UTILITY-SCALE BATTERY ENERGY STORAGE SYSTEM APPLICATIONS AND IMPACTS IN INDIANA

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Any errors remaining in this report are the sole responsibility of the authors.

Cover Photo: Pike County Battery Energy Storage System, developed by AES Indiana.
https://www.aesindiana.com/pike-county.

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ANSI	American National Standards Institute
BESS	Battery Energy Storage System
BMS	Battery Management System
CIP	Critical Infrastructure Protection
CPCN	Certificate of Public Convenience and Necessity
CSA	Canadian Standards Association
DER	Distributed energy resource
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DPP	Definitive Planning Phase
EOL	End of life
EPC	Engineering, Procurement, and Construction
EPRI	Electric Power Research Institute
ERP	Emergency Response Plan
ESHB	DOE Energy Storage Handbook
EV	Electric vehicle
FERC	Federal Energy Regulatory Commission
FTE	Full-time equivalent
GDP	Gross domestic product
GIA	Generator Interconnection Agreement
GW	Gigawatt
HEA	House Enrolled Act
IDEM	Indiana Department of Environmental Management
IDHS	Indiana Department of Homeland Security
IDNR	Indiana Department of Natural Resources
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IFC	International Fire Code
IMPLAN	Impact Analysis for Planning
IOED	Indiana Office of Energy Development
IPP	Independent Power Producer
IRA	Inflation Reduction Act
IRP	Integrated Resource Plan
ISA	International Society of Automation
ISO	International Organization for Standardization
IUP	Indiana Utility Projections
IURC	Indiana Utility Regulatory Commission
kW	Kilowatt
kWh	Kilowatt-hour
LFP	Lithium iron phosphate
Li-ion	Lithium-ion
MISO	Midcontinent Independent System Operator
MRIO	Multi-Regional Industry Output
MW	Megawatt
MWh	Megawatt-hour
NERC	National Electric Reliability Corporation
NFPA	National Fire Protection Association
NIPSCO	Northern Indiana Public Service Company
NREL	National Renewable Energy Laboratory
NREMC	Northeastern Rural Electric Membership Cooperative
O&M	Operations and maintenance
OCC	Overnight capital cost
PJM	PJM Interconnection, LLC
PSC	Public Service Commission
PV	Photovoltaic
R-STEP	Renewable Energy Siting Through Technical Engagement and Planning
RMDP	Recycling Market Development Program
RTE	Round-trip efficiency
RTO	Regional Transmission Organization
SIS	System Impact Study
SME	Subject matter expert
SNL	Sandia National Laboratories
SOC	State of charge
UL	Underwriters Laboratories
USGS	U.S. Geological Survey
WVPA	Wabash Valley Power Association

1. EXECUTIVE SUMMARY

Indiana's electric grid is confronting significant challenges: aging infrastructure, retiring power plants, rising demand, and the increased adoption of variable renewable energy generation. Utility-scale Battery Energy Storage Systems (BESS) are a flexible and, increasingly, cost-effective tool available to support Indiana's grid. BESS serve as a source of both energy supply and demand. In this capacity, BESS can help balance a diverse mix of power resources, enhance system reliability, and optimize energy costs. BESS development also presents economic opportunities and can be complementary to existing industries in Indiana. Deployment of BESS at scale, however, is not without its own challenges, including considerations related to siting and safety.

In light of the complexities facing Indiana's grid and the role of BESS therein, the Indiana Office of Energy Development (IOED) commissioned a comprehensive assessment of the role of utility-scale BESS in advancing Indiana's statutory energy objectives—reliability, affordability, resiliency, stability, and environmental sustainability—as established in Indiana Code § 8-1-2-0.6. This report specifically focuses on key information relevant to various stakeholders and best practices for the deployment, operation, and regulation of BESS. The objective of the report is to support informed policy, planning, and regulatory decisions throughout the state.

This report was prepared by Exeter Associates, Inc. (Exeter) pursuant to IOED Contract No. 88001 and CDFA 81.041 State Energy Program funding from the U.S. Department of Energy (DOE). Appendix A identifies the scope of Exeter's investigation in accordance with the IOED's requirements. Appendix A also identifies the applicable report section(s) where each RFP requirement is addressed. The subsequent overview reproduces key takeaways from the report, by section.

Current Status of BESS Technology

BESS technologies are an increasingly important part of the electric grid as technological advancements and rising demand both expand BESS's potential applications and increase deployment. This chapter reviews the major characteristics and status of BESS technologies both in Indiana and nationwide, including discussion of operational characteristics and deployment trends.

Key findings and insights from this analysis include:

- Lithium-ion (Li-ion) batteries currently lead the market. Li-ion battery systems are the most widely deployed BESS technology due to their high energy density, efficiency, and extensive operational experience. Their popularity also benefits from established supply chains and decreasing costs driven by manufacturing scale.
- Alternative technologies are advancing. Technologies such as flow, sodium-ion, and solid-state batteries continue to mature and have specific advantages compared to Li-ion batteries regarding safety, scalability, efficiency, and longevity.
- Operational performance differs by application. The ideal battery chemistry and configuration depends on the intended grid application. Frequency regulation and voltage support, for example, are best supported by batteries configured for short-duration, frequent cycling at low output levels. Conversely, capacity firming and grid resilience require longer discharge durations and higher power output.
- Policy and economic factors affect market growth. Policies at both the state and federal level, including investment tax credits, utility mandates, and market participation rules, have been key in facilitating BESS deployment. Indiana-specific market conditions depend on PJM Interconnection LLC (PJM), the Midcontinent Independent System Operator (MISO), both regional grid operators that each serve portions of the state.
- Projected growth is modest in all scenarios. Exeter estimates that Indiana's installed BESS capacity of approximately 225 megawatts (MW) (as of March 2025) will grow to between 2,156-2,975 MW by 2035, depending on the scenarios. The average scenario forecasts approximately 2,703 MW of installed capacity by 2035, driven primarily by federal incentives, declining costs, and planned utility projects. Growth forecasts are sensitive to economic and policy assumptions.
- Indiana's energy policies should continue to be technology-agnostic and outcome-focused. As conditions evolve, Indiana's energy policies and planning efforts should prioritize outcomes, such as reliability and cost, over specific technologies. Policymakers and regulators should design frameworks that are adaptable to innovations in grid solutions, including existing and emergent BESS technologies.

Installation, Operation, Decommissioning, and Recycling Practices

In Indiana, developing a utility-scale BESS from first design to operation can take 6-8½ years. Decommissioning occurs at the end of a BESS's useful life, usually 10-20 years after commencing operation. This chapter analyzes the life of a BESS project, including all stages of design, permitting, construction, decommissioning, and disposal.

Key findings and insights from this analysis include:

- Indiana BESS permitting requirements largely align with other states' standards. State regulatory authorities typically evaluate the necessity, reliability, safety, and economic benefits of a project before installation.
- Local governments need additional ordinance guidance. Since BESS technology is relatively new, there are additional steps that can be taken on a local level to better inform and support planning and zoning ordinances. Indiana should institute a task force of state and local officials to create model BESS safety and siting standards for planning and zoning staff to reference as they develop their own standards. Alternatively, local governments should reference New York's model BESS ordinances.
- Best practices for safety, design, construction, installation, and commissioning are largely established on a national level. Specialty associations, such as the National Electrical Contractors Association (NECA), National Fire Protection Association (NFPA), and Underwriters Laboratories (UL) Standards, develop standards specifically for BESS that are widely used in the industry. This report references several of these associations and the standards they have developed that should continue to be incorporated in legislation and regulation as they are routinely updated.
- Environmental and land impacts can be reduced depending on project location. BESS require access roads and semi-permanent structures, such as cement foundations, that impact the land on which they are developed. Best practice is to not site facilities in protected areas, wetlands, or habitat for endangered species. Local governments may also choose to encourage siting on brownfields to further reduce impact.
- BESS project timelines are longer than expected. BESS projects currently take up to eight and a half years from design to operation. Design and engineering typically overlap with the developer's pursuit of local, state, and Regional Transmission Organization (RTO) reviews, which can speed up the timeline for placing a BESS online. However, delays in the RTO process, which is needed to determine the cost and terms for the project to interconnect, are resulting in long wait times. RTOs are aware of the wait times in the interconnection queues. If RTOs can effectively speed up their review process, the time it takes for a BESS to come online would lessen by as much as half.
- System safety documentation should be reviewed by a third party prior to construction. The Indiana Department of Homeland Security (IDHS) does not have explicit authority to require BESS developers to seek third-party review of their safety reports, such as UL 9540A reports and hazard mitigation analyses. Establishing this requirement through legislative action would ensure compliance with all relevant codes and standards for all utility-scale BESS projects and reduce the review burden for IDHS.
- High-stress operating conditions can speed up BESS degradation. Battery modules have a useful life of approximately 10 years. Three main factors determine a battery's lifespan: temperature, depth of discharge, and state of charge. When batteries are operated under more extreme conditions or in more stressful ways, such as discharging the battery to low levels, they will degrade in performance and lifespan at a faster rate compared with optimal use. BESS lifespans can be extended by 10 or more additional years by replacing battery cells.
- Project owners should be required to update their decommissioning costs every five years following commercial operation. Most decommissioning agreements in Indiana require a one-time update to decommissioning costs five years after commercial operation. Decommissioning costs may change as more projects reach their end of life (EOL) due to increased need for facilities and labor related to BESS disposal and recycling. Requiring regular decommission cost updates will improve the estimates and ensure more accurate financial assurances.
- Establishing a BESS-specific recycling industry in Indiana requires additional guidance. A more formalized recycling network is needed to promote safe handling, economic reuse of components, and sustainable workforce development in this sector. Prospective frameworks should include guidelines for safe battery disassembly, certification standards for recycling technicians, and dedicated industrial zones to process and redistribute recovered materials.

Safety Considerations

The rapid growth of BESS installations, particularly those using lithium-ion chemistries, has elevated the importance of ensuring robust safety, security, and emergency response strategies. This chapter explores certain risks associated with BESS technologies and best practices for mitigating those risks.

Key findings and insights from this analysis include:

- BESS safety risks are real but manageable. While utility-scale BESS failure incidents remain rare, even infrequent events can carry significant consequences. Consistent adherence to all required safety measures outlined in House Enrolled Act (HEA) 1173 (2023), including compliance with NFPA 855 and emergency response planning, will be key to minimizing risk.
- Thermal runaway remains the most critical safety challenge. As Li-ion batteries dominate BESS deployments, thermal runaway remains the leading cause of catastrophic failure. Emergency response

planning should prioritize early detection, containment strategies, and coordination between system operators and emergency responders. IDHS should develop guidance to assist local fire departments in reviewing site-level safety protocols.

- Physical and cybersecurity must be prioritized. Indiana currently lacks formalized state guidance on physical and cyber threat mitigation for BESS. Local officials should consider requiring fencing, surveillance, and access control. The state should explore whether existing regulation or statutory authority allows it to require the use of cybersecurity best practices, aligned as applicable with National Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) standards and DOE guidelines. Cybersecurity expectations for BESS should be at least consistent with those for other critical energy technologies.
- Local facility design requirements should reflect industry best practices. Indiana planners should encourage (or require) containerized modular enclosures equipped with advanced ventilation, fire suppression, and explosion mitigation features. Local ordinances or zoning board approvals can be used to ensure projects meet or exceed design minimums, especially in populated or high-consequence areas.
- Setbacks and buffer zones should be uniformly applied. Local planning authorities should use existing tools, such as UL 9540A test data and NFPA 855 separation requirements for BESS containers, to establish setback distances and buffer zones for BESS installations. Siting projects on brownfields or co-locating them with substations may offer additional safety and land-use benefits.
- Emergency preparedness requires stronger state and local coordination. While HEA 1173 (2023) requires BESS operators to offer training and submit emergency response plans, recent discussions between Exeter and IDHS suggest these trainings are often underutilized. Indiana should consider making such training mandatory for local fire departments in proximity to BESS at the developer's expense. Other strategies could include embedding battery experts within emergency response teams and/or training regional BESS safety liaisons.
- Indiana's regulatory approach to BESS safety must remain adaptive. Lessons learned from past BESS safety incidents demonstrate the need for proactive, forward-looking safety policies capable of evolving alongside safety standards and industry best practices. One approach could be the creation of a BESS Safety Standards Advisory Panel, coordinated by IDHS, to evaluate new standards, issue interpretive guidance, and provide technical recommendations to counties and municipalities.

Economic Impacts and Workforce Development

This chapter of the report reviews the role of BESS in creating direct and indirect jobs in Indiana as well as contributing to Indiana's gross domestic product (GDP) and tax revenue.[i] It also evaluates economic growth opportunities in the state based on existing industry and resource gaps.

Key findings and insights from this analysis include:

- Input-Output modeling suggests modest economic benefits. The results of Exeter's economic impact analysis indicate that Indiana will observe modest growth both in terms of jobs created and economic output. Construction of BESS is estimated to contribute around $824.0 million in estimated cumulative sales (i.e., total output), with 61% of the total attributed to impacts directly associated with construction activities. Annual operations and maintenance (O&M) expenditures by the installed facilities are estimated to contribute roughly $831.9 million in total output.[ii] In aggregate, over the 10-year period analyzed, annual BESS deployment (construction and fixed O&M) is estimated to support between 719 and 1,007 full-time equivalent (FTE) jobs, on average.
- Construction and services industries contribute the most jobs. The identified economic benefits of BESS deployment are concentrated in the construction and service industries. During the construction phase, architectural, engineering, and related services comprise the highest (35%) portion of FTE job impacts, followed by power structure construction (16%). During the O&M phase of a project, activities are expected to be primarily sourced in-state and heavily concentrated (48%) in the commercial and industrial machinery repair services sector.
- Regional economic benefits align with the location of BESS deployments. The regions with the greatest concentration of actual BESS capacity also experience the highest economic benefits in terms of increased output and employment. However, Indiana's central region, including the Indianapolis metropolitan area, observed disproportionately higher indirect and induced benefits due to the concentration of service industries in the area. This includes firms providing architectural, legal, and engineering support to BESS facilities during construction and operations.
- Battery storage is not a direct economic substitute for retiring conventional energy plants. In general, BESS

[i] Note that the use of GDP throughout this report refers to Gross State Product (GSP), which is simply the state equivalent of the national GDP measure. Indiana's state GDP (or GSP) is simply the monetary measure of all final goods and services produced within the state of Indiana.
[ii] Both estimates regard the Benchmark scenario with a forecasted annual capacity addition of 247.8 MW.

facilities are less labor-intensive, smaller in scale, and often sited away from communities affected by conventional (e.g., coal, gas) plant closures. As a result, BESS offers only a partial substitute for the jobs and local economic activity once provided by coal and natural gas generating facilities. This difference highlights the need for intentional workforce planning and community reinvestment.

- Indiana's industrial base and emerging electric vehicle (EV) battery initiatives position it for growth in the BESS sector. The state's strengths in steel production, chemical processing, advanced manufacturing, and logistics are directly applicable to BESS deployment. These assets, along with Indiana's central location, can serve as a foundation for a broader in-state BESS supply chain and deployment hub.
- Targeted workforce development will be essential to capitalize on BESS-related opportunities. While Indiana's workforce possesses relevant industrial skills, specialized training for BESS installation, utility integration, and recycling remains limited. Expanding such efforts—especially to support transitions from legacy energy sectors and to differentiate between EV and BESS workforce needs—will help mitigate labor constraints and bolster Indiana's competitiveness in a growing regional "Battery Belt."

Community Engagement

Thoughtful community engagement is fundamental to effective BESS deployment. This chapter reviews best practices and strategies for local governments to facilitate effective communication and engagement with residents regarding utility-scale BESS technology. It also looks specifically at IOED's role in facilitating community engagement.

Key findings and insights from this analysis include:

- Survey results highlight educational needs. A statewide survey revealed predominantly neutral attitudes toward BESS, with increased support closely tied to greater familiarity. Most respondents recognized potential cost savings and local job opportunities. All residents, but particularly rural residents (where most BESS are located), expressed concern about rate impacts and environmental impacts. The results underscore the importance of clear, accessible information.
- Local governments should follow established community engagement practices. For BESS project planning and deployment, local governments should utilize established engagement practices. These include proactively developing and distributing clear, accessible educational materials tailored to local contexts; initiating public meetings and providing multiple participation channels early and consistently throughout the project lifecycle; and employing structured systems to gather, document, and review community feedback for consideration in relevant decision-making processes.
- Model ordinances streamline approvals. Adopting vetted templates—such as New York's model BESS ordinance or Michigan's BESS planning and zoning guide—can help localities ensure thorough and comprehensive standards.
- IOED has an important convening and technical assistance role. IOED can host public forums, produce outreach materials, and partner with experts to guide municipalities in establishing BESS permitting and zoning requirements, especially with regard to safety and land-use standards. IOED is well-positioned to assist because of its existing relationships with local governments, its under-standing of statewide energy policy goals, and its ability to coordinate across jurisdictions to align local implementation with best practices.

Conclusion

Projects like Northeastern Rural Electric Membership Cooperative's distributed batteries, the Petersburg Energy Center, and the Dunns Bridge Energy Center highlight how storage is already becoming an integral part of the grid. This study finds that utility-scale BESS has strong potential to continue supporting Indiana's energy goals across all five statutory pillars. Realizing this potential will require:

- Regulatory and permitting streamlining at regional, state, and local levels;
- Continued enforcement and refinement of safety standards;
- Workforce development and supply chain investments;
- Transparent, community-oriented project planning; and
- Policy flexibility to accommodate emerging technologies.

With appropriate policy and planning, Indiana can capitalize on opportunities to deploy BESS to enhance the state's grid and promote positive economic outcomes.

2. INTRODUCTION

Indiana's energy grid, like much of the rest of the United States, faces several significant challenges, including aging infrastructure; the retirement of traditional, dispatchable generation resources; the integration of intermittent, renewable energy sources; and rising electricity demand. Addressing these challenges involves considering a variety of tools and resources. One such tool, energy storage, offers the potential to enhance grid reliability, efficiency, and stability through its most fundamental characteristics: an ability to serve as both a source of energy supply and demand.

The Indiana Office of Energy Development (IOED) holds a central position in shaping the state's energy policies and supporting planning initiatives that enhance grid resiliency and affordability. IOED commissioned the following study to assess the applicability and impacts of utility-scale battery energy storage system (BESS) deployment in Indiana. The study aims to identify policy, regulatory, and economic considerations that could inform future decision-making in the state regarding BESS, and to document best practices that can guide local governments and utilities in managing BESS deployment through permitting, siting, safety planning, and community engagement.

2.1 Indiana Policy Objectives

Indiana's energy policy is structured according to five statutory priorities (i.e., pillars) detailed in Ind. Code § 8-1-2-0.6: reliability, affordability, resiliency, stability, and environmental sustainability. These five pillars serve as the foundation for energy planning and regulatory oversight within the state, and guide decisions on energy infrastructure investments and the integration of new energy technologies.[iii]

These pillars previously served as the foundation for the 21st Century Energy Development Task Force ("Task Force"), during which energy storage emerged as a potential resource available to address capacity needs and improve system flexibility in Indiana.[1] The Task Force also cited storage in discussions on resilience and emphasized the need for Indiana to consider policy and regulatory approaches that accommodate and/or enable emerging resources. Table 1 summarizes each of the five pillars as it relates to electricity policy in Indiana based on discussion in the 21st Century Energy Policy Development Task Force Final Report, published in November 2022, and references made by various stakeholders.

Table 1. Indiana's Electricity Policy Pillars

RELIABILITY	The reliability pillar stresses the need for resources that enhance grid reliability. Maintaining uninterrupted service under normal and emergency conditions is considered a core objective for future planning efforts.
AFFORDABILITY	Affordability is a guiding principle, highlighting the importance of ensuring that Indiana consumers continue to have access to reasonably priced energy. This pillar stresses the role of market forces and regulatory oversight in protecting ratepayers from undue costs.
RESILIENCY	The resiliency pillar stresses the need for approaches that support the ability of the electric grid to prepare for, adapt to, withstand, and recover from disruptive events. This includes both natural and human-caused threats that could impair system operations.
STABILITY	Stability is defined in terms of maintaining consistent grid operations, including voltage and frequency regulation, as the energy mix shifts. This pillar reflects concern over the operational implications of integrating new technologies and resources into the grid.
ENVIRONMENTAL SUSTAINABILITY	The environmental sustainability pillar acknowledges reductions in emissions and environmental impacts associated with energy generation and consumption as a long-term objective. Both state and federal environmental policy play a role in shaping Indiana's future energy trajectory.

[iii] Ind. Code § 8-1-2-0.6 mandates that these attributes be considered when making decisions about electric utility services. These attributes are often referred to as the "five pillars."

2.2 Study Overview

This study builds upon the Task Force's work by providing a detailed evaluation of utility-scale BESS in Indiana. Consistent with Indiana's five pillars, the subsequent sections focus on storage's role in advancing Indiana's energy priorities of reliability, affordability, resiliency, stability, and environmental sustainability.

This report evaluates the deployment of utility-scale BESS in Indiana with the following objectives: assess the technological feasibility of BESS, analyze its role in enhancing grid reliability and stability, evaluate economic and workforce impacts, examine environmental and safety considerations, and identify best practices for efficient and cost-effective deployment. The study also aims to explore regulatory frameworks and policy recommendations that can support long-term energy planning in Indiana. These goals are designed to address Indiana's unique energy challenges and support informed energy planning and policy development. In addition, the study documents siting, permitting, and safety practices that may serve as guidance for local governments and utilities as they evaluate, approve, and manage BESS installations within their jurisdictions.

The report commences with a brief examination of contemporary BESS technologies. This includes non-technical descriptions of storage technologies and their deployment opportunities, as well as a summary of current adoption trends both nationally and within Indiana. These trends help contextualize Indiana's progress relative to broader developments in energy storage. This initial section further reviews Indiana's legislative and regulatory landscape and provides an introduction to select existing storage installations throughout Indiana. Thereafter, the report investigates prospective storage deployment scenarios within Indiana. It employs data sourced from integrated resource plans, industry reports, and interconnection queues to evaluate how several market and policy conditions might influence future installation rates.

The subsequent chapter provides a detailed account of the regulatory and permitting procedures pertinent to BESS installations. This review encompasses environmental and safety stipulations, licensing and approval pathways, and protocols for decommissioning systems. Within this discussion, the report appraises national common practices as well as areas of potential refinement within Indiana, with particular attention given to recycling procedures. Lifecycle environmental considerations are also briefly addressed in this chapter, including consequences associated with battery manufacturing, location selection, and eventual disposal.

Attention then shifts toward safety. The BESS safety chapter covers physical security and cybersecurity vulnerabilities, potential fire hazards, and best practice for emergency response plans. This chapter also includes an examination of current standards and points toward necessary emergency response capabilities.

A separate chapter is dedicated to evaluating the economic and workforce ramifications of BESS deployment. It presents outcomes from IMPLAN (IMpact analysis for PLANning)-based modeling, an input-output modeling tool commonly used to estimate the economic effects of projects or policies. Modeling results are complemented by qualitative observations regarding BESS supply chain opportunities, effects on employment and specific industries, and potential deficiencies in workforce development.

Community engagement approaches are addressed in the next chapter through an assessment of outreach methods and the findings from a survey administered to Indiana residents. This discussion concentrates on matters of transparency, concerns related to facility siting, and the extent of local acceptance.

Each chapter includes an executive summary that synthesizes its findings and puts forward recommendations specifically relevant to policy and planning considerations within Indiana. Supplementary materials and informational handouts are also incorporated as appendices with the intent of assisting stakeholder comprehension and the broader dissemination of the report's contents.

2.3 Study Scope

The study's scope focuses principally on utility-scale battery energy storage technologies interconnected to Indiana's electric grid. Specifically, the study addresses policy, regulatory, planning, and technical issues associated with utility-scale BESS deployment, including permitting, safety, grid services, workforce needs, and potential economic outcomes. By providing policymakers and stakeholders with a comprehensive understanding of utility-scale BESS deployment in Indiana, this study aims to inform future energy planning efforts and support the state's long-term energy objectives, including all five pillars.

For the purposes of this study, utility-scale BESS refers to systems rated at 1 megawatt (MW) or greater and typically connected to utility-owned transmission or distribution infrastructure. Small-scale BESS, by comparison, includes residential, commercial, and behind-the-meter systems, usually installed at customer premises and operating below utility interconnection thresholds. Small-scale BESS can also include personal batteries, such as those embedded in electric vehicles. Although also relevant to Indiana's energy future, this study does not address small-scale or distributed storage applications in depth.

Energy storage includes a suite of technologies distinguished by their storage of energy in various forms (e.g., thermal, chemical, mechanical) prior to conversion into electricity. BESS technologies, which store energy in chemical form, are the primary storage technology being newly deployed on the grid today and, therefore, are the primary focus of this report. Mature non-battery storage technologies, such as pumped hydro or compressed air; emergent energy storage technologies, such as thermal batteries; and less-common storage devices, such as flywheels, all fall outside the scope of this study. Additionally, the analysis does not directly assess behind-the-meter battery systems not associated with utility infrastructure. These areas remain important for Indiana's broader energy strategy and merit further examination in subsequent research. For additional information on some of these topics, readers may consult the resources listed in Appendix B.

3. CURRENT STATUS OF BESS TECHNOLOGY

3.1 Executive Summary

BESS technologies are an increasingly important part of the electric grid as technological advancements and rising demand both expand BESS's potential applications and increase deployment. This chapter reviews the major characteristics and status of BESS technologies both in Indiana and nationwide, including discussion of operational characteristics and deployment trends.

Key findings and insights from this analysis include:

- <u>Lithium-ion (Li-ion) batteries currently lead the market</u>. Li-ion battery systems are the most widely deployed BESS technology due to their high energy density, efficiency, and extensive operational experience. Their popularity also benefits from established supply chains and decreasing costs driven by manufacturing scale.
- <u>Alternative technologies are advancing</u>. Technologies such as flow, sodium-ion, and solid-state batteries continue to mature and have specific advantages compared to Li-ion batteries regarding safety, scalability, efficiency, and longevity.
- <u>Operational performance differs by application</u>. The ideal battery chemistry and configuration depends on the intended grid application. Frequency regulation and voltage support, for example, are best supported by batteries configured for short-duration, frequent cycling at low output levels. Conversely, capacity firming and grid resilience require longer discharge durations and higher power output.
- <u>Policy and economic factors affect market growth</u>. Policies at both the state and federal level, including investment tax credits, utility mandates, and market participation rules, have been key in facilitating BESS deployment. Indiana-specific market conditions depend on PJM Interconnection LLC (PJM), the Midcontinent Independent System Operator (MISO), both regional grid operators that each serve portions of the state.
- <u>Projected growth is modest in all scenarios</u>. Exeter estimates that Indiana's installed BESS capacity of approximately 225 MW (as of March 2025) will grow to between 2,156-2,975 MW by 2035, depending on the scenarios. The average scenario forecasts approximately 2,703 MW of installed capacity by 2035, driven primarily by federal incentives, declining costs, and planned utility projects. Growth forecasts are sensitive to economic and policy assumptions.
- <u>Indiana's energy policies should continue to be technology-agnostic and outcome-focused</u>. As conditions evolve, Indiana's energy policies and planning efforts should prioritize outcomes, such as reliability and cost, over specific technologies. Policymakers and regulators should design frameworks that are adaptable to innovations in grid solutions, including existing and emergent BESS technologies.

3.2 Introduction

Energy storage technologies are, in essence, devices that charge (i.e., capture), store, and discharge (i.e., release) energy. Batteries are one type of energy storage. Specifically, batteries are electrochemical devices that store energy in chemical form and convert it into electricity. Battery cells store and release energy by moving ions and electrons between two electrodes, an anode and a cathode, through a material called an electrolyte. (See Figure 1 for a simplified representation of this structure.) The exact chemistry varies, but the basic process is the same across all BESS technologies. In utility-scale BESS, this basic functionality is scaled to a high level, enabling the storage and discharge of significant amounts of electricity to support grid operations.

The goal of this chapter is to provide readers with an introduction to the current status of BESS technologies. The chapter begins with a description of major system characteristics and grid-supporting attributes. Then, the chapter covers recent deployment trends, including the spatial distribution of existing projects and examples of operating BESS projects in Indiana. This leads to an overview of near- and long-term alternative technologies and discussion of Indiana's permitting requirements, market rules in MISO and PJM, cost recovery mechanisms, and relevant state and federal policies. The chapter concludes with growth projections. Appendix B includes a list of select additional sources of information regarding BESS. A brief discussion of deployment barriers is separately addressed in Appendix C.

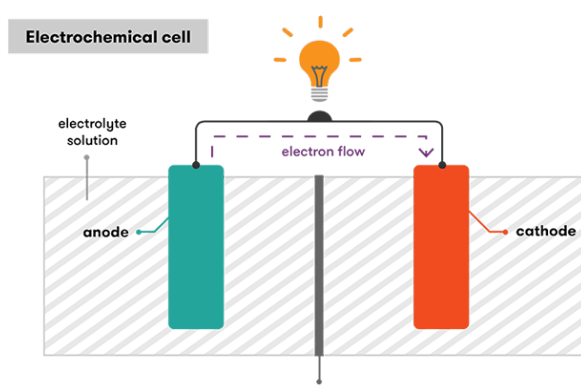

Figure 1. Basic Structure and Operation of an Electrochemical Cell

Source: Australian Academy of Science. *How a battery works.* https://www.science.org.au/curious/technology-future/batteries.

How a Battery Works

The battery storage process involves two electrical conductors (i.e., electrodes) referred to as the anode and cathode, and an electrolyte:[1]

- Anode: Electrode where energy is stored during battery charging, typically made of materials like graphite.[2]
- Cathode: Electrode where energy is released during battery discharge, often made of materials like lithium cobalt oxide or nickel manganese cobalt.[3]
- Electrolyte: Chemical material that enables the movement of ions (i.e., atoms or molecules with an electrical charge) between the anode and cathode, creating electrochemical reactions that support energy storage and discharge.

For a battery to store and release energy, it must be paired with an electrical circuit. An electrical circuit is a closed-loop pathway consisting of wires and other electrical equipment used to deliver electrical energy to an application. As electrons flow through the circuit, ions move through the electrolyte within the battery. When a battery is charging, electrons travel from the cathode to the anode, increasing the chemical potential energy in the battery. During discharge, the same process occurs in reverse—electrons travel from the anode to the cathode, converting the stored chemical potential energy into electrical energy. While either process occurs, oppositely charged ions travel through the electrolyte to ensure a stable, rechargeable system.[4]

[1] DOE. *DOE Explains…Batteries*. https://www.energy.gov/science/doe-explainsbatteries
[2] International Energy Agency. *Grid-scale Storage*. https://www.iea.org/energy-system/electricity/grid-scale-storage
[3] Ibid.
[4] DOE. *DOE Explains…Batteries*.

3.3 Major BESS Characteristics

Understanding BESS requires a closer look at its key characteristics. These characteristics, both individually and collectively, affect the system's performance, safety, and efficiency, as well as its cost and environmental impact. The subsequent sections categorize and describe some of the most significant characteristics.[iv]

3.3.1 Battery Construction

BESS installations are built from a series of interconnected components. Cells are the fundamental units that store and convert energy through electrochemical reactions. Groups of cells are organized into modules, which increase overall storage capacity and allow for flexible system design. Multiple modules are assembled into packs and racks to enable scalability to utility-scale applications.

Each BESS installation also includes a Battery Management System (BMS), which continuously monitors system parameters such as voltage, temperature, and state of charge to ensure safe and reliable operation. The physical arrangement and monitoring infrastructure of the system affects scalability, operational flexibility, and fault management capabilities. Safety considerations related to battery design are addressed in Chapter 5.

3.3.2 Resources Used

The materials used in BESS construction directly affect system performance, availability, and lifecycle management. Lithium is a common material used in utility-scale battery chemistries because of its high energy density and favorable electrochemical properties. Cobalt and nickel are typically incorporated into the BESS cathode to improve battery stability, longevity, and energy output. Graphite is a standard material for the BESS anode, and is selected for its electrical conductivity and structural durability over repeated charging and discharging cycles.

Emerging alternatives, such as sodium-ion batteries, are being developed to provide similar performance characteristics while reducing reliance on materials with constrained or geographically concentrated supply chains. Resource selection also has implications for cost structures, environmental impacts, and supply chain resilience. Material impacts and supply chain considerations are discussed in Chapters 4 and 6, respectively.

3.3.3 Energy Characteristics

Several energy-related characteristics define how BESS perform in operational settings. Storage duration, typically ranging from 1-4 hours for grid-scale systems, refers to the period over which a system can discharge at its rated power. Power capacity, measured in MW, describes the maximum rate at which energy can be delivered from the system. Energy capacity, expressed in megawatt-hours (MWh), quantifies the total amount of energy that can be stored and discharged.[v] Round-trip efficiency (RTE) represents the percentage of energy input that is recovered during discharge, with typical values ranging between 85-95%. These parameters influence how a BESS can be deployed to meet different grid needs, including load shifting, frequency regulation, and peak shaving.

3.3.4 Cost Factors

The economic profile of BESS includes several cost categories. Capital costs consist of the initial investment required for equipment procurement, site

[iv] For additional definitions, see: NASEO. *Accelerating Energy Storage Research, Development, and Demonstration: Policy, Programmatic, and Planning Considerations for States.* (August 2024). Table 1 - Energy Storage Characteristics, p. 10. https://www.naseo.org/data/sites/1/documents/publications/NASEO_Energy%20Storage_v2.pdf.

[v] For example, a 2-MW/4-MWh BESS can discharge up to 2 MW for 2 hours, for a total output of 4 MWh.

preparation, construction, and system installation. Operations and maintenance (O&M) costs are incurred through activities such as routine upkeep, performance monitoring, and the replacement of system components over time. These recurring expenses are needed to sustain system performance, minimize downtime, and extend useful life.

Lifecycle costs capture the total expenditures associated with a system across its full operational life, factoring in degradation, efficiency losses, and end-of-life (EOL) management. Lifecycle costs are usually expressed as a Levelized Cost of Energy (LCOE), which divides total costs by total expected production for the duration of an asset's useful life. Project-specific variables affect the magnitude and distribution of these costs, as well as the local economic benefits stemming from the investment. Job and economic output impacts are assessed in Chapter 6.

3.3.5 Other Characteristics

In addition to the factors described above, other characteristics are relevant for evaluating and comparing BESS technologies. Cycle life, defined as the number of charge and discharge cycles a system can undergo before performance degradation, influences system longevity and replacement needs. Response time refers to the speed at which a storage system can react to grid signals or load changes, which is important for frequency regulation and fast-response services (see below). Storage period refers to the maximum duration energy can be held before significant losses occur, influencing suitability for short-term versus seasonal storage.[vi] A wide array of additional characteristics, such as environmental impact, build time, space requirements, and weight, factor into subsequent discussion in other chapters. These additional characteristics provide further context for evaluating storage systems based on application-specific requirements.

3.4 Electric Grid-Supporting Attributes of BESS

Growing interest in BESS in Indiana and across the world is largely driven by its ability to address a wide range of evolving electricity system needs. As generation portfolios transition to higher shares of variable renewable energy, and as system reliability, flexibility, and resilience become increasingly important, BESS technologies are being deployed to provide targeted solutions. The attributes and capabilities of BESS are usually selected to align with specific system requirements, either to support current grid operations or anticipated requirements.[vii]

Case Study: Dunns Bridge Energy Center

The Dunns Bridge Energy Center, developed by NextEra Energy Resources and commissioned by NIPSCO, is located in Jasper and Starke counties. Phase I of the project consists of a 265-MW solar farm. Phase II, operational as of late 2024, includes 435 MW of solar capacity paired with a 75-MW, 4-hour BESS. The initiative is designed to address industrial energy demands in the region and enhance grid stability. This pairing of solar and BESS also enhances renewable energy integration by storing excess power during the day for use during evening peaks. Construction of the Dunns Bridge II project is anticipated to create up to 300 jobs and generate approximately $59 million in additional tax revenue for the two counties over its first 30 years of operation.[1,2]

[1] NextEra Energy. Project Overview: The Dunns Bridge Energy Center creates jobs, economic growth and clean energy. https://www.nexteraenergyresources.com/dunns-bridge-energy-center/project-overview.html.

[2] NiSource. (2023). NIPSCO, a subsidiary of NiSource, advances its electric generation transition plan with a first set of solar projects, generating 465 MW combined. https://www.nisource.com/news/article/nipsco-a-subsidiary-of-nisource-advances-its-electric-generation-transition-plan-with-first-set-of-solar-projects-generating-465-mw-combined-20230711.

3.4.1 Energy Arbitrage

Energy arbitrage entails purchasing and storing electricity during low-demand/low-cost periods and then discharging it during high-demand/high-cost periods. This application helps reduce energy costs by displacing higher-cost sources of power with stored, lower-cost power. BESS' ability to arbitrage depends on market structure, cycle management, and RTE, and arbitrage is most effective in markets with high price volatility between off-peak and on-peak periods. Arbitrage is one of the most common BESS applications.[2]

3.4.2 Capacity Firming

BESS can compensate for the variability of renewable energy sources such as wind and solar by storing variable energy and then controlling when it is released to the grid. This function helps maintain consistent capacity contributions from renewable resources. Firming also allows intermittent generation to be treated more like dispatchable generation in planning and reliability assessments.[3]

3.4.3 Black-Start Capability

BESS can provide black-start services, meaning restoring power systems following a grid outage. This function is increasingly being adopted as an alternative to traditional black-start methods, such as standby diesel generators.[4] Unlike conventional black-start

[vi] Energy losses refer to the reduction of usable energy as it is converted or transmitted through a system.

[vii] For a recent survey of applications, see: Zhao, C., Andersen, P. B., Traeholt, C., & Hashemi, S. (2023). Grid-connected battery energy storage system: a review on application and integration. *Renewable and Sustainable Energy Reviews*. *182*, 113400. https://www.sciencedirect.com/science/article/pii/S1364032123002575.

units, BESS can energize grid components without relying on fuel-based generation, which may face logistical constraints during systemwide outages.

3.4.4 Frequency Regulation and Voltage Support

Maintaining grid frequency and voltage stability within acceptable ranges requires the balancing of supply and demand. BESS can respond quickly to frequency and voltage deviations by injecting or absorbing power and reactive power, respectively. This ability is particularly valuable as inverter-based resources replace traditional rotating machines, which previously provided inertia and voltage regulation inherently.[5]

3.4.5 Transmission Congestion Relief

By discharging stored energy during peak demand, BESS alleviates congestion on transmission lines.[viii] This reduces stress on the grid and delays the need for costly transmission infrastructure upgrades.[6] BESS can also be strategically sited to mitigate localized constraints identified in transmission planning studies. Since stored energy can be discharged at or near the point of demand, it reduces the need to transmit electricity over long distances from remote generation sources, helping to relieve congestion along high-voltage corridors.

