translate them into measurable metrics by doing the following:

- Identify the primary issues and challenges the project seeks to address (e.g., frequent outages or high energy bills).
- Determine the specific outcomes stakeholders care about, such as improved affordability, enhanced resilience, or expanded access to reliable energy.
- Articulate these outcomes as measurable metrics.

Metrics should reflect the project type (e.g., schools, clinics, resilience hubs) and fit the local context, taking into account geographic, social, and institutional conditions. They should also be feasible to track with the available time, resources, and expertise.

> **Example:** If the stated project goal is to improve a school's resilience to outages, suitable metrics might include the "average number of hours the school maintained power during outages" or the "number of instructional days the school remained operational during outages."

4.1.2 Brainstorm Candidate Metrics

Generating candidate metrics is often a collaborative process that draws on diverse perspectives, including stakeholders, funders, and evaluation partners. Here are practical steps to ensure a robust and inclusive brainstorming process:

- **Literature Reviews and Prior Evaluations:** Look for metrics used successfully in similar projects.
- **Grant and Regulatory Requirements:** Align metrics with funder expectations and reporting criteria.
- **Stakeholder Engagement:** Conduct brainstorming sessions or focus groups to identify priorities and ensure metrics reflect local needs.
- **Partner Collaboration:** Collaborate with technical and project partners to identify relevant technical, operational, or environmental metrics.

Organizing metrics may help identify gaps or leverage efficiencies in the selected metrics and focus the brainstorming process. Grouping by broad impact categories is one approach. Categories of interest may include energy resilience, economic benefits, energy access, workforce development, energy security, and infrastructural benefits (Table 2). These reflect shared themes for priorities across BESS projects, such as reducing grid energy demand, lowering energy costs, ensuring the continuity of critical services, improving resilience, and advancing stakeholder priorities.

Metrics can also be organized by the following:

- **Data Collection Method:** Group metrics based on whether they rely on existing data (e.g., electricity bills or BESS performance data) or new data collected through surveys or interviews.
- **Level of Effort:** Sort metrics into those that require low, medium, or high levels of time and resources to gather and measure. For example, low effort might include tasks like reviewing electricity bills and BESS datasets to identify trends in consumption or cost savings; medium might include collecting information on new activities or pilot programs; and high might include detailed primary research, such as surveys to evaluate how resilience hubs are utilized by local residents or what services they find most impactful.

Table 2. Key Impact Categories Used to Organize Project Indicators

Category	Description	Examples
Economic Benefits	Includes cost savings and local economic opportunities created through the project	• Changes in average monthly household energy costs • Estimated cost savings from reduced outage frequency or duration • Avoided business losses because of improved power reliability
Energy Access	Measures how communities gain or improve access to reliable and affordable energy	• Number of households with newly established or expanded energy connections and number of critical facilities, such as clinics, that gain access to electricity or energy services like medication refrigeration during outages

Category	Description	Examples
Energy Resilience	Captures how well the energy system can withstand, adapt to, and recover from disruptions	• Number of residents served by a resilience hub • Duration of backup power availability • Time to resume critical services after outages
Energy Security	Continuous supply and access to affordable energy despite physical or cybersecurity threats	• Reduction in grid energy consumption • Types of safety mechanisms • Reduction in use of higher-risk alternatives
Infrastructural Benefits	Enhances grid stability and reduces grid stress	• Reduction in grid demand during peak hours • Number of times the hub participates in demand response programs • Contribution to voltage and frequency stability if grid-connected through advanced inverters
Workforce Development	Reflects training, job creation, and local workforce involvement in energy-related fields	• Number of participants completing training or certification • Number of jobs created through energy projects

4.2 Define Dimensions and Follow Principles of Metric Design

After developing a preliminary list of potential metrics, refine and screen the candidate metrics using structured criteria to ensure they are practical, meaningful, and effective for evaluation. This step focuses on assessing the feasibility of each metric and verifying it aligns with project goals and available resources, ensuring the final set of metrics is robust, interpretable, and useful for decision-making across the full life cycle of the project. At this stage, project teams should also consider how metrics will be measured against baseline conditions to support meaningful interpretation of project outcomes. Baseline and post-deployment measurement approaches are discussed further in Section 5.2. Metrics will measure progress toward project goals, so when defining metrics, keep in mind project challenges that are intended to be addressed by the BESS—in other words, what are issues the BESS is intended to address and how will that progress be tracked?

4.2.1 Define Key Dimensions of Metrics

Defining dimensions for each metric involves specifying practical details about how the metric will be measured, tracked, and analyzed. This ensures clarity for evaluators and stakeholders and prevents ambiguities during data collection and reporting.

For each metric, project teams should describe the following:

- **Measurement Frequency:** Will the metric be tracked monthly, quarterly, annually, or at another interval?
- **Time Frame:** Over what period will the metric be observed (e.g., for one year, three years, or the project's full life cycle)?
- **Measurement Level:** Identify the scale at which the data will be measured (e.g., household, facility, system, or region).
- **Units of Measurement:** Clearly define how the metric will be quantified (e.g., dollars, hours, kilowatt hours [kWh], number of participants).
- **Partners:** Identify which partners should be engaged and informed.

- **Data Source:** List potential sources of information to be analyzed.
- **Audience:** Identify who is the primary audience for each metric (e.g., funders, developers, stakeholders).

In addition to specifying these dimensions, metrics should be scored for their suitability and performance under key criteria such as the following:

- **Relevance:** Does the metric directly reflect project goals and stakeholder priorities?
- **Informative Value:** Does the metric provide meaningful insight into project outcomes?
- **Feasibility:** Can the metric be tracked affordably, reliably, and with available resources?
- **Scalability:** Is the metric suitable across varying project sizes and contexts (if appropriate)?
- **Replicability:** Can the metric calculation be reproduced and/or evaluated in a consistent manner over time?
- **Interpretability:** Is the metric easy to understand for decision-makers, funders, and stakeholders?
- **Time Frame Alignment:** Does the metric capture results that align with the project's reporting or evaluation timelines?
- **Data Reliability:** Are data sources (e.g., utility records, outage logs, operational data) consistent and trustworthy?
- **Balance:** Does the metric allow for both quantitative (numerical indicators) and qualitative (narrative or experiential information) insights where appropriate?

A complete description of these dimensions and criteria for each metric ensures clarity and facilitates consistency in data collection, calculation, and interpretation.