Case Study: Cavalry Solar

The Cavalry Solar Project in White County, developed by NextEra Energy Resources LLC and operational as of late 2023, includes a 200-MW solar farm integrated with a 45-MW BESS. The storage system is designed to improve grid stability by managing fluctuations in solar generation. Additionally, it allows for energy arbitrage by storing electricity for discharge when demand and market prices increase.[1] Northern Indiana Public Service Company (NIPSCO), which commissioned the project, anticipates cycling the battery unit less than 250 days per year.[2] The facility is expected to generate about $25 million in additional tax revenue for White County over its expected 30-year lifetime.[3]

[1] NIPSCO. NIPSCO's Electric Generation Transition Continues with Completion of Third Solar Project. (2024). https://www.nipsco.com/our-company/news-room/news-article/nipsco's-electric-generation-transition-continues-with-completion-of-third-solar-project.
[2] "Final Order." (2024) IURC Cause No. 45936.
[3] Markosyan, M. (2024). NiSource switches on 200-MW solar site in Indiana. https://renewablesnow.com/news/nisource-switches-on-200-mw-solar-site-in-indiana-866586/.

3.5 BESS Deployments

Nationwide BESS deployment has expanded significantly in recent years, growing from approximately 300 MW of installed capacity in 2014 to over 28,584 MW by 2024, a nearly 94-fold increase over the past decade.[ix] Indiana's deployment followed a similar trend, increasing from about 2 MW in 2014 to 82 MW by 2024. This growth trajectory is expected to continue, both nationwide and in Indiana. Figure 2 and Figure 3 show recent utility-scale BESS projections from S&P Global Market Intelligence for 2025-2034 at the national level and for Indiana, respectively.[x]

As shown in Figure 2, the United States will have just under 200,000 MW of installed BESS capacity by 2034. By comparison, Indiana's installed capacity is estimated to reach 2,776 MW by 2034.[xi] Both figures show a sharply accelerating growth trend through the mid-2020s, followed by a decreased rate of growth in the later years of the forecast period. The resources comprising this projected capacity are predominantly Li-ion BESS installations. However, the later years of the forecast period (post-2028) include a small but growing share of emerging storage technologies, including long-duration systems designed to complement traditional Li-ion deployments.

Two regional transmission organizations (RTOs) oversee Indiana's bulk power system (i.e., MISO and PJM, described below). For MISO, standalone BESS accounts for roughly 11% (34.7 gigawatts, or GW) of all nameplate capacity in the interconnection queue (312.9 GW) as of May 9, 2025.[7] Similarly, standalone BESS accounts for 10.3% (66.6 GW) of all PJM interconnection requests (643.7 GW) as of May 28, 2025.[8] Requested BESS deployments are even greater when including hybrid systems; for example, solar and storage systems represent 31.8 GW of PJM interconnection requests.[9]

[viii] Congestion refers to conditions where power cannot flow over the most cost-effective or direct transmission paths due to limited capacity.
[ix] For additional information regarding the methodology, see: S&P Global (2021). "Historical and Future Power Plant Capacity."
[x] S&P Global's capacity projections are based on known planned or under-construction projects. Estimates for specific power market regions reflect the best available public data regarding power purchase agreements, interconnection requests, and other announcements. [xi] These figures reflect point-in-time projections based on currently announced projects and modeling assumptions. Actual deployment levels may shift in response to changes in market conditions, policy frameworks, supply chains, or technological development.
[xi] These figures reflect point-in-time projections based on currently announced projects and modeling assumptions. Actual deployment levels may shift in response to changes in market conditions, policy frameworks, supply chains, or technological development.

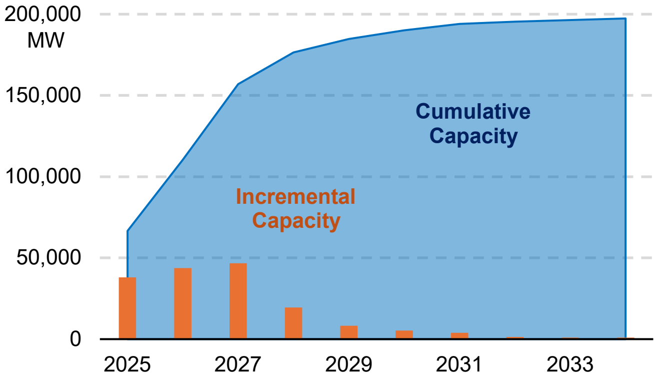

Figure 2. Projected Growth in U.S. BESS Capacity (2025-2034)

Source: S&P Global Market Intelligence. *Historical & Future Power Plant Capacity*.

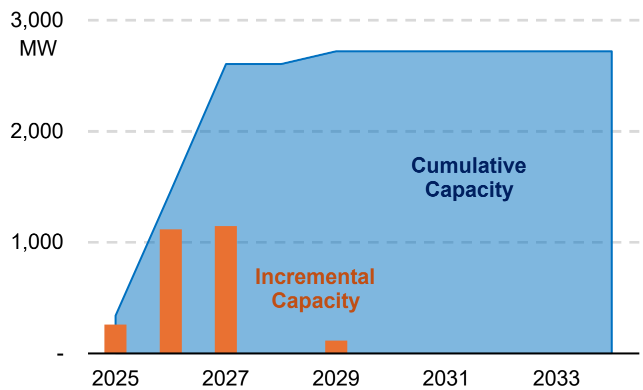

Figure 3. Projected Growth in Indiana BESS Capacity (2025-2034)

Source: S&P Global Market Intelligence. *Historical & Future Power Plant Capacity*.

Figure 4 maps the locations of operating and proposed battery storage facilities across Indiana. Most facilities, particularly those in operation, are located in rural areas, often situated away from major urban centers. A few larger proposed projects are sited near smaller cities such as Lafayette, Muncie, and Evansville, but generally not within densely populated areas. In general, facility placement aligns with access to grid infrastructure. Most planned and operational BESS capacity is located within the MISO footprint of Indiana.

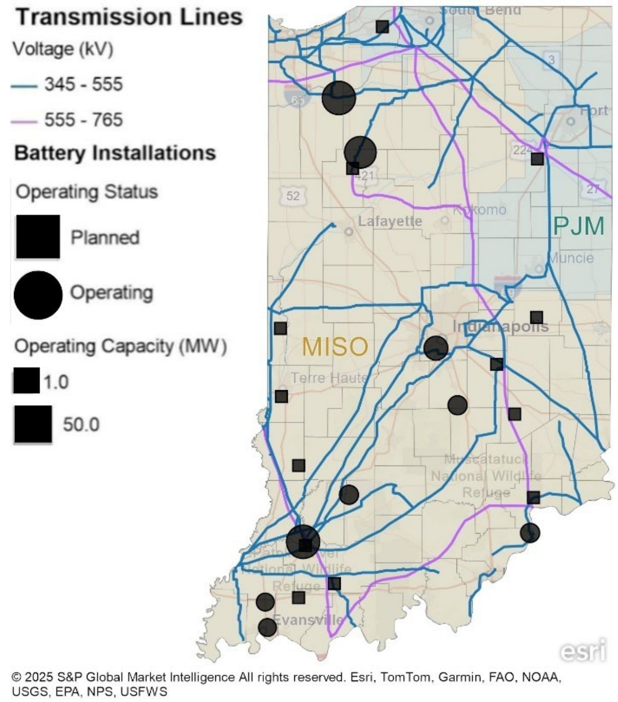

Figure 4. BESS and Transmission Lines in Indiana

Source: Adapted from S&P Global Market Intelligence.

3.6 BESS Technologies

Lithium-ion batteries currently dominate the utility-scale BESS market, especially within MISO and PJM. Li-ion batteries are a class of rechargeable electrochemical energy storage devices that use lithium ions as the primary charge carriers.[xii] In most grid-scale and commercial applications, the predominant Li-ion chemistry pairs a graphite anode with a lithium metal oxide cathode, such as lithium nickel manganese cobalt oxide.[10] Figure 5 visualizes a Li-ion cell using these predominant components. (For definitions of the labels in Figure 5, see Table 2.) As of 2025, Li-ion technology accounts for nearly 100% of installed battery storage capacity in MISO and PJM.[xiii] All existing utility-scale BESS in Indiana utilize Li-ion chemistries.

[xii] Unlike elemental lithium batteries, which use metallic lithium as the anode, Li-ion batteries use mineral compounds that store and release lithium ions during charge and discharge cycles. The use of lithium-ion, as opposed to metallic lithium, enables safer and more stable operation at scale

[xiii] PJM and MISO aggregate all technologies under the label "battery storage." Other non-Li-ion projects include iron air, flywheel batteries or thermal energy storage applications. For more information consult MISO (https://www.misoenergy.org/planning/resource-utilization/GI_Queue/gi-interactive-queue/) and PJM (https://www.pjm.com/planning/service-requests/serial-service-request-status) interconnection queue databases.

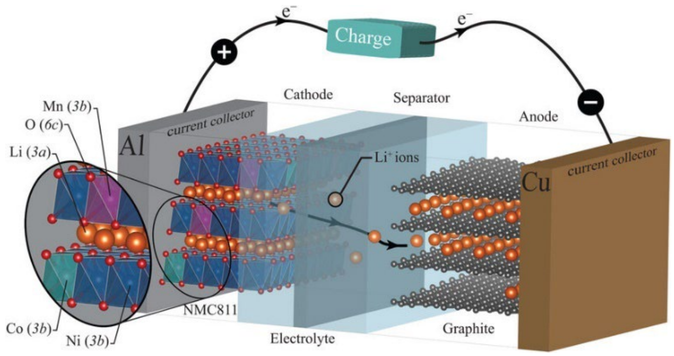

Figure 5. Diagram of Lithium-ion Battery Cell Structure and Components

Source: Taghikhani, K., Weddle, P., Berger, J.R., & Kee, R.J. (2021). Modeling Coupled Chemo-Mechanical Behavior of Randomly Oriented NMC811 Polycrystalline Li-Ion Battery Cathodes. *Journal of The Electrochemical Society. 168*(8). https://www.researchgate.net/figure/Li-ion-battery-schematic-with-NMC811-as-cathode-and-graphite-as-anode-during-charge-In_fig1_353499800.

Table 2. Label Definitions for Figure 5

Label	Definition
Al	Aluminum (cathode collector)
Anode	Negative electrode (oxidation)
Cathode	Positive electrode (reduction)
Charge	Energy storage/flow
Co (3b)	Cobalt
Cu	Copper (anode collector)
e-	Electron
Graphite	Anode material
Li (3a)	Lithium
Li+ ions	Lithium ions
Mn (3b)	Manganese
Ni (3b)	Nickel
NMC811	Nickel Manganese Cobalt Oxide (8:1:1)
O (6c)	Oxygen
Separator	Barrier, allows ion flow

Part of the reason for the predominance of utility-scale Li-ion batteries today is the scale economies and learning effects for the technology first achieved through earlier widespread deployment in consumer electronics. Today, utility-scale Li-ion BESS are increasingly considered commercially mature. As a result, Li-ion BESS face fewer barriers to project financing and integration into utility planning processes. Further, commercial deployment of the technology continues to drive additional cost declines through improvements in manufacturing and installation processes, as well as performance optimization.

Lithium-ion batteries are often cited as having several advantages that make them well-suited for a range of grid services, including high energy density, high RTE, and modular scalability. However, while Li-ion remains the dominant technology, various alternatives are under development or in early deployment. Some of these technologies are listed in Table 3 along with summary information regarding key characteristics. The technologies in Table 3 are also categorized as near-term and long-term options based on their state of commercialization.

The near-term technologies in Table 3 include chemistries that are currently being deployed or are approaching market readiness for utility-scale applications. These systems vary in terms of cost, energy density, scalability, and performance characteristics. Figure 6 visualizes the basic components of one of the near-term alternatives, flow batteries. Long-term alternatives, while not yet widely commercialized, represent areas of active research and pilot testing that may support future grid needs, particularly in the context of long-duration storage or alternative material use.

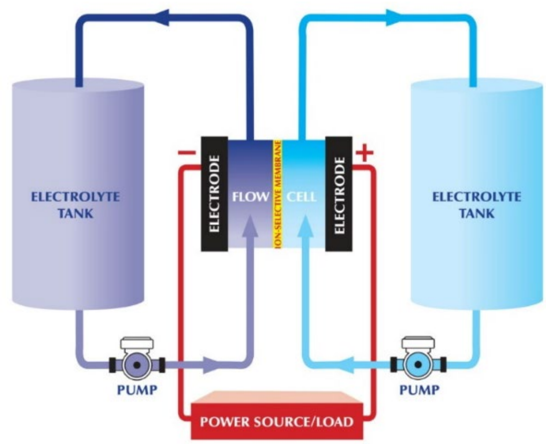

Figure 6. Diagram of Flow Battery Components

Source: International Flow Battery Forum. *What is a flow battery?* https://flowbatteryforum.com/what-is-a-flow-battery/.

Table 3. Characteristics and Status of Emerging and Established BESS Technologies		
Technology	Key Characteristics	Commercial Status
NEAR-TERM		
Lithium iron phosphate (LFP)	Uses iron and phosphate in the cathode, avoiding reliance on cobalt and nickel. Offers long cycle life and thermal stability but has lower energy density.	Deployed at scale in grid storage
Sodium-ion	Based on sodium chemistry rather than lithium. Reduces dependence on lithium supply chains but results in lower energy density and larger system size.	Early-stage commercialization underway; mass production by major manufacturers expected to commence in the next 2 years
Zinc-based	Provides high energy storage but has limited rechargeability. Supports recharge, unlike older zinc-based batteries, but is still in early-stage deployment.	Pilot deployments in progress; broader commercialization anticipated within the next 3-5 years
Lead-acid	Uses lead electrodes and sulfuric acid. Low-cost and well understood but with limited cycle life and energy density. Best suited for backup power.	Widely deployed, limited grid use
Flow (vanadium/ iron)	Stores energy in external liquid electrolyte tanks. Allows independent scaling of power and energy but offers lower RTE.	Commercial deployments underway; market growth projected through the 2030s
LONG-TERM		
Solid-state	Replaces liquid electrolyte with solid material, improving safety and potential energy density. Manufacturing and cost remain limiting factors.	Pilot production phase; commercial deployment expected before 2030s
Metal-air	Uses a metal anode and oxygen from air for reaction. High theoretical energy density but rechargeability and durability are unresolved.	Research phase

Note: See Appendix C for additional information regarding the characteristics and commercial status of various BESS technologies and Appendix D for specific references for each listed technology.

3.7 State and Federal Context

3.7.1 Indiana Context

Legislative Framework

Several statutes explicitly address utility-scale BESS. Indiana House Enrolled Act (HEA) 1173, effective July 1, 2023 and codified in Indiana Code § 22-14-8, establishes safety and permitting requirements for utility-scale BESS in Indiana. The legislation defines a utility-scale BESS as a system capable of storing and releasing more than 1 MW of electrical energy for a minimum of one hour using an alternating current (AC) inverter and direct current (DC) storage. Systems meeting this definition are required to comply with the National Fire Protection Association's (NFPA's) 855 Standard for the Installation of Stationary Energy Storage Systems. This standard establishes uniform guidelines for fire prevention, thermal runaway management, system configuration, and emergency response planning for energy storage systems.

HEA 1173 (2023) also mandates that any new installation or expansion of an existing utility-scale BESS by more than 10% of its original capacity must receive prior approval from the Indiana Department of Homeland Security (IDHS). Additionally, the total capacity of batteries within a single enclosure is limited to 10 MWh unless otherwise authorized by rules adopted by the Indiana Fire Prevention and Building Safety Commission.

Utility-scale BESS are also addressed in Indiana Code § 8-1-8.8-11, which authorizes the Indiana Utility Regulatory Commission (IURC) to encourage and approve "Clean Energy Projects," including energy storage systems. Under this provision, BESS projects can be designated as clean energy resources and therefore be eligible for financial incentives and streamlined regulatory treatment.[11] For example, AES Indiana's Pike County BESS project was approved as a Clean Energy Project under this statute.[12]

Various laws related to power plant siting, safety, or economic regulation affect BESS indirectly. For example, Indiana Code § 8-1-8.5 governs the Certificate of Public Convenience and Necessity (CPCN) process, which applies to major generation projects including those involving BESS.[xiv] Utilities in these cases are required to demonstrate the necessity and economic feasibility of such projects, and integrate them into their long-term resource planning.[13] (Chapter 4 and Chapter

[xiv] As discussed in Chapter 4, the IURC does not require a CPCN for BESS projects because they does not "generate" electricity. However, rate regulated utilities generally pursue CPCNs to ensure cost recovery through rates. For the relevant IURC precedent, see Cause 45863.

Case Study: NREMC Battery Storage Initiative

The Northeastern Rural Electric Membership Cooperative (NREMC) operates a 31-MW BESS that came online in 2022. Unlike most projects that focus on summer peaks, NREMC's system is designed to manage winter peaks, which have become a significant cost driver. Specifically, the project helps avoid transmission costs allocated by PJM based on load during network peaks. The system has achieved estimated savings of $35 million by offsetting the need for additional transmission capacity and avoiding certain PJM costs.[1]

Looking forward, NREMC plans to pair the storage system with solar to enhance peak-shaving and energy arbitrage. Additionally, the co-op has launched a technician training program to develop local expertise for BESS operations, ensuring sustainable support for its growing storage assets.[2] NREMC intends to limit storage to 20% of its total load to maintain reliability and cost-effectiveness.[3]

[1] Cash, C. (2021). Battery System Will Save Indiana Co-op Millions in Power Costs. National Rural Electric Membership Association. https://www.electric.coop/battery-system-will-save-indiana-co-op-millions-in-power-costs.
[2] NREMC call (December 18, 2024).
[3] Ibid.

5 further address statutes regarding the BESS's lifecycle and safety, respectively.)

Energy Market Structure

Indiana utilities participate in two RTOs: MISO and PJM. Both MISO and PJM are Federal Energy Regulatory Commission (FERC) regulated entities responsible for operating the bulk electric system within their respective footprints. In this role, each RTO is tasked with overseeing generation dispatch, conducting regional transmission planning, and administering competitive wholesale electricity markets, among other responsibilities. In Indiana, PJM serves the northeastern portion of the state's grid, including the service territory of AEP Indiana Michigan Power. The remainder of Indiana's electric grid, encompassing all other major investor-owned utility service territories, falls under the jurisdiction of MISO.

In both MISO and PJM, BESS are classified as distinct resource types, with specific tariff provisions defining how they participate in markets. In MISO, BESS can register as Stored Energy Resources – Type II (SER-II) under Module C of its approved FERC Electric Tariff, allowing them to offer both charging and discharging services into the energy, ancillary services, and capacity markets.[14] In PJM, BESS can participate on the grid under the rules for Energy Storage Resources (ESRs) as outlined in PJM Manual 11 (Energy and Ancillary Services Market Operations) and the PJM Open Access Transmission Tariff (OATT).[15,16]

BESS participate in wholesale markets in several ways. In the ancillary service markets, they provide frequency regulation by responding rapidly to control signals, a service standardized through participation in PJM's Regulation D and Regulation A markets and MISO's Regulation Service Market.[17,18] Storage resources bid into these markets through standard market participation processes, including the submission of offers that specify performance characteristics such as maximum charge and discharge rates, state-of-charge limitations, and response speed.

In capacity markets, BESS can offer unforced capacity (UCAP) in PJM's Base Residual Auction (BRA) and in MISO's annual Planning Resource Auction.[19] However, resource qualification requirements, such as demonstrating a minimum 4-hour discharge duration (in PJM) or compliance with seasonal accreditation rules (in MISO), must be satisfied.[20,21]

For energy markets, storage resources participate directly in the real-time and day-ahead markets, including purchasing energy during lower-priced periods (charging) and selling energy back to the system during higher-priced periods (discharging). BESS operators undertaking this form of arbitrage generally rely on price forecasts and optimization algorithms to maximize revenue.

The treatment of storage as generation (when discharging) or load (when charging) varies depending on operational circumstances. Both RTOs account for this dual nature in various ways. For example, in MISO's dispatch algorithms, BESS resources are modeled with both an offer curve (for discharging) and a bid curve (for charging), allowing MISO to optimize their status based on system needs. Similarly, in PJM, storage resources submit both buy and sell offers in the day-ahead and real-time energy markets.

In situations where the grid requires additional supply (such as during high demand periods), storage resources can be dispatched to inject energy. Conversely, during periods of excess supply or low demand, storage resources can absorb excess generation, helping to maintain system stability. Participation rules in both RTOs also allow storage to provide non-spinning reserve and other contingency services depending on their operating status and availability.

Regulatory Oversight

The IURC governs the deployment and integration of BESS in alignment with state law, rules, and regulations. While MISO and PJM are responsible for managing the operational interconnection of storage resources to the bulk power system, the IURC plays a separate role in approving aspects of interconnection that affect local utilities. Specifically, the IURC oversees technical and safety standards for BESS facilities connecting at the distribution system level, including reviewing utility interconnection tariffs, ensuring consistency with broader standards, and approving rules that affect non-transmission system interconnections.[22]

The IURC also reviews utility planning processes that propose incorporating storage into future resource portfolios. Utilities in Indiana are required to file Integrated Resource Plans (IRPs) on a triennial basis.[xv] An IRP is a long-term planning document in which a utility outlines its strategy for meeting forecasted electricity demand over a 20-year period, considering resource needs, technology options, and regulatory factors. The inclusion of BESS in IRPs indicates that utilities view storage as a potential economic resource to meet capacity, reliability, and/or flexibility needs. The IURC does not formally approve IRPs, but it provides oversight, produces staff reports on each filed IRP, and solicits public input on those staff reports. IRPs may influence subsequent utility resource procurement decisions based on the planning process.

Regarding cost recovery, energy storage projects are generally treated as capital assets, similar to traditional generation or transmission investments. Rate-regulated utilities that propose to build or procure BESS facilities may seek cost recovery through standard ratemaking processes. This typically involves filing an application with the IURC to include the investment as part of rate base, allowing the utility to earn a return on and return of the asset over its useful life.[xvi] The IURC approves retail rates that incorporate these investment costs. For additional information about decommissioning and other regulatory considerations, refer to Chapter 4.

State Agency Oversight

The Indiana Department of Environmental Management (IDEM) oversees environmental aspects of BESS projects under the state's hazardous waste management authority.[23] This oversight is established by the Indiana Hazardous Waste Management statutes and implementing regulations,[24] which incorporate federal standards under the Resource Conservation and Recovery Act (RCRA).[25]

In the context of BESS, IDEM's responsibilities include hazardous materials management, specifically the regulation of the handling, storage, and disposal of Li-ion batteries and related system components.[xvii] IDEM also monitors battery recycling and disposal activities. Facilities and utilities managing EOL batteries must adhere to Indiana's hazardous waste recycling regulations, including Universal Waste standards where applicable.[xviii] IDEM's oversight ensures that batteries from BESS facilities are either properly recycled through approved programs or disposed of in a manner that protects public health and the environment. For more discussion on battery EOL considerations, recycling, and disposal, refer to Chapter 4.

In addition to IDEM, IDHS is tasked with enforcing safety standards for utility-scale energy storage systems as described above (in accordance with Indiana Code §

Case Study: Petersburg Energy Center

The Pike County BESS, developed and commissioned by AES Indiana, is a 200-MW standalone facility located at the site of the former Petersburg Generating Station in Pike County. Approved by the IURC in January 2024, the project became operational in April 2025, making it one of the largest battery storage installations within MISO.

The BESS is strategically sited on the grounds of the decommissioned coal-fired plant and leverages existing interconnection infrastructure. The system is designed to deliver 200 MW of dispatchable power during peak demand period as well as support frequency regulation services. The project is part of AES Indiana's broader $1.1 billion investment in Pike County, which includes the repowering of Petersburg Units 3 and 4 from coal to natural gas and the development of additional renewable energy resources, which will also include paired storage.[1]

Shown in the figure below are the battery storage units at the Petersburg Energy Center.

[1] AES Indiana. (2025). AES Indiana Celebrates Earth Day with two generation project updates. https://www.aesindiana.com/press-release/aes-indiana-celebrates-earth-day-two-generation-project-updates.

Battery Storage Units at the Petersburg Energy Center

Source: Pike County Battery Energy Storage System, developed by AES Indiana. https://www.aesindiana.com/pike-county.https://www.aesindiana.com/pike-county.

[xv] This requirement applies to Indiana's investor-owned utilities as well as Indiana Municipal Power Agency, Wabash Valley power Association, and Hoosier Energy, each of which owns generation and transmission,

[xvi] Rate base is the value of the utility's invested capital on which it is allowed to earn a regulated return.

[xvii] Li-ion batteries may be classified as hazardous waste when they are damaged, spent, or otherwise designated for disposal. IDEM enforces requirements related to the accumulation, transportation, and final disposition of such materials in compliance with applicable hazardous waste rules.

[xviii] Universal Waste rules, which streamline certain requirements for battery management, are incorporated into Indiana law consistent with federal regulations at 40 CFR Part 273.

22-14-8). One of its primary responsibilities is ensuring compliance with the NFPA 855 Standard. All qualifying BESS projects must demonstrate adherence to this standard as part of their permitting and commissioning processes.

IDHS also exercises permitting oversight for new or expanded BESS installations, and works with local fire departments and emergency response agencies to ensure preparedness for potential incidents involving BESS facilities. This includes facilitating access to technical information about installed systems, supporting firefighter training on battery-specific hazards, and promoting coordination between facility owners and first responders.[26] For additional information about safety standards and emergency response protocols, refer to Chapter 5.

3.7.2 Federal Context

Federal policies and initiatives play a significant role in shaping the deployment and integration of BESS. Among the most consequential federal actions is FERC Order 841, issued in 2018, which directed RTOs to remove barriers to energy storage participation in wholesale electricity markets.[27] In response, both MISO and PJM revised their tariffs to allow storage resources to participate fully in energy, ancillary service, and capacity markets. Order 841 further mandates that storage resources be treated comparably to traditional generation, with allowances for their unique characteristics (e.g., bidirectional energy flows), and that they be permitted to set market prices when operating as the marginal resource.

Although MISO and PJM have both implemented Order 841, thereby expanding market opportunities for BESS in Indiana, functional differences remain. For example, developers must navigate differing rules between the two RTOs concerning capacity accreditation and eligibility for ancillary services.

Federal incentives have also played a central role in improving the financial viability of storage development to-date.[xix] The Investment Tax Credit (ITC), as modified by the Inflation Reduction Act (IRA) of 2022 (P.L. 117-169), provides a 30% tax credit for eligible project costs for current standalone storage systems and for historical hybrid (e.g., battery and solar or battery and wind) projects. This reduces upfront capital investment requirements and enhances project economics. The IRA further allows for bonus credits for facilities that meet additional criteria, such as being sited in low-income communities or the use of domestically produced materials.[28]

In addition to market and tax policy, the U.S. Department of Energy (DOE) supports BESS advancement through multiple research and demonstration initiatives. The Energy Storage Grand Challenge is DOE's flagship program aimed at reducing the levelized cost of storage to $0.05 per kilowatt-hour (kWh) by 2030 for long-duration applications. The initiative also funds research on advanced technologies, including solid-state and flow batteries, to improve performance, duration, and safety. DOE's broader support efforts include the development of domestic manufacturing capabilities to reduce reliance on imported components and enhance supply chain resilience.[29]

Various federal agencies (e.g., the U.S. Department of Defense) also fund demonstration projects that test advanced storage technologies in real-world utility and grid environments, often in partnership with utilities and RTOs. In parallel, DOE and its National Laboratories provide technical assistance to state energy offices and utilities through modeling tools, data, and planning guidance to support integration of storage into resource planning and market participation processes.[xx] The availability of federal resources is subject to change in response to changing federal policy priorities.

3.8 Storage Scenarios for Indiana

Examples of how Indiana is already incorporating utility-scale BESS are included in call-out boxes throughout the chapter. BESS projects in the state support the integration of intermittent renewable resources, stabilize grid operations by providing ancillary services, address localized demand constraints, and contribute to transmission system support by relieving congestion or deferring the need for new infrastructure, among other services.

Between 2025-2035, Indiana's electricity generation portfolio is expected to undergo significant adjustments, primarily shaped by the retirement of coal-fired power plants and the addition of new generation sources, as outlined in the IRPs of major utilities. Northern Indiana Public Service Company (NIPSCO), for example, plans to phase out its coal fleet by 2028 and introduce approximately 1.5 GW of solar capacity, much of it paired with energy storage, alongside wind and limited natural gas capacity.[30] Duke Energy Indiana intends to retire its coal units at Gibson Station by 2035, with a gradual transition to natural gas, solar, and wind installations projected in its IRP.[31] AES Indiana aims to cease coal operations at its Petersburg site by 2026, replacing that capacity with a mix of natural gas and approximately 1,300 MW of wind, solar, and energy storage resources.[32] CenterPoint Energy is similarly shifting its portfolios, moving toward a predominantly gas and renewable mix by 2030.[33]

As the state's generation mix evolves, BESS can play a

[xix] As of the publication of this report, there is uncertainty regarding the continued availability of federal tax credits and other federal programs supportive of BESS development, pending U.S. Congressional and Executive Branch action.
[xx] See, for example, the resources identified at: https://docs.nrel.gov/docs/fy23osti/84252.pdf.

supportive role in optimizing the performance and reliability of new resources. For solar and wind, BESS can store excess generation during periods of high output and release it when demand increases, effectively smoothing intermittent supply and minimizing curtailment. For natural gas plants, BESS can provide quick-response capacity to handle sudden demand spikes, reducing the need for fast-ramping gas peaker plants. BESS can also enhance resiliency when winter conditions constrain the availability of natural gas fuel. In terms of grid operations, BESS can alleviate transmission congestion by managing localized demand peaks and supporting voltage stability, potentially deferring the need for costly infrastructure upgrades. These applications allow for more flexible use of existing and new generation resources without necessarily expanding grid infrastructure.

As apparent from the above discussion, a variety of factors are driving the exploration and implementation of energy storage solutions in Indiana, both to date and going forward. The following sections take a closer look at key drivers, discuss already planned storage, and provide projections for future deployments.

3.8.1 Drivers

BESS projects are being deployed in Indiana primarily because they are cost-effective. Recent modeling suggests that Indiana utilities could save customers a combined $73 million by investing in battery storage rather than building new gas-fired generation.[34] These cost advantages emanate from avoided capacity investments, reduced peak demand charges, and participation in wholesale markets. Additional cost savings also exist from avoiding certain transmission costs and increasing the utilization of intermittent energy sources through capacity firming.

3.8.2 Already Planned Storage

Integrated Resource Plans

Previous and current IRPs of several Indiana utilities outline plans to expand battery energy storage capacity as a means to address various energy needs. This planned capacity factors into expected storage adoption. It also represents the diversity of justifications provided for BESS adoption.

A key example is AES Indiana's Pike County BESS, a 200-MW facility that repurposes the interconnection rights of a retired coal plant. By using the interconnection infrastructure from the former coal facility, AES Indiana can avoid the need for new approvals through the interconnection queue. This approach utilizes existing grid access to expedite deployment. AES Indiana has also planned a 60-MW BESS at the Petersburg Energy Center, expected to be operational by 2025. This facility is designed to complement renewable energy generation and provide additional capacity during periods of high demand.[35] These resources were first identified as part of AES Indiana's 2016 IRP (filed as Indianapolis Power & Light).[36]

Duke Energy Indiana plans to deploy 400 MW of standalone battery storage by 2030, which will be paired with 500 MW of solar generation. These standalone systems are designed for a 4-hour storage duration and are intended to provide additional capacity and support renewable energy integration. Duke first proposed this development in its 2024 IRP.[37]

NIPSCO developed 75 MW of battery storage at the Dunns Bridge Energy Center, completed in late 2024, consistent with its 2020 IRP proposal.[38] This project integrates solar and battery storage, offering a combination of renewable energy generation and backup capacity. AEP Indiana Michigan Power and Wabash Valley Power Association (WVPA) plan to collectively add 30 MW of storage by 2026, focusing on improving reliability across their service areas. These projects were proposed within the WVPA 2023 IRP,[39] which outlines plans to integrate storage solutions for improved grid reliability, and Indiana Michigan Power's 2024 IRP, which identifies storage investments to enhance system flexibility and renewable integration.[40] Combined, proposed storage projects represent over 500 MW of planned storage capacity by 2030.

Interconnection Queues

Since 2022, developers have issued approximately 70 interconnection requests for battery storage projects located in Indiana, representing a combined capacity of approximately 12 GW awaiting approval.[41,42] This brings the cumulative amount of Indiana battery storage capacity in PJM's and MISO's interconnection queues up to just over 15 GW of active requests.[43] Not all queued projects are likely to come to fruition; the current interconnection process can incentivize early and speculative submissions—some of which may never advance beyond the application stage.[xxi] Nevertheless, the quantity of proposed capacity signals strong interest in energy storage development.

The interconnection queue determines how quickly these proposed projects can move from planning to operation, as discussed in Chapter 4. Delays in processing these applications slow Indiana's ability to expand its storage capacity. If approval rates were to improve, even partial activation of the queued projects would allow Indiana to surpass the projections outlined in current forecasts. For instance, operationalizing just 8% of the 27 GW in the queue could nearly triple the state's projected battery storage capacity by 2033. This capacity, should it move forward, could provide Indiana with a pathway to achieve earlier-than-expected widespread adoption of energy storage.

[xxi] Developers often submit projects to secure a spot in the queue before finalizing financing, land use, or technology plans.

3.8.3 Potential Outcomes

Exeter developed three BESS deployment forecasts – low, average, and high growth – based on varying assumptions regarding BESS deployment conditions. These forecasts are comparable to the S&P Global projections listed above as well as Indiana Utility Projections (IUPs) made as part of IRP proceedings.[xxii]

All of Exeter's forecasts use 225 MW of nameplate capacity as the starting point for Indiana battery storage.[xxiii] Subsequent growth is modeled as a logarithmic function, meaning adoption occurs in two distinct phases. First, during the acceleration phase (2026-2029), Exeter's estimates show Indiana rapidly adding capacity. Second, during the stabilization phase (2031-2033), annual additions slow.

The average growth scenario is derived from the mean of two Indiana-specific projections by S&P Global, which were proposed to establish growth rate assumptions. In contrast, the low growth scenario outlines conditions that would result in a slower rollout of BESS, such as the elimination of state and federal policy incentives.[xxiv] Conversely, the high growth scenario presupposes the ongoing availability of federal incentives under the IRA, including tax credits for both standalone and co-located storage, alongside reduced project costs. To calibrate these modeled growth rates and derive those assumptions, Exeter utilized data and assumptions from several other sources, encompassing the U.S. Energy Information Administration (EIA),[44] Bloomberg New Energy Finance,[45] and Wood Mackenzie.[46]

Table 4 lists the expected capacity and assumed growth rate applied to each scenario. Figure 7 illustrates the projected battery storage capacity in Indiana for each scenario through 2035. Notably, most storage additions are driven by utility commitments during IRP proceedings. The resources proposed by Indiana utilities tend to be larger than the resources brought online by Independent Power Producers (IPPs), sometimes called merchants.[xxv]

See Appendix E for additional description of Exeter's growth projections. Exeter's estimates are subsequently deployed as part of economic impact modeling in Chapter 6.

Table 4. BESS Growth Scenarios

Scenario	Expected Capacity (MW)	Growth Rate
Low	2,156	72%
Average	2,703	80%
High	2,975	84%
Utility Projections	2,700	51%
S&P Global	2,776	88%

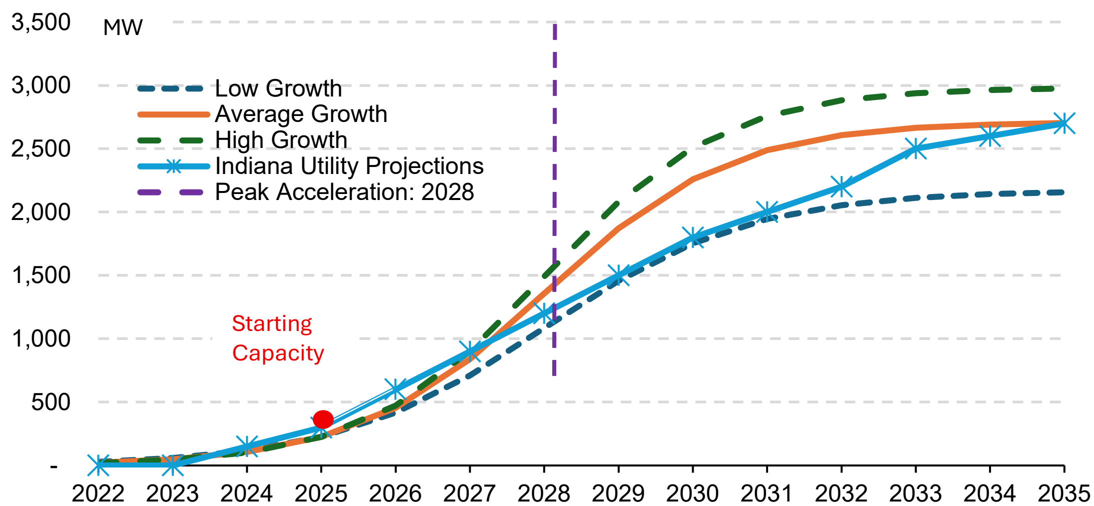

Figure 7. Projected Battery Storage Capacity Growth in Indiana (2025-2035)

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xxii The Indiana Utility Projections data represents storage proposed by NIPSCO, Duke Energy Indiana, AES Indiana, and Indiana Michigan Power.

xxiii The actual quantity of near-term capacity may differ due to recent changes in completion schedule for projects under development.

xxiv The lower growth scenario reflects the anticipated completion of projects in more advanced stages of development. Additional changes in market conditions, such as supply chain disruptions and uncertainty regarding federal incentives, may cause this curve to shift right (i.e., development is pushed further out in time).

xxv The proposed 400-MW Pumpkinvine Energy Storage Project is not incorporated into Exeter's projections as a result of local permitting uncertainty. For additional information, see: Juranovich, T. (2024). Proposed BESS halted by Kokomo Plan Commission. *Kokomo Tribune, Ind.* https://www.yahoo.com/news/proposed-bess-halted-kokomo-plan-231600914.html.

Additional BESS Applications in Indiana

Non-grid-scale applications of BESS provide many of the same services as utility-scale projects, including renewable integration, energy arbitrage, and backup power, but at a smaller scale or to serve a more direct customer need. At a customer level, storage solutions can be leveraged to manage rates (e.g., avoid demand charges or shift energy time-of-use) and provide resilience against grid interruptions. Furthermore, BESS is increasingly relevant for EV charging infrastructure, with vehicle-to-grid opportunities in the early stages of evaluation. The following examples highlight additional BESS applications, including deployments intended to support specific customers.