4.2.2 Apply Principles of Strong Metric Design

After defining the practical dimensions of each metric, project teams should evaluate whether the selected metrics adhere to guiding principles of strong metric design. These principles ensure metrics reflect the desired outcomes, remain actionable, and support meaningful evaluation throughout the project life cycle.

Strong metrics should do the following:

- **Directly Link to Project Goals and Desired Outcomes:** Metrics should provide evidence-based insights into whether project goals are being achieved.
- **Focus on Outputs and Outcomes, Not Inputs or Activities:** Strong metrics measure tangible results, such as reduced energy costs or enhanced reliability, rather than describing implementation details.
- **Be Measurable and Consistently Interpretable:** Metrics should be clearly defined and quantifiable, avoiding ambiguity or subjectivity in their interpretation.
- **Rely on Accessible and Transparent Data Sources:** Metrics should rely on data that are readily available for use, either publicly or through established agreements. Data sources should be trustworthy, clearly documented, and reputable, allowing external reviewers,

stakeholders, or future evaluators to locate and validate the information. If the data source is proprietary or restricted, it should still be well-defined and understandable in its methodology.

- **Reflect Meaningful Project Impacts:** Metrics should measure results impacted directly by project activities rather than unrelated external factors.
- **Support Ongoing Evaluation:** Metrics should be realistic to collect and review periodically throughout the project's life cycle, enabling tracking of trends and adaptive management over time.

Adhering to these principles ensures that selected metrics are robust, actionable, and aligned with broader regional priorities while remaining practical to implement.

4.3 Down-Select Metrics to a Manageable Number

A comprehensive list of potential metrics must be refined to a manageable number that effectively tracks project progress without overwhelming resources. To narrow the list, do the following:

- **Evaluate Feasibility:** Confirm that metrics are realistic given staffing, skills, budget, and data availability. If limitations exist, prioritize straightforward metrics that highlight primary project goals and select proxies for complex measures.
- **Align Metrics with Broader Plans:** Metrics should align with established local, regional, or state plans, such as resilience frameworks or energy security targets implemented at school district, city, county, or state levels. Selected metrics should also work collectively to provide a cohesive narrative of the project's impacts.
- **Prioritize Simplicity:** Where resources are constrained, simple or low-effort metrics should take precedence over complex ones. Projects with additional funding or technical expertise may implement more detailed methodologies to capture nuanced insights into project outcomes.
- **Balance Themes:** Avoid overloading metrics in one area (e.g., economic benefits) while under-representing others (e.g., resilience or access). Keep metrics for primary project goals prioritized but ensure broader benefits are adequately represented.

Thoughtful metric down-selection ensures the project evaluation process remains efficient and focused while delivering meaningful insights to stakeholders.

4.4 Document Selected Metrics

To ensure consistency throughout the multi-year project life cycle and enable future replication, it is essential to clearly document selected metrics. Documentation should include the following:

- **Definitions:** Describe each metric, ensuring all stakeholders agree on its meaning and purpose.
- **Calculation Methodologies:** Outline how results will be calculated, specifying how each metric will be measured and reported. Familiar methods, such as calculating an average or percent change, can often be used. Appendix B provides an introduction to basic statistics for project evaluation.
- **Data Sources:** Identify where the data will come from.

Comprehensive documentation ensures transparency, facilitates stakeholder alignment, and enhances the utility of metrics for both reporting and decision-making. Some examples of metrics that have been used to assess BESS impacts at resilience hubs are listed in Appendix C.

Case Study Example: Project Goals with Down-Selected Metrics and Metric Definitions

Table 3 illustrates how clearly defined project goals guide the examples of down-selected impact assessment metrics and their corresponding definitions. Goals articulate what the project intervention is intended to achieve, while the selected metrics translate those goals into measurable indicators. Metric definitions further clarify how each indicator is interpreted to support consistent tracking and evaluation.

Table 3. Example of Project Goals with Down-Selected Metrics and Metric Definitions

Project Goal Examples	Down-Selected Metrics	Definitions for Metrics
By December 2026, reduce School A's annual electricity costs by at least 20% by installing and operating on-site generation paired with battery energy storage to offset grid electricity use during high-cost demand periods.	• Annual reduction in electricity bills ($ or %)	• Track changes to electric bills from year to year.
Design, construct, and operationalize a resilience hub capable of serving 25–35 local residents for Organization B during emergency events, including prolonged power outages. The hub will provide reliable backup power and access to essential services to enhance preparedness and response capacity.	• Length of time (defined in hours) the hub can sustain operations during an outage • Number of critical services functioning during emergency use	• Track how long the resilience hub can operate autonomously during a grid outage, showcasing battery capacity and system reliability. • Track which infrastructure services (e.g., water, electricity, refrigeration, cooking, lights, heat, air filtration, computers and electronics, medical devices, internet access, device charging, etc.) remain operational during outages.

5.0 Collecting Data and Measuring Outcomes

Building on the metrics selected and refined in Section 4.0, this section focuses on implementing those metrics to measure outcomes. It provides guidance for planning data collection efforts, managing data responsibly, and performing calculations to translate raw data into actionable insights. Measuring outcomes is both a technical exercise and a project management task, requiring clear planning, coordination among partners, and alignment with realistic timelines and available capacity.

As discussed in Section 2.0, measurement should be treated as a structured workstream with clearly defined roles, resources, and milestones. This section builds on that foundation to guide project teams in operationalizing metrics and ensuring assessments are feasible, credible, and useful.

5.1 Confirm Final Metrics

Before beginning data collection, project teams should ensure that metrics (already defined in Section 4.2.1) are ready for implementation. This step confirms that metrics are fully specified, actionable, and aligned with the project's data collection strategy.

Project teams may briefly revisit metrics to ensure clarity around details such as measurement frequency, timeframes, scales, and units. Examples include the following:

- If tracking energy cost savings, confirm whether data collection will occur monthly or annually, what the measured variables will be (e.g., electricity, fuel, or generator costs), and how the savings will be calculated (e.g., percentage change in annual energy costs before and after deployment). Cost-related metrics should also be interpreted in the context of broader retail electricity price trends over time and may be indexed for both cost and consumption to improve comparability across time and sites.
- For service reliability during outages, the measured variable might be the number of hours or days a facility remains operational during grid outages.

This step ensures that each metric has a clear and operational definition before any data collection begins and helps avoid ambiguity or inconsistent interpretation later in the process.