- Energy arbitrage: The Cherry Hill Battery Storage Project in LaGrange County, a 25-MW facility, is designed to store electricity during low demand periods and discharge it during high-cost hours, enabling cost savings for nearby businesses.[1]
- Backup power: Duke Energy's smaller-scale installation at Camp Atterbury in Johnson County provides backup during grid outages.[2]
- Residential use: A residential property in Evansville (Vanderburgh County) underwent a large-scale solar installation in June 2022, featuring a 40-kW system with 118 QCell 340W panels and SMA inverters. The system includes a Tesla Powerwall battery that provides backup power during outages and enables daily cycling to maximize financial benefits. This setup allows the homeowner to reduce reliance on the grid and manage energy costs by utilizing stored solar energy during peak demand periods.[3]
- Commercial use: The Pumpkinvine Energy Storage Project in Howard County is a planned 400-MW BESS being developed by Spearmint Energy. The project is strategically located near Kokomo's industrial sector and is expected to provide enhanced energy reliability and cost-savings opportunities for surrounding commercial and industrial facilities. Though still in the development phase, the project is designed to store electricity during low demand periods and discharge during peak hours, potentially enabling manufacturers to stabilize energy costs and improve operational efficiency.[4]

[1] IURC Case No. 45863, Cherry Hill Application.
[2] Ryan, C. (2017). Duke Energy develops 5MW Indiana National Guard microgrid storage and substation project. *Energy Storage News*. https://www.energy-storage.news/duke-energy-develops-5mw-indiana-national-guard-microgrid-storage-and-substation-project/.
[3] Solar Energy Solutions. 40 kW Residential Install in Evansville, Indiana. https://www.sesre.com/case-study/40-kw-residential-install-in-evansville-indiana/.
[4] Pumpkinvine Battery Energy Storage. *Project Details*. https://www.pumpkinvinebattery.com/project-details.

4. INSTALLATION, OPERATION, DECOMMISSIONING, AND RECYCLING PRACTICES

4.1 Executive Summary

In Indiana, developing a utility-scale BESS from first design to operation can take 6-8½ years. Decommissioning occurs at the end of a BESS's useful life, usually 10-20 years after commencing operation. This chapter analyzes the life of a BESS project, including all stages of design, permitting, construction, decommissioning, and disposal.

Key findings and insights from this analysis include:

- Indiana BESS permitting requirements largely align with other states' standards. State regulatory authorities typically evaluate the necessity, reliability, safety, and economic benefits of a project before installation.
- Local governments need additional ordinance guidance. Since BESS technology is relatively new, there are additional steps that can be taken on a local level to better inform and support planning and zoning ordinances. Indiana should institute a task force of state and local officials to create model BESS safety and siting standards for planning and zoning staff to reference as they develop their own standards. Alternatively, local governments should reference New York's model BESS ordinances.
- Best practices for safety, design, construction, installation, and commissioning are largely established on a national level. Specialty associations, such as the National Electrical Contractors Association, National Fire Protection Association, and Underwriters Laboratories (UL) Standards, develop standards specifically for BESS that are widely used in the industry. This report references several of these associations and the standards they have developed that should continue to be incorporated in legislation and regulation as they are routinely updated.
- Environmental and land impacts can be reduced depending on project location. BESS require access roads and semi-permanent structures, such as cement foundations, that impact the land on which they are developed. Best practice is to not site facilities in protected areas, wetlands, or habitat for endangered species. Local governments may also choose to encourage siting on brownfields to further reduce impact.
- BESS project timelines are longer than expected. BESS projects currently take up to eight and a half years from design to operation. Design and engineering typically overlap with the developer's pursuit of local, state, and RTO reviews, which can speed up the timeline for placing a BESS online. However, delays in the RTO process, which is needed to determine the cost and terms for the project to interconnect, are resulting in long wait times. RTOs are aware of the wait times in the interconnection queues. If RTOs can effectively speed up their review process, the time it takes for a BESS to come online would lessen by as much as half.
- System safety documentation should be reviewed by a third party prior to construction. IDHS does not have explicit authority to require BESS developers to seek third-party review of their safety reports, such as UL 9540A reports and hazard mitigation analyses. Establishing this requirement through legislative action would ensure compliance with all relevant codes and standards for all utility-scale BESS projects and reduce the review burden for IDHS.
- High-stress operating conditions can speed up BESS degradation. Battery modules have a useful life of approximately 10 years. Three main factors determine a battery's lifespan: temperature, depth of discharge, and state of charge. When batteries are operated under more extreme conditions or in more stressful ways, such as discharging the battery to low levels, they will degrade in performance and lifespan at a faster rate compared with optimal use. BESS lifespans can be extended by 10 or more additional years by replacing battery cells.
- Project owners should be required to update their decommissioning costs every five years following commercial operation. Most decommissioning agreements in Indiana require a one-time update to decommissioning costs five years after commercial operation. Decommissioning costs may change as more projects reach their EOL due to increased need for facilities and labor related to BESS disposal and recycling. Requiring regular decommission cost updates will improve the estimates and ensure more accurate financial assurances.
- Establishing a BESS-specific recycling industry in Indiana requires additional guidance. A more formalized recycling network is needed to promote safe handling, economic reuse of components, and sustainable workforce development in this sector. Prospective frameworks should include guidelines for safe battery disassembly, certification standards for recycling technicians, and dedicated industrial zones to process and redistribute recovered materials.

4.2 Introduction

The sequence of steps required to bring a BESS project proposal to fruition potentially begins years in advance. In Indiana, if any of the five major investor-owned utilities or three major generation and transmission cooperatives intend to incorporate battery storage into their resource portfolios, it will include estimates of storage cost and benefits in its IRP. The resources incorporated into IRPs are intended to provide safe and reliable service at the best value for ratepayers on a long-term basis. IPPs do not have a similar planning requirement.

The project developer (utility, utility affiliate, or IPP) then begins the processes of siting and engineering the project. These processes consider land use, safety, cost, financing, land availability and size, proximity to transmission interconnection, land ownership (i.e., whether land is owned by the developer or utility, or leased from a landowner), and community trust and engagement. BESS projects undergo review processes at the RTO, state, and local levels, and receive approval prior to installation. The regulatory and permitting approval process can take 5-7 years under current conditions.[47] This timeline does not include prior resource planning by utility companies (which occurs every three years) or the steps involved in locating, leasing/purchasing, and zoning land for the project. Securing zoning approval at the local level may cause delays and extend the overall timeline for full regulatory review.

After receiving the proper approvals, project construction typically takes 3-12 months, barring delays such as the unavailability of skilled labor and supply chain constraints, as further discussed in Chapter 6. During construction, the developer procures the necessary equipment, prepares the land for installation, and builds the BESS. Commissioning is planned at the start of construction to ensure BESS components are properly tested during procurement, throughout construction, and once the installation is completed.

In total, it can take 6-8½ years from the start of siting approval proceedings to operational status for a BESS.[48] Long interconnection queue times and other delays, as described later in this section, contribute to this extended process which, in the absence of such interferences, might take half as long.

BESS projects can be operated for an average of 10-20 years. Once a BESS reaches its EOL, BESS facilities are decommissioned and all components are either disposed of or recycled. As described below, IDHS reviews the BESS's original decommissioning plan prior to construction and again when the BESS is ready to be retired.

The goal of this chapter is to review each of the above stages in a BESS's lifecycle to inform readers about best practices and opportunities for Indiana. The chapter begins with discussion of lifecycle stages prior to installation, including grid-level interconnection, state regulatory reviews, and local planning processes. Discussion then shifts to deployment considerations for BESS, including engineering, design, construction, installation, and commissioning phases of a project. Next, EOL considerations are examined, including decommissioning and recycling. The chapter concludes with a discussion of BESS materials including key minerals, providing additional information relevant lifecycle considerations.

4.3 Pre-Installation

4.3.1 MISO/PJM Interconnection Review Stages

The grid interconnection of utility-scale battery storage, like other bulk-system generation resources, is reviewed by the appropriate RTO. Most of the state's utilities' service territories are within MISO, except for the AEP zone (serving AEP Indiana Michigan Power and several small cooperatives) which is within PJM.

MISO has an annual interconnection application cycle that begins with an initial application period, followed by three Definitive Planning Phases (DPPs), and ending with a Generator Interconnection Agreement (GIA). The application period is open annually for approximately one month with an April due date.[xxvi] During this time, MISO personnel will review the application for any deficiencies and allow the applicant 10 days to revise the application before the start of the DPP.

During Phase 1 of the DPP, MISO performs a preliminary System Impact Study (SIS) which is designed to evaluate the project's impact on the transmission system's reliability. Phase 2 consists of a revised SIS and an Interconnection Facilities Study based on the projects that remain after Phase 1.[xxvii] Phase 3 consists of the final SIS and the Network Upgrade Facilities Study which accounts for any project withdrawals after Phase 2. After completion of the DPP, the developer and MISO negotiate the GIA, which is filed with FERC.

As shown in Figure 8, MISO estimates that Phases 1, 2, and 3 take 100, 105, and 60 days to complete, respectively, under MISO's Reducing Generator Interconnect Process Timeline initiative, which took effect in March 2022. Under the reduced timeline, the subsequent GIA negotiation and filing process is estimated to take an additional 108 days. In theory, the process should take a little over a year under these parameters. However, most MISO regions do not meet these timelines and have experienced delays in each step of the application, DPP, and GIA process.

[xxvi] For example, the 2023 Cycle application opened March 18, 2024 and the deadline was April 18, 2024.
[xxvii] Developers may withdraw projects from the MISO interconnection queue based on costs or other issues discovered during the SIS.

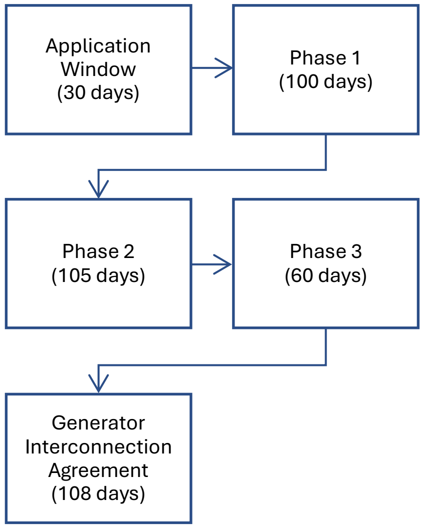

Figure 8. MISO Generator Interconnection Process Timeline

Projects within the AEP zone are subject to the PJM generator interconnection process. In 2023, PJM converted to studying projects in clusters rather than on a first-come, first-served basis. Under the cluster system, PJM evaluates groups of projects every six months. Inclusion in a group is based on a determination that a particular project is more likely to proceed and is ready for review. The queue for a given cycle is open to applications for six months.[xxviii]

For proposed projects, PJM conducts a Feasibility Study, Impact Study, and Facilities Study:

- Feasibility Study: At a high level, determines whether a project interconnection is feasible based on project design and equipment, and establishes potential connection points to the operator's grid.
- Impact Study: Determines how the project will impact grid reliability and power quality.
- Facilities Study: Determines what new facilities or grid updates are needed to interconnect the project and allocates costs (if applicable) between the developer and load, either regionally or RTO-wide.

The Feasibility Study, Impact Study, and Facilities Study are conducted sequentially and take three, four, and six months, respectively, to complete. Each study includes modeling periods where PJM reviews and runs the studies' analyses to identify issues or costs associated with each proposed project. After each study is completed, the project developer evaluates the results of the study, including any associated requirements from PJM, and determines whether to move forward with the subsequent study.

Prior to the Impact Study and Facilities Study, the developer signs a System Impact Study Agreement and Facilities Study Agreement, respectively, as well as pays the corresponding deposit.[49] After the studies are complete, and assuming the developer opts to continue, the developer and PJM enter into a Construction Service Agreement, required for any construction of facilities needed to interconnect a new project. Developers also enter into one or both of the following:[50]

- Interconnection Service Agreement, which defines the developer's cost responsibilities for upgrades; and/or
- Upgrade Construction Service Agreement, which defines costs and needed upgrades for developers making an upgrade to an existing transmission facility.

The applicable agreement is based on grid needs associated with the proposed interconnecting resource. PJM estimates that, if a project enters the queue on the first day that the queue is open to applications, and experiences no delays, the interconnection process would be complete within a minimum of two years and three months.[51]

PJM and MISO, like all of the country's RTOs, are seeing more queue submissions and, as a result, developers are experiencing longer queue wait times.[52] For Interconnection Agreements executed in 2018-2023, it took a project, on average, 38 months and 44 months to move through the MISO and PJM queues, respectively. However, some projects experience queue wait times of up to 73 months (MISO) and 178 months (PJM).[53]

4.3.2 IURC

Indiana Resource Planning

The IURC oversees the state's electric utilities' resource planning by reviewing IRPs. Per 170 IAC 4-7, the five investor-owned electric utilities,[xxix] as well as Indiana Municipal Power Agency (IMPA), Hoosier Energy Rural Electric Cooperative (Hoosier Energy), and WVPA, must file 20-year IRPs every three years. The intent of IRPs is for each utility to lay out its long-term plan for serving its ratepayers, but can also later serve as evidence of need for CPCN or Clean Energy Project petitions.

IRPs include historical and forecasted data that supports the utilities' proposed and alternative resource portfolios. IRPs also address the potential impact of legal, regulatory, economic, and technological changes since the last plan, and describe the models used to support the proposed portfolios. Examples of the information required for IRPs include (1) the utility's forecasted (20-year) and historical data regarding peak demand and energy usage; (2) the utility's existing resources and proposed future resources; (3) the effect of transmission planning

[xxviii] Current cycles include Transition Cycle #1 and #2 and Cycle #1.
[xxix] Duke Energy Indiana, Indiana Michigan Power Company, Indianapolis Power & Light Company, Northern Indiana Public Service Company, and Southern Indiana Gas and Electric Company.

on the utility's portfolios; (4) the impact of changing laws on the utility's resources; and (5) a three-year, short-term action plan for the utility's preferred resource portfolio and strategy.

Before filing the IRP with the IURC, the utility holds public advisory meetings to introduce the IRP process; describe modeling methods, inputs and outcomes; and present the utility's recommended resource portfolio. An IURC employee is appointed as the "IRP director" and is responsible for reviewing the IRP and relevant stakeholder comments and then preparing a report addressing the utilities' compliance with the IURC's resource planning requirements. Currently, the Director of the Research, Policy, and Planning Division of the IURC serves in this role.

The IURC may also host an annual meeting where it identifies contemporary issues to be addressed by the utility in its next IRP, provided that its next IRP is more than a year away. Contemporary issues presented in the 2024 annual meeting include Loss of Load Expectation Studies, Resource Adequacy and Capacity Accreditation in PJM, Resource Accreditation Reform, Policy Effects on Load Curves, and Load Forecast Development and Use in MISO and PJM.[54] Electric utilities in Indiana have already incorporated existing and proposed BESS into their IRPs. Duke Energy Indiana (Duke), for example, proposed 400 MW of battery storage, either paired or standalone, by 2030 as part of a short-term plan.[xxx,55] In its IRP, Duke stated that the battery storage is meant to address incremental capacity needs.[56]

Necessity Certification

The IURC reviews three types of petitions related to battery storage projects: a CPCN petition, a Clean Energy Project petition, and a declination of jurisdiction. Table 5 summarizes the proceedings for each type of BESS project.

A utility will file a CPCN application when it is developing a generator (e.g., solar) and battery storage hybrid project. Under this process, the IURC evaluates the project based on the "five pillars,"[xxxi] financial metrics, and whether there is a "need" for the

Resource Planning in Other States

A variety of states deploy some form of electricity resource planning that includes BESS as an eligible resource.[1] The following overview summarizes practices for several comparable states.[2]

Kentucky: Electric utilities under the Kentucky Public Service Commission's (KY PSC) jurisdiction (i.e., that generate an annual revenue greater than $10 million and are not a cooperative) must file an IRP every three years with historical and projected data to support their load and performance forecasts for 15 years. Utilities must also include relevant financial assumptions, a resource assessment, and a resource acquisition plan that supports the utility's CPCN and acquisition applications for the first year of the IRP.[3] KY PSC Staff prepare a report on the IRP and provide feedback for the utility to implement in its next IRP filing. KY PSC has an advisory role and does not approve or disapprove the IRP.

West Virginia: Electric utilities must file an updated IRP every five years for West Virginia (WV) PSC review. The IRPs include current and planned resources (including those recommended by the utility) that balance cost and risk. WV PSC rules require that the IRP include a description of the utility's model assumptions, rationale for preferred and considered resources, rationale for internal review processes, 3-year historical demand and supply data, and 10-year forecasted demand and supply. IRPs are informational in nature and do not require commission approval, per WV PSC clarifications.[4] WV PSC also allows utility companies to create a renewable electric facilities program where the utility provides its plan to construct, design, purchase, and operate renewable electric generating and energy storage facilities subject to WV PSC review. This program permits accelerated prudency determination and recovery of costs.[5]

Michigan: IRPs are required for electric utilities whose rates are regulated by the Michigan (MI) PSC and have more than 1 million customers. The IRP is intended to exhibit a utility's ability to provide reliable, cost-effective service, and includes demand and load forecasts as well as scenario modeling. With its IRP, a utility may file a certificate of necessity for investment in an electric generation plant or power purchase agreement exceeding $100 million that, if approved by MI PSC, would allow for cost recovery.[6] If the utility is found to have demonstrated a need for the investment through its IRP, MI PSC will grant the certificate of necessity. IPPs can also seek to fulfill utility resource needs through an Alternative Competitive Proposal, also subject to MI PSC review.

[1] For additional information, see State Energy and Environment Guide to Action: Electricity Resource Planning and Procurement. U.S. Environmental Protection Agency (2022).
[2] Comparable on the following bases: (1) vertically integrated; (2) near Indiana; (3) share at least one major electric utility; and (4) operate in both or either of the same regional grids (i.e., PJM and MISO).
[3] See 807 Kentucky Administrative Regulations (KAR) 5:058.
[4] See W.Va Code Section 24-2-19.
[5] See W.Va.Code Section 24-2-1o.
[6] See Public Act 341 of 2016/ MCL 460.6t and 460.6s. IRP requirements were established in the Order for MI PSC Case Nos. U-15896 and U-18461.

[xxx] A short term plan covers the three-year planning period between the current IRP and the next IRP.
[xxxi] See Chapter 2 for addition discussion of the five pillars.

project.[xxxii] The major financial metrics, of which the utility files and provides support for in its application, include an estimation of costs, and a plan for cost recovery through rates. The utility will also use its IRP as evidence for the IURC to weigh when determining whether the project fulfills a need based on the utility's forecasted demand and load.

A utility proposing a standalone battery storage project may file a Clean Energy Project application. For example, the IURC ruled in Cause No. 45920, Pike County Battery Energy Storage Project that a stand-alone battery storage is considered energy production, not generation (as discussed further below), and is therefore not required to obtain a CPCN before being built.[57] However, even under the Clean Energy Project application, the utility must file similar information to that required for CPCN projects.

IPPs can also file a petition for the IURC to decline to exercise its jurisdiction in the case of a standalone energy storage project. In this proceeding, the IURC determines whether the project requires IURC review. Justifications for not conducting a more comprehensive review include: it would be duplicative of other regulatory bodies, introduce inefficiencies and impede the project's operation, or be an unnecessary use of IURC resources.[xxxiii] In the same proceeding, the IURC evaluates the project for the factors listed in Table 5.

4.3.3 IDNR and IDEM

BESS facilities are subject to similar review and regulatory processes as other energy resources (e.g., substations, transmission, generation) to mitigate potential adverse environmental effects. In Indiana, both the Indiana Department of Natural Resources and IDEM oversee environmental permits related to siting BESS facilities when wetlands and floodways are impacted by the proposed project site.[xxxiv] Best practice is to not site facilities in protected areas, wetlands, or habitat for endangered species, though such facilities may be permissible in exceptional circumstances. The length of time these reviews may take is highly dependent on the project location. In most cases, developers avoid disturbing sensitive areas or locating projects in zones that would require extensive evaluation.

Table 5. IURC BESS Application Review Proceedings

Proceeding Type	Developer Type	Project Type	Legality	Factors Evaluated	IURC Judgement Timeline	Example
CPCN	Utility	Paired battery with other generating source	Indiana Code 8-1-8.5	▫ Five pillars ▫ Financial metrics ▫ Need	Up to 240 days	IURC Cause No. 45591, Petersburg Energy Center Project
Clean Energy Project	Utility	Standalone battery	Indiana Code 8-1-2.5; 8-1-8.8; and IURC Cause No. 45920	▫ Cost ▫ Consistency with utility's IRP ▫ Need ▫ Whether the project resulted from competitive solicitation	Up to 120 days	IURC Cause No. 45920, Pike County Battery Energy Storage Project
Declination of Full IURC Jurisdiction	Independent Power Producer (IPP) or merchant	Paired or standalone battery	IURC Cause No. 45863	▫ Public interest ▫ Five pillars ▫ Project location ▫ Merchant's financial management	Typically 90 days	IURC Cause No. 45863, Cherry Hill

[xxxii] "Need," when used in the context of energy resource adequacy, is the necessary power required to meet energy and capacity demands. A utility's need to provide adequate power to customers can be fulfilled through construction of additional utility-owned power plants or purchase of additional power from third-party power plants.
[xxxiii] IURC. Cause No. 45863. Final Order (November 28, 2023). pp. 5, 10-11. In this specific case, the exempt facility injects and furnishes electricity rather than generates it, with capacity and pricing regulated by FERC.
[xxxiv] See Cause No. 45476, Order of the Commission (June 9, 2021), p. 4, as an example.

Licensing in Other States

Best practice does not yet exist for licensing and review of BESS. Instead, most states either work within the parameters of the existing regulatory processes used to review generation projects or have enacted legislation or regulation that specifically addresses the siting of battery storage projects. The following overview summarizes practices for several comparable states.[1]

Kentucky: Utilities must show that: (1) a project is necessary to provide safe and reliable service; (2) the utility considered other options for meeting the need that the project would fulfill and determined that the proposed project is the preferred option; (3) the project is not duplicative of other projects that would fulfill the same need; and (4) the project is the least-cost reasonable option.[2] The KY PSC has previously approved CPCN applications for battery storage projects under its current statutes, and the broad nature of existing legislative language allows the KY PSC to incorporate new technologies (e.g., BESS) into existing regulatory processes. In contrast to Indiana, the KY PSC considers BESS's to be generation resources. The utility must therefore apply for a site compatibility certificate under KRS 278.216. The KY PSC has 90 days, unless extended to 120 days for good cause, to issue a decision on a CPCN application.

West Virginia: BESS can be reviewed and approved through three different processes.[3] Under W.Va.Code Section 24-2-11c, major utilities must apply for a siting certificate. The WV PSC reviews the application for public interests, state and local economic interests, and interests of the applicant, and rules on the application within 300 days of the application filing date. An electric utility can also apply for the renewable electric facilities program in lieu of a CPCN by petitioning the WV PSC to determine whether a purchased or constructed renewable facility, or energy storage resource, is prudent. Through this process, facilities are subject to certain size, cost recovery, and tariff provisions. The application includes descriptions of the resource, proposed cost recovery and projected capital costs, and other WV PSC-requested information. The WV PSC rules on the application within 150 days.[4]

Non-utilities (i.e., an IPP) that file to construct and operate a BESS can qualify as an exempt wholesale generator under federal law. Exempt entities still file a siting certificate application with the WV PSC. The WV PSC must issue a final order on these applications within 150 days of the filing date.[5]

Michigan: If the MI PSC finds that the utility has demonstrated a need for the investment through its IRP, it will grant a certificate of necessity. IPPs can also seek to fulfill utility resource need through an Alternative Competitive Proposal, which is also reviewed before the MI PSC. Siting certifications are for electric utilities and IPPs; these regulations include storage facilities as an "energy facility."[6] Prior to applying with the MI PSC, the project must first receive siting approval from the local government(s), which can take up to 330 days with mutually approved extensions. The MI PSC has preemptive power over local governments in certain situations under Public Act 233. Projects may seek a certificate of necessity from the MI PSC in place of local approvals if (1) requested to do so by the local government; (2) the local government fails to act on the project's application; or (3) the local government "unduly denies" the application.

The application process before the MI PSC can take up to a year. The MI PSC provided additional guidance regarding its evaluation of certificate application in Case No. U-21547. The Order in this case certified the "Application Filing Instructions and Procedures," which includes provisions for the MI PSC to evaluate environmental impacts, public benefits, safety, land use, and decommissioning of a project.

[1] Comparable on the following bases: (1) vertically integrated; (2) near Indiana; (3) share at least one major electric utility; and (4) operate in both or either of the same regional grids (i.e., PJM and MISO).
[2] Kentucky Revised Statutes (KRS), Section 278.020.
[3] W.Va. Code Section 24-2-11 for major utilities, W.Va.Code Section 24-2-1o(d)-(e) for major utilities, and W.Va.Code Section 24-2-1o(n) and 150 C.S.R. 39 for entities that are not major utilities.
[4] W.Va. Code Section 24-2-1o(d).
[5] W.Va. Code Section 24-2-1o(n).
[6] Michigan Compliance Laws Sections 460.1221-1232/Public Acts 233 of 2023.

4.3.4 IDHS

As a BESS project goes through any of the above three types of proceedings before the IURC, it must also receive certain approvals from IDHS. In accordance with HEA 1173 (2023), as codified in IC Section 22-14-8-6, prior to construction, IDHS reviews each proposed BESS's site plans, location, emergency plans and trainings, commissioning plan, and compliance with NFPA 855 and Federal Emergency Management Agency (FEMA) flood plain regulations. (See Chapter 3 for additional discussion of IDHS's role.) IDHS review takes 30 days to complete for both utility and IPP developers. Figure 9 visualizes IDHS review alongside the above state regulatory steps.

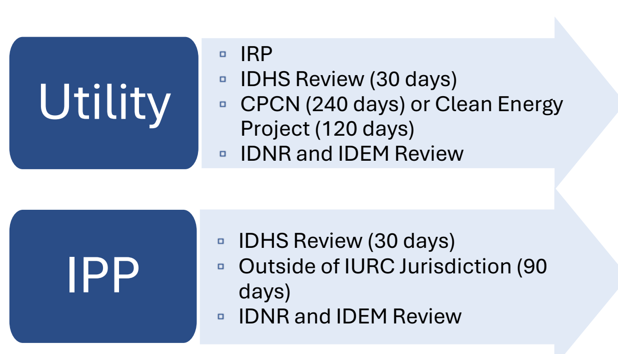

Figure 9. State Regulatory Steps and Timelines

4.3.5 Local Government Planning

For a developer or utility to begin development of a project, it must be located within an appropriate designated land use "zone." The typical categories of land use zones include residential, agricultural, rural, commercial, industrial, and utility. There may be sub-zones or variations depending on the local ordinances and land use requirements. Within each zone, municipalities only permit certain land uses. For example, a residential zone may only allow residential housing and therefore preclude industrial activities absent re-zoning or variance approval. Re-zoning and variance processes occur prior to other regulatory reviews.

A planning and/or zoning board (or similar local agency) generally reviews project considerations related to land use. Generally, Indiana municipalities and counties allow utility- or energy-related projects within agricultural, commercial and/or industrial land use zones, with special exemptions.[xxxv] However, there is no consensus among local governments in Indiana regarding allowable BESS zones or exceptions, in part because BESS projects are not yet prevalent in the state. When a municipality does not have BESS-specific standards or siting guidance, planning and zoning board staff often reference requirements for sufficiently similar technologies, such as a utility substation or generation station, as a proxy for BESS.

Typical planning and zoning processes include the submission and review of the following:

- Site plans
- Use permissions
- Environmental reviews
- Road use permitting
- Vegetative management plan
- Decommissioning agreements
- Fire and safety plans

A local government may require additional information and studies based on a project's site location and specific plans.

When applying for approval from the IURC, an applicant may submit either county or municipality reviewed environmental reviews, decommissioning agreements, site plans, and other applicable agreements, or gives status updates as to when these documents are expected to be submitted. Once approved, if battery storage facilities or developers are not in compliance with local regulations, the municipality can sue the developer to enforce its standards. In general, other enforcement tools that can be utilized by local governments include stop-work orders, revocation of permits, fines and citations, and legal action.

Local governments can also provide financial incentives for BESS projects. County or municipal councils typically oversee planning boards as well as fiscal matters. In some instances, councils will enter into economic development agreements with BESS developers, where the county/municipality will abate property taxes levied on the project in exchange for direct funding for local initiatives. (See Chapter 5 for additional discussion of the economic impacts of projects on local governments.)

Generally, in cases where the state and local government disagree on the approval of a project, Indiana cannot supersede (i.e., preempt) the local government's authority unless it is directly in violation of state legislation. Therefore, if the IURC approves a BESS project, and a local government rejects the project, the IURC cannot overrule the rejection. Similarly, if IDHS rejects certain attributes of a project, such as its location due to its proximity to a 100-year flood plain, then the local government cannot approve the project's location.

Environmental impact is an instrumental component of siting, and is typically addressed through the permitting and CPCN processes described above. Outside of regulatory processes, however, various stakeholders also have an interest in broader location-related considerations, including land use, ecological impact, risks to public safety, and impact on viewshed. Local governments often take these considerations into account during their review processes. (See Chapter 7 for additional discussion of how local governments typically address related public concerns.)

Land Use and Ecological Impacts

Relative to other large-scale energy projects, utility-scale standalone BESS have a small footprint; studies estimate the land use requirements for BESS projects at 0.03-0.1 acres/MW.[58] For reference, the average land use requirements for natural gas plants are estimated at 0.343 acres/MW. This small footprint allows for greater siting flexibility than most other generation technologies.

Additionally, BESS installations are not constrained by resource availability, unlike gas-fired plants which need access to natural gas pipelines, coal plants that rely on rail or waterway infrastructure to transport fuel coal, or renewable projects dependent on areas with high solar or wind potential. Consequently, developers have a great deal of flexibility when locating BESS resources. In most cases, economic factors (e.g., land cost, wholesale market conditions), ability to interconnect to the grid (e.g., proximity to transmission with headroom), and ease of local permitting, among other factors, are the predominant drivers of BESS location. (See Chapter 6 for additional discussion of Exeter's

[xxxv] Special exemption is a zoning term meaning that a land use is permitted within a certain zone if the land use complies with additional conditions, usually to mitigate potential negative impacts.

assumptions regarding the regional placement of future BESS.) To date, most Indiana BESS are sited in rural communities.

Despite the above advantages, depending on location, size, and design factors, BESS projects can have various land use and ecological impacts. Like any power generation technology, building the facility requires land disturbance. The most significant impacts come from establishing access roads and permanent structures, such as cement foundations. Other potential disturbances include fencing and lighting. Beyond facility boundaries, additional environmental disturbances may emanate from grid interconnection, including the placement of distribution, substation, and transmission equipment. Local governments often try to minimize all the above impacts, typically by imposing restrictions, implementing requirements as part of approval processes, and/or encouraging specific project locations.

Another method of reducing the land use and ecological consequences of BESS installations is "brownfield development." This is the practice of siting BESS projects on land that has already been disturbed by previous use, such as a retired energy plant, industrial sites, or a landfill.[59] For example, a 2024 project in Michigan utilized brownfield associated with a retired coal plant for a 50-MW BESS installation.[60] Encouraging BESS on brownfields creates opportunities for communities to preserve undeveloped land, where possible. Colocation of BESS with substations, solar and wind farms, and other existing grid infrastructure should also be considered as a potential pathway for minimizing the direct environmental impact of BESS development.

Siting Considerations

Decisions pertaining to where and how a system is sited can influence the degree of land disturbance, proximity to sensitive areas, and potential risks to surrounding properties. Clear and consistent permitting and siting frameworks help ensure that BESS projects are integrated into communities in a way that minimizes adverse impacts.

To support local decision-making, a number of best practice resources have been developed. Among the most comprehensive is the Battery Energy Storage System Guidebook developed by the New York State Energy Research and Development Authority (NYSERDA), last updated in November 2024. The guidebook offers detailed permitting and siting guidance that can serve as a valuable reference for both community officials and developers. The most prominent recommendations address siting in relation to safety. (See Chapter 5 for a more extensive discussion of BESS safety.)

For instance, the guidebook recommends UL 9540A fire propagation testing for projects exceeding 600 kWh, which is far below the threshold for a utility-scale BESS project. This testing provides safety data that can help determine appropriate setback distances between battery enclosures and between the system and adjacent properties or structures. In Indiana, these test reports are already required under NFPA 855, the National Fire Protection Association's "Standard for the Installation of Stationary Energy Storage Systems."

As another example, the guidebook recommends deploying visible safety signage both directly at the BESS unit(s) and around perimeter fences and security barriers. Signage should prominently feature a map of the site, clearly indicating the locations of BESS enclosures and associated equipment. While Indiana specifically requires safety signage directly on or near BESS units per NFPA 855, perimeter signage, though recommended, is not mandatory.[xxxvi]

Delays Due to Local Concerns

In certain cases, actions taken by local government boards have blocked or delayed battery storage development, typically for IPPs. This may occur when a developer seeks exemptions or rezoning of land to align the project with local ordinances. In these instances, communities have voiced concerns about BESS that surpass the typical ordinance parameters. In response, municipalities often seek further assurances from the developer to ease community concerns, such as assurances regarding steps to avoid safety issues like thermal runaway (see Chapter 5). Intervention at a local level can effectively halt a projects before it is reviewed by other state agencies.

An example of this is Pumpkinvine Battery Energy Storage in Howard County. The developer, Spearmint Energy, requested that the project's proposed location be rezoned from "Agriculture" to "Low-Intensity Industrial Business Park" to allow for placement of the project. The project received resistance from the community and, in turn, the Kokomo City Plan Commission rejected the rezoning request. As a consequence, the project could not move forward and was required to wait at least six months before reapplying for rezoning.[1]

The planning and zoning officials consulted during development of this report indicated that one of the biggest issues facing their agencies is developing the standards in their respective ordinances for BESS, if not already in place. This challenge is compounded by a lack of guidance from state agencies and uncertainty as to whether existing standards effectively address community concerns.[2]

[1] Kokomo City Plan Commission, Case No. P20-Z-24, November 12, 2024.
[2] Meeting with Planning Officials, December 17, 2024.

[xxxvi] NFPA 855 mandates adherence to specific color and design standards for safety signage as defined by the American National Standards Institute (ANSI) in the ANSI Z535 standard.

For all siting and permitting topics, the guidebook emphasizes the importance of peer review and expert oversight. It encourages Authorities Having Jurisdiction (AHJs) to mandate third-party peer reviews of system safety documentation, for example. In Indiana, IDHS serves as the AHJ and currently does not explicitly possess the authority to require such third-party peer reviews. Granting this authority could benefit local communities by enabling reliance on qualified external experts to ensure compliance with applicable codes, standards, and manufacturer specifications during permitting processes.

Other siting considerations not explicitly addressed in the NYSERDA guidebook include land, screening, access, and environmental factors:[61]

- Screening: Existing and additional vegetative or engineered screening can mitigate viewshed and aesthetic impacts. Constructing and maintaining additional screening minimally increases costs.
- Access: Construction, maintenance, and emergency vehicles require access to the project site. Access roads must be wide enough and adequately constructed and maintained to accommodate these large vehicles. Relatedly, prior to construction, all applicable road and access permits must be obtained from local and state authorities. In planning reviews, local authorities also sometimes analyze the local traffic impacts to limit disturbance to school and commuter drive times.
- Environmental: Local habitat, topography, soil conditions, and prevalence of extreme weather are also studied when siting a BESS. These considerations reduce the impact that the project may have on the environment and risks to the project related to natural disasters.

Setback Considerations

Local governments require setbacks for a variety of reasons, including environmental protection, emergency response access, and aesthetics. The most universal reason, however, is safety. Safety guidance pertaining to setback and separation is provided by NFPA 855, as enforced by IDHS in a manner consistent with its role under HEA 1173 (2023). NFPA 855 includes setback specifications for maintaining appropriate separation distances between energy storage systems and nearby property lines, structures, and other potential exposures. However, local governments still explicitly preserve the authority to regulate land use through zoning ordinances. This includes the ability to establish and enforce setback requirements, screening standards, and other site-specific conditions.

While setback and buffering distances can vary according to locality, BESS type, size, capacity, and the project environment, NFPA 855 provides the following general classifications and requirements for an energy storage system, including BESS:[62]

- Remote versus near exposure classifications: A BESS is considered “remote” if it is sited at least 100 feet from property lines, public roads, buildings, combustible or hazardous materials, and other exposure risks. Remote systems are exempt from additional spacing and clearance requirements under NFPA 855.
  - If the BESS is located within 100 feet of these features, it is classified as “near exposure” and must meet additional design requirements, including minimum 10-foot setbacks from lot lines, public ways, structures, and materials that present fire or safety risks.
- Clearance reduction exceptions: NFPA 855 allows setback reductions from 10 feet to 3 feet under specific conditions, such as:
  - Installation of a 1-hour, fire-rated, free-standing barrier extending 5 feet above and beyond the system boundary;
  - Use of noncombustible exterior walls with no openings and a minimum 2-hour fire resistance rating;
  - Demonstrated performance through fire and explosion testing showing no harmful radiant heat sufficient to ignite nearby exposures; and
  - Installation of a 2-hour, fire-rated enclosure for the BESS itself.
- Means of egress: Outdoor BESS installations must maintain at least a 10-foot separation from all building egress components, including exit access paths and discharge areas, unless reduced clearance (minimum of 3 feet) is approved by the AHJ based on validated fire performance data. This requirement ensures safe evacuation during an emergency. Egress separation is typically not applicable to unmanned utility buildings.
- Vegetation clearance: All outdoor BESS installations must maintain a minimum 10-foot clearance from combustible vegetation on all sides. While decorative plants like grass, isolated trees or shrubs are permissible, they must not pose a fire spread risk. Additionally, the height and proximity of trees should be evaluated to prevent fall hazards or increased fire exposure to the BESS equipment.

4.4 Deployment

Deployment encompasses project phases between initial conception and full operation, including engineering and design, installation and construction, and commissioning stages of development. The engineering and design stage primarily occurs before regulatory review and licensing. Once a project receives all necessary approvals, engineering and design work is finalized and construction begins. Simultaneously, the commissioning process starts as developers prepare equipment and assess BESS components for functionality. The below sections outline nationwide best practices for deployment stage processes.

4.4.1 Engineering and Design

During the engineering stage, developers design the project in accordance with the best available information regarding applicable codes and standards established by the RTO, local utility, and state and local authorities. Project engineering and design typically begin up to three years prior to any regulatory review with a series of site studies and assessments. Revisions to engineering studies and final design continue throughout the regulatory and permitting processes.

When designing a project, developers consider a variety of BESS characteristics, such as battery type, required infrastructure (wiring, breakers, fire system), physical system size, energy and power ratings, thermal management, and more.[63] (See Chapter 3 for additional discussion of these considerations.) These design characteristics can be determined in-house, but are typically outsourced to a third-party firm and addressed in an Independent Engineering Report.[64]

The developer also studies the proposed project site and conducts environmental review and socioeconomic studies. Certain studies are required from state or local regulatory bodies, while others simply inform the developer of the best project design. Some common studies include the Environmental Site Assessment, Site Survey, Biological Resource Review, Geotechnical Report, Soil Report, Cultural Resources Analysis, Water Delineation Study, and Wetlands and Water Survey. However, not all of these studies are relevant or required for each project. It typically takes 2-3 years to complete all studies. While this takes place, the developer revises designs and seeks local regulatory reviews.

Developers regularly undertake these processes and may be evaluating multiple areas at the same time for suitability. Conceptual site plans and related design factors go through numerous renditions as engineers receive feedback from studies, local planning and zoning boards, system operators, and other stakeholders.

Throughout these processes, developers consider the potential costs and revenues for a project to assess project viability. Revenue considerations include arbitrage opportunities, ancillary services, peak shaving, capacity revenues, and energy revenues. (These opportunities are addressed further in Chapter 3.) Cost considerations include legal and regulatory costs, land lease or purchase costs, equipment costs, labor costs, and grid upgrade costs. (These costs are described further in Chapter 5.)

4.4.2 Construction and Installation

The construction of a BESS entails project development, procurement of equipment, construction design, finalization of site drawings, contractor and workforce retention, and the actual building of the facility.

Most developers use Engineering, Procurement, and Construction (EPC) services through which they issue an RFP to hire an independent firm that oversees final design, procurement, and construction. EPC providers help manage risk by securing specialized professionals for various project components. These providers coordinate development through subcontractors and suppliers and ensure that appropriate levels of expertise are applied to various aspects of the project.[65] Developers sign EPC contracts approximately 15 months prior to commercial operation.

Equipment procurement typically begins once the project receives all regulatory approvals, as certain design components may depend on permits. Supply chain issues may delay procurement and, subsequently, construction and installation. (See Chapter 6 for additional discussion.)

Installation standards are largely guided by the National Electrical Contractors Association (NECA) 416 standard, Recommended Practice for Installing Energy Storage Systems. NECA 416 provides best practices for BESS installation, but should be cross-referenced with local codes and standards, as local standards may not reflect the latest version of NECA 416 or may call for additional measures.[66]

Barring delays in the regulatory process and supply chain issues, project construction and installation typically take 6-20 months depending on the size of the facility and other project specifications. However, in Indiana, the above challenges contribute to delays in construction start dates, sometimes pushing back original estimates of commercial operation dates by years. For example, the Cherry Hill project (see IURC Cause No. 45863), was originally proposed with a commercial operation date of December 2025. However, the most recent informational filing projects a commercial operation date of December 2027.[67] Similarly, in the Fletcher Power cause, the original filing projected a commercial operation date of November 2025. The most recent informational filing projects a commercial operation date of January 2027.[68]

4.4.3 Commissioning

Commissioning involves various reviews intended to ensure proper BESS operation. Organization and planning of the commissioning process begins during project design. This ensures that the personnel conducting the commissioning tests possess the relevant designs, equipment details, drawings, and codes and standards. In accordance with HEA 1173

(2023), IDHS reviews a project's commissioning plan and tests for compliance with NFPA 855. IDHS may approve or reject a project based on its compliance with this standard. The full commissioning process typically includes the following steps:[69]

- Step 1: Factory Acceptance Test (AT): Review of BESS components from the vendor before they are shipped to the project site.
- Step 2: Design verification: Review of BESS components, equipment, and project site to ensure each correlates with the design and can pass necessary inspections.
- Step 3: Operation Acceptance Test (OAT): Conducted after equipment is installed to verify that the individual components work appropriately.
- Step 4: Equipment start-up test: Confirms that the components operate together as designed. At this stage, the developer will also record baseline metrics of the BESS and any potential errors in measurements.
- Step 5: Functional Acceptance Test (Func. AT): Verifies that the BESS operates as specified in plans and designs once connected to the grid. This includes the ability of the BESS to respond to grid signals and perform at pre-established metrics.
- Step 6: Shakedown: Final test to address and resolve all remaining errors prior to full deployment.

Once the BESS passes all tests, the project can be put into operation. The project is considered "in service" when it can function but is not yet in use. There is a 60- to 90-day testing period for final commissioning tests (i.e., shakedown) and associated system adjustments prior to project operation. The project is operational when it can be used to store and deploy energy. Figure 10 visually depicts all major commissioning steps in order.

Commissioning occurs simultaneously with construction and installation, with certain tests run as equipment is installed to ensure functionality. Once construction is complete, further commissioning occurs, for 1-3 months, prior to commercial operation. Original estimates of commercial operation, provided to the IURC and the public, can be deferred up to two years due to permitting, sourcing, or contractual delays.

Figure 10. BESS Deployment Steps

4.5 End of Life

According to climate and stress simulations conducted by the National Renewable Energy Laboratory (NREL) in 2017, the typical lifespan of a grid-connect battery module is 7-10 years.[70] However, battery module lifespans are more often measured in cycles than years. On average, Li-ion BESS last 3,000 cycles at 80% depth of discharge (DOD). DOD and number of cycles have an inverse relationship, meaning as DOD increases, number of cycles decreases.[71] In general, BESS capacity does not degrade linearly. Rather, degradation increases rapidly as the battery approaches EOL.[72] When battery modules are replaced or otherwise augmented, the life of the overall BESS can be extended.[73]

Since most existing utility-scale BESS deployments in Indiana (and elsewhere) only began operating in recent years, there are limited examples of actual EOL procedures. Nevertheless, preparing for a battery's EOL can begin even prior to regulatory approval, with the review and/or approval of decommissioning plans by local governments, IDHS, and IURC.

As the BESS reaches EOL, the developer and project owner may choose to replace battery modules or other components to extend the operational life of a BESS. Absent this action, the facility will be decommissioned using predetermined and approved procedures. Decommissioning entails shutting down the BESS, removing it from service, and disassembling physical system components. Once decommissioned, the BESS components are either recycled or disposed of at appropriate facilities.[xxxvii] Developers are also responsible for restoring the project site to pre-system conditions. Best practices for each EOL stage are further addressed below.

4.5.1 Decommissioning

Indiana addresses decommissioning requirements for several energy technologies through existing laws. For example, Indiana Code § 8-1-42-18 addresses decommissioning, restoration, financial security, and other EOL requirements for commercial solar facilities. No similar provisions exist for BESS.

Under current IURC regulatory processes, BESS projects are generally required by the IURC to execute a Decommissioning Agreement with the local government as part of the IURC's Order granting the utility or IPP the ability to move forward with the project. These agreements outline the steps taken in the decommissioning process and financial assurances that the project owner has the funds to properly decommission the project at EOL. Decommissioning agreements are filed with the IURC either as part of an application or in a subsequent quarterly filing, once the

[xxxvii] The recycling of BESS, and of other energy systems, presents economic and industrial opportunities in Indiana that are separately addressed in Chapter 6.

local government has approved the agreement.

Decommissioning Steps

There are seven general steps to decommission a BESS project:[74]

1. System disconnection: The battery is disconnected from the grid before removal begins, usually by contacting the grid operator. Once disconnected, any remaining cables or wires are immediately removed for safety reasons.
2. Right of way: Removing a BESS can require heavy-duty equipment such as cranes and trucks. Bringing this equipment to the BESS site requires communication with local governments and neighboring property owners to secure rights of way and avoid potential traffic issues.
3. Battery removal: After disconnecting the battery from the feeder circuit and arranging access for required equipment, the battery is then physically removed. Timing and equipment required for this step can vary depending on the number of modules. If the modules are larger or more numerous, battery handlers may rely on forklifts or cranes.
4. Packaging: The U.S. Department of Transportation (DOT) oversees requirements for packaging and shipping batteries. Specifically, Title 49 includes requirements such as inner/outer packaging, weight limits, size-specific exemptions, appropriate package markings, and other transportation protocols.
5. Transportation: Once packaged and labeled, the battery is then transported. Hazardous materials management (HAZMAT) workers may be required to determine how hazardous the batteries are and complete shipping papers for transporters.
6. Recycling: Upon arrival at the recycling facility, the battery may be recycled for raw materials or repurposed for other tasks such as backup storage.
7. Record retention: As required by state and federal law, all stages of the above process are logged. Related documents are filed with the appropriate authorities to mark completion of the decommissioning procedure.

Before disconnection, BESS must be fully discharged to avoid a stranded energy hazard. Once the battery is fully discharged, the materials are considered "hazardous waste," as opposed to a battery, for disposal purposes. Beyond the above steps, land restoration may also be part of decommissioning, depending on the original scope of the project. Restoration can include fence and foundational structures removal, planting native vegetation, and controlling runoff, among other remediation.

Causes of BESS Degradation

Several factors contribute to battery degradation over the course of a BESS's useful life. One primary cause is cycling; the repeated charging and discharging of a battery causes chemical and physical changes within the battery cells. This leads to the gradual breakdown of electrode materials, diminishing the ability of the battery to hold a charge. These changes can eventually decrease the economic and technical capacity of a utility-scale BESS to support its originally intended application.[1] Besides cycling, other factors that commonly contribute to battery decline include:

- Temperature: Operating a BESS in extreme temperatures, particularly higher temperatures, can degrade the system faster.
- Depth of discharge: Discharging the BESS to low levels can decrease lifespan and performance by causing system stress and accelerating chemical breakdown.
- State of charge (SOC): Regularly storing amounts of energy above or below the optimal level of charge can reduce performance and lifespan by accelerating decomposition.

Various sources claim ideal temperatures, depth of discharge, and SOC for battery lifespan and performance. For example, prior studies have found that temperatures ranging between 59-77°F (15-20°C) are optimal for Li-ion batteries.[2] These factors are highly dependent on battery chemistry.

[1] Rhaman, T. & Alharbi, T. (2024). Exploring Lithium-Ion Battery Degradation: A Concise Review of Critical Factors, Impacts, Data-Driven Degradation Estimation Techniques, and Sustainable Directions for Energy Storage Systems. Batteries. 10. 220. https://www.researchgate.net/publication/381681019_Exploring_Lithium-Ion_Battery_Degradation_A_Concise_Review_of_Critical_Factors_Impacts_Data-Driven_Degradation_Estimation_Techniques_and_Sustainable_Directions_for_Energy_Storage_Systems.
[2] Xu, B., Oudalov, A., Ulbig, A., et al. (2016). Modeling of lithium-ion battery degradation for cell life assessment. *IEEE Transactions on Smart Grid*, *9*(2), 1131-1140. https://ieeexplore.ieee.org/document/7488267.

Decommissioning Costs

Decommissioning Agreements outline how the project owner will fund the removal and disposal of the BESS at EOL. Typically, the project owner will propose, and local governments will approve, milestones as to when a portion (e.g., 25%, 50%) and all (100%) of the decommissioning costs will be secured during the course of the BESS's lifespan. These costs, encompassing the above-listed seven steps, depend on the BESS size and chemistry.

A study conducted by the Electric Power Research Institute (EPRI) based on a hypothetical 20-MW/10-MWh BESS located in California estimated total decommissioning costs at $1.2 million (2030$). This total includes the dismantling and packaging of the BESS components ($348,000),[xxxviii] removal of BESS components from the site ($292,000),[xxxix] and recycling ($545,500).[75] Recycling costs are partially offset by salvage value.[xl,76] Dismantling offsite can potentially lower these costs due to lower labor costs, less travel time to the project site by decommissioning personnel, and greater efficiencies from the use of dedicated recycling facilities.[77]

In Indiana, most BESS projects' Decommissioning Agreements include a provision that a professional engineer be hired to make decommissioning cost estimates five years after the project is commercially operational. These estimates inform the project owner's financial assurances.

4.5.2 Recycling

Recycling typically entails removing useful BESS components, such as key minerals, and preparing them for reuse. Alternatively, recycling also includes steps to prepare diminished capacity battery systems for reuse as part of alternative applications. Due to reduced capacity and safety concerns (see Chapter 5), aging batteries cannot handle the load and stress of grid use.[78] These batteries, however, can be used for less demanding roles. For example, a module that is no longer suitable for grid applications may still be deployed behind-the-meter as backup generation that requires infrequent cycling.

Interest in battery recycling has risen in recent years due to a variety of reasons, including in response to an increase in battery deployments; a sharp rise in battery material cost—especially lithium, nickel, and copper—between 2021-2023; and interest in reducing reliance on mineral supply chains that are based abroad (see below), and instead increasing domestic supply options. The emergence of a market for recycled BESS resulted in a variety of firms entering with various proposed approaches to extract valuable component parts from decommissioned systems.

The global market for BESS recycling is estimated to grow to approximately $95 billion by 2040 according to a McKinsey study.[79] Although the electric vehicle market is responsible for most of this growth, other Li-ion-based equipment like utility-scale BESS have nearly identical recycling processes, allowing for utilities and IPPs to benefit from the growth of a larger recycling supply chain.

Recycling Approach: Pyrometallurgy

Pyrometallurgy, or smelting, is the process of melting down resources in a specialized furnace to extract certain materials. Since smelting is a relatively old and straightforward approach to material extraction, it has both scalability and cost advantages compared with other BESS recycling methods. Many pyrometallurgy steps have already been optimized for battery recycling. One issue with pyrometallurgy for BESS is that lithium recovery is minimal; during the melting process, lithium either volatizes or oxidizes.[1] Pyrometallurgy also processes pollutants, such as carbon tetrafluoride, and is relatively energy-intensive.[2]

[1] Rinne, M., Lappalainen, H., & Lundström, M. (2025). Evaluating the possibilities and limitations of the pyrometallurgical recycling of waste Li-ion batteries using simulation and life cycle assessment. *Green Chemistry*. https://pubs.rsc.org/en/content/articlelanding/2025/gc/d4gc05409a.
[2] Stegemann, L., & Gutsch, M. (2025). Environmental Impacts of Pyro- and Hydrometallurgical Recycling for Lithium-Ion Batteries-A Review. *Journal of Business Chemistry*, *22*(1). https://www.businesschemistry.org/article/4899-2/.

Recycling Approach: Hydrometallurgy

Hydrometallurgy focuses on chemical reactions to extract specific metals. For a battery, the first step is shredding the battery into much smaller components. Then, strong acids, such as dilute sulfuric acids, are added to segments of the battery. These acids separate the targeted materials from other battery components in a process known as "leeching." Once separated, the metals are categorized as "useful recoveries" or "waste." Lastly, the useful metals are recovered and reused. For example, lithium can be isolated and extracted.

Currently, hydrometallurgy is limited in the U.S. and has not seen any large-scale output. A major drawback with hydrometallurgy is the waste created during the above chemical processes, which requires additional treatment. Additionally, since hydrometallurgy involves complex chemical processes, there are more risk vectors, such as chemical leaks due to acidic corrosion.[1] Hydrometallurgy, however, is more sustainable compared to pyrometallurgy. Not only does it have a higher material recovery rate, but it also emits fewer emissions and requires less energy. Since hydrometallurgy has a much higher lithium recovery rate, it is expected this process will continue to grow and gain market share.[2]

[1] Jain, S., Hoseyni, S.M., & Cordiner, J. (2024). Safety considerations for hydrometallurgical metal recovery from lithium-ion batteries. *Process Safety Progress*, *43*(3), 542-549. https://www.researchgate.net/publication/380485106_Safety_considerations_for_hydrometallurgical_metal_recovery_from_lithium-ion_batteries.
[2] Davis, K., & Demopoulos, G. P. (2023). Hydrometallurgical recycling technologies for NMC Li-ion battery cathodes: current industrial practice and new R&D trends. *RSC Sustainability*, *1*(8), 1932-1951. https://pubs.rsc.org/en/content/articlehtml/2023/su/d3su00142c.

[xxxviii] On-site dismantling and packaging costs include the disconnection of the BESS, removal of the battery model and surrounding equipment (container, transformer, and other infrastructure), and post-removal clean-up of the project site.
[xxxix] Transportation costs include the removal and transportation of said battery model and related equipment and the rental of construction equipment, such as cranes, and trucks.
[xl] The salvage value of a BESS is not presented separately in EPRI's analysis.

Indiana Recycling

In recent years, Indiana has taken initiative to improve BESS recycling operations. The most notable development is Indiana Code § 13-20-16-4, which provides guidelines and procedures to manufacturers and distributors about transporting and recycling lead-acid batteries. The state has shown interest in expanding further into the recycling industry through the Recycling Market Development Program (RMDP), overseen by IDEM and established through IC § 4-23-5.5.[80] The RMDP recently awarded over $3 million in grants to expand recycling industries in Indiana, including $900,000 awarded to American Metals for equipment to process batteries and similar materials.[81] Other battery recycling initiatives are focused on smaller batteries, such as those used in cellphones and other small appliances. Indiana has the potential to expand its recycling practices and infrastructure given the state's major metal, chemical, and manufacturing industries. (See Chapter 6 for additional economic development opportunities related to recycling.)

Recycling Best Practices and Outlook

As with decommissioning, best practices in the U.S. for BESS recycling are still emerging since most BESS have not yet reached EOL. One incentive for recycling is the creation of Extended Producer Responsibility (EPR) requirements at a state level. For example, in 2022, California passed Assembly Bill (AB) 2440 and Senate Bill (SB) 1215,[82] both of which expanded already-in-place EPR practices to encompass electronic waste.[xli] These bills require manufacturers to create or fund stewardship programs that limit battery waste. Other states, such as Illinois and Washington, also have EPR requirements applicable to small-to-medium or otherwise portable battery recycling.[83] Notably, California extends its EPR requirements to batteries of all chemistries. This framework ensures that as technology evolves, waste is still reduced.

Besides lifecycle management regulation, states can support recycling with financial incentives. California, for example, funds BESS recycling efforts through its Electric Program Investment Charge program under the state Energy Research and Development division. Specifically, the program awards funding for Li-ion battery reuse and recycling advancement with the goal of reducing recycling costs.[84] This program is similar to the above-mentioned RMDP in Indiana. These efforts support domestic supply chain creation and the expansion of industrial recycling capabilities.

The federal government also provides regulatory guidance and financial support regarding BESS recycling. The U.S. Environmental Protection Agency (EPA) regulates BESS recycling and disposal through hazardous waste regulations, and the DOT oversees

SungEel Recycling Park

In mid-2023, South Korean battery recycling company SungEel announced plans to establish a recycling park in Whitestown, Indiana.[1] The hub will focus on recovering key minerals from lithium-ion batteries to help supply EV batteries. These materials include lithium, cobalt, and nickel. SungEel strategically selected Whitestown due to its interconnectedness with the Midwest and the East Coast. Moreover, the robust highway system in Indiana allows for easy travel to Canada and Mexico, which are becoming EV battery manufacturing hubs.[2]

SungEel opened an initial facility in March 2025 with a nameplate capacity of 20,000 tons of cell scrap per year. The company plans to expand capacity to 40,000 tons annually.[3] At full capacity, the plant is expected to help supply 100,000 EVs with battery materials. Shown in the figure below is the newly constructed SungEel Recycling Park.

Notably, SungEel intended the Whitestown plant to be its second U.S. location, after having previously announced plans to develop a facility in Georgia. The company recently reassessed and canceled the planned facility in Georgia, citing declining interest in EVs.[4]

[1] Lee, S. (2023). SungEel HiTech to build battery recycling park at Indiana. THE ELEC. https://thelec.net/news/articleView.html?idxno=4628.
[2] PR New Square. (2024). Korean battery recycling company SungEel HiTech to build 'North American Recycling Park'. https://prnewsquare.com/news/industrial/electronic/sungeelhitech-northamerican-recyclingpark.
[3] Benchmark. (2025). SungEel begins operations in the US and cancels JV in Germany – Benchmark Black Mass. https://www.benchmarkminerals.com/recycling/sungeel-begins-operations-in-the-us-and-cancels-jv-in-germany-benchmark-black-mass
[4] Dorsett, C. SungEel Pulls Plans for Plant in Stephens County. 92.1 WLHR Lake Hartwell Radio. https://921wlhr.com/sungeel-pulls-plans-for-plant-in-stephens-county/.

SungEel Recyling Park in Whitestown, Indiana
Source: SungEel HiTech LinkedIn. SungEel HiTech Begins Operations at Indiana Recycling Park. https://www.linkedin.com/feed/update/urn:li:activity:7306115766666334208/.

[xli] Extended Producer Responsibility (EPR) is an environmental policy that assigns the responsibility for EOL products to the producer.

transportation of hazardous waste.[85] The federal government has also enacted a variety of incentives to advance battery and recycling technology, though funding levels are subject to change.[86,87,xlii]

Public-private partnerships are key in supporting the expansion of in-state BESS recycling, as the private sector can provide specialized knowledge with pre-established resources to complement public sector regulation and funding. A prominent example of public-private partnerships is Cirba Solutions, a battery recycling and management company, and its funding from DOE through the Bipartisan Infrastructure Law.[88] In 2024, Cirba received grants totaling $75 million to expand its Li-ion recycling factory in Lancaster, Ohio.

Including existing and proposed plants, the U.S. has a recycling capacity potential of 1.3 million electric vehicle (EV)-equivalent batteries once all projects are fully operational.[89] The recycling technologies adopted by current and proposed facilities vary. Future efforts to support a recycling industry in Indiana should remain methodology-agnostic in order to allow for the emergence of a preferred market solution among competing approaches.

4.6 Material Extraction and Manufacturing

Conventional energy generation (e.g., coal-fired generation) and the electric grid (e.g., substations) have long relied on minerals such as copper, nickel, aluminum, and chromium.[90] These resources, however, have historically accounted for only a modest share of global mineral demand. The ongoing energy transition is expected to increase the energy sector's demand for a wide range of minerals. Minerals play a vital role in virtually all emerging energy technologies; solar photovoltaic (PV) plants, wind farms, and batteries used in BESS installations and EVs require significantly more minerals for their operation than their conventional counterparts.[xliii] Among these minerals, lithium stands out as one of the most critical minerals for battery technologies, as it is a key component in the Li-ion chemistries that dominate utility-scale BESS. In addition to lithium, batteries also rely heavily on nickel, cobalt, manganese, and graphite.

4.6.1 Key Minerals and Their Uses

The following subsections provide detailed descriptions of the primary materials used for BESS technologies, highlighting their specific applications, usage patterns, and sourcing information relevant to the United States.

Lithium

In 2024, 87% of global lithium consumption was for the production of Li-ion batteries used in energy storage, EVs, power tools, and portable consumer electronics, as depicted in Figure 11.[91]

The U.S. imported 3,300 tons of lithium for consumption in 2024, with 50% of total imports coming from Chile and 47% from Argentina, based on data from 2020-2023. U.S. production and consumption of lithium was not reported in the U.S. Geological Survey Mineral Commodity Summaries 2025 (2025 USGS Report) to avoid disclosing company proprietary data.

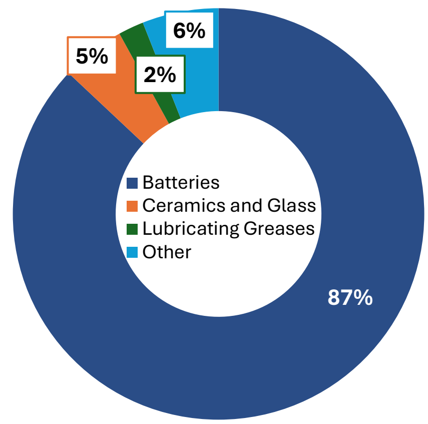

Figure 11. Global Lithium Consumption by Use

Graphite

The major uses of natural graphite in 2024 were batteries, brake linings, lubricants, powdered metals, refractory applications, and steelmaking. Natural graphite was not produced in the U.S. in 2024, and instead was imported from China (43%), Canada (13%), Mexico (13%), Mozambique (13%), and other countries (18%). The United States consumed an estimated 52,000 tons of natural graphite in 2024.

Nickel

The leading uses for nickel in the U.S. in 2024 were alloys and steels, electroplating, and other smaller uses, including catalysts and chemicals. Alloy steel and nickel-containing alloys accounted for more than 85% of consumption according to the 2025 USGS Report. In 2024, the U.S. produced an estimated 8,000 tons of nickel in concentrate, all of which was exported, and imported an estimated 100,000 tons of primary

[xlii] Under the Biden Administration, several initiatives, such as the Critical Minerals Collaborative and the Electric Drive Vehicle Battery Recycling and Second Life Applications Program, promoted research and development into supply chain improvements and post battery decommissioning practices. Additionally, credits such as the Qualifying Advanced Energy Project Tax Credit and financial support available through Innovative Energy Loans supported the development of more advanced battery designs and battery materials factories. DOE's American Made program also sought to incentivize U.S.-based recycling through its U.S. Battery Recycling Prize, totaling $5.5 million, which was meant to spark innovation and introduce collaboration across industries and sectors. The continued availability of these initiatives will depend on federal policy priorities during the Trump and future administrations.

[xliii] For example, an onshore wind plant demands nine times more mineral resources than a gas-fired plant. See: The Role of Critical Minerals in Clean Energy Transitions Executive Summary. International Energy Agency.

Domestic Supply Chain

Li-Bridge, led by the Argonne National Laboratory (ANL), is a public-private partnership intended to support the development of a domestic battery value chain in the U.S.[1] Through Li-Bridge, ANL serves as the middleman between private battery companies and the federal government's national laboratories. One of the most impactful results of ANL's partnership is the coordinated research and operations information between several private battery companies and the Federal Consortium for Advanced Batteries. This effort helped produce the National Blueprint for Lithium Batteries, which includes key objectives for the U.S. to develop domestic Li-ion manufacturing capabilities.[2]

[1] See: Argonne National Laboratory. *Li-Bridge – Bridging the U.S. Lithium Battery Supply Chain Gap.* https://www.anl.gov/li-bridge.
[2] Federal Consortium for Advanced Batteries. *National Blueprint for Lithium Batteries 2021-2030, Executive Summary*. https://www.energy.gov/sites/default/files/2021-06/FCAB%20National%20Blueprint%20Lithium%20Batteries%200621_0.pdf.

nickel from Canada (46%), Norway (11%), Australia (5%), Brazil (6%), and other countries (29%) based on data from 2020-2023.

Cobalt

In 2024, cobalt was used in the U.S. for superalloys (51%), mainly in aircraft gas turbine engines; chemical applications (25%); various metallic applications (15%); and cemented carbides for cutting and wear-resistant applications (9%). While production data is not available in the 2025 USGS Report, the U.S. imported an estimated 11,000 tons of cobalt for consumption from Norway (27%), Finland (17%), Japan (14%), Canada (13%), and other countries (29%).

Manganese

Between 85-90% of demand for manganese in the U.S. comes from steelmaking. Other uses include the production of animal feed, brick colorant, dry cell batteries, and fertilizers. Manganese ore with 20% or more manganese has not been produced in the U.S. since the 1970s. In 2024, the U.S. imported and used an estimated 320 tons of manganese ore and concentrates. Imports were from Gabon (63%), South Africa (23%), Mexico (13%), and other countries (1%).

4.6.2 Global Production, Reserves, and Ownership

The global extraction of minerals is characterized by significant geographic concentration and ownership discrepancies, highlighting potential vulnerabilities related to geopolitical tensions, supply disruptions, and trade restrictions. Appendix F summarizes global production, reserves, and ownership distributions for reserves for lithium, cobalt, nickel, manganese, and graphite using data from the 2025 USGS Report and a study conducted by Greitemeier, et al. (2025).[xliv,92] The tables in Appendix F illustrate the substantial control held by countries such as China and the United States over mineral resources located internationally. For instance:

- The U.S. and China hold significant ownership stakes in Australia's lithium mining operations.
- China controls 86.73% of Indonesian nickel mining and 47.16% of cobalt mining operations in the Democratic Republic of the Congo (DRC).

This disparity between mine location and ownership raises concerns about sustainability and geopolitical stability. For example, China's ownership of Congolese cobalt mines originated from a 2008 infrastructure-for-minerals agreement. The agreement was renegotiated in 2023, but challenges persist regarding transparency and accountability for infrastructure investment by China in the DRC.[93]

4.6.3 Environmental and Social Implications

Increased mineral extraction introduces numerous environmental and social challenges. Brine-based lithium mining, for example, involves pumping saline water to the surface and evaporating the water to concentrate the lithium. This process consumes extensive water resources—approximately 2 million liters per ton—exacerbating water scarcity and displacement of communities, notably in regions like Chile.[94]

Additionally, critical mineral extraction often occurs near ecologically sensitive areas, protected habitats,[95] and indigenous territories,[96] risking habitat destruction, biodiversity loss, pollution, and infringement upon indigenous rights. Given forecasts from the International Energy Agency that demand for critical minerals will triple by 2040 to meet global goals,[97] these environmental and social risks intensify concerns over sustainable and ethical mining practices.

Organizations like the United Nations Environment Programme emphasize that sustainable mineral extraction, guided by robust policies and safeguards, can significantly support economic development and poverty reduction. Additionally, promoting circular economy practices such as those described above can alleviate some pressures of increased extraction. Amnesty International further recommends leveraging corporate responsibility to enforce ethical sourcing practices throughout supply chains.[98] Collectively, these strategies represent pathways toward sustainable management of the mineral resources used in BESS and other clean energy technologies.

Process to Open a BESS Recycling Facility

The pathway to develop a BESS recycling center—from project announcement to operational status—varies greatly depending on facility size, the BESS chemistries processed, the recycling approach used, and the developer's level of readiness. Nevertheless, there are general steps that each prospective facility developer must follow.

First, the developer must identify a potential site with appropriate land use zoning and other beneficial characteristics, such as proximity to transportation infrastructure. Once a suitably zoned site has been selected and approved, the developer must initiate the process of securing several environmental permits.

Currently, the IDEM Office of Air Quality (OAQ) requires all stationary sources to obtain one of three permits:[1]

1. Part 70 Operating Permit (Title V Permit): Required for major sources exceeding pollutant thresholds under the federal Clean Air Act.
2. Federal Enforceable State Operating Permit (FESOP): Applicable when the developer agrees to limit the potential to emit (PTE) to levels below the Title V pollutant threshold.[2]
3. Minor Source Operating Permit (MSOP): Applicable to projects with relatively low emissions.

Additionally, if the recycling facility intends to discharge treated wastewater from chemical processing such as hydrometallurgy, it must file a National Pollutant Discharge Elimination System Permit with IDEM's Water Quality division. Much of the development timeline will be driven by the air and water permitting processes.

Once permits are in the final stages of approval, construction may begin. For reference, SungEel HiTech, a Korean battery recycling company, began operations at its Whitestown recycling park within a year of permit approval and within roughly two years of announcing the project in August 2023.

[1] A stationary source refers to a facility that is sited in a single location with no intentions to relocate, and contains at least one emission unit such as an industrial boiler.
[2] PTE/potential to emit: the maximum capacity of a facility to emit air pollution under the facility's design.

5. SAFETY CONSIDERATIONS

5.1 Executive Summary

The rapid growth of BESS installations, particularly those using lithium-ion chemistries, has elevated the importance of ensuring robust safety, security, and emergency response strategies. This chapter explores certain risks associated with BESS technologies and best practices for mitigating those risks.

Key findings and insights from this analysis include:

- BESS safety risks are real but manageable. While utility-scale BESS failure incidents remain rare, even infrequent events can carry significant consequences. Consistent adherence to all required safety measures outlined in HEA 1173 (2023), including compliance with NFPA 855 and emergency response planning, will be key to minimizing risk.
- Thermal runaway remains the most critical safety challenge. As Li-ion batteries dominate BESS deployments, thermal runaway remains the leading cause of catastrophic failure. Emergency response planning should prioritize early detection, containment strategies, and coordination between system operators and emergency responders. IDHS should develop guidance to assist local fire departments in reviewing site-level safety protocols.
- Physical and cybersecurity must be prioritized. Indiana currently lacks formalized state guidance on physical and cyber threat mitigation for BESS. Local officials should consider requiring fencing, surveillance, and access control. The state should explore whether existing regulation or statutory authority allows it to require the use of cybersecurity best practices, aligned as applicable with National Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) standards and DOE guidelines. Cybersecurity expectations for BESS should be at least consistent with those for other critical energy technologies.
- Local facility design requirements should reflect industry best practices. Indiana planners should encourage (or require) containerized modular enclosures equipped with advanced ventilation, fire suppression, and explosion mitigation features. Local ordinances or zoning board approvals can be used to ensure projects meet or exceed design minimums, especially in populated or high-consequence areas.
- Setbacks and buffer zones should be uniformly applied. Local planning authorities should use existing tools, such as UL 9540A test data and NFPA 855 separation requirements for BESS containers, to establish setback distances and buffer zones for BESS installations. Siting projects on brownfields or co-locating them with substations may offer additional safety and land-use benefits.
- Emergency preparedness requires stronger state and local coordination. While HEA 1173 (2023) requires BESS operators to offer training and submit emergency response plans, recent discussions between Exeter and IDHS suggest these trainings are often underutilized. Indiana should consider making such training mandatory for local fire departments in proximity to BESS at the developer's expense. Other strategies could include embedding battery experts within emergency response teams and/or training regional BESS safety liaisons.
- Indiana's regulatory approach to BESS safety must remain adaptive. Lessons learned from past BESS safety incidents demonstrate the need for proactive, forward-looking safety policies capable of evolving alongside safety standards and industry best practices. One approach could be the creation of a BESS Safety Standards Advisory Panel, coordinated by IDHS, to evaluate new standards, issue interpretive guidance, and provide technical recommendations to counties and municipalities.

5.2 Introduction

BESS technologies have seen dramatic growth in usage across the United States, as documented in Chapter 3. However, certain high-profile incidents at utility-scale BESS facilities, discussed below, have raised local and community-level concerns about the safety of BESS installations. In response to this concern, the Indiana Assembly passed HEA 1173 (2023), codified in IC Section 22-14-8-6, which adopted NFPA's BESS safety standards. It also delegated utility-scale BESS permitting regulatory responsibility to IDHS and tasked IDHS with the enforcement of safety standards.

Even with IDHS playing a role, however, the bulk of safety considerations falls to local planning authorities, many of which have limited experience with BESS safety. As a result, it is essential to understand the key failure modes, hazards, and risks associated with these systems, and strategies for minimizing these risks.

This chapter's goal is to provide readers with a clear, accessible understanding of the multiple dimensions of battery energy storage safety and security. It begins with an overview of common BESS hazards, followed by an explanation of failure modes for BESS technologies. This leads into a discussion of the risks commonly associated with BESS installations from both a safety and security standpoint. Then, the chapter covers best practices for mitigating safety, security, and risk concerns for BESS installations, including emergency response plans and training strategies for emergency responders. It concludes with additional discussion of thermal runaway as a topic of interest to state and local stakeholders involved in safety.

While the subsequent text does touch upon multiple battery technologies in nascent stages of development, it focuses on assessing safety considerations for Li-ion batteries, the predominant BESS technology.[xlv] Additionally, the bulk of the discussion focuses on front-of-the meter utility-scale BESS applications, as distinct from small-scale and behind-the-meter. Distinctions between utility-scale and small-scale BESS safety are briefly addressed toward the conclusion of the chapter. All codes, standards, and guides mentioned in this chapter are defined in Appendix G.

5.3 Potential BESS Hazards

There are a variety of hazards posed by BESS technologies that can contribute to safety incidents. Safety hazards associated with BESS installations—particularly those using Li-ion battery technology—include "stranded" energy in damaged batteries, off-gassing, deep-seated fires within battery modules, and thermal runaway.

5.3.1 Stranded Energy

When a battery with a partial or full charge gets damaged to a point where it cannot be safely discharged, the stored energy in that battery is said to be "stranded energy." Stranded energy can lead to delayed ignition or re-ignition of the battery—either after an initial fire has been extinguished or following non-fire damage, such as mechanical impact. The presence of stranded energy can pose risks to anyone that handles or works with damaged batteries, as the stranded energy poses a shock hazard.

5.3.2 Off-Gassing

When batteries undergo thermal runaway or are otherwise damaged, abused, and/or misused, they can release flammable and toxic gases. This release of gases is called "off-gassing," and it can pose several safety hazards, including the risk of fire, toxic exposure to first responders or facility personnel, and the potential for explosion if flammable gases accumulate and ignite. Common examples of gases released by various BESS technologies include carbon monoxide, carbon dioxide, hydrogen, methane, ethane, and other hydrocarbons. The type and quantity of gases released depends on battery chemistry and type.

5.3.3 Deep-Seated Fires

BESS are commonly housed within protective casings made of metal or plastic within larger cabinets. While these layers of protection serve a critical purpose for BESS safety by protecting the system from damage, they can also pose challenges when attempting to extinguish a fire in the batteries by preventing water from reaching the "seat" of the fire. Because of this, cooling off BESS fires can require copious amounts of water if the hottest part of the fire is difficult for water to effectively reach. As discussed in subsequent sections, it is often best practice for firefighters to adopt a non-intervention strategy and allow the fire to burn itself out, especially when the affected battery enclosure is isolated from adjacent units and poses no immediate threat of fire propagation. Non-intervention can also minimize risk to personnel and avoid an unintentional buildup of flammable gases.

5.3.4 Thermal Runaway

Thermal runaway is a chemical reaction within a battery cell where the rate of internal heat generation exceeds the battery's ability to dissipate heat, leading to a cycle of rapid, uncontrolled temperature and pressure increases (see Figure 12). A thermal runaway event can cause the affected battery to rupture, release flammable gases, and in some cases, ignite. If thermal runaway propagates through a module, flammable gases may build up within the BESS enclosure, creating the conditions for an explosion to occur if not adequately mitigated by venting, gas detection, deflagration panels, or other protective systems.

While thermal runaway is most commonly associated with Li-ion battery technologies—currently the predominant chemistry used in BESS—it can also occur in other battery types, including nickel-based and lead-acid chemistries. However, the mechanisms, likelihood, and consequences of thermal runaway vary by chemistry, with Li-ion batteries presenting the highest risk due to their high energy density and flammable electrolyte (see Figure 12). Additional considerations regarding thermal runaway are addressed at the end of this chapter.