5.2 Design the Data Collection and Management Plan

Once it is clear what will be measured, the next step is to design a practical data collection and management plan. This plan should specify the following:

- **What Data Will Be Collected:** Identify the data types required.
- **Where the Data Will Come From:** Identify primary or secondary data sources.
- **How and When the Data Will Be Collected:** Include timelines, measurement intervals, and approved methodologies.

- **Who Is Responsible**: Assign roles for data collection, validation, quality assurance, storage, and analysis.
- **How the Data Will Be Stored and Managed:** Outline data governance to ensure secure storage and ethical use, as well as how the data will be prepared for analysis.

As emphasized in Section 2.0, this planning should align with available capacity, staffing, budget, and timelines.

5.2.1 Common Measurement Scenarios

BESS and resilience hub projects typically use one or more of the following measurement scenarios. Select the approach (or combination of approaches, such as baseline and ongoing monitoring) that best fits project timeline, resources, and data availability.

Scenario A: Two-Point-in-Time Measurement (Baseline + Post-Deployment)

This is the most robust and commonly preferred approach. Data are collected at two points: baseline (pre-deployment), which establishes conditions before the project is implemented, and post-deployment, which measures outcomes after the system is operational (see Figure 3).

This approach allows for direct, before-and-after comparison and is especially useful for indicators such as energy costs or bill savings, outage impacts and service continuity, and facility operations or service levels. It provides the strongest basis for attributing changes to the project but requires early planning and time to collect baseline data.

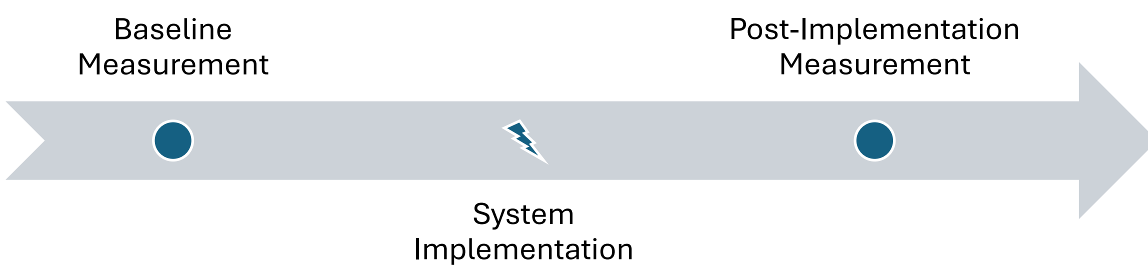

Figure 3. Two-Point-in-Time Measurement

> **Example:** Track electricity bills for 12 months before installation and 12 months after installation to assess changes in energy costs or peak demand.

Scenario B: Single-Point-in-Time Post-Deployment Measurement (Retrospective or Recall-Based)

In cases where baseline data cannot be collected or reconstructed (e.g., the project may already be operational), this approach relies on retrospective or recall-based techniques (see Figure 4). In these situations, teams may rely on a single post-deployment data collection effort, often using surveys asking participants to reflect on changes, administrative or operational records, or engineering estimates or modeled counterfactuals. This is sometimes referred to as an ex-post impact evaluation.

This approach has lower cost and is easier to implement, and it can be useful when capacity is constrained. However, it relies on memory and perception, which may introduce uncertainty. It might be less precise but can still generate useful insights when designed carefully.

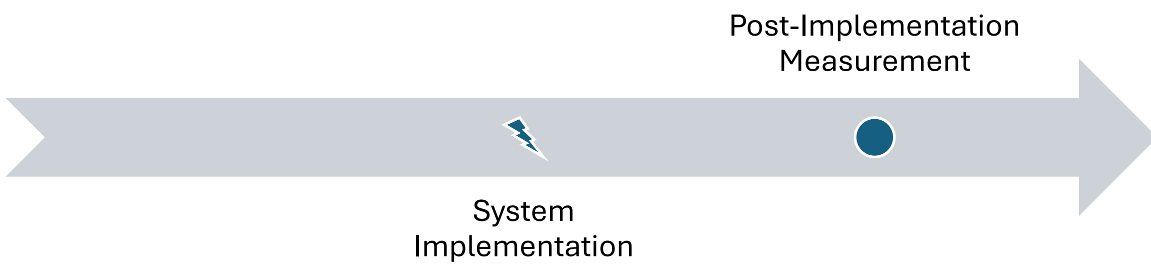

Figure 4. Single-Point-in-Time Post-Deployment Measurement

Example: Conduct a post-deployment survey asking facility staff whether and how backup power availability has changed operations during outages compared to previous years.

Scenario C: Ongoing or Longitudinal Monitoring

Some indicators benefit from or require continuous or repeated measurement over time (see Figure 5), particularly for system performance and reliability, usage patterns, maintenance, operations, degradation, and long-term socioeconomic or institutional outcomes.

This approach supports adaptive management, trend analysis, and reporting across the full project life cycle but requires sustained capacity and long-term commitment.

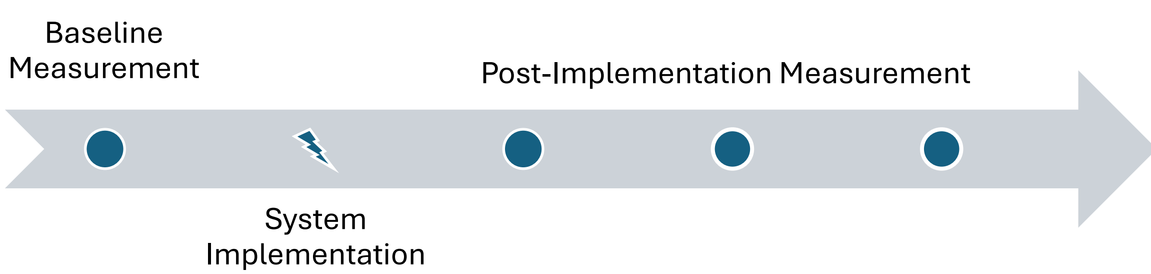

Figure 5. Ongoing or Longitudinal Monitoring

Example: Automatically log system performance, outage events, and load coverage continuously over multiple years and summarize results annually.

5.2.2 Aligning Data Sources with Collection Strategies

Selecting an appropriate data source ensures accuracy and alignment with the chosen measurement scenario. Depending on the indicator and measurement scenario, data may come from the sources listed below.