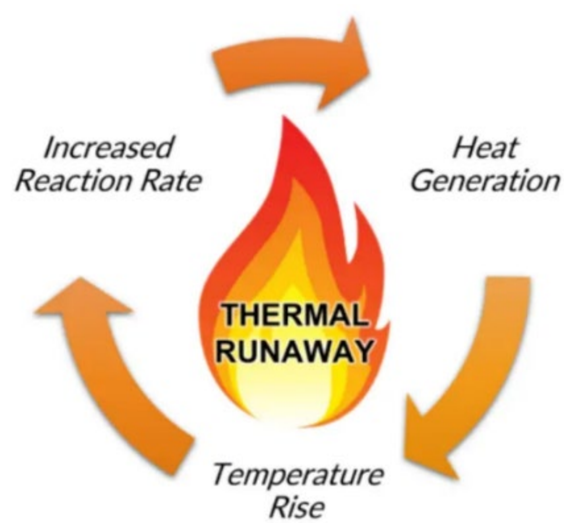

Figure 12. Thermal Runaway Cycle

Source: MoviTHERM. movitherm.com/blog/battery-thermal-runaway-risk-prevention/.

[xlv] Over 95% of all currently operable BESS installations in the U.S. utilize Li-ion batteries.

Contextualizing BESS Incident Frequency

Although BESS incidents have generated significant attention, large-scale BESS failure incidents remain statistically uncommon. Based on data from Form EIA-860 and the EPRI BESS Failure Incident Database, as of Q4 2023, there were approximately 4,996 operational Li-ion BESS projects (≥1 MW) in the U.S., with 16 failure incidents reported from 2012-2023, translating to a failure rate of 0.32%.[i] Failure rates are lower for newer systems than older systems.

[1] EPRI. BESS Failure Incident Database. storagewiki.epri.com/index.php/BESS_Failure_Incident_Database.

5.4 BESS Failure Modes and Consequences

There are a multitude of ways in which various BESS technologies can fail. Failure modes and consequences of failure are well-documented for Li-ion and lead-acid batteries. Some of the potential failure modes for alternative battery types, such as nickel-based and flow batteries, have also been documented; however, a lack of real-world deployments (and, therefore, failure occurrences) limits the availability of information. Table 6 and Table 7 summarize the major failure modes for utility-scale Li-ion and lead-acid BESS, respectively.[xlvi] These tables also highlight how each failure may lead to worst case outcomes, such as thermal runaway. In practice, the consequences of any particular failure can vary based on the cause, degree, and features of the failure. Additionally, as discussed in subsequent sections, many of these failures can be mitigated.

Other BESS technologies, such as nickel-based, sodium-based, and flow batteries, have more limited real-world deployment and, consequently, existing literature on the failure modes and consequences of failure for these technologies is more limited. NFPA 855 discusses some potential failure modes and consequent hazards for nickel-based, sodium-based, and flow batteries.

In most cases, the failure modes of these technologies are similar or identical to those for Li-ion or lead-acid batteries. There are some exceptions; for example, flow batteries are generally less prone to thermal runaway due to their use of aqueous electrolytes and separation of stored energy from the battery cell itself. Additionally, nickel-based batteries pose lower safety hazards stemming from thermal abuse, as their operating temperature range is much wider.

Table 6. Failure Modes: Lithium-Ion Batteries

THERMAL ABUSE	Batteries used in Li-ion BESS must operate within manufacturer-specified temperature ranges; exceeding these limits can cause premature aging, malfunction, or complete failure, which in some cases can lead to fire and explosion. External heat sources, adjacent overheating cells, and environmental conditions can also create conditions for thermal abuse.
ELECTRICAL ABUSE	Overcharging, overdischarging, charging or discharging too rapidly, and external short circuits can lead to overheating, fire, and explosion in Li-ion BESS installations.
MECHANICAL ABUSE	Crushing, dropping, penetrating, or otherwise physically damaging a Li-ion battery can compromise internal components, including the separator, potentially causing an internal short circuit. Mechanical abuse may also lead to vent failure or uncontrolled gas generation, any of which can initiate localized heating and trigger thermal runaway.
INTERNAL FAULTS	Defects in design, materials, or manufacturing can cause internal failures, though the failure rate for Li-ion batteries is estimated at roughly one in a million.
ENVIRONMENTAL IMPACTS	Extreme temperatures, seismic activity, flooding, other natural disasters such as tornadoes, environmental debris, and rodent damage can lead to Li-ion battery failure.

[xlvi] Note that the terminology in these tables reflects language used by the National Fire Protection Association in its standards.

Table 7. Failure Modes: Lead-Acid Batteries	
SULFATION OF NEGATIVE PLATES	Lead sulfate crystals can form on the battery's negative plates when a lead-acid battery remains undercharged for long periods. If left unaddressed, these crystals can harden and become difficult to reverse, which increases internal resistance and reduces overall battery capacity. Chronic undercharging or repeated overdischarging can exacerbate this process.
ELECTROLYTE LOSS (DRY-OUT)	Loss of electrolytes caused by overcharging, excessive heat, and/or inadequate ventilation can lead to potential thermal runaway and fire risks.[1]
POSITIVE PLATE CORROSION	Corrosion of the positive electrode grid can lead to structural weaknesses, which increases the risk of internal short circuits. It can also cause high internal resistance within the battery, which ultimately leads to increased heat generation and a greater risk of thermal events.[1]
WATER LOSS	Water loss can be caused by overcharging, high ambient temperatures, and other factors. Water loss in a lead-acid battery can make it more susceptible to overheating and thermal runaway.[1]
ACID LEAKAGE	Battery acid leakage is often associated with thermal runaway events that compromise battery structure, but it can also result from overcharging, excessive heat, mechanical damage, or aging seals. In lead-acid batteries, internal pressure buildup or deterioration of the valve system can cause acid to escape the battery.

[1] Li, Z., Wang, Z., & Wang, L. (2020). Discussion of the relationship between failure and fire of valve regulated lead acid battery. In *E3S Web of Conferences* (Vol. 185, p. 01058). EDP Sciences. https://www.e3s-conferences.org/articles/e3sconf/pdf/2020/45/e3sconf_iceeb2020_01058.pdf.

5.5 Risks

5.5.1 Physical Security Risks

As with any energy installation, BESS face certain risks that are best addressed through physical security. Sandia National Laboratories (SNL), a research and development laboratory of the DOE, defines physical security as a "combination of physical protective measures and security procedural measures employed to safeguard personnel, property, operations, equipment, facilities, materiel, and information against loss, misuse, theft, damage, or destruction by disaffected persons (insiders), vandals, activists, extremist protesters, criminals (individuals and organized groups), terrorists (domestic, state-sponsored, and transnational), saboteurs and spies."[99] The typical strategy to mitigate physical risks is hardening, meaning the implementation of protective measures including physical barriers, secure enclosures, and access controls.

The susceptibility of BESS installations to physical risks is site-specific and varies according to size, technology, and space constraints. Utility-scale BESS installations are commonly housed in modular units, as depicted in Figure 13. These housing units protect the BESS from environmental factors (addressed separately below) and provide physical access control for the battery racks, power conversion systems, and other components. In other cases, BESS installations are housed within an indoor enclosure, which controls physical access via locked doors.

There are few existing guides that explicitly cover the topic of BESS physical security; currently, the most direct guide is the DOE Energy Storage Handbook (ESHB) (Chapter 18), which outlines industry best practices applicable to physical protection systems for energy storage facilities. Key industry best practices recommended by the DOE ESHB are summarized in Table 8.

Figure 13. Modular BESS Unit

Source: Dennis Schroeder, NREL 56318.

Table 8. Industry Best Practices for BESS Physical Protection Systems	
DETECTION AND ASSESSMENT METHODS	These may include fence vibration sensors, video surveillance monitoring, and motion sensors.
PERIMETER SECURITY	Perimeter security relies primarily on fencing and gated entry points, often reinforced with vehicle barriers to provide added intrusion resistance.
RESPONSE	For BESS installations in remote, rural locations, there is typically not an on-site response force. Instead, these locations rely on offsite law enforcement, with response times that vary according to the speed of dispatch communication and travel distance to the installation. At sites with on-site security teams, security personnel must comply with state and local weapon laws.
ACCESS CONTROL	Access controls at facility perimeters vary according to size, criticality of the facility, and proximity to a response force. Smaller sites frequently rely on simple padlocks and chain-link fences, while larger, higher-priority facilities may utilize badge or card swipe systems and PIN verification. These measures are sufficient to meet industry security standards.
MITIGATION	In the event of a successful attack at a BESS facility, effective strategies for mitigation are crucial in preventing cascading issues that affect the broader power grid. If a successful attack focuses on components of the BESS other than the control house, then the control house can reroute power and prevent cascading failure. If the control house is attacked or compromised, rapid detection of the compromise and communication to the grid operator is crucial for shutting down the site and redirecting power.
FIRE SUPPRESSION	Internal and external fire suppression are also crucial aspects for mitigation of physical risk and resilience.

Source: Johnson, J., Hoaglund, J.R., Trevisan, R., & Nguyen, T.A. *Energy Storage Handbook*. Chapter 18 - Physical Security and Cybersecurity of Energy Storage Systems. Sandia National Laboratories. U.S. Department of Energy. https://www.sandia.gov/app/uploads/sites/163/2021/09/ESHB_Ch18_Physical-Security_Johnson.pdf.

Additionally, the DOE ESHB recommends that the physical protection approach should incorporate multiple, sequential protective layers with balanced detection and delay mechanisms to consistently challenge adversaries regardless of their chosen attack paths. Effective detection systems must promptly identify threats, ideally at significant distances from protected targets, followed by strategically positioned delays to allow timely response. Specifically, the combined times for detection, assessment, communication, delay, and response must be shorter than the adversary's task completion time.

There are few existing standards that explicitly cover the topic of BESS physical security. The National Electrical Code (NFPA 70) requires all large electrical installations (including energy storage systems) to have a perimeter fence at least seven feet high to prevent unauthorized access. Seven feet should be considered a minimum standard; site-specific requirements, such as visibility from nearby residences or schools, or heightened threat assessments, may merit a taller perimeter fence.[100] Notably, the DOE ESHB recommends a robust perimeter intrusion detection and assessment system that includes dual fence lines, multiple sensor modalities within the protected zone, and vehicle barriers.

Resource allocation for physical security should be guided by risk and vulnerability analyses, consequence evaluations, and threat assessments. This includes considering site-specific factors such as facility criticality, proximity to urban centers, available response forces, and facility size.

5.5.2 Cybersecurity Risks

BESS installations are exposed to many of the same cybersecurity risks present at other energy generation assets. This includes unauthorized intrusion, malware and ransomware attacks, data interception and manipulation, and other cybersecurity breaches that comprise system operations. These risks exist because BESS utilize computers and other networked technologies to operate key systems. Additionally, similar to other energy technologies, it is virtually impossible to determine what vulnerabilities may be exploited, and additional vulnerabilities can be discovered at any time.

As a fundamental approach to BESS cybersecurity, SNL recommends a "zero-trust approach" and "defense-in-depth." Under a zero-trust approach, it should never be assumed that any system is immune to compromise. Authentication, authorization, and validation procedures are crucial for employing a zero-trust approach to cybersecurity. Defense-in-depth entails multiple layers of protection for each system. Backup layers of protection can significantly reduce the consequences of a cyberattack that successfully penetrates some, but not all, the existing defense layers.

A variety of specific standards and compliance requirements apply to transmission-connected BESS. This includes the NERC CIP standards identified in Table 9.

Table 9. NERC CIP Standards for Utility-Scale BESS

Standard	Title
CIP-002-5.1a	Cyber systems and asset categorization
CIP-003-6	Security management controls
CIP-004-7	Personnel training and security awareness
CIP-005-7	Electronic security perimeters for critical assets and border access point protections
CIP-006-6	Physical security of Bulk Electric System Cyber Systems
CIP-007-6	Security system management
CIP-008-6	Incident Reporting and Response Planning
CIP-009-6	Recovery Plans
CIP-010-2	Configuration change management and vulnerability assessments
CIP-011-2	Information protection

Additional standards for BESS cybersecurity include IEC 62351, IEEE 1686-2022, ISA/IEC 62443, IEC 61850, ISA/IEC 27000, and UL 2900. These standards address secure communication protocols, authentication and access control mechanisms, system integrity and vulnerability management, and overall cybersecurity risk management. While there are numerous cybersecurity standards and best practices that apply to energy systems broadly, there remains a lack of guidance developed specifically for BESS. Most current frameworks are designed for broader categories such as bulk electric system equipment, operational technology, or distributed energy resources.[xlvii]

5.5.3 Environmental Risks

Similar to the above discussion of physical and cybersecurity risks, many of the environmental risks faced by BESS are comparable to those affecting other energy technologies. These risks include hazards or failure modes induced by extreme weather, natural disasters, or other hazard events. In Indiana, more common weather-related risks include flooding, tornadoes, severe storms, winter storms, and extreme cold. Most of these risks are geographically concentrated. For example, tornados more regularly occur in central Indiana.[101] Other environmental hazards include animal entry and vegetation overgrowth.

To address potential extreme weather events, natural disasters, and environmental hazards, the BESS site should be secured and have plans in place to prevent or mitigate dangerous situations that could impact personnel or damage equipment and the surrounding environment. This includes plans to monitor and respond to extreme weather and natural disasters, including protocols for when personnel should vacate and system shutdown conditions. BESS should also be designed to withstand environmental hazards that may arise in the area. Table 10 provides several examples of design resiliency.

Table 10. Design Considerations for Environmental Resiliency
▫ Isolating electronics
▫ Designing physical enclosures, buildings, and drainage systems so that they meet local building code requirements regarding wind speed, snow load, snow shed, standing water, and flash floods
▫ Seismic hardening sites in earthquake-prone regions as per local building codes and IEEE 693/IEEE 693a-2024
▫ Shielding equipment from lightning strikes and/or affixing lightning rods to taller structures as per NFPA 70, NFPA 780, or IEEE C2, as applicable
▫ Controlling temperatures and protecting against excess humidity, salinity, and dust
▫ Designing enclosures to prevent animals and plants from entering

5.6 Best Practices for Safety and Risk Mitigation

Ensuring the safety of BESS requires coordinated effort among multiple stakeholders, application of industry best practices, and robust risk mitigation. This section outlines the key stakeholders involved with BESS safety. It then reviews industry best practices for safety and risk mitigation in the areas of hazard detection and protection, fire suppression and mitigation, and structural/environmental protection. Finally, failure modes and consequences for various BESS types and sizes are addressed.

5.6.1 Key Stakeholders in BESS Safety

Multiple stakeholders, each with distinct responsibilities, collectively contribute to the overall

[xlvii] More information regarding BESS cybersecurity, relevant resources include the DOE's Cybersecurity Capability Maturity Model (C2M2); NIST Cybersecurity Framework 2.0; and multiple reports from SNL, including the Electrical Energy Storage Data Submission Guidelines (Version 3) and Ch. 18 of the Energy Storage Handbook (2020).

safety of BESS in Indiana.

Manufacturers

Manufacturers, such as Panasonic Corporation, LG Energy Solution (LG), and Samsung SDI, are responsible for the design, production, and testing of battery cells, modules, and complete energy storage systems. Their role is to ensure that manufactured BESS products meet safety standards and perform reliably during normal operation.

Operators

Operators of BESS installations, including Indiana utilities and independent power producers, are responsible for the daily operation of BESS installations, as well as overseeing maintenance, monitoring, and safety procedures necessary to prevent BESS failures and mitigate potential hazards. Per HEA 1173 (2023) requirements, operators also provide training to all personnel who hold responsibilities in the event of failure (including first responders), conduct safety drills, and maintain compliance with regulatory requirements as they pertain to operation of the BESS installation.

Local Planning Authorities

Local planning authorities are responsible for overseeing the siting, zoning, and land-use considerations for BESS projects. Their role in BESS safety is to ensure that BESS installations are placed in areas that minimize risks to surrounding communities and infrastructure. Local planning authorities may review or require environmental impact assessments, with the responsibility of conducting these assessments typically resting with the project owner/developer. Local authorities may also establish safety buffer zones as part of land-use approvals. How local planning authorities address BESS safety in Indiana is locally specific. In some counties and municipalities, BESS safety-related planning considerations have not yet been addressed.

Regional Transmission Organizations

The technical integration of BESS into the electric grid, including interconnection processes and system reliability standards, is primarily the responsibility of MISO and PJM, the RTOs serving Indiana. RTOs manage the regional power grid and ensure that all connected resources, including BESS, can interconnect and operate without compromising grid reliability. RTO responsibilities include conducting interconnection studies to evaluate grid impacts, setting requirements for interconnecting resources (e.g., fault protections), and establishing operational requirements for grid-connected resources. These functions ensure that BESS operate safely and reliably as part of a broader grid.

Indiana Department of Homeland Security

HEA 1173 (2023) delegates responsibility to IDHS for the enforcement of safety standards for utility-scale energy storage systems. IDHS's responsibilities include compliance with NFPA 855 Standards, including ensuring that all BESS installations meet the fire safety guidelines set by the NFPA; permitting oversight, including reviewing and approving plans for new or expanded BESS installations that meet certain size thresholds; and emergency response preparedness, which includes ensuring that appropriate emergency responder training and resources are in place to manage potential emergencies involving BESS facilities.

Emergency Responders

Emergency responders play a key role in BESS safety in the event of a hazardous BESS failure. They are responsible for developing and maintaining knowledge of the unique hazards present in BESS installations and implementing effective emergency response tactics for BESS failure events, including fires and hazardous material spills. It is crucial that emergency responders are equipped with the appropriate knowledge to respond to BESS safety incidents. In Indiana, IDHS currently requires operators of BESS systems to offer voluntary, site-specific annual training to emergency responders.

5.6.2 Hazard Detection and Protection Systems

Hazard detection and protection systems are utilized by BESS operators to identify the stages associated with thermal runaway: temperature increases, off-gassing, smoke, and fire. Best practice dictates the adoption of all of the following common hazard detection and protection tools.

Battery Management System

A BMS functions by continuously monitoring the voltage, current, and temperature of cells and modules within the BESS, calculating state of charge (SOC) and state of health (SOH) of the system, and managing charge-discharge cycles of the batteries. Through this continuous process of monitoring and management, the BMS helps prevent battery cells and modules from exceeding their safe operating area (SOA), thereby mitigating the risk of thermal runaway. The inclusion of a BMS is considered an industry standard and is a critical measure used to minimize the risk of thermal runaway; however, it should not be relied upon as the sole layer of protection from explosion or fire.

Smoke and Heat Detectors

Conventional smoke and heat detectors may be placed within the BESS enclosure as an additional hazard detection measure; however, their utility in preserving a BESS that has undergone thermal runaway is low, as

Moss Landing Energy Storage Facility Incident

The Moss Landing Energy Storage Facility in California is one of the largest BESS installations in the world, with a total capacity of 750 MW and approximately 3,000 MWh. On January 16, 2025, the facility experienced a significant fire that triggered evacuations for approximately 1,500 local residents. While the exact cause of the fire remains under investigation, several contributing factors were identified. One key factor was the failure of the fire suppression system within a battery rack, which allowed the fire to spread. Additionally, the facility's design, housed within a repurposed turbine hall rather than a modular, containerized structure, intensified the fire and complicated firefighting efforts.

Lessons Learned

- Importance of adopting updated standards: Facilities should proactively adhere to the most current safety standards available, including UL 9540/9540A, NFPA 855, and forthcoming standards like NFPA 800, to ensure critical safety measures are in place.
- Facility design considerations: Containerized modular systems can provide better fire containment and easier emergency access compared to large-scale, building-based installations.

the presence of smoke/heat typically arises during the final stages of thermal runaway.[102] Increasingly, BESS developers instead rely on smoke detection systems that can identify the presence of smoke at miniscule levels, such as a very early smoke detection apparatus (VESDA). Using a VESDA, BESS operators have the ability to initiate emergency response prior to a fire outbreak. These systems can add an additional element of protection against injury to staff and emergency response personnel, as well as damage to the BESS system. Thermal imaging and flame detectors are also commonly used for monitoring multiple BESS units from outside of the enclosures.

Other Monitoring Systems

Internal camera systems, placed within BESS enclosures, allow for remote visual confirmation of potential fires without endangering staff or emergency responders.[103] These systems are often set up in parallel to external camera systems utilized for physical security. Another common monitoring system is off-gas detection technologies, which can alert BESS operators to early-stage Li-ion battery failures prior to a thermal runaway event.[104] These systems work by detecting the release of volatile organic compounds and gases that are emitted during the decomposition of battery cell materials when a fault begins to develop. Early detection of these gases allows operators to take preventive action, such as isolating affected battery modules or safely shutting down the system for maintenance evaluation.

5.6.3 Fire Suppression and Mitigation Strategies

The best strategies for fire mitigation begin with detection and protection systems that help avoid incident escalation in the first place. In the event of a fire outbreak, however, several common system characteristics can help suppress or mitigate worst case scenarios, such as thermal runaway.

Design Considerations

BESS enclosures are designed with safety features according to relevant fire codes and industry engineering standards. This includes design features that mitigate potential explosion risks. The two most common approaches for explosion control are ventilation and blast panels. Enclosures may be designed to prevent conditions that create the possibility of explosion by maintaining continuous exhaust ventilation systems, in accordance with NFPA 69: Standard on Explosion Prevention Systems. This ventilation helps prevent explosions altogether. Additionally, enclosures can be designed to dissipate pressure buildup using deflagration venting techniques. Deflagration vents relieve pressure by releasing combustible gases through engineered vents, also known as blast panels, before structural damage occurs.[105]

Fire Extinguishment Systems

Because water is readily available and has useful cooling properties, it is a well-regarded tool for preventing propagation of BESS fires. However, the suitability of traditional water suppression systems, such as overhead pendant nozzle sprinklers (in accordance with NFPA 13 standards), is highly dependent on system conditions and circumstances.

First, some BESS chemistries have the potential to adversely react to water by short-circuiting. This can lead to overheating and, potentially, a thermal runaway event. Second, a poorly targeted water-based fire suppression system may create short circuits in adjacent equipment. Finally, a system that does not direct enough water at the origin of the incipient fire may not prevent module-to-module propagation.

Failure to address the above risks could lead to situations where water suppression efforts escalate battery hazards or introduce additional failure modes. Additionally, fully containing all water used during fire suppression can be prohibitively expensive, as it often requires specialized drainage infrastructure, dedicated storage basins, and hazardous material handling procedures.

To address the above risks, one emerging strategy is to apply in-rack suppression system designs. This approach targets water more directly at the initial fire source. Another increasingly common approach is to incorporate a "dry pipe" system into BESS systems. This provides an exterior point of connection through which water can be directed into a BESS without opening the enclosure. It also allows the controlled environmental release of hazardous gases. For certain BESS chemistries, gaseous suppression agents, like FM-200 or Novec 1230, should be considered for use against incipient fires.

However, once a fire escalates, most of the above systems cannot prevent or stop thermal runaway. At that stage, continued water application often provides limited benefit. Instead, best practice suggests that emergency responders should focus on containment and prevention of further propagation to surrounding units. This approach minimizes runoff, since water used in suppression may carry toxic substances released from damaged battery modules.[106] It also minimizes personnel safety risk.

When deciding whether to adopt a non-intervention strategy and allow the fire to burn itself out, emergency responders should determine whether the battery enclosure is isolated from adjacent units as well as evaluate the threat of fire propagation. These considerations should be supported by an Emergency Response Plan (ERP), described below.

Safety Practice Differences Across BESS Technologies

Most of the potential hazards and subsequent safety practices for BESS apply broadly across chemistries; however, certain safety strategies are tailored to the unique characteristics of specific battery types.

Lithium-ion BESS, the most widely deployed, present well-known risks related to thermal runaway. As a result, Li-ion systems typically require robust off-gas detection, thermal monitoring, and in-rack suppression systems. Oftentimes, they also incorporate gaseous or water-based fire suppression systems specifically designed to address early-stage thermal events.

Sodium-ion BESS, while emerging and less common, tend to offer improved thermal stability and are less prone to thermal runaway. Consequently, while general fire detection and emergency response measures still apply, sodium-ion systems may not require the same level of localized suppression or early gas detection. Additionally, sodium-ion batteries often operate at lower voltages, which can reduce risks related to electrical arcing and simplify some aspects of isolation and shutdown procedures.

Flow batteries, such as vanadium redox systems, store energy in external electrolyte tanks and are generally not susceptible to thermal runaway. Their primary safety concerns include electrolyte leaks, chemical exposure, and fluid management, requiring practices focused on spill containment, ventilation, and hazardous material handling. Solid-state batteries, still in development for utility-scale applications, are expected to reduce flammability risks due to their non-volatile electrolytes, though specific safety protocols are still being defined.

With most technologies, system-level protections—including physical containment, access control, environmental monitoring, and site configuration informed by equipment testing such as UL 9540A—remain essential. As new chemistries enter the market, safety practices will continue to evolve in response to their specific failure modes and operational characteristics.

5.6.4 Other Risk Mitigation Strategies

The O&M phase of a BESS project is the longest phase in the system's lifecycle, often spanning 20 years of active service. The safety of a BESS installation during normal operations depends largely upon the quality of maintenance execution. Maintenance can be performed internally or by third-party specialists, particularly for widely distributed assets.

To ensure reliable operation of BESS installations, preventative maintenance measures should be implemented, including regular inspections, software updates for control systems, and testing of safety mechanisms. While industry standards for O&M remain scarce, an increasing number of operators are utilizing predictive maintenance technologies, which use real-time data from sensors and control systems to identify early indicators of failure. For example, thermal sensors may detect abnormal heat patterns in battery racks, or voltage monitoring systems may flag deteriorating cell performance before a fault occurs.

East Hampton BESS Fire

On May 31, 2023, a 5-MW Li-ion BESS unit at the Cove Hollow Road substation in East Hampton, New York experienced a fire event. The unit's water-based fire suppression system activated as designed, quickly containing the fire to the site and preventing cascading propagation. No injuries were reported, and no further emergency response was required. The incident highlighted the effectiveness of integrated fire protection systems in utility-scale BESS installations.

Lessons Learned

- <u>Effectiveness of integrated fire suppression</u>: Properly designed and maintained fire suppression systems can swiftly contain fires within BESS facilities, minimizing damage and risk to adjacent battery racks and surrounding areas.
- <u>Importance of regular maintenance for fire suppression systems</u>: Regular maintenance of fire suppression systems ensures that they can respond to fire incidents swiftly and as designed. This is crucial to prevent the spread of fire to other battery racks.

5.7 Training and Emergency Response for Local Responders

It is imperative that first responders are included early in the planning of BESS installations and provided with the training and real-time information necessary to gauge conditions at a battery facility and respond accordingly.[107] Training should include any jurisdictions that may be asked to assist the primary fire department. Periodic updated training should be given to address turnover. The cost of these trainings should be supported by the BESS owner throughout the lifetime of the system.

HEA 1173 (2023) requires that BESS operators provide responding fire departments copies of Emergency Response Plans and offer annual training. However, discussions held between Exeter and representatives from IDHS suggest that, despite the training being offered to fire departments annually, participation is voluntary and knowledge gaps continue to exist between system operators and first responders. Mandatory trainings can help address knowledge gaps among first responders.

5.7.1 Emergency Response Plans

HEA 1173 (2023) requires that utility-scale BESS operators provide an ERP to local fire departments as a condition of project approval through NFPA 855. A similar standard applies in several other states, including Massachusetts, Washington, California, and New York. ERPs are a critical source of communication between BESS operators and first responders, and a well-developed ERP can reduce response times, ensure first responders are adequately protected against system-specific hazards, and promote appropriate response (e.g., not relying on water to extinguish a BESS during thermal runaway).

On December 15, 2023, the New York Battery and Energy Storage Technology Consortium (NY BES+) published the "Battery Energy Storage System Emergency Response Plan Guide."[108] This document, prepared by the Fire & Risk Alliance, provides a framework "to assist BESS project developers, owners and operators in preparing for potential emergencies and addressing the concerns of emergency responders and members of the first services." The following sections describe components of an effective ERP based on this guide's recommendations and other best practices.

Energy Storage System Overview and Definitions

An ERP should begin with a system overview, including details regarding site characteristics, equipment, and battery specifications. Information such as water supply availability, facility layout, surrounding environmental risks, and community impact assessments should also be documented in the ERP. Additionally, details on battery chemistry, fire behavior, and explosion potential must be included to aid in risk mitigation. Presenting these details at the beginning of the ERP helps ensure maximum visibility of essential information. Finally, since various stakeholders may read the ERP, it should provide clear explanations of technical terms related to BESS components and emergency response systems. Illustrations should accompany definitions to improve clarity.

Incident Communication and Command Structure

The ERP must include site ownership details, emergency contacts, and scope of coverage to clarify responsibilities during an incident. Contact lists should include emergency responders, battery subject matter experts (SMEs), and electrical technicians.

A structured notification matrix within an ERP should define who to contact during an emergency, how they will be reached, and the appropriate response escalation levels. This type of structured approach is intended to ensure a timely and effective emergency response.

In addition to notification escalation levels, the ERP should also identify an "Incident Command" structure during an event. Best practice is to follow National Incident Management System (NIMS) guidelines, which identify coordination structures among fire services, law enforcement, environmental agencies, and facility representatives. In complex incidents, a Unified Command Structure can be established for joint decision-making.

Battery Management System

The BMS functions as the core monitoring system for a BESS, similar to a fire alarm control panel in a building. During a safety incident, BESS operators or designated battery experts should be sufficiently trained to interpret BMS data to quickly assess system condition and provide actionable information to emergency responders. Because many battery hazards, such as thermal runaway, may not be externally visible, responders rely heavily upon timely interpretation and communication of BMS data by trained personnel. The personnel responsible for interpreting BMS information can be on-site or remote. In some cases, severe system failures may interrupt normal BMS data reporting, reinforcing the importance of having battery SMEs available to help emergency responders safely manage the incident.

Hazard Identification, Detection, Suppression, and Response

The ERP should be comprehensive and cover all potential hazards. However, typical practice is to document cybersecurity and security threats separately. The remaining potential hazards are generally categorized as chemical, electrical, and explosion risks. The ERP should identify the full range of potential hazards as well as requirements to protect personnel from hazard exposure. For example, addressing chemical hazards may require that first responders wear specific personal protective equipment, while addressing electrical risks may require safe standoff distances for emergency personnel accessing unshielded high-voltage areas.

Fire detection, alarm sequences, and suppression systems within the BESS facility should be clearly documented in emergency plans. This also includes documenting the sequencing of fire mitigation or suppression efforts. For example, an ERP should designate whether clean agents and aerosols are used to address early-stage fires or electrical ignition events. The ERP should also address response strategies following the escalation of a fire. For example, suppression strategies in a thermal runaway situation typically prioritize containing the event, preventing the spread to adjacent BESS modules, and reducing overall thermal exposure, rather than attempting to extinguish the flames. Water use by emergency responders is often a last resort during a thermal runaway event. If water is used as part of an incident response, it must come from a potable water source; drafted or saltwater sources are prohibited due to conductivity risks.

The ERP must also define mitigation responsibilities for facility operators. It should be clearly understood that all energized equipment shutdowns, including emergency stop activations, are to be performed solely by trained facility personnel. First responders should be dissuaded from operating system controls. Additionally, if safe intervention is not possible, non-intervention may be the safest course of action.

Post-Incident Operations

After an incident is stabilized, a series of defined tasks must be completed before transitioning the site into recovery and decommissioning phases. These tasks enable Incident Command (or Unified Command) to verify that hazards are controlled, conditions are stable, and the impacted areas are safe for limited reentry and recovery actions. The ERP should address post-incident operations, including the steps required to verify system stability; evaluate structural, thermal, electrical, and chemical safety; and determine when it is safe to open impacted BESS enclosures. This last decision should be informed by system readings (e.g., thermal imaging, gas detections) and coordinated with facility operators and battery SMEs. After an incident is contained, responders must assess stability before declaring control over the site.

Post-incident operations should transition directly into executing a Decommissioning Plan, as applicable. A Decommissioning Plan, as outlined in NFPA 855, should be followed to ensure safe disposal, transport, and recycling of damaged battery modules. This plan must account for the requirements of qualified recycling facilities, which may vary based on the condition and state of charge of recovered battery modules. Some recycling facilities will accept undamaged modules at full SOC, while others require modules to be discharged to 30% SOC or lower. Recycling facilities should also provide guidance on compliant packaging and shipping protocols for damaged or compromised battery modules, consistent with DOT standards.

To ensure operational readiness, best practice dictates developing Commissioning and Decommissioning Plans in parallel. This ensures that the facility is prepared for any potential failure scenarios from the time it first enters service.

Training and Exercises

Annual fire service training and site familiarization tours should be conducted before batteries arrive on-site. The ERP serves as the foundation for training programs insofar as it covers BESS system components, hazard identification, emergency shutdown procedures, and post-fire operations. Per NFPA 855 requirements, emergency response exercises should be conducted on a three-year cycle, gradually increasing in complexity. Exercises should include tabletop drills, functional tests, and full-scale emergency scenarios,

Arizona BESS Explosion

In 2019, an explosion occurred at a Li-ion BESS facility in Surprise, Arizona. During this event, thermal runaway propagated within the battery modules in the absence of visible flames. This process resulted in the accumulation of highly flammable off-gasses, creating an explosive atmosphere within the BESS enclosure. Upon opening the battery container, firefighters inadvertently introduced oxygen into this environment, triggering a severe explosion that injured four emergency responders.

Lessons Learned

- Certification and Compliance: The BESS lacked third-party certification according to UL 9540 and UL 9540A standards.[i] Additionally, the BESS was placed into service in 2017, prior to the publication of NFPA 855. Subsequent analysis by NFPA indicated that adherence to NFPA 855, which requires deflagration venting and explosion prevention measures, would have likely prevented or mitigated this event.[i]
- Emergency Response Training: Specialized training for emergency responders on BESS-specific incidents, particularly thermal runaway scenarios, is crucial. This training should emphasize recognition and safe handling of situations involving explosive gas buildup.

[1] Underwriters Laboratories. (2021). Battery Energy Storage System Incidents and Safety: A Technical Analysis by UL. collateral-library-production.s3.amazonaws.com/uploads/asset_file/attachment/31719/UL_Response_to_DNVGL_APS_Report.pdf.

with after-action reviews ensuring ERP effectiveness.

5.7.2 Embedding Experts

Best practice suggests ensuring local first responders are trained to address safety issues regarding utility-scale BESS. The infrequency of major events, however, has led some commenters in Indiana to suggest developing a centralized group (or groups) of specialized battery fire responders. This group would be specifically trained to understand the unique characteristics of BESS-related hazards, especially fires, and serve as command during incidents.

One potential model for a group like this is IDEM's Emergency Response team.[109] This specialized unit responds to environmental emergencies across the state involving the release of pollutants or hazardous materials. A similar entity addressing BESS safety incidents could also be housed within a state agency, potentially IDHS or IDEM, and centralized. An entity based out of Indianapolis, for example, could reach most jurisdictions in the state within approximately three hours. Alternatively, specialized experts could be strategically positioned throughout the state for purposes of quickly responding to fires.

To date, there is no widely recognized state-level emergency response teams in the U.S. solely dedicated to BESS incident response. This approach has, however, been considered in states including Maryland, California, and New York. For example, in February 2024, New York's Inter-Agency Fire Safety Working Group released 15 draft recommendations for enhancing BESS safety standards.[110] One of the recommendations suggested requiring "qualified personnel" or representatives of the site owner/operator with specialized knowledge of the BESS installation to dispatch to a fire incident within 15 minutes, and arrive within four hours, to provide expert guidance to local first responders. These responders would undertake a specialized certification program based on International Fire Code (IFC) and NFPA standards.

In reviewing the above New York proposal, many commenters, including industry representatives and local community groups, asserted that this recommendation was impractical due to the costs of embedding local experts. Instead, community groups indicated that their preferred solution would be to embed Li-ion battery experts within county/state emergency response and hazmat infrastructure, akin to the more centralized approach being considered for Indiana. The Working Group suggested that "a hazmat cost recovery system could be effective in defraying public costs of integrating battery experts into existing public infrastructure." To date, New York has not adopted the model of embedding experts within state/county infrastructure; instead, BESS system owners are responsible for dispatching hazard support personnel at their own expense.

Outside of BESS-specific examples, centralized response teams are a common approach to address infrequent but severe hazards and fire emergencies. For example, South Carolina's State Fire division includes an Emergency Response Task Force intended to provide subject matter expertise during emergencies that exceed local resources, and Idaho's State Emergency Response Team provides additional resources and coordination during severe fire events. A more novel example is the Seattle Fire Department and Seattle City Light's "Energy 1 Emergency Response Unit," created in 2023 for fighting electrical fires in substations and underground vaults.[111]

5.8 Utility-Scale vs. Small-Scale BESS

BESS installations can generally be categorized as utility-scale or small-scale according to their capacity and point of interconnection.[xlviii] The differences between utility-scale and small-scale BESS systems affect how each is designed, sited, operated, and regulated. These differences also influence risk and resultant safety considerations. Table 11 outlines key distinctions in safety, siting, and emergency response based on the scale of the BESS system.

Table 11. Utility-Scale vs. Small-Scale BESS: Safety, Siting and Emergency Response

Aspect	Utility-Scale	Small-Scale
FIRE SAFETY	Large-scale fire suppression required; safety addressed through siting and design requirements	Smaller suppression systems sometimes available; indoor (residential) fire safety considerations
ELECTRICAL SAFETY	Higher voltage and arc flash risk; accessed and maintained exclusively by trained technicians	Lower voltage; exposure may be incidental to regular usage or occur during homeowner troubleshooting
SITING	Frequently in industrial or remote locations, though not universally	Higher number of indoor/residential placements; closer proximity to occupied buildings
EMERGENCY RESPONSE	Coordination with first responders is mandated by site-specific Emergency Response Plans	Local emergency response is relied upon to handle small-scale BESS safety incidents

[xlviii] As discussed in previous sections, for the purposes of this report, utility-scale BESS refers to systems rated at 1 MW or greater and typically installed as part of transmission or distribution infrastructure. Small-scale BESS includes residential, commercial, and behind-the-meter systems, usually installed at customer premises and operating below utility interconnection thresholds. Small-scale BESS can also include personal batteries, such as those embedded in electric vehicles.

5.8.1 Regulatory and Safety Standards

While the regulatory framework for utility-scale BESS has matured in recent years, particularly with increased adoption of NFPA 855 and UL 9540/9540A, there remains a notable gap in how safety standards are applied to small-scale systems. Small-scale BESS installations are governed by general building and fire codes such as the 2021 International Residential Code: Section R328, and NFPA 70 (National Fire Code), respectively. However, they are not subject to the same siting, separation distance, or emergency response planning requirements as utility-scale projects. As deployments increase in occupied spaces, certain standards developed for large-scale systems—particularly those related to first responder coordination—may also be appropriate for small-scale BESS applications.

5.8.2 Risk Profiles in Stationary and Portable Battery Applications

Battery safety risks vary considerably between stationary BESS and more portable small-scale battery applications. Utility-scale BESS installations, which predominantly utilize Li-ion chemistries, operate in highly controlled environments. These systems are stationary, undergo continuous monitoring, and are equipped with layered fire suppression, thermal management, and hazard detection systems.

Conversely, portable Li-ion battery applications, such as those used in EVs and e-bikes/e-scooters (collectively, "micromobility devices"), are subject to inherently greater risks due to dynamic environmental conditions, less protective system designs, limited regulatory oversight, and increased physical stress. These portable batteries routinely experience exposure to vibrations, mechanical impacts, wide temperature fluctuations, and moisture intrusion.

Although EV batteries receive rigorous oversight under automotive-specific standards and extensive regulatory scrutiny, micromobility devices have historically received significantly less attention and oversight, increasing the risk of safety incidents. Relevant standards for micromobility devices include UL 2272, covering electrical systems in personal electric micromobility devices, and UL 2849, specific to e-bikes. Recent regulatory efforts, such as the 2024 edition of NFPA 1, introduce targeted safety measures like requirements for safe charging practices indoors or near buildings.

This disparity in oversight is reflected in incident data. The New York City Fire Department reported over 250 fires involving micromobility devices between 2022 and 2023—nearly 20 times the number of BESS-related fire incidents reported *nationally* over the past decade.[112] While comprehensive national data on micromobility device fires remains limited, the high volume of incidents in a single jurisdiction highlights the comparatively higher risks associated with portable battery applications.

The distinct risk profiles between stationary BESS and portable battery applications emphasize the significantly enhanced safety associated with stationary installations. Stationary BESS, operating in stable, controlled environments, are far less likely to experience failure incidents. In contrast, portable Li-ion battery applications—particularly micromobility devices—face higher inherent risks. Some misconceptions related to the safety risks of utility-scale BESS emerge from widely reported stories of safety incidents caused by portable battery applications.

5.9 Additional Considerations for Thermal Runaway

Thermal runaway receives significant attention throughout this chapter because it has been the primary cause of the most notable safety incidents associated with Li-ion BESS installations. Given the prominence of Li-ion technology in current and planned BESS projects, understanding thermal runaway is critical for ensuring the safe deployment and operation of energy storage systems. The following sections provide an in-depth examination of thermal runaway, outlining its causes, available mitigation strategies, and recommended practices for prevention.

5.9.1 Causes of Thermal Runaway

Thermal runaway can be triggered by several factors, including:

- <u>Overcharging or overdischarging</u>: Charging a battery above its upper voltage limit or discharging it below its lower voltage limit can destabilize the cell chemistry and generate excessive internal heat. Repeated abuse of voltage thresholds can degrade a battery's internal components and increase the risk of thermal runaway.
- <u>Internal short circuits</u>: Most rechargeable electrochemical batteries, including Li-ion, lead-acid, and nickel-based chemistries, contain a separator. A separator is a thin, porous material placed between the anode and the cathode to prevent direct electrical contact while permitting ion transport. In alternative chemistries, such as flow batteries, this role is performed by ion-exchange membranes. If the separator is damaged, it can allow the electrodes to touch. This creates an internal short circuit: an unintended low-resistance path within the cell that enables uncontrolled current flow. The resulting spike in internal temperature can initiate thermal runaway.
- <u>External short circuits</u>: External short circuits occur when an unintended conductive path forms outside

of the battery, often due to physical damage, faulty wiring, or moisture ingress into the battery enclosure or circuitry. This conductive path draws large amounts of current, causing the battery to overheat and potentially initiate thermal runaway.

- Mechanical damage: Crushing, puncturing, or otherwise deforming a battery can breach internal layers, damaging the separator or electrodes. This often leads to internal short circuits or localized hotspots, both of which are common precursors to thermal runaway.
- Extreme-temperature environments: Exposure to high ambient temperatures can accelerate internal degradation in batteries and increase the likelihood of off-gassing. Conversely, very low temperatures can cause structural stresses that damage internal components, which may later fail under normal conditions.
- Manufacturing defects: Imperfections during battery fabrication, such as electrode contamination, improper cell assembly, or separator defects, can compromise a battery's internal safety barriers. These defects may go undetected during quality assurance inspection and initial testing but can degrade the battery over time or under stress. These defects can cause internal short circuits and localized heating, either of which can initiate thermal runaway. While manufacturing defects are rare, the potential consequences of such latent failures underscore the importance of rigorous quality control.

5.9.2 Preventing Thermal Runaway

Thermal runaway has a statistically low chance of occurring in any one battery cell (approximately one in a million), and there are several mitigation measures that can prevent or reduce the risk of overheating which leads to thermal runaway. [113] These include:

- Current Interrupt Devices (CIDs): These are built-in safety features within Li-ion battery cells that physically break the internal circuit if excessive pressure or temperature is detected. By halting current flow early, CIDs prevent further heating that could initiate thermal runaway.
- Ceramic-coated separators: This advanced separator material improves thermal stability by resisting shrinkage or meltdown at elevated temperatures. It serves as a physical safeguard that maintains separation between the anode and cathode, even if the cell is subjected to thermal or mechanical stress.
- Solid-State or polymer electrolytes: Unlike conventional liquid electrolytes, these materials are non-flammable and more chemically stable at high temperatures. Their use significantly reduces the risk of internal short circuits and subsequent thermal events. Incorporation of these materials into commercial, utility-scale BESS is still nascent.
- Battery Management Systems: A BMS continuously monitors cell voltage, temperature, and current. It automatically limits or disconnects charge/discharge activity when parameters deviate from safe operating conditions. This proactive control system is critical for preventing conditions that can initiate thermal runaway.
- Forced shutdown mechanisms: Many BESS designs include redundant safety systems that trigger forced shutdown if temperature thresholds or fault conditions are exceeded. These systems act as a last line of defense and can isolate the battery from the grid or other system components to contain the hazard.
- Thermal barriers and fire containment features: Materials such as intumescent coatings, thermal insulation, and compartmentalized battery racks help localize heat and inhibit the propagation of thermal runaway across modules.
- UL 9540 and UL 9540A certification: These standards require that BESS demonstrate thermal runaway detection, suppression, and containment through rigorous third-party testing. Certification ensures that system-level protections are integrated and effective under failure conditions.
- HVAC and thermal management systems: Heating, ventilation, and air conditioning (HVAC) systems regulate ambient and cabinet temperatures. These systems prevent battery overheating during high-load conditions or heatwaves, and may include active cooling loops, phase-change materials, or thermal monitoring algorithms.

5.9.3 Stopping Thermal Runaway

In a thermal runaway event involving a single battery cell, clean-agent fire suppressants such as FM-200 or Novec 1230 can be effective at limiting and reducing downtime. However, in the case of a cascading thermal runaway event involving multiple cells, these agents may not prevent further propagation and can increase the risk of explosion. This occurs when the suppressant displaces oxygen and suppresses flames as flammable gases continue to accumulate inside the enclosure. If those gases reach an explosive concentration and are ignited, an explosion may occur. Thus, in many circumstances, the best practice for stopping thermal runaway is to allow the fire to extinguish on its own without additional interference while only taking steps to mitigate further spread of the fire.

6. ECONOMIC IMPACTS AND WORKFORCE DEVELOPMENT

6.1 Executive Summary

This chapter of the report reviews the role of BESS in creating direct and indirect jobs in Indiana as well as contributing to Indiana's gross domestic product (GDP) and tax revenue.[xlix] It also evaluates economic growth opportunities in the state based on existing industry and resource gaps.

Key findings and insights from this analysis include:

- Input-Output modeling suggests modest economic benefits. The results of Exeter's economic impact analysis indicate that Indiana will observe modest growth both in terms of jobs created and economic output. Construction of BESS is estimated to contribute around $824.0 million in estimated cumulative sales (i.e., total output), with 61% of the total attributed to impacts directly associated with construction activities. Annual O&M expenditures by the installed facilities are estimated to contribute roughly $831.9 million in total output.[l] In aggregate, over the 10-year period analyzed, annual BESS deployment (construction and fixed O&M) is estimated to support between 719 and 1,007 full-time equivalent (FTE) jobs, on average.
- Construction and services industries contribute the most jobs. The identified economic benefits of BESS deployment are concentrated in the construction and service industries. During the construction phase, architectural, engineering, and related services comprise the highest (35%) portion of FTE job impacts, followed by power structure construction (16%). During the O&M phase of a project, activities are expected to be primarily sourced in-state and heavily concentrated (48%) in the commercial and industrial machinery repair services sector.
- Regional economic benefits align with the location of BESS deployments. The regions with the greatest concentration of actual BESS capacity also experience the highest economic benefits in terms of increased output and employment. However, Indiana's central region, including the Indianapolis metropolitan area, observed disproportionately higher indirect and induced benefits due to the concentration of service industries in the area. This includes firms providing architectural, legal, and engineering support to BESS facilities during construction and operations.
- Battery storage is not a direct economic substitute for retiring conventional energy plants. In general, BESS facilities are less labor-intensive, smaller in scale, and often sited away from communities affected by conventional (e.g., coal, gas) plant closures. As a result, BESS offers only a partial substitute for the jobs and local economic activity once provided by coal and natural gas generating facilities. This difference highlights the need for intentional workforce planning and community reinvestment.
- Indiana's industrial base and emerging EV battery initiatives position it for growth in the BESS sector. The state's strengths in steel production, chemical processing, advanced manufacturing, and logistics are directly applicable to BESS deployment. These assets, along with Indiana's central location, can serve as a foundation for a broader in-state BESS supply chain and deployment hub.
- Targeted workforce development will be essential to capitalize on BESS-related opportunities. While Indiana's workforce possesses relevant industrial skills, specialized training for BESS installation, utility integration, and recycling remains limited. Expanding such efforts—especially to support transitions from legacy energy sectors and to differentiate between EV and BESS workforce needs—will help mitigate labor constraints and bolster Indiana's competitiveness in a growing regional "Battery Belt."

6.2 Introduction

Energy jobs make up a significant share of Indiana's overall employment, encompassing 9.1% of the job share in 2023.[li] As of that year, Indiana had an estimated 18,608 jobs in the electric power generation sector and 26,974 jobs in the transmission, distribution, and storage sector, an increase of 418 jobs (2.3%) and 1,426 jobs (5.6%) from 2022, respectively.[lii] Wind generation, the largest contributor to electric power generation employment in the state, encompassed 6,976 (38%) of the electric power generation sector jobs. Storage accounted for 2,134

[xlix] Note that the use of GDP throughout this report refers to Gross State Product (GSP), which is simply the state equivalent of the national GDP measure. Indiana's state GDP (or GSP) is simply the monetary measure of all final goods and services produced within the state of Indiana.

[l] Both estimates regard the Benchmark scenario with a forecasted annual capacity addition of 247.8 MW.

[li] Estimates sourced from: DOE. (2024). *Energy and Employment by State 2024*. https://www.energy.gov/sites/default/files/2024-09/USEER%202024%20States_0913.pdf. Note the total share includes 170,086 jobs in the motor vehicles sector and 51,790 jobs in the energy efficiency sector. Removal of those jobs from the total energy sector workforce estimate lowers the share of energy jobs to roughly 2%.

[lii] By comparison, overall energy sector jobs in the state decreased by 3,300 jobs from 2022 to 2023, driven by changes in motor vehicle related energy employment.

(8%) of transmission, distribution, and storage sector jobs.[liii]

Exeter conducted an Economic Impact Analysis to estimate the impacts of future BESS deployment within Indiana, both at a statewide level and a regional level. This analysis is based on a forecasted installed capacity averaging between 195-253 MW per year over the 10-year period ranging from 2026-2035.[liv]

The goal of this chapter is to discuss the economic impacts of BESS identified by the above analysis, as well as identify workforce development opportunities for the state. The chapter begins with a review of Exeter's methodology and modeling assumptions for the economic analysis. It then presents the results of Exeter's input-output model covering estimated economic impacts at a state and a regional level, including jobs (in FTE), impacts on GDP (value-added), and tax revenues. Discussion then shifts to BESS's role as a replacement for economic losses in communities that host retiring conventional power plants, and closes with a review of current Indiana BESS workforce and potential workforce development opportunities.

6.3 Estimated Economic Impacts

To accurately model realistic economic impacts of BESS within the State of Indiana, Exeter utilized the IMPLAN Input-Output (I-O) model. Specifically, Exeter forecasted potential impacts of BESS rollout at both a statewide and regional level to estimate job creation and spending associated with the forecasted BESS construction, operation, and maintenance from 2026-2035. With IMPLAN, an initial change in spending is referred to as a change in "final demand." It is considered a direct effect, which then creates indirect and induced effects.[lv] Indirect effects stem from local industries' purchases of inputs (i.e., goods and services) from other local industries. Induced effects reflect the spending of wages from residents involved in providing the goods and services being modeled.

6.3.1 Modeling Approach

For this analysis, Exeter relied upon the 2023 IMPLAN data year which includes the most up-to-date economic multipliers for Indiana and its counties and zip codes. Exeter's IMPLAN modeling process builds upon a bill-of-goods approach relying on IMPLAN's Regional Purchase Coefficients (RPCs) to estimate the amount of local demand that can be met by local supply for each analyzed industry. The overnight capital costs (OCC) and O&M costs for this study were sourced from NREL's Annual Technology Baseline (ATB) (2024 edition) and applied to annualized capacity additions by year (see Chapter 3). These annual costs were then apportioned into various industries as changes to final demand, using resources such as NREL's technology-specific benchmark reports and the NREL Jobs and Economic Development Impact (JEDI) model.

As previously noted, Exeter relies upon IMPLAN's estimated RPCs to estimate final demand for each industry from various resources. This in-state final demand was modeled in IMPLAN as Commodity Output events resulting in estimated economic impacts per scenario at both the state and regional levels. Figure 14 shows these steps sequentially as they were used to derive the economic impact estimates below.

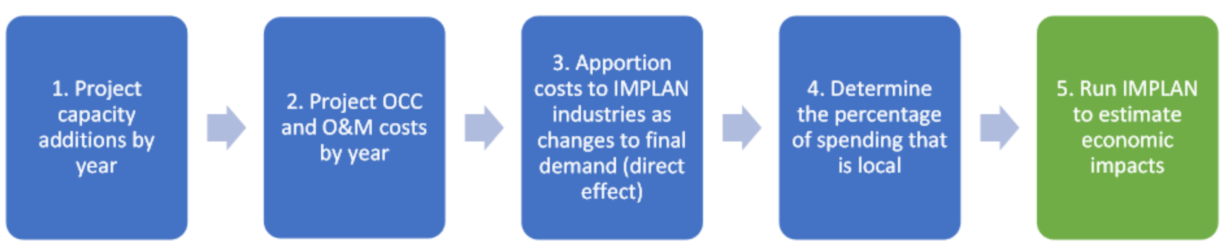

Figure 14. Basic Steps to Developing IMPLAN Economic Projections

[liii] Note that the detailed technology type "Storage" includes technology beyond battery storage such as pumped hydro storage, mechanical storage, thermal storage, LNG storage, coal storage, biofuel storage, etc. See Appendix p. A-59 of the 2024 USEER report for the full breakdown of the TDS sector by technology type.
[liv] Depending upon the scenario considered. Note, estimates only reflect projected incremental additions and not previously commissioned projects. See Chapter 3 for additional discussion of storage deployment going forward estimates.
[lv] Final demand is the demand for goods that is not used to produce other goods.

IMPLAN Modeling Limitations

IMPLAN has several important limitations. First, IMPLAN multipliers, upon which these results depend, reflect industry linkages in a local economy at a given time; the multipliers do not account for price elasticities (i.e., changes in price due to changes in other factors). Second, IMPLAN does not completely account for economy-wide net impacts or leakages (i.e., impacts associated with out-of-state industries). For example, increases in jobs and spending for BESS projects may be offset by contractions in other parts of a regional or national economy, such as fossil fuel power production. Third, IMPLAN does not reflect job reductions as a result of increased electricity prices, as applicable. Finally, IMPLAN may overestimate direct O&M employment since BESS repair services is modeled as an annual expenditure in line with literature on fixed O&M costs for BESS facilities. Exeter received feedback from three separate BESS developers suggesting that each project expects to employ approximately 2-3 full-time equivalent staff for O&M.

BESS Cost

Appendix H provides a breakdown of specific industries utilized in the OCC and O&M estimates. These tables also identify the current costs to build a BESS project, by component, using NREL categories. These costs assume a 60-MW, 4-MWh Li-ion BESS.[lvi]

A variety of factors can contribute to BESS costs that are higher or lower than the levels assumed for economic modeling purposes. Foremost among these factors is the system specifications themselves. For example, larger designs (i.e., higher capacity and/or duration) or the selection of higher-cost battery chemistry (e.g., nickel-manganese-cobalt) can increase costs.

Non-system drivers of increased BESS costs include, but are not limited to, complex site conditions, extensive civil engineering needs, and challenging regulatory and permitting processes. In some cases, these costs can be avoided during the design and siting phases of project development. In other cases, however, additional costs are unavoidable due to system conditions (e.g., grid constraints that dictate the location of a battery). Project costs may also increase due to shifts in macroeconomic conditions. For example, supply chain disruptions affecting equipment availability and pricing can lead to higher costs, as can unanticipated tariffs. Over time, costs may also increase due to inflation.

Conversely, BESS costs may decrease due to the use of more standard designs, favorable regulatory environments (e.g., streamlined permitting), and supportive incentives or tax abatements from a community. More broadly, leveraging economies of scale through larger projects or consolidated procurement strategies can help decrease overall costs. Over time, costs may also decline due to learning effects and technological advancement.[lvii]

Regional Analysis

To conduct its regional analysis, Exeter created a Multi-Regional Industry Output (MRIO) IMPLAN model and combined Indiana's counties into 10 distinct groups, referred to as Regions 1 -10.[lviii] In developing this model, Exeter relied heavily upon Indiana's Regional Economic Acceleration and Development Initiative (READI) to determine an appropriate county-grouping representative of certain demographic and economic characteristics (see Figure 15).[lix]

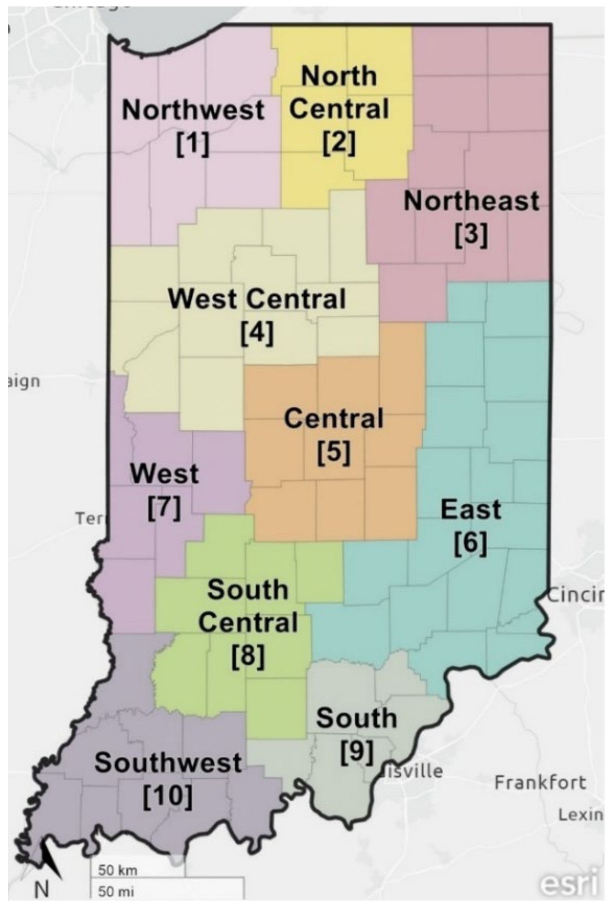

Figure 15. Indiana Regions for Purposes of Regional Economic Analysis

Source: Adapted from S&P Global Market Intelligence.

The State-Level model relies upon multipliers representative of the average economic activity of all

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[lvi] NREL's Annual Technology Baseline (ATB) estimates cost and performance across a duration range of 2-10 hours representative of Li-ion batteries of nickel manganese cobalt (NMC) and lithium iron phosphate (LFP) chemistry.
[lvii] For additional discussion of these and other factors, see NREL's ATB 2024. Available at: https://atb.nrel.gov/electricity/2024/utility-scale_battery_storage.
[lviii] IMPLAN Support recommends the number of Groups modeled in a MRIO analysis to be no more than 10 distinct groups (aka regions).
[lix] See more here: https://indianareadi.com/.

existing industries in Indiana and the related trade flows and leakages outside of the state. The MRIO Regional model, by comparison, allows for capture of leakages to linked regions as well as additional interregional commodity trade and commuting flows.[lx] This MRIO Regional model provides visibility into the demand changes across Indiana regions stemming from a change in production and/or income in another region. See Appendix I for a list of counties included in each region.

Exeter used regional weights to assign where BESS is deployed within Indiana for purposes of the MRIO Regional model. Table 12 lists the final weights for each region as applied to the annual forecasted capacity additions. Regions with more established energy projects and related industries were assigned a higher weight. For example, regions with renewable energy projects under construction or currently operating would increase a region's weight due to the fact that intermittent energy resources are complemented by BESS.

As another example, regions with advanced manufacturing capabilities related to BESS, such as EV and battery manufacturing, were also assigned greater weight due to potential utilization of skilled workers during BESS construction. (See Appendix J for a review of the eight factors used when developing these weights.) Note that subsequent estimates of regional economic impacts are sensitive to these assumptions, and changes may cause shifts in projected outcomes.

Table 12. Annual Capacity Additions for Regional Economic Analysis

Northwest (Region 1)	17.5%
North Central (Region 2)	10.0%
Northeast (Region 3)	2.0%
West Central (Region 4)	25.0%
Central (Region 5)	8.0%
East (Region 6)	10.0%
West (Region 7)	3.0%
South Central (Region 8)	5.0%
South (Region 9)	2.0%
Southwest (Region 10)	17.5%
Total:	**100.0%**

Scenarios and Other Assumptions

Exeter's IMPLAN analysis examined three indicative scenarios:

1. Benchmark Scenario – Average annual deployment (installed capacity in MW), moderate research and development (R&D) scenario for OCC from NREL Annual Technology Baseline (ATB) ($/kW-year for O&M) ($/kW-year for O&M), regional weights assigned in order of most to least likely deployment areas and held constant over a 10-year period.
2. High-Growth Scenario – High annual deployment, all else equal.
3. Low-Growth Scenario – Low annual deployment, all else equal.

Final demand inputs were derived for each scenario from the forecasted incremental installed capacity (for the construction phase) as well as the forecasted cumulative installed capacity (for the O&M phase). For modeling purposes, projects were assumed to become commercially operational in the year after which they are forecasted to be installed. O&M expenditures were assumed to apply to the entire fleet of installed capacity, lagged by one year to account for the fact that O&M developers will likely begin to incur the majority of O&M costs in the year following construction as opposed to the year of construction (i.e., the year capacity is predicted to be added).

Since the final demand inputs are reliant upon forecasted capacities, scenarios with higher forecasted capacities generally result in higher employment and output values, whereas the opposite is true for scenarios with lower forecasted capacities. Average employment and output/value-added values reflect a similar relationship as moderated by the year of capacity addition. Moreover, since regional weights are held constant over the study period, the correlation between regional weights and estimated economic impacts mostly exhibits the same relationship.

6.3.2 State-Level Job Impacts

Figure 16 illustrates the estimated average FTE employment impacts from utility-scale BESS deployment from 2026 to 2035 for each deployment scenario: Benchmark, High, and Low.

As shown in Figure 16, direct average annual job creation (FTE) surpasses indirect and induced job creation by 68% on average. The relative number of FTEs added per deployment scenario corresponds directly with the amount of capacity added in the model. The Benchmark deployment scenario forecasts 2,478 MW of storage to be constructed and placed in service by 2035, whereas the High and Low deployment scenarios forecast 2,751 MW and 1,931 MW, respectively. The High deployment scenario represents an 11% increase in cumulative energy storage capacity relative to the Benchmark deployment scenario,

[lx] To appropriately account for intra- and interregional induced effects, IMPLAN estimates "commuter employee compensation" (essentially employee compensation less payroll taxes) utilizing Journey to Work data from the U.S. Census Bureau as well as IMPLAN's own estimates. Since payroll taxes are assessed in the region of direct employment and household demand occurs at the region of residence, employee compensation is treated as a leakage from the county where the employee works. When utilizing the MRIO model, IMPLAN treats this compensation leakage as an induced effect in the linked region representing consumption within the region of residence. For example, commuting flows capture the scenario in which an employee lives in Indianapolis but works in Kokomo. The employee pays taxes in Kokomo but brings their paycheck home and spends it on goods and services in Indianapolis (induced effects).

whereas the Low deployment scenario represents a 22% decrease in cumulative energy storage capacity. Consequently, the average annual FTE creation is 11% higher in the High deployment scenario (1,007 FTE jobs/year on average) and 21% lower in the Low deployment scenario (719 FTE jobs/year on average) compared to the Benchmark deployment scenario (911 FTE jobs/year on average).

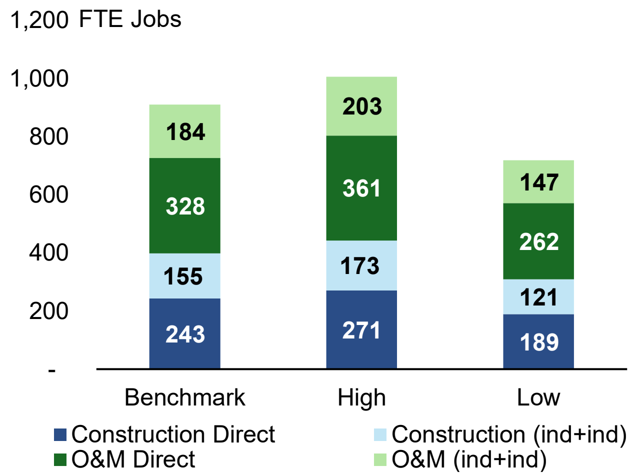

Figure 16. Average Annual Job Creation by Scenario, State-Level (2026-2035)

Again, since IMPLAN does not consider out-of-state contributions to construction or O&M, several manufacturing-related industries are not impacted due to the fact that Indiana does not currently have a robust utility-scale BESS manufacturing sector. On the other hand, O&M expenditures are assumed to be captured almost entirely by in-state industries.

Importantly, impacts associated with construction and O&M are distributed throughout the economy due to consumption expenditures (induced impacts) and, to a lesser extent, supply chain transactions (indirect impacts). Consequently, BESS deployment creates jobs across the occupational spectrum. The ranking of the top 10 industries in terms of job creation is presented in Figure 17 and Figure 18 for Construction and O&M expenditures, respectively, based on the Benchmark deployment scenario. The “All Other” category includes smaller job impacts across hundreds of industries, summed together.

As visualized in Figure 17, architectural, engineering, and related services are the top job types supported for the construction phase of utility-scale deployment, reflecting the specialized design, planning, and ongoing technical support required for the installation of BESS. The majority of FTE employment impacts during construction can be attributed to three industries: architectural, engineering, and related services; construction of new power and communication structures; and retail – building material and garden equipment and supplies stores. These three industries account for roughly 55% of the 399 average annual jobs that could be added to the State of Indiana.

For the O&M phase (visualized in Figure 18), commercial/industrial machinery and equipment repair service jobs are the top job type supported. Other key jobs supported by construction and O&M of Indiana’s energy storage facilities include the construction of new power and communication structures (representative of the construction sector necessary to build the sites), legal services, and sectors like restaurants, real estate, and hospitals.

The industries benefiting the most from consumption expenditures (induced impacts) or supply-chain transactions (indirect impacts) across both construction and O&M phases are full and limited-service restaurants, hospitals, employment services, and real estate services. This illustrates the impact of direct job creation for construction and operations of these facilities trickling through Indiana’s economy as those new workers ultimately spend their labor income and require medical services.

For all top industries, additional employment will peak in 2029, with a gradual decrease thereafter until 2035 corresponding to the flattening of the OCC investment curve as BESS deployment slows. Conversely, O&M-related job impacts increase through 2035, representative of the fact that O&M is a fixed, ongoing expense which accumulates as additional BESS facilities reach commercial operation. Notably, all three deployment scenarios estimate modest BESS benefits to the manufacturing sector. This aligns with the absence of an existing utility-scale battery storage manufacturing sector in Indiana that could be targeted to grow as a result of increased BESS deployments.

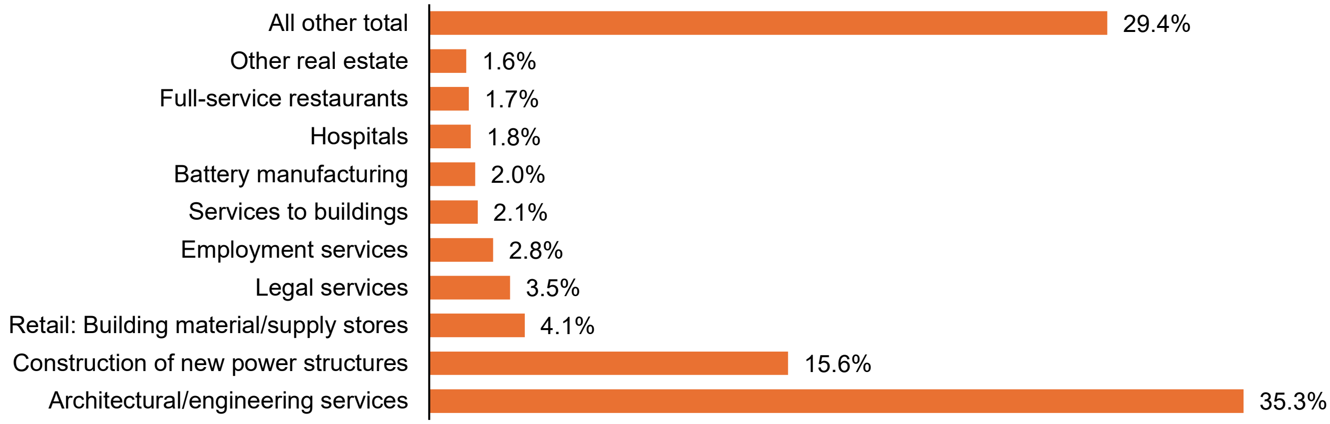

Figure 17. Industries Benefiting from BESS Construction (% FTE Jobs), Benchmark Scenario, State-Level (2026-2035)

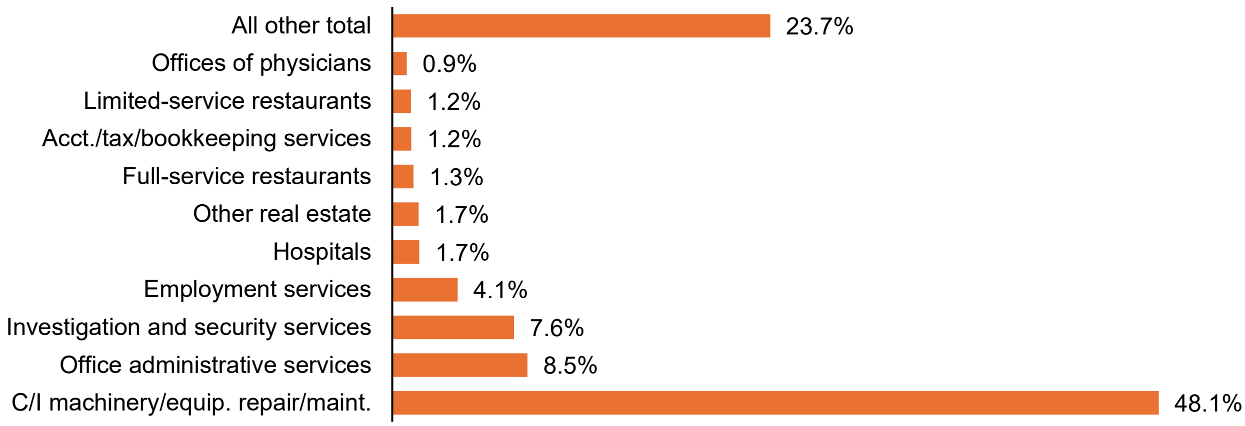

Figure 18. Industries Benefiting from BESS O&M (% FTE Jobs), Benchmark Scenario, State-Level (2026-2035)

6.3.3 State-Level Economic Output

The combined direct, indirect, and induced employment effects over the 10-year period (2026-2035) contribute to an overall economic output (representative of cumulative sales or revenue of in-state businesses) estimated at approximately $1.6 billion in additional economic activity in Indiana. This total consists of $824 million in economic output resulting from the construction phase of deployment and $832 million representative of the O&M phase.

Across all three scenarios, the sales impact from direct investments and expenditures is consistently greater than indirect and induced impacts; around 55% higher for construction investment and 27% higher for fixed O&M expenditures. The concentration of jobs around the top job sectors (discussed above) generally aligns with which industries contribute the most to economic output. Figure 19 shows state-level economic output by scenario.

Total output, as shown above, measures the collective value of all goods and services produced within the region of focus (i.e., Indiana), inclusive of intermediate sectoral supply chain inputs. Another way to evaluate economic impact is to look at value added, which is a subset of output and only focuses on the value of the final good or service produced by an industry, exclusive of any intermediate inputs. This distinction is crucial, as value added provides a clearer picture of the actual wealth produced from investment and operation of BESS facilities and represents contribution to the state's GDP. Figure 20 shows value added by scenario. Under this formulation, overall economic impact is estimated at approximately $1.0 billion. This total consists of $513 million in cumulative value-add resulting from the construction phase of deployment and $505 million from the O&M phase.

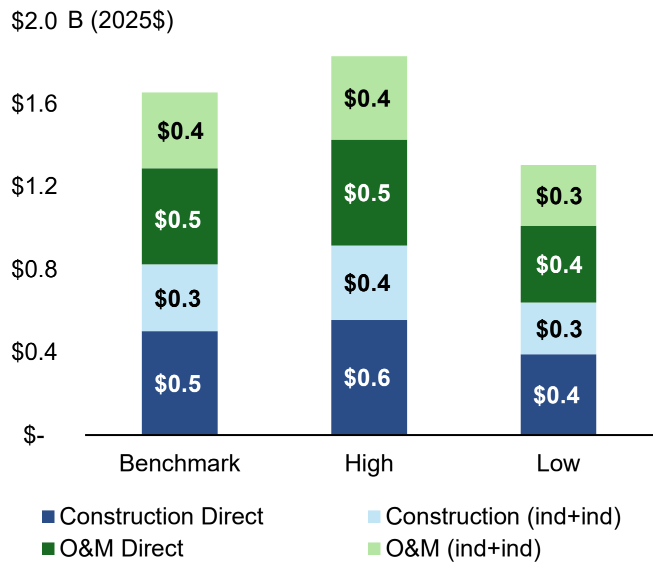

Figure 19. Cumulative Output by Scenario, State-Level (2026-2035)

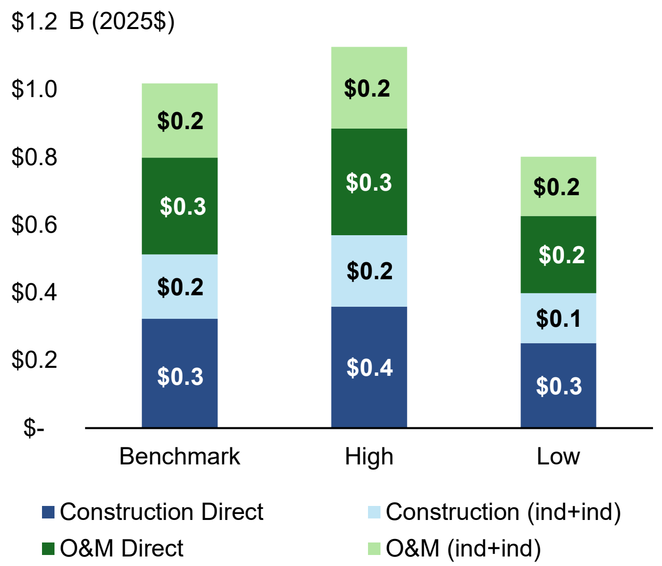

Figure 20. Cumulative Value Added by Scenario, State-Level (2026-2035)

Regarding tax revenue, both the OCC and O&M stages contribute to Indiana's tax revenue at high levels, but their cashflow timelines differ greatly. State tax revenue from construction of energy storage systems peaks in 2028, when forecasted annual deployment reaches a peak, and declines sharply after 2029. Tax revenue from annual O&M expenditure has the opposite trajectory; it starts at a much more modest level and then increases substantially to peak in 2033. Combining both phases' tax revenues results in a smoother cash flow over the review period, with an average collection of roughly $24.5 million in tax revenue annually, dominated by state and federal taxes representative of $21.6 million, or 88%, of the total annual tax revenue impacts.[lxi] Figure 21 visualizes both sources of tax revenue over time.

Actual tax revenue impacts from BESS facilities are contingent upon state and local tax ordinances and whether these ordinances include provisions with special tax treatments. For example, a county may exclude commercial industries from business personal property taxes to incent relocation of industry to the county. On-site BESS equipment would be considered a business personal property and therefore be excluded from the county's tax unless the county has enacted a specific carve-out to the ordinance addressing this. As another example, the state, in an effort to incentivize BESS deployment, could lower or remove personal property tax obligations for co-located/hybrid projects, making development of hybrid resources more favorable than stand-alone BESS.

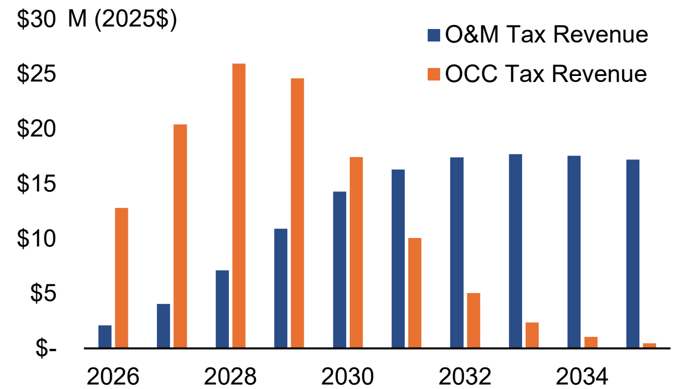

Figure 21. OCC and O&M Yearly Total Tax Revenues, Benchmark Scenario, State-Level (2026-2035)

6.3.4 Regional-Level Job and Economic Impacts

At the regional level, employment and economic impacts from BESS deployment range significantly, corresponding to the weighted construction investment and O&M expenditures assumed for each region.