Primary Data (Newly Collected)

Collected directly through project or stakeholder efforts to capture experiences, perceptions, or outcomes not available in existing datasets. Common sources include local surveys, interviews, or focus groups; public meetings or workshops; and site visits or structured observations.

Tip: When collecting individual-level data, define sampling methods, sample size, and analysis plans in advance. Determine whether ethical review (e.g., Institutional Review Board, tribal government) is required.

Secondary Data (Existing Data)

Obtained from existing public or proprietary sources like BESS logs, utility outage records, Supervisory Control and Data Acquisition (SCADA) data, census data, local planning or housing data, land use, public health datasets, hazard exposure, and emergency response records.

Tip: Confirm whether data are free and accessible or require data-sharing agreements or purchase. When access is constrained, consider proxies or alternative indicators.

Each metric should specify the following:

- Which measurement scenario is being used (two-point, single-point, or ongoing).
- What data source(s) will be used.
- How often data will be collected.
- What time periods will be compared.
- What tools or instruments will be used (e.g., surveys, logs, templates, automated systems).

Additional information is provided in Appendix D.

5.2.3 Define Roles, Responsibilities, and Timeline

Measuring outcomes requires clear assignment of roles and responsibilities as a formal part of the project action plan (discussed in Section 2.0), ensuring each aspect of data collection, validation, quality assurance, storage, and analysis is carried out effectively. Responsibilities may include the following:

- **Data Collection:** Requesting or collecting data for defined intervals.
- **Data Management:** Safely storing, organizing, and maintaining datasets.
- **Data Analysis:** Cleaning and validating data, performing calculations, and reporting results.
- **Data Sharing:** Communicating and sharing data with partners or external technical assistance providers.

Aligning these responsibilities with the project timeline reduces the risk of delays and ensures evaluations align with reporting and milestone requirements. Clear ownership and scheduling reduce the risk that data collection or analysis is delayed or incomplete.

5.2.4 Data Integrity and Responsible Use

High-quality, trustworthy data are essential for credible impact assessment. At the same time, data collection and management must respect privacy, protect participants, and follow applicable ethical and legal requirements. Project teams should establish clear procedures that address data quality, data stewardship, access control, and responsible use from the outset.

- **Establish Data Quality and Validation Procedures:** Standardize data templates and formats, check for inconsistencies and obvious errors, document steps to clean and validate data, and ask others to review data to ensure they make sense in context.
- **Ensure Secure Storage, Clear Documentation, and Traceability:** Maintain secure storage protocols and clear file inventories to ensure continuity through staff transitions, transparency, and availability for future reuse without ambiguity.
- **Address Ethics, Privacy, and Legal Responsibilities:** Protect participant privacy, minimize collecting personally identifiable information, and ensure compliance with applicable regulations (e.g., Institutional Review Board approval for human subjects research).
- **Define Data Governance and Control:** Collaborate with stakeholders on how data will be used, shared, and retained, as well as how results will be communicated and to whom.

5.3 Carry Out Calculations and Produce Results

Once data have been collected according to the data collection and management plan, the next step is to compute the selected metrics and translate raw data into meaningful, interpretable results. This step focuses on execution: applying consistent calculation methods, documenting assumptions, and producing credible and comparable outputs that can be used for learning, reporting, and decision-making.

Across all projects and measurement scenarios, the following good practices apply:

- Clearly document all formulas, assumptions, and calculation steps.
- Keep a record of where each data input came from.
- Use consistent methods across time periods, sites, and participant groups.
- Separate raw data, cleaned data, and calculated results.
- Document any exclusions, adjustments, or data limitations.
- Design calculations so they can be repeated in future years or applied to other projects.

In practice, the calculation workflow depends on which measurement scenario is being used. The sections below describe how calculations are typically carried out under the three common scenarios introduced in Section 5.2.1.

Calculations for Two-Point-in-Time Measurement (Baseline + Post-Deployment)

Under this scenario, results are derived by comparing pre-deployment (baseline) values with post-deployment values.

Typical steps include the following:

1. Prepare the baseline dataset (cleaning, formatting, aggregation).
2. Prepare the post-deployment dataset using the same rules.
3. Align the two datasets to ensure comparability (e.g., similar time periods or operating conditions).
4. Compute changes (differences, percentages, or ratios).
5. Aggregate results across households, facilities, or sites if needed.

> **Example:** If the metric is "average monthly energy cost savings," the calculation may involve subtracting the average pre-deployment monthly cost from the average post-deployment monthly cost for each installation site, then averaging across all participating installation sites.

Calculations for Single-Point-in-Time Post-Deployment Measurement

In this scenario, calculations are based on data collected at one point in time, typically using retrospective or recall-based estimates of pre-project conditions. Typical steps include the following:

1. Structure the dataset so that "before" and "after" values are stored as separate variables.
2. Check internal consistency and completeness.
3. Compute within-unit differences (e.g., per household or per facility).
4. Summarize results across all respondents.

> **Example:** If households report both current monthly energy costs and estimated pre-project costs in a single survey, the metric can be calculated as the average of (reported before cost – reported current cost) across all households.

Results from this approach should be interpreted with appropriate caution, and documentation should clearly note that values are based on self-reported or recalled estimates.

Calculations for Ongoing or Longitudinal Monitoring

For projects that collect data repeatedly over time, calculations focus on trends, variability, and performance over longer periods.

Typical steps include the following:

1. Organize data into a time-series format with consistent intervals.
2. Compute period-level indicators (e.g., monthly averages, annual totals, per-outage performance).
3. Analyze trends and changes over time.
4. Summarize results for reporting (e.g., annual summaries, multi-year comparisons).

> **Example:** If system logs record outage performance continuously, the metric "total hours of service maintained during outages per year" can be computed annually and compared across years.

Case Study Example: Down-Selected Metrics, Calculation Methods, and Data Sources

Table 4 builds upon the preceding examples by further specifying the down-selected metrics, along with their calculation methods and associated data sources. This table continues the progression from identified challenges and goals to measurable metrics, providing additional detail on how each metric will be quantified and supported by verifiable data.