As shown in Figure 22, the top regions in terms of job growth are the Northwest, West Central, and Southwest (Regions 1, 4, and 10). These three regions are also home to important complementary industries and manufacturing hubs, which Exeter factored into the

[lxi] The tax revenue estimates presented in this analysis are generated using IMPLAN's built-in tax impact modeling system, which uses nationally calibrated average effective tax rates based on data from the Bureau of Economic Analysis (BEA), National Income and Product Accounts (NIPA), and U.S. Census Bureau. These rates apply proportionally to changes in economic activity modeled. Importantly, the results do not reflect Indiana-specific statutory tax codes, but rather standardized estimates of likely tax revenue, distributed across federal, state, and local levels of government, using IMPLAN's Social Accounting Matrix (SAM)-based allocation methods. As such, these tax impacts should be interpreted as modeled approximations of fiscal effects under typical conditions, rather than as precise forecasts of revenue collections for a specific jurisdiction or project.

assigned weights for the location of BESS deployment and, therefore, investment.

As with the State-Level model, the Regional model reinforces the complexity of engineering, designing, and developing a BESS facility, with architectural, engineering, and related services being the number one industry type impacted by construction in terms of jobs for nine out of the 10 analyzed regions. This is followed by impacts to the construction industry itself. The third most impacted industry varies by region between legal services, battery manufacturing, and retail building materials' supply stores (such as Lowes, Home Depot, Ace Hardware, etc.).

As illustrated in Figure 23, which shows jobs supported in the Northwest (Region 1), other common industries impacted by construction activities in terms of jobs supported are employment services, full and limited-service restaurants, hospitals, and real estate. Growth in these industries reflects the effects of direct employment trickling through the economy as economic activity spurs household consumption.

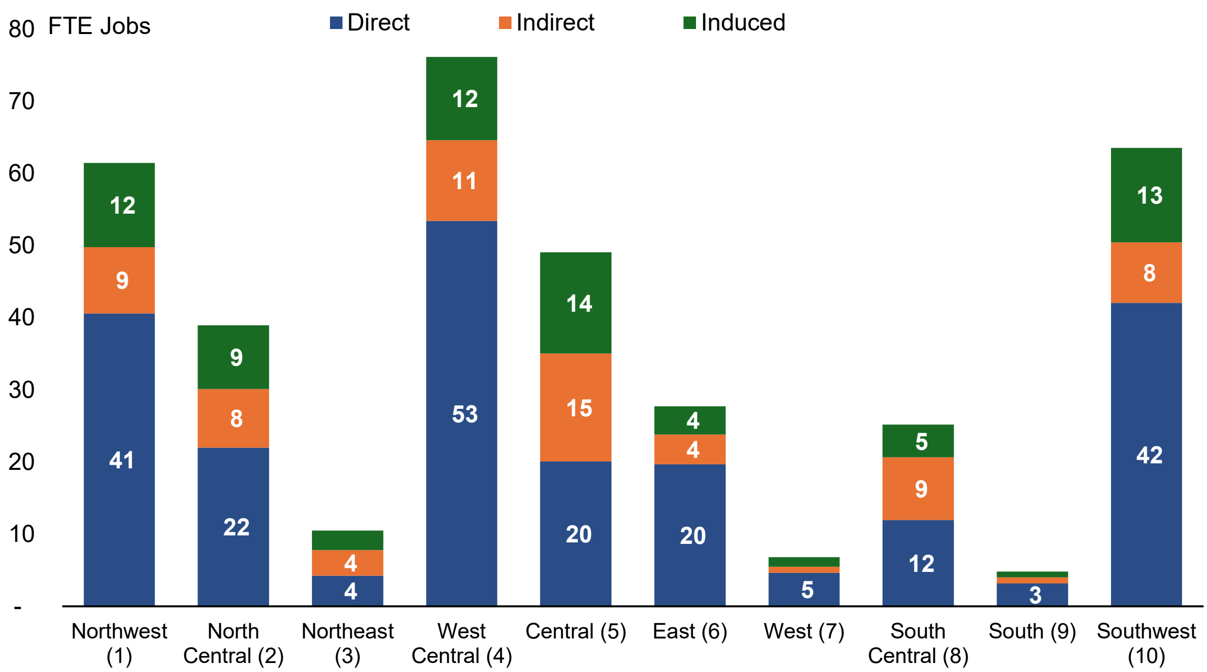

Figure 22. Average Annual Jobs Supported by BESS Construction per Region, Benchmark Scenario (2026-2035)

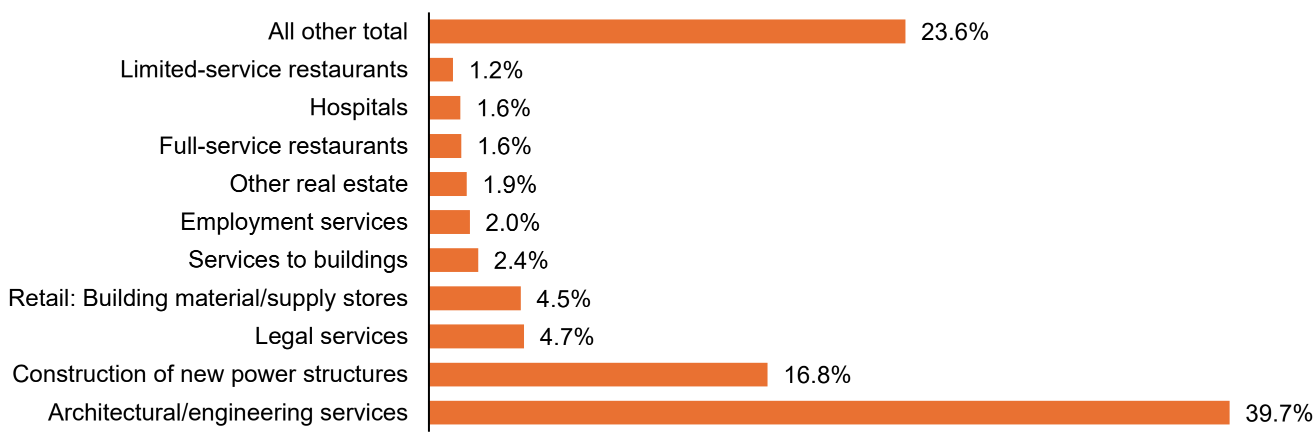

Figure 23. Northwest (Region 1) Industries Benefiting from BESS Construction (% FTE Jobs), Benchmark Scenario (2026-2035)

The Regional model also exemplifies regional differences in Indiana job opportunities, with some regions expected to support a greater share of manufacturing jobs versus service jobs. For example, the Northwest (Region 1), which includes the City of Gary and Valparaiso University, has a relatively dense population with a moderate share of Indiana's white-collar workforce as well as existing renewable industry (e.g., the Mammoth Solar Project). On average, BESS construction activity in the Northwest supports around 61 jobs per year.

By comparison, the West Central (Region 4), which includes the Cities of Kokomo and Lafayette, sees a greater portion of job benefits to its Battery Manufacturing sector located in the region. On average, BESS construction activity in the West Central supports around 76 jobs per year, representing approximately a quarter of Indiana's BESS deployments.

In line with regional job impacts, the impacts to value-add (GDP) across all 10 regions are also concentrated in those regions Exeter predicts are more likely to host the BESS projects. This suggests that the greatest benefits that come from BESS installation and operation will remain local to the regions where deployment occurs (i.e., direct impacts). The Northwest, West Central, and Southwest (Regions 1, 4, and 10) are positioned to see the highest direct impacts to regional value add, estimated as an additional $99.1M, $113.7M, and $102.0M to regional GDP, respectively.

The Northwest and Southwest regions currently host a significant number of solar and wind projects and have strong manufacturing hubs related to batteries and/or steelwork, whereas the West Central region is uniquely positioned between the state capital (located in Central Indiana, Region 5) the Chicago metropolitan statistical area (MSA) (located in Northwest Indiana, Region 1), and estimated to host the greatest deployment of BESS over the 10-year period. See Figure 24 for value add represented for all 10 regions separately.

Mapping out the interregional economic interactions, it becomes clearer that the Central region (Region 5) is a centerpiece in the larger statewide supply chain. Despite relatively modest forecasted BESS deployment (8% of the state's total per year), the Central region accounts for the fourth-largest impact to regional GDP ($137.5M, inclusive of both construction and O&M over the 10-year period). This result is driven by outsized indirect and induced impacts (representative of around 60% of the total value-add impacts for the Central region) from broader battery deployment in Indiana.[lxii]

Figure 25 visualizes the interregional linkages estimated in the Regional model. In this figure, "Origin" indicates where direct impacts occur (i.e., BESS construction) relative to the "Destination" where indirect and induced impacts arise.[lxiii]

The largest linkage is between the West Central (Region 4) and Central (Region 5), with BESS deployment in the West Central resulting in large inter-industry spending (indirect) and household consumption (induced) in the Central region. In fact, a large portion of benefits from investment in other regions will flow back to the Central region.

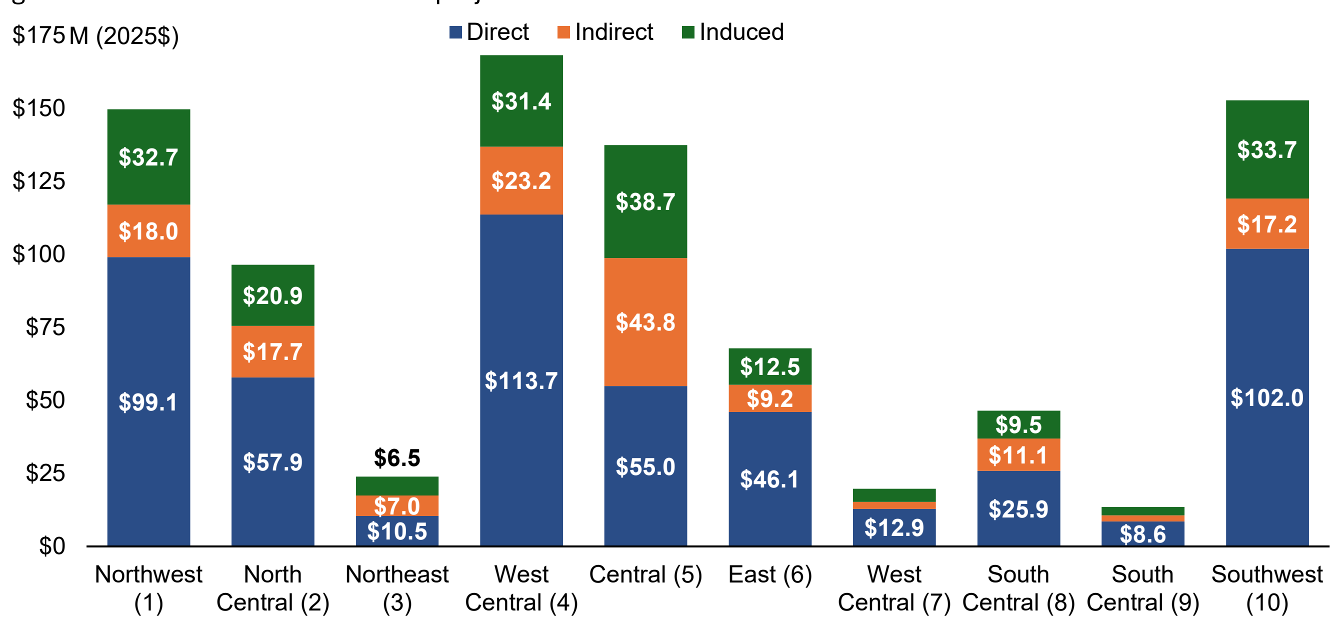

Figure 24. Cumulative Value Added by Region, Benchmark Scenario (2026-2035)

[lxii] Direct investment and O&M in all other regions heavily spur economic activity in the Central Region (indirect and induced) even though the Central Region has minimal direct investment itself.
[lxiii] For example, construction and O&M of BESS in the Southwest Region (Origin) spurs economic activity in the form of indirect and induced impacts primarily in the South Central and Central Regions (Destination).

The Central region's strong interregional economic linkages are further illustrated by the types of industries benefiting from BESS deployment elsewhere in Indiana. As shown in , the majority of jobs supported in the Central region through indirect and induced channels occur in labor-intensive service sectors and professional support industries that play vital roles in the statewide BESS supply chain. The largest indirect employment gains accrue to employment services, real estate, management consulting, and warehousing, indicating the region's role in providing staffing, contracting, logistics, and organizational support to BESS projects across Indiana. Meanwhile, induced impacts are strongest in healthcare (e.g., hospitals, physicians' offices) and food services (e.g., full- and limited-service restaurants) reflecting how construction- and service-related incomes spent locally translate into broader economic benefits.

Notably, the Central region also captures significant indirect employment in architectural, engineering, and related services, further reinforcing its position as a central hub for project design, permitting, and technical support.

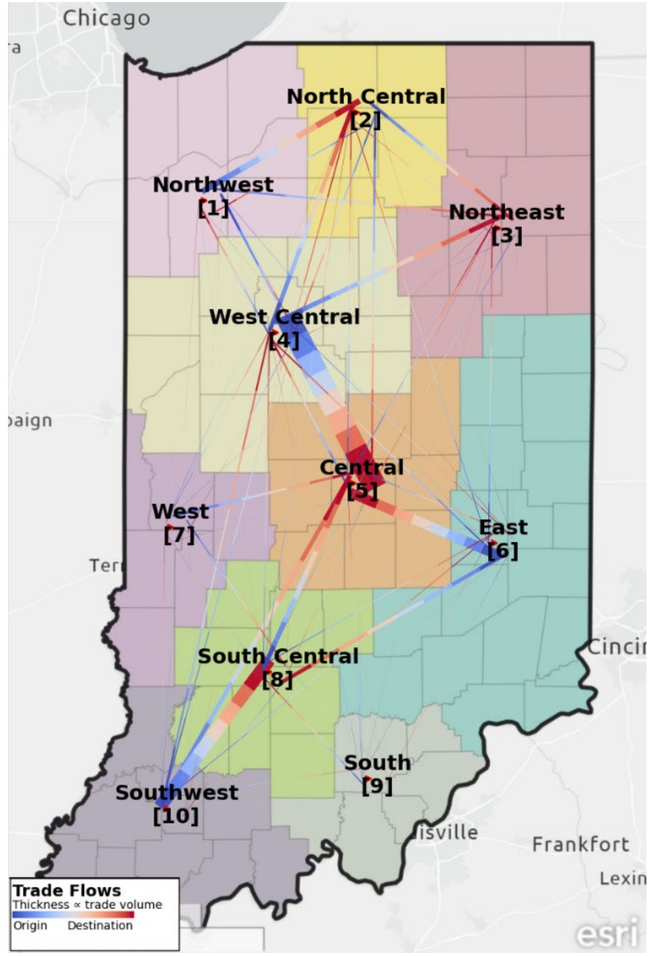

Figure 25. Cumulative Trade Flows Between Regions, Benchmark Scenario (2026-2035)

Source: Adapted from S&P Global Market Intelligence.

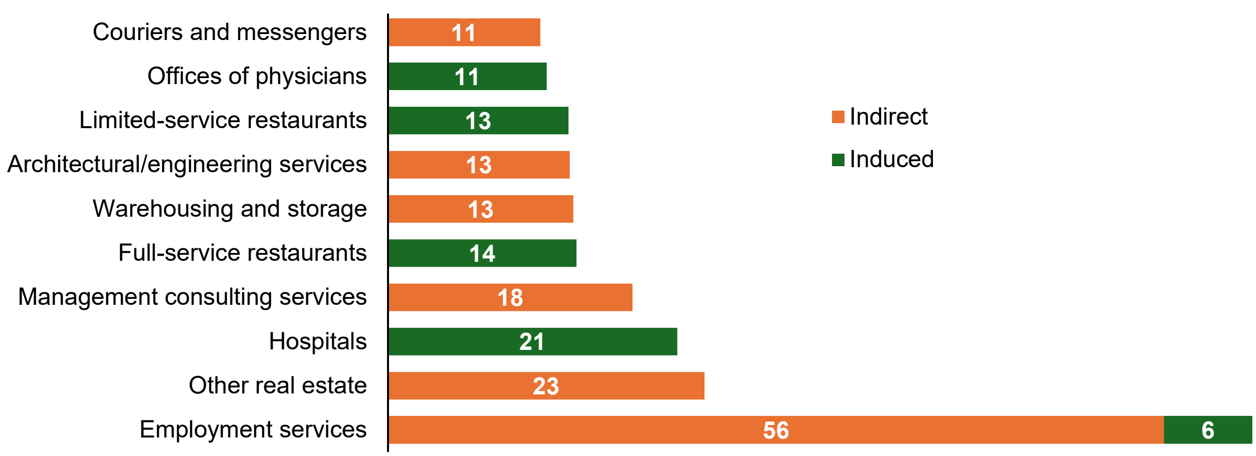

Figure 26. Top Central (Region 5) Industries Benefiting from BESS Deployment Throughout Indiana (Total FTE Jobs), Benchmark Scenario (2026-2035)

6.4 Substitution for Retired Plants

Between 2020-2024, Indiana experienced the retirement of approximately 2,400 MW of coal and natural gas generation nameplate capacity across the Northwest, West Central, South, and Southwest (Regions 1, 4, 9, and 10).[114] These retirements correspond to an estimated loss of approximately 550 direct, long-term operations jobs based on technology-specific staffing rates of 0.2351 FTEs per MW for coal and 0.1213 FTEs/MW for gas.[115] Affected jobs were predominantly on-site roles that supported local

Local-Level Economic Impacts

The economic impacts of BESS deployment in Indiana, although estimated above at a state and regional level, are also applicable at a county or municipal level. This includes the economic benefits of increased economic activity from investment, jobs, and additional tax revenue.

The specific tax treatment of BESS facilities is subject to local tax codes, including potential abatements or incentives under economic development agreements. Three general types of taxes may apply, depending on local ordinance: real property taxes on the land and permanently affixed structures, personal property taxes on equipment and machinery, and utility infrastructure taxes. Local taxing authorities may adopt payments in lieu of taxes (PILOTs) or negotiated community benefit agreements as a substitute for traditional taxation. In general, the installation of a utility-scale BESS leads to increased assessed value for the host property due to the added infrastructure investment. The specific county or municipal benefits, however, can only be determined based on location-specific evaluation.

economies and tax bases in regions where fossil plants have historically served as major employers. Because the above estimates do not account for indirect and induced jobs, they are likely underestimates to the full economic impact.

As discussed above, over the next decade, Exeter estimates about 1,536.5 MW of utility-scale BESS capacity additions in these same regions. Assuming an average BESS project size of 50 MW and three permanent operations roles per project, these installations will create roughly 92 FTE direct jobs—only about one-sixth of those lost from recent fossil retirements.[lxiv] As the net job losses illustrate, utility-scale BESS is an incomplete economic substitute for retiring, traditional power generation resources. Table 13 provides a summary of the regional impacts.

The decision to retire fossil plants is typically driven by economics, asset age, and market structure. However, these decisions have direct consequences for the people and communities that supported these plants for decades. Workers displaced by plant closures often hold highly specialized skills and face barriers to transitioning into alternative employment. At the same time, the economic ripple effects in plant-hosting communities can be profound—declining property values, local business losses, and weakened municipal tax bases are all commonly observed outcomes.

The introduction of clean energy infrastructure like BESS is vital for grid modernization, but these facilities are less labor-intensive, smaller in scale, and often sited based on grid needs rather than considerations of fairness or local reinvestment priorities. This means they may not directly benefit the communities most affected by conventional power plant closures. Even with permanent job creation accounted for, clean energy deployments like BESS do not currently match the employment scale, location, or local economic value of the conventional resources they replace. This underscores the need for energy transition strategies that go beyond capacity replacement to include intentional workforce planning and community reinvestment.

6.5 Current Workforce and Development Opportunities

Indiana is well suited to support a variety of work associated with BESS. The state's industrial capabilities span metal fabrication, chemical processing, advanced manufacturing, logistics, and increasingly, battery component research. Additionally, EV-related BESS manufacturing is already a burgeoning industry in the state. For example, the StarPlus Energy battery plant, a joint venture between Stellantis and Samsung SDI, secured a DOE loan in December 2024 to develop EV battery manufacturing facilities in Kokomo, Indiana. This and other initiatives potentially position Indiana to develop a broader BESS industry that builds on Indiana's emergent EV BESS capabilities.[116]

The subsequent sections review various factors to consider when it comes to opportunities to develop large-scale BESS manufacturing and installation capabilities in Indiana. This includes discussion of Indiana's existing commercial and industrial workforce, talent pools, comparative advantages, and potential supply chain and workforce obstacles.

[lxiv] Note that these estimates are conservative and based on discussions with BESS developers. The direct job estimates modeled above reflect annual fixed O&M spending allocated across Office Administration, Private Security, and Commercial Repair Services, using IMPLAN to estimate direct, indirect, and induced effects. However, because the model applies new O&M spending each year without capping direct jobs, it overstates labor impacts by treating them as recurring rather than sustained. In reality, BESS O&M roles are typically stable, limited in number, and sustained over the asset's lifetime; thus, the 92-job estimate is likely a more accurate reflection of actual direct employment, with modeled results offering a broader upper-bound range that incorporates less easily observed direct impacts on other service industries.

Region	Fossil Retirements (MW)	Coal (MW)	Natural Gas (MW)	Projected BESS (MW)	BESS Jobs Created	Jobs Lost	Net Job Change
Northwest	936.0	903.0	33.0	433.7	26.0	216.3	**-190.3**
West Central	25.2	23.2	2.0	619.6	37.2	5.8	**+31.4**
South	280.0	280.0	-	49.6	3.0	65.8	**-62.8**
Southwest	1,142.3	1,142.3	-	433.7	26.0	269.0	**-243.0**
Total	**2,383.5**	**2,348.5**	**35.0**	**1,536.5**	**92.2**	**556.9**	**-464.7**

Table 13. Regional Employment Impacts of BESS Additions (2026-2035) and Fossil Fuel Retirements (2020-2024)

6.5.1 Relevant Existing Industry

A variety of Indiana companies are already engaged in activities relevant to BESS development. Most notably, Indiana leads the U.S. in steel production.[117] Since BESS requires battery racks and containers, Indiana's steel industry can become a key link in the state's storage supply chain. More specifically, BESS enclosures and components heavily rely on galvanized, stainless, and carbon flat roll steel.[118] Indiana's large and versatile steel industry can help retain the BESS supply chain for these materials in the state. Local availability of steel can also help reduce development costs by decreasing transportation expenses during construction.

According to the American Iron and Steel Institute, Indiana steelmakers (e.g., Cleveland-Cliffs Burns-Harbor facility) produced roughly 22.07 million tons of steel in 2024, accounting for roughly 25% of all steel manufactured in the entire U.S.[119] The state also hosts finishing facilities (e.g., Gary Plate) and value-added product plants (e.g., Columbus Electric Resistance Welded Tubing). Many of these facilities are part of broader, fully integrated supply manufacturers with capabilities to oversee steel manufacturing from raw materials through downstream production (i.e., tooling, tubing, and stamping). Many of these facilities are entwined with the automotive industry.

Although Indiana comprises a high share, both Indiana's steel output, as well as the U.S.'s output as a whole, have declined since the early 1970s, with associated declines in steel-related employment. The Northwest region of Indiana, which is historically known for steel production, would stand to benefit from a broader BESS industry in the state.

Indiana's chemical industry also has a potentially important role to play in future BESS deployment, including the provision of chemicals used for fire safety (e.g., flame retardants), thermal management (e.g., specialized coolants), and the batteries themselves (e.g., electrolytes, separator coatings, electrode materials), among other relevant applications. Indiana, as the second-largest chemical manufacturing state in the U.S., benefits from proximity to major feedback pipelines and intermodal transportation infrastructure.[120] Dow (e.g., Kendallville site) and SABIC (e.g., Mount Vernon facility) maintain operations in Indiana, and several specialty chemical companies are headquartered in the state (e.g., Calumet, Inc.). These industry assets position Indiana's chemical industry to support the evolving technical demands of utility-scale energy storage systems. The presence of major chemical producers also creates opportunities to source materials necessary for in-state recycling and reclamation of battery components. In general, though, Indiana hosts a workforce with blending, purification, and production capacities relevant to BESS manufacturing.

Beyond steel and chemical components, Indiana hosts several companies specifically engaged in BESS-related activities, including power system components and batteries themselves. Cummins Inc., based in Columbus, Indiana, has been awarded $75 million to convert approximately 360,000 square feet of existing manufacturing space at its Columbus Engine Plant for zero-emissions components and electric powertrain systems.[121] Terra Supreme Battery, based in Albion, Indiana, is a start-up focused on advanced lead-acid technologies.[122] Additionally, EnPower Inc. operates a 92,000-square-foot facility in Indianapolis producing up to 800 MWh of advanced Li-ion batteries annually.[123] These companies exemplify Indiana's growing involvement in the manufacturing and system integration of BESS technologies.

Another key contributor to the expansion of BESS industry in Indiana is the existing Battery Innovation Center (BIC), headquartered in the Bloomington Metropolitan Statistical Area. The BIC provides key research to battery development, installation, and commercialization.[124] Moreover, BIC helps incorporate local universities and state agencies to maximize Indiana's potential in this space. In the past, BIC partnered with Purdue University to hold forums focused on commercialization, research and innovation. Additionally, they have a department dedicated to battery testing and evaluation. Known as the "boom room", the BIC tests batteries to the point of failure in order to help understand the strengths and limits of different commercial or prototypes batteries.[125] The results are then shared with different agencies and companies to gain a deeper understanding of what batteries to implement or specific scenarios.[126]

6.5.2 Potential Pipeline

Battery manufacturing remains relatively new in Indiana, and workforce development support will be essential as employees transition from sectors such as conventional utility-infrastructure and traditional manufacturing. Indiana can support this transition by expanding targeted certification programs and workforce pipelines focused on BESS-specific roles.

Moreover, Indiana is home to several universities that have had a growing investment in semiconductor research and other similar fields. Currently, universities are graduating with over 5,000 students annually with degrees related to semiconductor research and development.

While this helps build a high-skilled talent pool, specialized training for BESS construction, installation, and utility integration remains limited. Certification programs offered by institutions such as Ivy Tech Community College typically take 6-24 months, depending on whether the focus is on manufacturing technicians, utility operators, or safety inspectors.[127]

Hoosier Energy and Indiana State University have begun addressing the need for a larger high-skilled workforce through their Emerging Energy Technology Program.[128] This initiative helps workers develop skills needed in electric transmission and distribution through certification programs targeted at skills relevant to emerging energy technology. This program serves as an example of how reskilling and retraining programs can offer direct pathways into BESS-related occupations for workers from traditional energy sectors. For further information about certifications and skillsets, see Table 14.

Indiana can also investigate developing battery recycling hubs. In March 2023, Entrek, a “wet-process” Li-ion recycling company, announced it is opening the first of its kind recycling center in Terre Haute to address the heavy reliance on imported materials.[lxv]

Table 14. BESS-Related Current Training Resources

Training	Institution	Duration	Description
Energy Storage Installation Professional[1]	North American Board of Certified Energy Practitioners (NABCEP)	2-3 mos.	A competitive, nationally recognized certification focused on the design, installation, and maintenance of standalone and PV-integrated energy storage systems. Participants complete 58 hours of advanced storage training, OSHA 30, and must document field experience. The certification process includes a rigorous exam to ensure practical and technical proficiency.
Energy Storage & Microgrid Training & Certification[2]	Pennsylvania State University	Approx. 40 hours + exam	The training and exam cover safe installation, maintenance, and decommissioning of BESS and microgrids. Skills covered include system wiring, standard battery handling, and following safety protocols.
Entry-Level Bess Technician Training Guidelines[3]	American Clean Power	N/A	A standardized outline to guide the development of entry-level technician training programs. Includes key competencies such as electrical safety awareness, basic O&M, system shutdown procedures, and emergency protocols. Ideal for employers or schools building workforce training programs.
PV System Fundamentals[4]	Solar Energy International	Approx. 40 hours	Through focusing on the intersection of battery systems and solar systems, this course covers the important foundations of designing, installing, and maintaining PV systems with batteries. Skills covered include load analysis, electrical integration of components, and safety considerations.
Associate’s Degree in Energy Technology[5]	Ivy Tech Community College	60 credit hours	Local to Indiana, Ivy Tech offers a degree in energy technology where students learn about and operate different classes of energy tech, including batteries. Specifically, the college hosts a course dedicated to different energy storage systems, from chemical batteries to hydroelectric storage.

[1] https://www.nabcep.org/certifications/energy-storage-installation-professional-esip/.
[2] https://esamtac.org/.
[3] https://cleanpower.org/resources/guidelines-for-entry-level-bess-technician-training/.
[4] https://www.solarenergy.org/courses/solar-training-pv-system-fundamentals-battery-based-online/.
[5] https://www.ivytech.edu/programs/all-academic-programs/school-of-advanced-manufacturing-engineering-applied-science/energy-technology/.

[lxv] Hydrometallurgy or “wet-process” is a recycling process focused on chemical reactions to extract specific metals.

RecycleForce and Workforce Development

The RecycleForce is a "social enterprise" that hires ex-incarcerated individuals to recycle electronic waste. Since its founding in 2006, RecycleForce has recycled more than 65 million pounds of electronic components. Current Indiana Governor Mike Braun visited the facility during his tenure as a U.S. senator, where he stressed the importance of "urban mining." Organizations such as RecycleForce can help address current limitations with BESS recycling as well as address gaps in battery recycling workforce. Entities like this are an important step toward development of a broader BESS recycling network, with associated economic development opportunities. (See Chapter 4 for additional discussion of recycling processes.)

6.5.3 Shortfalls in Supply Chain

While Indiana possesses foundational manufacturing strengths, several stages of BESS production and deployment remain constrained by structural and logistical limitations. The largest shortcoming involves electronic components and materials needed for BESS. BESS requires small electronic components that Indiana currently does not manufacture. These electronics help regulate energy flow and maintain battery health among other functions. Despite seeing strong growth in the manufacturing of computer and electronic products since the late 1990s, Indiana's production has decreased since 2009.[129] From 2009, when growth halted, to the present day, Indiana's computer manufacturing sector decreased by roughly -24% compared to the national growth of 41% over the same period.[lxvi] These high value-added components are largely manufactured in Asia.

Although there are federal and state efforts to increase domestic chip and electronics manufacturing through the CHIPS and Science Act and efforts led by the Indiana Economic Development Corporation, Indiana has not yet captured a substantial portion of these investments related to BESS applications.[130] A notable exception is SK hynix's 2024 announcement of a $4 billion investment to construct a semiconductor packaging and R&D facility in West Lafayette. While the project is focused on dynamic random access memory (DRAM) chips for computing, the associated workforce development and infrastructure investments may eventually facilitate co-located or adjacent industries, including power management components essential for BESS.

Indiana also benefits from a highly competitive cost of doing business which makes these investments attractive. According to the Tax Foundation, a nonpartisan thinktank that researches state and federal tax policy, Indiana has the 12th best structured corporate tax ranking and the 10th ranking overall.[131] Indiana also maintains the highest credit ratings available by all three major credit rating agencies.[132]

Along with manufacturing, Indiana also lacks a key input for electronics: access to minerals. Indiana is not host to known significant reserves of critical minerals such as lithium and nickel. This reliance on imported materials can be overcome to some degree through advanced battery and electronic recycling facilities, but at additional cost.

Lastly, there is the issue of opportunity cost. EV-related investment that is increasing demand for highly skilled workers may paradoxically also limit BESS manufacturing in the short term. Labor force constraints mean that expanding both EV and BESS production could result in talent competition between sectors. Workforce development strategies that distinguish between roles in EV manufacturing (e.g., vehicle assembly, battery integration) and BESS applications (e.g., utility-scale installation, inverter systems, site operation) will be needed to avoid displacement or bottlenecks in labor availability. Notably, HEA 1168 (2021) previously established the Electric Vehicle Product Commission to promote EV manufacturing growth and industry needs in Indiana.[133] A similar effort for utility-scale BESS could comprehensively address workforce and economic development opportunities.

6.5.4 Regional Competition

Battery manufacturing growth across the Midwest and Southeast has intensified regional competition, particularly within the so-called "Battery Belt" — a corridor of states that includes Michigan, Ohio, Kentucky, Tennessee, and Georgia.[lxvii] States in the Midwest and Southeast are attracting substantial federal and private investment in battery production due to their existing automotive manufacturing infrastructure, logistics networks, and favorable economic development programs. For instance, Georgia has secured more than $6 billion in battery manufacturing commitments since 2021, while Michigan and Ohio have added new cell production lines through partnerships with LG and Honda, respectively.[134,135,136]

In September 2021, five states joined to form the Regional Electric Vehicle Midwest Plan to accelerate EV supply, share industry knowledge and create regulatory uniformity across the region.[137] This helped create stronger supply chains and ensure economic growth. A similar initiative should be created for batteries as this initiative also helped ensure costs remained low, as

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[lxvi] Indiana's real GDP for computer and electric product manufacturing shrunk from $2.53 billion in 2009 to $1.92 billion as of January 1, 2023, while the average real GDP for all states nationally increased from $4.37 billion to $6.16 billion over the same time period.

[lxvii] The battery Belt refers to states undergoing surge in battery manufacturing. These mainly states include Georgia, North Carolina, South Carolina, Tennessee, Kentucky, Michigan, Indiana and Ohio.

states/firms did not need to compete by offering higher wages. This multi-state initiative, while focused on EVs, provides a potential model for extending collaboration to utility-scale battery storage.

With many states in the region having similar goals of manufacturing batteries for different purposes, the supply chain can be streamlined and used to address specific weaknesses within each state. One aspect Indiana would benefit from is exporting its steel production. Indiana's central location between MISO and PJM service territories also positions it as a potential training and deployment hub for grid-scale BESS projects. Aligning training programs with RTO-specific interconnection and grid services requirements could increase the state's value in regional storage planning. In-state resources could also be deployed to either market to support the development of batteries, with resource flows responsive to changing market conditions.

Indiana Competitiveness

Indiana already features several characteristics that make it an attractive destination for energy technology research, development, and deployment (RD&D). For example, the state offers a competitive tax structure, a strong existing manufacturing base, and a strategic location with convenient access to key interstate highways. In addition, Governor Mike Braun recently issued Executive Order 25-40 which aims to expedite permitting timelines by publicly disclosing data on permitting delays.[1] The business magazine *Area Development* ranked Indiana 4th in availability of sites, 6th in Favarable Regulatory Environment, and 8th in Site Readiness Programs.[2]

[1] State of Indiana Executive Order 25-40. (2025). *Increasing Opportunity for Indiana's Businesses and Hoosiers through Permitting Transparency and Accountability.* https://www.in.gov/gov/files/EO-25-40.pdf.
[2] Greiner, A. (2024). Top States for Doing Business in 2024: A Continued Legacy of Excellence. *Area Development.* https://www.areadevelopment.com/Top-States-for-Doing-Business/q3-2024/top-states-for-doing-business-in-2024-a-continued-legacy-of-excellence.shtml.

Indiana BESS Workforce at Scale

Scaling a utility-scale BESS industry in Indiana will require a specialized and multidisciplinary workforce that combines electrical, mechanical, chemical, and environmental competencies. While several skill areas are emerging as priorities, the specific workforce needs remain fluid and somewhat uncertain due to rapid technological evolution, diverse project configurations, and limited historical precedent.

Current and potential needs include:

- Field Installation and Commissioning Technicians: There is rising demand for skilled tradespeople who understand both high-voltage systems and the unique requirements of battery installation in commercial, industrial, and utility-scale settings.
- Battery Chemistry and Thermal Management: Few training programs in Indiana currently provide in-depth instruction on BESS chemistries, battery management systems (BMS), or safety protocols associated with storage units.
- Recycling and Decommissioning Skills: As the installed base of BESS grows, Indiana must prepare for downstream job demand in safe disassembly, materials recovery, and environmental compliance—areas that require coordination with chemical handling and waste management standards.

Developing a BESS Recycling Industry

BESS recycling remains a nascent industry. As a result, companies and governments investing in recycling still face significant risks, as illustrated by the recent bankruptcy filing by industry leading BESS recycling start-up Li-Cycle in May 2025. Nevertheless, the emerging market for recycling of both distributed and utility-scale BESS represents a meaningful economic development opportunity for the state. Common approaches to facilitate development of nascent energy technologies include:

1. Land-readiness: Pre-zoning or designated specific areas for specialized use, such as BESS recycling.
2. Tax abatements: Temporarily reducing property or business taxes to lower operating costs for recycling companies.
3. Financial incentive: Providing grants or low-interest loans to support facility construction and equipment investment.
4. Consolidated permitting: Streamlining approvals across agencies to shorten project timelines and reduce uncertainty.

All the above strategies, ultimately, incentivize economic development by reducing various types of developer risk or shifting the risk to state or local entities. Bonding requirements, performance based incentives, and due diligence processes can help mitigate shifted risk. State entities like IOED can also provide technical assistance.

While early activity can occur within a few years, building a fully scaled, competitive BESS recycling industry may take a decade or more. Market maturation depends on steady policy support, permitting capacity, and long-term signals of battery supply availability.

7. COMMUNITY ENGAGEMENT

7.1 Executive Summary

Thoughtful community engagement is fundamental to effective BESS deployment. This chapter reviews best practices and strategies for local governments to facilitate effective communication and engagement with residents regarding utility-scale BESS technology. It also looks specifically at IOED's role in facilitating community engagement.

Key findings and insights from this analysis include:

- Survey results highlight educational needs. A statewide survey revealed predominantly neutral attitudes toward BESS, with increased support closely tied to greater familiarity. Most respondents recognized potential cost savings and local job opportunities. All residents, but particularly rural residents (where most BESS are located), expressed concern about rate impacts and environmental impacts. The results underscore the importance of clear, accessible information.
- Local governments should follow established community engagement practices. For BESS project planning and deployment, local governments should utilize established engagement practices. These include proactively developing and distributing clear, accessible educational materials tailored to local contexts; initiating public meetings and providing multiple participation channels early and consistently throughout the project lifecycle; and employing structured systems to gather, document, and review community feedback for consideration in relevant decision-making processes.
- Model ordinances streamline approvals. Adopting vetted templates—such as New York's model BESS ordinance or Michigan's BESS planning and zoning guide—can help localities ensure thorough and comprehensive standards.
- IOED has an important convening and technical assistance role. IOED can host public forums, produce outreach materials, and partner with experts to guide municipalities in establishing BESS permitting and zoning requirements, especially with regard to safety and land-use standards. IOED is well-positioned to assist because of its existing relationships with local governments, its understanding of statewide energy policy goals, and its ability to coordinate across jurisdictions to align local implementation with best practices.

7.2 Introduction

Community engagement is a foundational element for the successful deployment of many energy technologies—particularly for emerging technologies like BESS, which remains unfamiliar to many residents. Effective community engagement hinges on a clear understanding of local perspectives, what residents know, what they expect, and what concerns they may have regarding new energy solutions. Without engagement, BESS projects risk facing public opposition, delays, or missed opportunities to deliver local benefit.