Table 4. Down-Selected Metrics, Calculation Methods, and Data Sources

Down-Selected Metrics	Calculation Methods	Data Sources
School A: • Annual reduction in electricity bills ($ or %)	• Calculate the absolute and percentage change in dollars in annual electricity bills. Define a baseline period (at least 12 months before deployment). Compute baseline annual bill directly from utility bills (energy charges, demand charges, fees). Compute post-deployment annual costs from bills after deployment, subtract operations and maintenance and insurance to get net post-deployment cost. The time period evaluated will be 12- or 24-month pre-deployment (depending on data availability) and 12-month post-deployment.	• Electricity Cost: School utility bills. • Operations and maintenance cost and insurance after deployment can be provided by the school officials.
Organization B: • Length of time the hub can sustain operations during an outage • Number of critical services functioning during emergency use	• Length of time: Monitoring systems will be set up to track outages, their length, and the hub's operational hours. Determine the actual measured time for every outage event. Each outage event during the 12-month post-deployment period will be evaluated. • Number of critical services: Determine which services are critical. The criticality of infrastructure services is determined by local needs. Conduct baseline assessment of which functions the resilience hub provides during a blue-sky day. Measure how many services and how long they are supported by the resilience hub during an outage. Record the number of people who come into the hub to use its services. The time period for evaluation is 12-month post-deployment.	• Length of time: Use battery discharge logs to show power provided during outages and the duration of this power provision. Supplement with uptime reports from energy monitoring systems. May involve simulations if outages are rare. • Number of critical services: Utilize a combination of technical monitoring (uptime logs for services) and local feedback (e.g., surveys about what services are critical or about usage after an outage/emergency event).

6.0 Reporting and Using Results

With data collected and outcomes measured using the approaches described in the previous sections, the final step of the impact assessment focuses on interpreting results and putting them to use. Reporting and applying findings ensures that the assessment not only documents project performance, but also informs decision-making, supports learning, and guides future BESS deployments.

The culmination of the impact assessment is analyzing and reporting results that illustrate how the BESS system influenced key outcomes. Comparing pre- and post-deployment metrics provides insight into whether the project goals defined in Section 3.0 were achieved and supports actionable decision-making for optimizing current systems, scaling similar projects, and guiding future investments. As outlined in Section 2.0, many impact assessment objectives include explicit plans for using results, so reporting should be viewed not only as documentation but as a bridge to action. Beyond numerical findings, reporting should also incorporate narratives and qualitative feedback from stakeholders and impacted parties, offering a more holistic view of project outcomes.

6.1 Interpreting the Results

Results should be interpreted to connect project performance with broader plans, as defined in Section 2.0 and refined throughout the assessment process. Comprehensive interpretation requires a structured approach:

- Compare pre-deployment metrics with post-deployment outcomes.
- Identify areas where outcomes exceeded expectations and analyze contributing factors.
- Assess gaps where results fell short, investigate challenges during implementation, and derive practical lessons learned.
- Explore unexpected outcomes, both positive and negative, that reveal new insights or opportunities for improvement.

Critical findings should not be interpreted in isolation but contextualized with input from stakeholders and system users. This inclusive approach ensures the analysis reflects a wide range of priorities, perspectives, and lived experiences while guiding robust decision-making.

6.2 Practical Applications of Results

Impact assessment results provide a rich source of data that can be applied to improve system performance, support decision-making, and guide future projects. The intent of the BESS project will determine how results are used—for example, a pilot project may use results to inform future installations and investment, while a full-scale rollout may use results to inform system operations and communications. Specific applications of results may include the following:

1. **Evaluate Goal Achievement:** Compare targeted project goals, such as energy cost savings or increased resilience to grid disruptions, against actual outcomes to assess the extent to which these goals were achieved. Translate results into clear, quantifiable achievements to effectively showcase the project's success to stakeholders.
2. **Optimize the Current System:** Use the assessment findings to identify actionable system improvements. Examples include adjusting operational parameters to address any

underperformance, implementing training programs for building occupants to optimize energy use behaviors during critical periods, and integrating new strategies for demand management or maintenance.

3. **Inform the Design of Future Projects and Investments:** Apply lessons learned to inform decision-making for upcoming BESS projects. This could include better aligning resilience hub setup with user needs, identifying more effective battery configurations, or developing tailored engagement strategies. Assessment results can help allocate resources effectively for even greater impact in future deployments.
4. **Support Strategic Research:** Impact assessment results may identify gaps in knowledge or opportunities for research. For instance, data on BESS performance can inform studies on optimizing energy storage configurations or improving operational integration with broader grid systems.
5. **Strengthen Reporting and Accountability:** Use assessment results to demonstrate accountability to stakeholders, grantors, donors, or funders. This includes transparent reporting on resource allocation, achieved benefits, and areas for improvement. Actionable, well-documented results build credibility and strengthen stakeholder relationships.
6. **Demonstrate Project Value in Policy and Funding Contexts:** Transparently communicated results highlight the performance of the system and its potential for replicability. These insights strengthen applications for future grant funding, encourage institutional investment, and demonstrate the efficacy of BESS projects to decision-makers.

The ultimate goal of applying impact assessment results is to ensure that outcomes are not simply documented but used to drive meaningful improvements in BESS system performance, inform strategic planning, and deliver broader benefits to local residents and the energy sector.

6.3 Aligning Results with Broader Energy Plans

Aligning impact assessment results with broader strategic plans enhances the value of BESS deployments and strengthens the case for continued public and private investment. Positioned within the context of grid modernization and evolving policy priorities, documenting these results can demonstrate progress toward priorities such as energy affordability, resilience, and disaster preparedness. BESS systems also support critical services during extreme weather and emergencies, helping maintain continuity of essential resources. Clearly reporting how these outcomes contribute to both immediate needs and long-term energy priorities helps build stakeholder confidence and supports future project development and scaling.

6.4 Communicating and Disseminating Results

Successfully reporting results requires reframing key findings within actionable, audience-specific narratives. The data collected during an impact assessment provides insights useful for local residents, project managers, policymakers, funders, and utility operators, but each audience may require different types of information and messaging.

Reports for technical audiences, like policymakers or funders, should include detailed analyses of outcomes, potential scalability, and alignment with broader planning frameworks. Comprehensive documentation of results against initial project goals also provides evidence of cost-effectiveness and replicability potential.

For broader audiences, such as communities, project results should be communicated in tangible terms that connect to daily life. This includes focusing on practical benefits, like energy cost savings, improved service reliability, and disaster preparedness, and delivering information in accessible formats such as infographics, summary briefs, or public presentations.

Tailored dissemination strategies increase the likelihood that results not only provide a clear record of project impacts but also inform energy storage adoption, infrastructure planning, and policy development, where relevant to stakeholder priorities and available resources.

6.5 Advancing Future Energy Initiatives

Impact assessment results support continued innovation in energy resilience and storage applications by providing critical evidence for sustaining and expanding future initiatives. Findings can help address questions like optimizing BESS sizing, informing energy strategy and planning, or improving system integration with grid infrastructure.

Sharing findings with research organizations, policymakers, utility planners, and local leaders can accelerate decision-making, inform broader adoption across regions or communities, and guide the evolution of energy storage technologies. Additionally, results tied to economic development, resilience, and infrastructure will demonstrate the comprehensive value of BESS projects, aligning with broader public-sector and private-sector priorities.

Case Study Example: Performance Metrics, Results, and Narrative Interpretation

Table 5 presents the selected performance metrics, observed results, and accompanying narrative interpretation. Building on the previously defined challenges, goals, and metrics, this table summarizes project performance and explains how results are being interpreted and applied to inform decision-making and future replication efforts.

Table 5. Performance Metrics, Results, and Narrative Interpretation

Metrics	Result	Narrative and Interpretation
School A: • Annual reduction in electricity bills ($ or %)	• Installation of on-site generation paired with battery energy storage. • The system is designed to provide up to seven days of backup power in the event of a prolonged grid disruption. • Total direct bill reduction is $70 thousand (K) per year (including $51K energy charge reduction and $19K demand charge reduction).	• Demonstrate the financial benefits of the BESS system. • Variations between projected and actual savings may result from factors such as changes in electricity consumption patterns, behavioral adjustments, fluctuations in utility rate structures, weather variability affecting solar generation, or operational performance of the battery energy storage system.
Organization B: • Length of time the hub can sustain operations during an outage • Number of critical services functioning during emergency use	• Installation of on-site generation paired with battery energy storage, enabling the facility to operate independently for up to three days during a power outage. • Under a resiliency scenario, the hub is projected to serve 25–35 local residents, maintaining critical services, including heating and air conditioning, refrigeration, lighting, Wi-Fi access, and phone charging. • These capabilities significantly enhance the hub's ability to maintain essential services during prolonged grid disruptions.	• Project results have been shared with regional organizations engaged in resilience planning. The demonstrated performance of the BESS system is being used to inform planning efforts and support decision-making for similar installations. • By demonstrating both operational performance and wider benefits, the project is generating momentum for peer institutions to pursue similar investments.

7.0 Conclusion

This guide provides a practical framework for assessing the impacts of BESS installed at resilience hubs and other critical infrastructure. By linking project goals to measurable outcomes, identifying feasible metrics, planning data collection, and reporting results in ways that support decision-making, the guide helps project developers, facility operators, and partners move beyond technical performance alone to understand how BESS installations affect energy costs, service continuity, resilience, and future project planning. Impact assessment is most effective when integrated from the early planning stages and aligned with the broader project schedule, but the guide is designed so that project developers, facility operators, local partners, and other interested parties can carry out meaningful assessment using available data, straightforward methods, and realistic levels of effort. The framework is designed to be rigorous but achievable under real-world constraints, including limited staffing, variable data availability, and evolving project timelines. Used consistently, this approach can help document project value, improve current system operations, inform future deployments, and strengthen the evidence base for energy storage investments that support reliable and resilient critical services.

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Appendix A – Tools for Identifying Local Assets, Resources, and Expertise

Capacity (or asset) mapping is a process used to identify, organize, and analyze community assets, resources, expertise, partnerships, and needs to inform planning and decision-making. It emphasizes building on existing strengths and relationships rather than focusing only on gaps. Capacity mapping can help project teams identify available skills, technical expertise, organizational support, and partnership opportunities needed to implement and sustain an effective impact assessment process.

Tool 1: Local Capacity Inventory (Examples)

Develop a preliminary inventory of local assets using sources such as directories, planning departments, and community organizations. Organize assets by sector and document key contact information.

Examples of asset categories:

- **Grassroots/community groups:** neighborhood associations, community centers, senior groups, local leaders
- **Institutions:** schools, universities, hospitals, libraries, public agencies, emergency services
- **Community-based organizations:** housing groups, shelters, clinics, advocacy groups, faith-based organizations
- **Private sector:** local businesses, banks, chambers of commerce, business associations
- **Population groups:** youth, seniors, artists, students

Tool 2: Sample Questions for Capacity Mapping

Use interviews or stakeholder conversations to better understand local resources, relationships, expertise, and community needs. Below are example questions.

Organization overview

- What does your organization do, and who do you serve?
- How many staff, volunteers, and members do you have?

Resources and capacity

- What funding, facilities, or equipment do you have access to?
- What are your organization’s strongest assets?

Activities and services

- What services or programs do you provide?
- What projects are you currently working on?

Partnerships and networks

- Which organizations do you collaborate with?
- Are there other groups providing similar services?

Future needs and opportunities

- What additional support or resources would help your work?
- What new projects would you like to pursue?
- What changes would you like to see in the community?

Tool 3: Example Experts and Partners for Impact Assessment Activities

This tool provides examples of experts, organizations, and partners that may support different stages of project development and impact assessment for resilience hub and BESS projects. Staffing and partnership needs should be tailored to project scale, available resources, evaluation goals, and community context.

Table A.1. Example Experts and Partners for Impact Assessment Activities

Project Stage/ Assessment Activity	Example Experts or Partners	Potential Roles and Contributions
Project Planning and Scoping	Project managers, community organizations, facility operators, local government staff	Define project goals, establish scope and timelines, coordinate activities, and support stakeholder engagement
Stakeholder Engagement and Needs Assessment	Community organizations, public engagement specialists, social scientists, survey specialists	Conduct outreach, facilitate workshops or focus groups, develop surveys, and identify community priorities
Technical System Design	Electrical engineers, energy storage developers, microgrid or nanogrid specialists, utility representatives	Support BESS sizing and integration, evaluate technical feasibility, and assess operational requirements
Metric Selection and Evaluation Design	Economists, data analysts, policy researchers	Identify feasible metrics, develop assessment methodologies, and align metrics with project goals
Data Collection and Management	GIS analysts, data managers, survey teams, facility staff	Collect, organize, manage, and validate technical, operational, and survey data
Economic and Financial Analysis	Economists, financial analysts, utility experts	Estimate energy cost savings, avoided outage losses, and other economic impacts
Resilience and Infrastructure Assessment	Emergency management professionals, infrastructure planners, public safety agencies	Assess resilience benefits, infrastructural benefits, and continuity of essential services
Statistical and Analytical Support	Statisticians, data scientists, academic researchers	Conduct statistical analysis, modeling, uncertainty analysis, and interpretation of findings

Project Stage/ Assessment Activity	Example Experts or Partners	Potential Roles and Contributions
Reporting and Communication	Communications specialists, technical writers, graphic designers	Prepare reports, visualizations, and stakeholder-facing materials
Implementation and Continuous Improvement	Facility operators, O&M contractors, project managers, community partners	Operate and maintain the BESS, track performance and impacts over time, incorporate community feedback, refine metrics, data collection, and reporting for future implementation

Learn More

For additional tools and examples of capacity mapping, readers can refer to resources such as:

- University of Kansas, Community Tool Box: https://ctb.ku.edu/en/table-of-contents/assessment/assessing-community-needs-and-resources/identify-community-assets/tools
- California Department of Social Services, Asset mapping / Strength and Needs Assessment Toolkit: https://www.cdss.ca.gov/inforesources/cdss-programs/ffpsa-part-iv/asset-mapping-strength-and-needs-assessment-toolkit
- National Center for Farmworker Health, Inc. (NCFH), Community Asset Mapping Guide: https://www.ncfh.org/wp-content/uploads/2025/04/ncfh_asset_mapping_tool.pdf
- Institute for People, Place, and Possibility (IP3), Community Commons, a hub for community health and resilience data, tools, and resources from many different organizations: https://www.communitycommons.org/
- U.S. Department of Housing and Urban Development (HUD), Community Planning and Development Maps: https://egis.hud.gov/cpdmaps/
- Data.gov, a platform for the public to easily find, download, and use datasets that are generated and held by the federal government: https://data.gov/

Appendix B – Statistical Methods and Data Preparation

Purpose

This appendix provides a consistent framework for analyzing and interpreting the impact metrics associated with the energy storage project. It outlines the approach for collecting, comparing, and summarizing data from both pre-installation (baseline) and post-installation (follow-up) periods.

Monitoring Framework

If a metric is evaluated more than once (e.g., before and after project installation), use consistent data sources and geographic boundaries.

Let:

$$\Delta M_i = M_{i,post} - M_{i,pre} \tag{1}$$

where M_i = value of metric *i* (e.g., employment rate, median income)
$M_{i,pre}$ = baseline value before project installation
$M_{i,post}$ = value measured after project operation begins
ΔM_i = observed change attributed to project activities (to be interpreted along with contextual factors)

Percentage change measures the relative change in a metric between the baseline and follow-up periods and can be calculated as follows:

$$Percent\ Change_i = \frac{\Delta M_i}{M_{i,pre}} \times 100 \tag{2}$$

This framework enables consistent comparison across locations and time periods.

Descriptive Statistics

The following basic statistical measures are broadly useful:

- Mean (average):

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i \tag{3}$$

  where X_i represents each observation and n is the total number of observations.

- Median: The midpoint value in the ordered dataset, useful when the data are skewed or contain extreme values.
- Standard Deviation (SD): Measures the variability of observations around the mean.

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(X_i - \bar{X})^2} \tag{4}$$

These summary statistics provide a clear understanding of the central tendency and spread of data.

Treatment of Outliers: The 3-Sigma Rule

For datasets that approximately follow a normal (bell-shaped) distribution, outliers can be identified using the three-standard-deviation rule, sometimes called the empirical rule or 3-sigma rule.[1]

The rule states that:

$$Lower\ Bound = \mu - 3\sigma \tag{2}$$

$$Upper\ Bound = \mu + 3\sigma \tag{3}$$

Where:

μ = mean of the dataset
σ = standard deviation

Any data point that falls outside this range is typically considered an outlier.

[1]For more information about how to detect and handle the data outliers, readers can refer to U.S. Environmental Protection Agency (EPA) (2006). *Data Quality Assessment: Statistical Methods for Practitioners (QA/G-9S).*

Appendix C – Example Metrics

The indicators in Table C.1 were co-designed with participants in the ES4RH program in response to the specific conditions their projects were designed to address. Some metrics are defined at the household level, while others focus on facility or hub-level performance. They are presented here as examples and should be adapted to local priorities, data availability, and capacity.

Table C.1. Example Metrics by Category

Category	Metric
Access	• Number of distinct household activities supported by increased energy access (e.g., refrigeration, device charging, lighting, use of appliances). • Estimated value of avoided spoilage from refrigeration (e.g., value of food, medications, or other temperature-sensitive goods not lost during outages, per year). • Impacts of avoided use of alternate sources (e.g., time saved, avoided costs). • Percentage of surveyed users reporting that the BESS helped them meet basic healthcare needs (e.g., powering medical devices, access to cooled/heated space, refrigeration). • Percentage of surveyed users reporting that the BESS improved their mental wellbeing and support network.
Economic	• Annual change in energy-related operating costs at the facility (e.g., change in total annual electricity charges, fuel costs, or other energy expenditures). • Change in average monthly facility electricity bill and variability (e.g., change in mean and standard deviation of monthly costs pre- vs. post-BESS installation). • Number of new or expanded facility programs, services, staffing roles, or improvements funded in whole or in part by energy-related cost savings associated with the BESS project. • Simple payback period for the BESS and any associated on-site generation (years). • Percentage of total annual facility electricity consumption supplied by on-site resources (e.g., on-site generation and BESS). • Annual volume of electricity exported or sold back to the grid or utility (kWh/year), if applicable.
Infrastructure	• Change in voltage or frequency deviation events at the facility connection point, based on available monitoring data. • Change in measured loading or congestion on the relevant feeder or circuit, if such data are available from the utility. • Number of grid-support services provided by the system per year (e.g., load shifting events, voltage support events, demand reduction events, black start services), where applicable. • Number of times per year the facility participates in an organized demand response or load reduction program. • Reduction in facility peak demand during defined peak periods (kW or percent change, pre- vs. post-BESS installation). • Annual revenue or bill credits received from participation in grid services or demand response programs, if applicable.

Category	Metric
Resilience	• Number of hours critical facility systems (e.g., communications, lighting, key HVAC zones) remain operational during grid outages, per event and per year. • Change in typical travel distance or travel time between users' residences and the nearest facility with backup power and essential services. • Percentage of surveyed users—including children (e.g., students) and adults—who report that access to the facility and its services during outages helped them feel safer or less worried and reduced disruption to daily routines. • Maximum duration (hours) that the facility can sustain prioritized loads during a modeled or observed outage scenario. • Number of people supported during outage events (e.g., number of visitors or occupants using the facility's services during each event). • Number of critical services (e.g., potable water access, refrigeration, device charging, conditioned space) that can be supported by BESS under outage conditions. Where relevant, the facility may track both (a) potential capacity (services connected to backup) and (b) actual use during events (number of people and services used).
Security/ Energy Use	• Change in documented interest or requests for similar systems from other facilities or organizations after the project is installed (e.g., number of inquiries or follow-up discussions recorded over a year). • Percentage reduction in use of delivered fuels for backup power or heating at the facility (e.g., annual fuel purchases, pre- vs. post-BESS installation). • Annual reduction in grid-supplied electricity consumption at the site (kWh/year), where applicable.
Workforce	• Annual maintenance and operations costs associated with the BESS and related systems, as a share of total facility energy costs, assessing availability of affordable maintenance service providers. • Percentage of installation, operations, and maintenance roles filled by workers from the local area, as defined by the project. • Number of students or trainees engaged through project-related education or demonstration activities (e.g., site visits, hands-on training, curriculum modules). • Number of trainees from project-related programs who subsequently contributed to similar or related projects (e.g., additional energy or resilience projects in the region).

Appendix D – Detailed Data Sources

This appendix provides additional details on the primary and secondary data sources referenced in Section 5.2.2. These sources support the measurement of impact assessment metrics and the evaluation scenarios described in the main report.

Primary Data Sources

Primary data may be collected directly from project participants, local residents, and relevant stakeholders to capture experiences, perceptions, and outcomes that are not available through existing datasets. Major data sources could include the following.

- **Participant Surveys**

  Structured surveys may be administered to households, facility users, or other stakeholders to assess experiences related to energy reliability, resilience, service access, or other project outcomes. Surveys may capture perceptions, behavioral responses during outage events, and other qualitative or quantitative indicators relevant to the assessment.

- **Interviews and Stakeholder Engagement**

  Semi-structured interviews, focus groups, or town hall meetings may be conducted with stakeholders such as local residents, facility operators, local organizations, or project partners. These engagements help document perspectives, implementation experiences, and perceived benefits or challenges associated with the project.

- **Site Observations and Field Documentation**

  Site visits or structured observations may be conducted to document facility operations, infrastructure conditions, or project implementation activities. Observational data may complement survey and interview findings by providing contextual information on how facilities and systems are used during normal operations or emergency events.

Secondary Data Sources

Secondary data will be drawn from publicly available datasets and administrative records to characterize local conditions, infrastructure performance, and the broader socioeconomic and environmental context in which the project operates.

A. Socioeconomic

This category includes indicators related to employment, housing conditions, income distribution, energy access, and energy affordability.

Data Sources:

- U.S. Census Bureau, American Community Survey: Demographic characteristics, household income, housing conditions, and educational attainment.
- Bureau of Labor Statistics: Local employment levels, industry composition, and wage statistics.
- U.S. Energy Information Administration: Energy consumption patterns, electricity and fuel prices, and utility sector data.

- DOE Office of State and Community Energy Programs: Low-Income Energy Affordability Data (LEAD) Tool, which provides low-income and moderate-income household energy characteristics (https://www.energy.gov/scep/low-income-energy-affordability-data-lead-tool).
- Local Utility Records: Baseline (pre-deployment) and post-deployment energy bills can be applied to assess the energy cost savings for BESS installations.
- Local Government Departments (planning, emergency, etc.): Land use, zoning, development, and emergency plans.

B. Technical and Operational

This category includes data related to energy system performance, grid reliability, facility operations, and project implementation. These datasets help assess how energy infrastructure performs during normal operations and disruption events and provide evidence for evaluating resilience and operational outcomes.

Data Sources:

- BESS Operational Logs: System charge/discharge cycles, available capacity, and operational events during grid outages.
- Utility Outage Records: Historical outage frequency, duration, and service restoration information.
- Supervisory Control and Data Acquisition (SCADA) Data: Operational data used to monitor electricity flows, system status, and grid performance.
- Facility Maintenance and Operations Logs: Records documenting building operations, maintenance activities, and facility conditions.
- Emergency Shelter Usage Records: Documentation of facility use during emergency events, including shelter capacity and occupancy levels.
- Administrative Program Participation Records: Enrollment or participation data for programs associated with the project, such as energy or resilience initiatives.

C. Resilience and Public Health

This category considers vulnerability, exposure to environmental risks, and potential health disparities that may influence resilience outcomes.

Data Sources:

- Agency for Toxic Substances and Disease Registry: Environmental exposure and health risk data.
- U.S. Department of Health and Human Services emPOWER Map: Medicare At-Risk Populations by Geography, which provides real-time, ZIP-code-level data on Medicare beneficiaries relying on electricity-dependent medical equipment (e.g., ventilators, home oxygen) (https://empowerprogram.hhs.gov/empowermap).
- State and Local Health Departments: Public health indicators such as hospitalization rates, asthma prevalence, and heat-related illness.

D. Environmental

This category includes indicators related to land use, air and water quality, noise, and environmental compliance.

Data Sources:

- EPA NEPAssist: Mapping tool for environmental indicators and regulated facilities.
- U.S. Geological Survey National Map and Land Cover Data: Land use and land cover datasets.
- EPA Enforcement and Compliance History Online: Facility-level emissions data, regulatory compliance, and enforcement history.
- State Environmental Agencies: Air quality monitoring data, water quality records, and environmental permits.
- DOE Argonne GREET (Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation) Model or JISEA (Joint Institute for Strategic Energy Analysis) Models: Life-cycle emissions and resource use estimates for energy technologies.
- National Laboratory of the Rockies: Solar and energy storage datasets, including site suitability and technology performance information.
- Additional Sources: Local, state, and federal agency websites; universities; and research organizations.

Appendix E – Five Core Components of Impact Assessment Detailed Steps

The detailed steps under the Five Core Components of Impact Assessment are outlined in Figure E.1.

Figure E.1. Five Core Components of Impact Assessment Detailed Steps

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