The goal of this chapter is to explore nuances related to community engagement regarding BESS in Indiana. The chapter begins with a review and summary of findings from a high-level survey of Indiana residents. Following the survey analysis, the chapter examines common standards and best practices for effective community engagement concerning all energy projects, including BESS. The chapter then reviews strategies for proactively addressing key community concerns, such as safety, land use, and economic impacts. The chapter concludes by exploring the multifaceted role IOED can play in BESS deployment. This includes IOED's potential to support public outreach, guide the development of model ordinances, clarify state and local regulatory authority, advise on structured incentive frameworks, lead economic and workforce impact assessments, and identify funding and incentive opportunities.

7.3 Survey Design and Results

To understand public awareness, perceptions, and concerns regarding BESS deployment in Indiana, IOED conducted a survey to gather input from residents. The survey assessed knowledge of BESS technology, level of support or opposition, perceived benefits and concerns, and expectations for community engagement in decision-making.

Dynata LLC, a survey research firm, administered the online survey among 1,000 Indiana residents aged 18 and older. Survey quotas targeted three categories—age, gender, and location—to ensure representative-ness. In several cases, to accomplish the original quota requirements, Exeter employed data "weighting" methods as is standard practice in survey research. All responses were subject to quality control through several consistency check questions. Subsequent discussion of the survey results is based on the final, weighted data. For additional information about the survey methodology, stratification, and weighting, see Appendix K. Appendix K also includes the complete survey results, including the text responses to open-ended questions.

The survey results, generally, show that public opinion about BESS is still developing. Figure 27 graphs responses to QSUPPORT, which asked about support or opposition to BESS in Indiana. The majority (61.1%) of survey respondents had a neutral opinion on BESS. Among respondents with an opinion, however, support for BESS (35.4% "Support" or "Strongly support") exceeded opposition (3.5% "Oppose" or "Strongly oppose") by a factor of nearly 10.

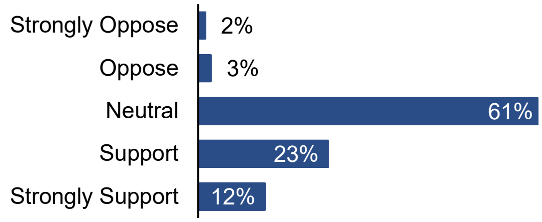

Figure 27. Public Support for BESS

For typical sources used by residents to obtain information regarding energy technologies (including BESS), results varied. The most common response to QINFORMATION was "No Active Research," selected by 36% of respondents. Additionally, no single source predominated among respondents who selected at least one source of information. However, a handful of sources were repeatedly mentioned. These include social media, news media, and word of mouth, identified by 30%, 29%, and 27% respondents, respectively. Few (8%) residents identified government agencies as a source of information regarding energy technologies.

Familiarity is closely linked to sentiment toward BESS; most respondents (88%) "Extremely familiar" with the technology also expressed strong support. Those "Not familiar at all" or "Slightly familiar," meanwhile, predominantly expressed neutral views (73%). Figure 28 shows crossed data from QFAMILIARITY and QSUPPORT.

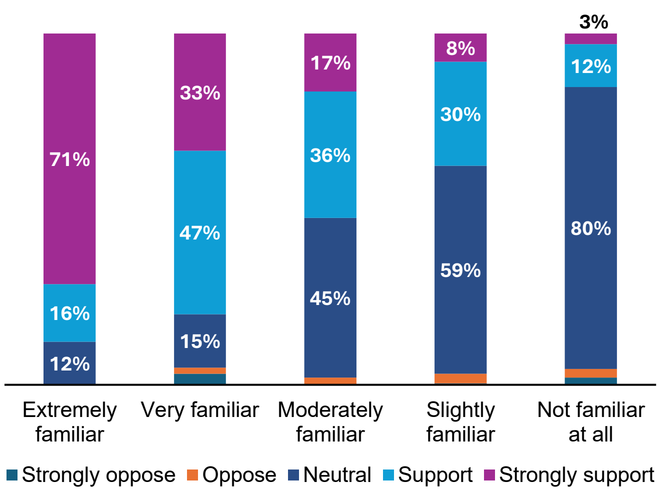

Figure 28. Relationship Between Familiarity and Public Support for BESS

No single issue emerged as a predominant BESS concern among Indiana residents. Out of six options included in QCONCERNS, environmental impact was the most selected (36% of respondents), followed by impact on electricity rates (31%) and general lack of information (30%). Impact on viewshed was the least selected option (4%), which is consistent with BESS having a much smaller footprint than other energy technologies.

Respondents who described their familiarity of BESS as "Not familiar at all" in response to QFAMILIARITY cited their largest concern as lack of information (38%), followed by environmental impact (29%) and electricity rate impact (28%). This highlights the importance of furthering BESS education among the general population.

A subsequent question, QENVIRCONCERNS, probed further into the level of concern among respondents regarding environmental impact. Despite environmental impact being the most selected response to QCONCERNS, there was approximately the same number of respondents "Not very concerned" (17%) as "Very concerned" (19%) in response to QENVIRCONCERNS. The plurality of respondents instead reported themselves as "Somewhat concerned" (48%).

Survey responses for possible BESS benefits were more concentrated, with the most common perceived benefit being backup power during emergencies (43%), followed closely by lowering electricity rates (41%) and improving power reliability (38%). Job creation and economic opportunities ranked the lowest, with only 25% of respondents selecting these benefits. Among respondents who claimed they were "Extremely familiar" or "Very familiar" with BESS, the majority cited providing backup power during emergencies (57%) and improving power reliability and reducing outages (50%) as the top benefits.

Most respondents demonstrated a shared understanding of the most important economic benefits of BESS when probed further. Figure 29 weighs the responses to QECONBENEFITS, which asked respondents to select up to three important economic benefits of BESS in Indiana. The majority of respondents (71%) identified "Lower energy costs" as among the most important economic benefits of BESS installations.

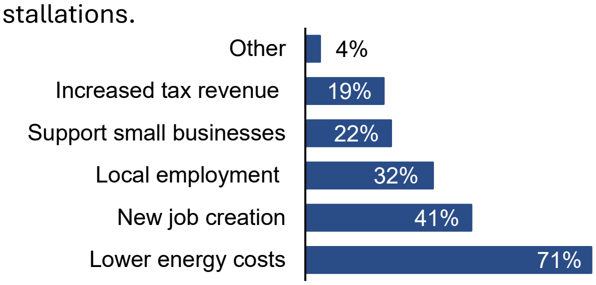

Figure 29. Public Perception of BESS Economic Benefits

Exeter also examined the above responses in consideration of the three major stratification demographics (age, gender, and urbanicity). Figure 30 and Figure 31 break down QCONCERNS and QBENEFITS responses by age, respectively. All age categories shared "environmental impact" as the most prevalent topic of concern related to BESS. The two older age groups (35-54 and 55+) were more concerned about higher electricity rates compared to younger age groups. The youngest (18-34) age group, by comparison, was more concerned with safety and tax impacts from BESS.

The most common perceived benefits among Indiana's broader population, including backup power during emergencies, lowering electricity rates, and improving power reliability, are largely the same irrespective of age. Younger (18-34) respondents were more likely to select "Supporting Renewable Energy" and "Creating Economic Opportunity" as benefits. A relatively higher portion of residents between 35-54 identified BESS's potential to lower electricity costs as a benefit, while a higher portion of the oldest age group (55+) identified BESS's ability to provide backup power during an emergency as a benefit.

Figure 32 and Figure 33 break down QCONCERNS and QBENEFITS responses by urbanicity, respectively. A plurality of respondents identified environmental impact as a concern irrespective of urbanicity. Residents in rural areas, where most BESS are located, were relatively more concerned with environmental impacts and rising electricity rates compared to their urban and suburban counterparts. In contrast, suburban respondents were more likely to anticipate improvements in backup power availability due to the deployment of BESS.

Respondents across all community types most cited backup power and lower electricity costs as the primary benefits of BESS, with suburban respondents especially emphasizing backup power. Suburban and urban residents more frequently identified support to renewable energy as a benefit from BESS, as compared to rural residents.

Similar analysis was conducted using gender, with no significant differences observed for most questions, including QBENEFITS and QCONCERNS.

Overall, the survey indicates that many Indiana residents hold neutral attitudes regarding BESS. It also illustrates the need for improved access to information about BESS; the most common concern of respondents who were not familiar with BESS technologies was simply a lack of general information. This suggests that there is an opportunity to increase BESS support simply with increased information.

Additionally, over 91% of respondents indicated that local community involvement in BESS decisions is at least "Somewhat important" in response to QINVOLVEMENT. BESS decision-making processes undertaken by local governments provide an opportunity to address the above information gaps. These efforts, however, should utilize alternative, more widely used sources of energy information (e.g., social media, news outlets). Entities providing information regarding BESS should also be aware of benefits and concerns unique to deployment urbanicity.

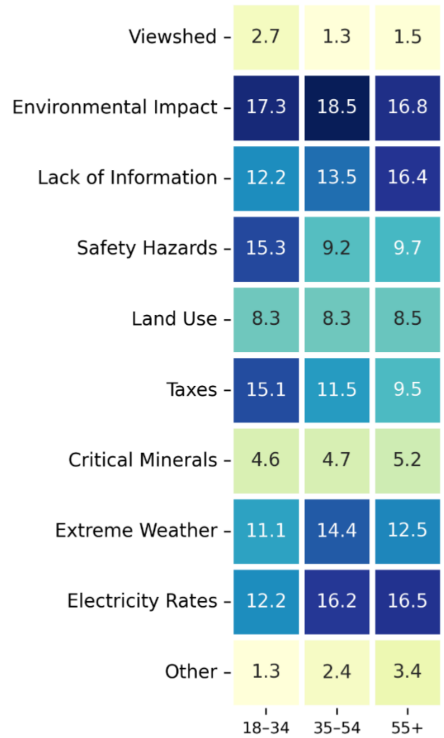

Figure 30. Distribution of Perceived BESS Concerns, by Age

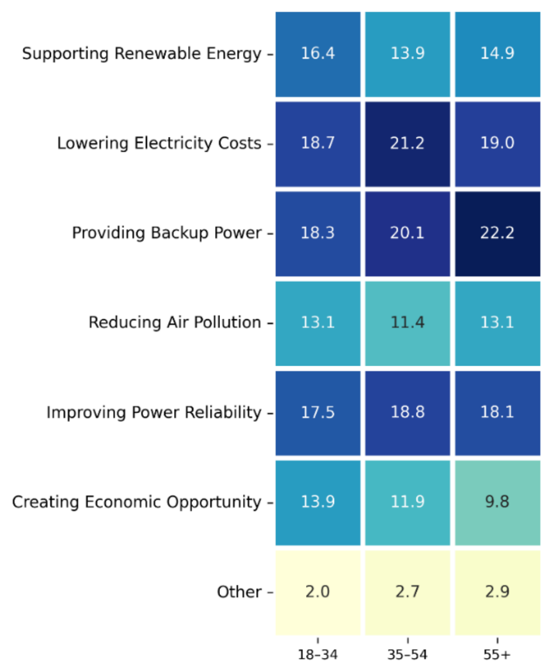

Figure 31. Distribution of Perceived BESS Benefits, by Age

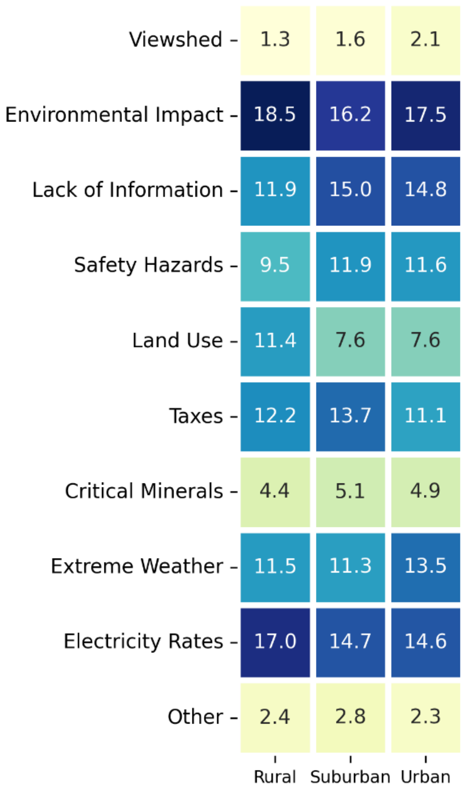

Figure 32. Distribution of Perceived BESS Concerns, by Urbanicity

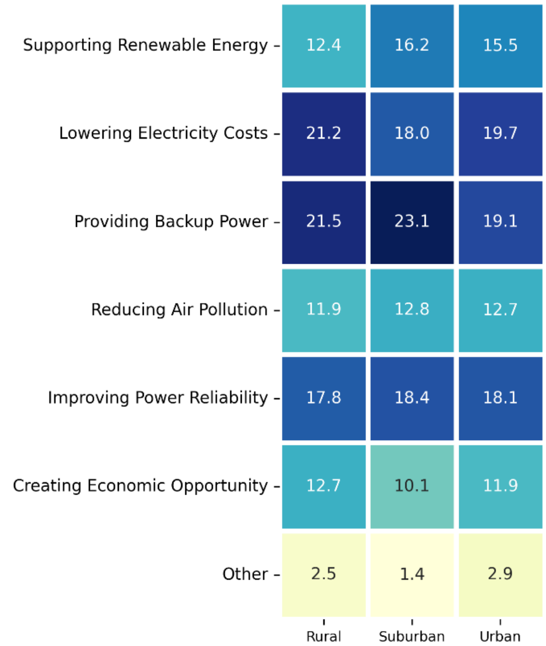

Figure 33. Distribution of Perceived BESS Benefits, by Urbanicity

7.4 Common Community Engagement Standards and Practices

Common, let alone "best," practices for community engagement regarding BESS are still emerging, especially as deployments continue to rise. Nevertheless, certain established engagement standards and practices exist that can help guide local governments as they engage with residents regarding existing and/or prospective BESS. In most cases, these strategies follow models established for conventional energy and infrastructure projects.[lxviii]

7.4.1 General Principles of Effective Community Engagement

Local governments play a crucial role in ensuring that community engagement for BESS projects is transparent, inclusive, and responsive to public concerns. Engagement efforts should prioritize education, early participation, and structured feedback mechanisms to build public trust.

Transparency and Accessibility

Practices related to transparency and accessibility in community engagement for BESS projects include:

- Providing clear, easily understandable information about BESS, especially material that addresses common misconceptions;
- Making technical documents, permitting details, and safety plans readily available to the public; and
- Establishing a dedicated point of contact who is available to address community questions and concerns.

This need for proactive and transparent community engagement is emphasized in research conducted by NREL. NREL specifically highlights the importance of building authentic relationships with local stakeholders and ensuring that community feedback is visibly integrated into project outcomes. When community members see their concerns reflected in permitting and safety measures, resistance often diminishes and trust is established. This structured feedback loop is a recommended best practice for any local government considering BESS projects.[138]

[lxviii] For more information on the topics addressed below, readers should consult the additional resources listed in Appendix L.

BESS Impacts on Property Values

Research on the impact of BESS on nearby property values remains relatively limited, but available literature and analogous infrastructure studies suggest that effects are context-dependent and typically modest. Several studies of comparable energy infrastructure (e.g., solar farms and power lines) indicate that proximity influences property values, though the degree and direction of impact varies with factors such as visibility, noise, prior land use, urbanicity, perceived safety, and community engagement.[1] While dedicated peer-reviewed studies on BESS are sparse, anecdotal evidence suggests that when well-sited, screened, and managed with transparent safety protocols, BESS facilities are unlikely to affect property values.

[1] See, for example, recent LBNL studies evaluating solar (https://emp.lbl.gov/publications/shedding-light-large-scale-solar) and wind (https://emp.lbl.gov/news/do-large-scale-wind-projects-impact). For a more comprehensive evaluation of earlier literature evaluating all energy infrastructures, see https://www.sciencedirect.com/science/article/abs/pii/S2214629618300495.

Early and Ongoing Public Engagement

Local governments regularly address new projects in public meetings as part of local development and siting approval processes. Best practice for effective community engagement leans into these meetings, including structured meeting schedules that begin prior to project approval and then continue on an ongoing basis=. This includes meeting throughout the entire lifecycle of the project, from the initial development stages through construction, operation, and, ultimately, decommissioning. Additionally, regular communication through municipal websites, newsletters, and community boards helps residents stay informed about project developments. This whole range of engagements provides community members with meaningful opportunities for input and discussion.

Forming local advisory groups can be an effective strategy to ensure continuous dialogue, transparency, and responsiveness to community interests. These advisory groups should include diverse representation, involving stakeholders such as homeowners, local businesses, and environmental groups to reflect the broader spectrum of community perspectives and concerns.

DOE's Renewable Energy Siting Through Technical Engagement and Planning (R-STEP) Program has supported over a dozen states with developing collaboratives focused on engagement with local communities and other stakeholders.[139] This includes an Indiana R-STEP program hosted by Purdue University. The purpose of this collaborative is to support Indiana communities with the resources necessary to plan for utility-scale renewable energy. The topics addressed by the collaborative as part of webinars, workshops, and in-person meetings, however, could easily apply to utility-scale BESS. This includes discussions about local planning and permitting, economic impacts, agrivoltaics, property value impacts, and more.[lxix]

Additionally, municipalities can enhance public understanding by providing community members with direct opportunities to engage with experts, developers, and local officials. Northeastern Rural Electric Membership Cooperative (NREMC), for example, regularly makes itself available as a resource to address questions from local government and utility stakeholders. Offering site visits to existing BESS installations can also help residents and other community leaders become more familiar with storage technologies and operations.

Structured public feedback collection is also an important component of successful community engagement strategies. Communities can implement surveys or on-record listening sessions to gauge public sentiment and identify prominent concerns. Providing multiple channels for participation, including public forums, opportunities for submitting written comments, and online Q&A sessions, can enhance the accessibility of these efforts. Moreover, thoroughly documenting and responding to community feedback clearly demonstrates how public input is integrated into the decision-making process.

7.4.2 Addressing Specific Community Concerns

As described above in the Survey Results review, Indiana residents are concerned about various facets of BESS deployment on Indiana's grid. The following sections review potential approaches and strategies to address community concerns and questions about topics including safety, land use, and economic impact.

To accompany this brief discussion, Exeter also prepared short "briefing" materials intended to support local governments in Indiana as they introduce BESS to constituents. These materials, which are included in Appendix M, address common questions and concerns from community members related to various topics. By offering these resources, Exeter aims to enhance local governments' ability to engage with residents effectively and transparently, building community trust and support for energy storage initiatives.

[lxix] Participants include Purdue Extension Community Development, IOED, Ball State University, Center for Energy Education, Center for Infrastructure & Economic Development, IN-ACRE, American Planning Association-Indiana, Indiana University Public Policy Institute, JWM Co., Myerson Consulting, and The Nature Conservancy. For additional information, see: Purdue University. *Renewable Energy Siting Through Technical Engagement and Planning (R-STEP)*. https://extension.purdue.edu/cdext/thematic-areas/community-planning/collaborative-projects/rstep/index.html.

Safety and Emergency Preparedness

Local governments can provide transparent and easily accessible information regarding fire prevention measures, such as detailed Emergency Response Plans. Regular community safety briefings, organized in collaboration with local fire departments and emergency personnel, can further enhance community awareness and preparedness. Additionally, the publication of third-party safety assessments can strengthen public confidence by demonstrating independent evaluation and oversight.

Local governments can also adopt regulatory measures that define specific operational requirements, such as routine inspections, that ensure consistent protection and risk mitigation throughout the system's lifecycle. Additional best practices regarding Emergency Response Plans, coordination with local fire departments, and emergency training are discussed in Chapter 5.

Land Use and Aesthetics

Municipalities and project developers can present visual renderings and site mock-ups illustrating the appearance of proposed BESS projects upon completion. These renderings can help clarify community expectations about BESS, which remains a relatively novel technology in contrast to increasingly prevalent resources like solar and wind.

To further address visual impact concerns, local governments can implement zoning, setback, and site preparation measures. This includes vegetation buffer, fencing, and screening requirements. Requirements that developers support community beautification initiatives near storage project locations may help alleviate aesthetic concerns and foster positive local perception. Additional best practices regarding siting and environmental mitigation are discussed in Chapter 4.

Economic and Property Value Considerations

Economic impacts and property value considerations are common concerns for residents living in proximity to any proposed energy infrastructure. To address questions regarding local benefits during the initial siting and approval phases, municipalities might require economic development agreements that ensure ongoing local economic benefits, such as job creation and workforce training. Municipalities can also address concerns by sharing clear and accurate data regarding potential local tax revenue generated from BESS installations, particularly highlighting how these revenues might support public services. Encouraging the development of community investment programs directly tied to BESS projects may further strengthen local support and engagement. (See Chapter 6 for additional discussion of the economic impacts, property value effects, and workforce development opportunities associated with BESS.)

BESS Engagement Examples

New York State's energy storage planning serves as a model for public engagement. The New York Battery and Energy Storage Consortium (NY-BEST) developed an Energy Storage Toolkit with customizable community outreach templates, fact sheets, and engagement guides for local governments.[1]

Stanford University's Uncommon Dialogue provides an additional framework that illustrates the benefits of multi-stakeholder collaboration. The dialogue provided a platform to resolve disputes before they escalated and facilitated agreements between developers, conservationists, and local governments on principles for solar and storage projects.[2]

[1] NY-BEST. (2024). Strategy for Community Partnerships and Equitable Energy Storage Deployment. https://cdn.ymaws.com/ny-best.org/resource/resmgr/resource_library/ny-best_-_strategy_for_commu.pdf

[2] Stanford University's Uncommon Dialogue (2023). Collaboration Agreement on Large-Scale U.S. Solar Development: Integrating Climate, Conservation and Community. https://woodsinstitute.stanford.edu/system/files/publications/Solar_Uncommon_Dialogue_Agreement_-101223.pdf.

Decommissioning

An effective decommissioning plan, developed prior to project operation, can comprehensively address a variety of safety, environment, and land use concerns held by the public. Local governments can require developers to prepare detailed decommissioning plans outlining site restoration methods, timelines, and estimated costs. Local governments can also establish specific financial requirements, usually in the form of a decommissioning trust, bonding, or escrow account, to ensure adequate resources are available for site restoration and waste disposal. Additionally, municipalities may implement ordinances that mandate specific site restoration activities. New York State Energy Research and Development Authority BESS guidelines offer recommendations on financial assurances and related best practices.[140] Additional best practices regarding decommissioning are discussed in Chapter 4.

7.5 Role of IOED

As discussed in Chapter 3, IOED oversees energy policy in relation to Indiana's energy goals. In this capacity, IOED can facilitate dialogue between local governments, utilities, industry representatives, and the public about a variety of issues, including utility-scale BESS. This includes conducting public forums, developing outreach materials, and partnering with industry experts to provide technical assistance to local governments considering BESS projects. IOED's support to local governments can also include advising on permitting and zoning, helping local leaders navigate state regulations, and helping communities find state and federal grants and incentives for energy storage projects.

Financial and technical support is important to ensuring Indiana communities have the opportunity to deploy BESS technology, where suitable, as a means to enhance grid reliability, promote economic development, and achieve state and local energy goals. Additionally, IOED has an important role to play in preventing fragmented, inconsistent, or incomplete local standards, which can be detrimental to all parties involved. The following sections further review IOED's roles and responsibilities.[lxx]

7.5.1 Technical Support

Developing and Disseminating Model Ordinances

Many municipalities have limited experience with energy storage and, without standardized guidance, they may implement overly restrictive regulations that deter development or, conversely, approve projects without sufficient oversight. IOED can encourage local governments to reference and/or adopt model ordinances as way to ensure robust laws consistent with best practice. As discussed in both Chapter 4 and Chapter 5, New York State has developed a model BESS ordinance that streamlines the approval process while incorporating safety and land-use requirements.[141] The ordinance includes setback distances, fire safety protocols, and decommissioning provisions that could be incorporated into Indiana-specific guidance. This model is regularly cited by federal entities and other states as best practice for project siting.

Another example is the guide produced by the University of Michigan's Graham Sustainability Institute titled, "Planning & Zoning for Battery Energy Storage Systems: A Guide for Michigan Local Governments." the guide details zoning recommendations designed to mitigate risks and impacts, such as compliance with the NFPA 855 safety standards. The guide also identifies considerations for local zoning regulations, including setbacks, sound levels, lighting, fencing, and visual screening.[142]

Addressing Zoning Ambiguity

Ambiguities in zoning classifications create challenges for local governments in determining whether BESS should be treated as industrial, commercial, or utility-scale infrastructure. This ambiguity can lead to project delays or inconsistent regulatory treatment.

Many municipalities lack clear definitions for BESS within existing zoning laws, according to research by the American Planning Association.[143] This absence of standardized terminology and classification often results in varying approval processes across jurisdictions, contributing to project delays and regulatory inconsistencies. To address this issue, IOED can develop and disseminate guidance aimed at clarifying the appropriate zoning classifications for BESS installations. This guidance would establish whether BESS projects should be regulated in a manner similar to substations and other energy equipment, categorized as standalone industrial sites, or treated otherwise.

Standardizing Roles, Processes, and Protocols

Regulatory inconsistencies across counties and municipalities can create challenges for project developers and local officials. IOED can coordinate with emergency responders, planning boards, and other stakeholders to develop a standardized permitting framework. This framework could address areas such as fire safety standards and environmental review processes applicable to local communities.

For fire safety, NFPA 855 provides fire safety guidelines for BESS installations. However, many local fire departments may not be fully familiar with these requirements, which can lead to challenges in enforcement and compliance. IOED can assist by offering training sessions and providing reference materials that support local fire departments in meeting these standards.

In terms of environmental review processes, IOED can gather and share best practices and existing guidance from state and federal sources, supporting local governments as they seek to streamline their environmental reviews for BESS projects. Although IOED itself does not possess regulatory authority to establish environmental review requirements, its role in disseminating information and best practices can help local officials enhance the consistency and predictability of their permitting processes.

7.5.2 Liaison Between Local Governments, Industry, and Developers

Many local governments do not have the internal resources to navigate the regulatory and technical complexities of BESS deployment. IOED can serve as a coordination hub. Research from Clean Power indicates that facilitating collaboration between local governments and industry stakeholders can reduce project delays and avoid regulatory conflicts.[144] IOED could support such collaboration by hosting regular working groups, potentially on a quarterly basis, where municipal officials could discuss regulatory challenges, permitting procedures, and solutions.

Additionally, IOED could establish a centralized

[lxx] For additional information regarding the roles that State Energy Offices play in support energy storage research, development, and deployment, see: Hoyt, M., Amsallem, J., & Clark, C. (2024). *Accelerating Energy Storage Research, Development, and Demonstration: Policy, Programmatic, and Planning Considerations for States*. NASEO. https://www.naseo.org/data/sites/1/documents/publications/NASEO_Energy%20Storage_v2.pdf.

resource hub that provides municipal governments with timely updates regarding industry standards, emerging BESS technologies, and relevant case studies from other states. IOED could also offer organize training sessions designed specifically for local officials to enhance their knowledge of best practices in zoning, permitting, and public engagement related to BESS.

IOED already serves as a liaison through its supportive role with Purdue University's R-STEP program, as discussed above. Many of the same parties engaged in R-STEP would also be relevant stakeholders for efforts to facilitate utility-scale BESS.

7.5.3 Supporter of Local Economic and Policy Planning

Conducting Economic and Workforce Impact Assessments

BESS deployment is not solely a technical issue—it has financial and workforce implications for Indiana communities. IOED can support municipalities by providing detailed information and data to inform their decision-making processes. Specifically, IOED can support the estimation of projected tax revenues generated by BESS facilities, as well as comparative analyses relative to other energy infrastructure investments. Additionally, IOED can provide insights into employment opportunities associated with energy storage, covering roles in manufacturing, construction, and ongoing maintenance activities. This role is consistent with the findings of recent National Association of State Energy Officials (NASEO) research that suggested thorough economic impact assessments help local officials better engage their communities regarding energy storage, as residents can clearly see the financial benefits associated with BESS projects.[145]

Identifying Funding and Incentive Opportunities for Local Governments

Municipalities may have a specific interest in attracting BESS development for a variety of reasons, including economic development, to address local reliability needs, or alleviate local grid constraints that inflate electricity costs. Creating an environment conducive to BESS, however, requires advanced planning. For example, a community may invest in research to identify preferred sites, or conduct economic analysis to better understand the costs or benefits of potential BESS projects. These types of engagements require financial resources that local entities may not have.

IOED can help address this limitation by maintaining and regularly updating a database of potential funding sources available to Indiana communities. Such a database could include information on federal grant opportunities specifically targeting energy infrastructure investments, such as the DOE Energy Storage Grand Challenge. It could also outline state-level incentive and financing programs designed to encourage local investment in BESS. Additionally, IOED could identify low-interest loan programs that municipalities might leverage to form public-private partnerships, enabling communities to pursue storage projects that might otherwise remain financially unattainable. In some states, state energy offices also serve as a distributor of these types of funding.

APPENDIX A. Study Content Requirements and Applicable Report Chapter

RFP Requirement	Chapter
2.1 Literature Review: Current Status of BESS Technology	
1. The contractor shall provide an analysis of the existing landscape of BESS technologies across the nation and in Indiana. This section should include but is not limited to an overview of information on relevant state and federal laws related to BESS technology, how batteries are generally built, resources and minerals and their sources that are used to build batteries, the supply chain from sourcing, refinement, and manufacturing of batteries and battery materials.	3, 4.5, 4.6, 6.5
a. The literature review shall also evaluate the scale, scope, and types of Indiana companies currently engaged in the sourcing, refine, manufacturing, transportation, operation, and recycling of BESS technologies utilized within the electric grid (i.e., utility-scale) or on the grid-edge (e.g., behind-the-meter battery systems).	
2. The contractor shall provide information on the types of electric grid-supporting attributes BESS can provide, including capacity, energy, and/or ancillary services. This should also include how BESS may fit within Indiana's current and expected generation portfolio mix and its relationship with other generation resources, as applicable. The contractor should also evaluate BESS attributes and how the resources are generally applied/used within the Midcontinent Independent System Operator (MISO) and PJM Interconnection (PJM) wholesale power markets.	3
3. The contractor shall provide information on any current licensing and regulatory approvals needed to implement a BESS project at the federal, state, and local level, as applicable.	4
4. The contractor shall provide potential use case or scenario-type information, including the usage of BESS as a utility-scale asset, as well as other use cases in industrial, commercial, and residential settings or other relevant applications. The contractor shall evaluate how the use cases/scenarios affect resource adequacy, reliability, affordability, and decarbonization.	3
5. The contractor shall provide general timelines of the completion of a BESS from conceptualization to commercial operation.	4
a. This shall be accomplished through the lens of both utility-scale as well as other identified support functions.	
6. The contractor shall identify the type and scale of BESS technology that exists in the state today as well as those identified for future implementation by Indiana utilities (primarily gathered through IRPs and interconnection queues), and the timing and trajectory of the technology's use in Indiana for utility-scale operations.	3, Appendix E
2.2 Safety	
1. The contractor shall provide information related to laws, regulations, standards, and/or best practices for safety surrounding BESS technology, including any built-in safety features that may exist for BESS. This information should include both physical and cybersecurity risks.	5
2. The contractor shall provide information on the potential environmental impact from BESS technology, including a discussion surrounding the environmental impacts of components used to construct a BESS.	4, 5.5
3. The contractor shall provide information related to safety for BESS project siting, and considerations for developers and communities.	5
4. The contractor shall provide information surrounding the differences in safety practices between different types of BESS.	5
a. An example includes, but is not limited to, different practices for lithium ion vs. sodium ion technologies.	
5. The contractor shall provide information on safety differences between different scales of BESS, and potentially unique hazards for each system.	5
a. An example includes, but is not limited to, different practices for utility scale vs. residential battery systems.	
6. The contractor shall provide information on the development of specialized state-level battery fire responders strategically positioned throughout the state.	5.7

RFP Requirement	Chapter
2.3 Workforce Development and Employment	
1. The contractor shall model potential workforce impacts (both direct and indirect) that a hypothetical BESS project could make in one or more potential scenarios. Examples of direct workforce impacts would include construction and permanent job creation, and examples of indirect workforce impacts would be supply-chain-based and localized economic impact.	6
2. The contractor shall examine the talent development pipeline and explore recommendations to support the workforce for BESS technologies and explore options for the state to consider to further develop BESS-related workforce and talent development programs.	6
a. This shall include manufacturing, construction, and any applicable permanent jobs created.	
b. The contractor shall provide information on the length of time required to acquire the necessary trade certifications or training for various positions or groups of positions likely involved with BESS facilities.	
c. The talent pipeline should consider differences between BESS field staff and utility operation staff.	
3. The contractor shall evaluate opportunities for re-skilling and re-training of jobs that are impacted by the energy transition and whether adequate crossover exists for affected workers and BESS technology.	6
4. The contractor shall provide a detailed analysis of any challenges that currently face the workforce as it relates to BESS development and operation.	6.5
5. The contractor shall evaluate the potential for Indiana to serve as a BESS training hub due to positioning between the Midcontinental Independent System Operator (MISO) and the PJM regional transmission organizations.	6.5
2.4 State and Local Economic Impact	
1. The contractor shall research and model economic impact (both costs and benefits) at the state and local levels that a BESS facility provides. Local-level analysis should include regional, county, and municipal levels. Modelling outcomes should include, but are not limited to the following:	6
a. Associated tax revenue impacts of BESS, including impacts when BESS is paired with existing and new renewable energy systems and stand-alone BESS systems.	
b. Tax revenue changes for the local and state governments, especially in areas where revenue replacement for a retired generation is a high priority.	
c. Expected economic impact from wages of construction, temporary, and permanent workers.	
2. The contractor shall provide information on the current costs to build a BESS project, and a detailed description of aggravating and mitigating factors that can affect the total cost of construction and operation of a BESS facility. The information should include, but is not limited to:	6, Appendix H
a. Total construction and project costs to achieve commercial operation. This may include construction, licensing, production, and ongoing operation and maintenance costs.	
3. The contractor shall consider the potential opportunities for a BESS manufacturing supply chain to be developed in the state.	6, Appendix F
a. This opportunity should consider resource limitations from components and materials not available in the United States, as applicable.	
4. The contractor shall provide information on the potential impacts to property values and property taxes for houses located near a BESS facility.	6.3, 7.4

RFP Requirement	Chapter
2.5 Installation, Operation, Decommissioning, and Recycling Practices	
1. The contractor shall provide information surrounding existing laws, regulations, standards, and best practices for the installation, operation, decommissioning, and recycling of all BESS components. This information should include, but is not necessarily limited to, how a developer and/or owner achieves each step of the process and a description of ongoing activities throughout the life of a BESS development. Additionally, the contractor should identify the extent to which BESS operators must comply with certain practices as it relates to standards (e.g., UL Standards, National Fire Protection Association (NFPA), etc.).	4-5, 4.6, 6.5 Appendix G
a. This should include both national and existing Indiana practices, specifically related to local impacts during construction, installation, and operation of BESS.	
b. The contractor shall provide information concerning estimated decommissioning costs and timelines for full decommissioning.	
c. The contractor shall identify existing gaps in Indiana BESS recycling practices and make recommendations to establish a framework for BESS recycling network in Indiana that can promote safety of the technology, economic development, and workforce development for the state.	
2.6 Community Engagement Needs and Best Practices	
1. The contractor shall provide information on the best practices for thoughtful community engagement on BESS technology deployment.	7, Appendix L
2. The contractor shall provide pertinent information on common questions and answers community members may have related to BESS technology including, but not limited to: economic impact, health and safety, aesthetics, decommissioning, and land use/siting.	7
3. The contractor shall conduct a high-level survey of Indiana residents and community leaders on overall understanding, awareness, and attitudes towards BESS technology, including potential interests and concerns.	7.3, Appendix K
4. The contractor shall identify opportunities for local units of government to establish appropriate development standard topics of interest that facilitate a safe and reasonable deployment of BESS in a community, including types of commonly used standards and practices, and the potential methods of application (e.g., economic development agreements, ordinances, regulations, etc.). The contractor shall provide example development standard topics of interest for these local standards, which should capture all elements: installation, operation, decommissioning, and recycling, as applicable.	3-7
2.7 Key Findings	
1. The contractor shall conclude the study and present key findings and recommendations from the information gathered in a thorough and complete analysis, considering both costs and benefits, and the alignment with current state energy policy. Key findings shall include a summary of the strengths and weaknesses of BESS development opportunities in the state. Recommendations should be generally limited to state and local actions or opportunities.	2-7
2. The contractor shall develop executive summaries, handouts, and other communique to provide brief and easily digestible information in addition to the comprehensive report.	1, Appendix M

APPENDIX B. Additional General Resources Regarding BESS

- *Utility-Scale and Distributed Storage in Integrated Resource Plans: A Comparison of Plans for Indiana and Other States* by Lawrence Berkeley National Laboratory (LBNL), which compares utility assumptions and methodologies for incorporating utility-scale and distributed energy storage in integrated resource plans, including those filed by Indiana utilities. smartersmallbuildings.lbl.gov.
- *Energy Storage Roadmap Report* by Energy Systems Network, which provides an overview of energy storage technologies and their potential applications. energysystemsnetwork.com.
- *Storage Futures Study* by the National Renewable Energy Laboratory (NREL), which analyzes utility-scale storage deployment and grid evolution scenarios. nrel.gov
- DOE Office of Fossil Energy. (2020). *Electricity Storage Technology Review*. https://www.energy.gov/sites/default/files/2020/10/f79/Electricity%20Storage%20Technologies%20%20Report.pdf
- DOE. (2024). *Draft Energy Storage Strategy and Roadmap*. https://web.archive.org/web/20241230184517/https://www.energy.gov/sites/default/files/2024-12/DOE%20--%20DRAFT%20Energy%20Storage%20Strategy%20%20Roadmap_Dec2024_public%20comment.pdf.
- NREL. (2024). *Annual Technology Baseline: Utility-Scale Battery Storage*. https://atb.nrel.gov/electricity/2024/utility-scale_battery_storage
- DOE. (2024). *Battery Energy Storage Systems Report*. https://www.energy.gov/sites/default/files/2025-01/BESSIE_supply-chain-battery-report_111124_OPENRELEASE_SJ_1.pdf
- Nyamathulla, S., & Dhanamjayulu, C. (2024). A review of battery energy storage systems and advanced battery management system for different applications: Challenges and recommendations. *Journal of Energy Storage*, *86*, 111179. https://www.sciencedirect.com/science/article/pii/S2352152X24007631
- Krichen, M., Basheer, Y., Qaisar, S. M., & Waqar, A. (2023). A survey on energy storage: Techniques and challenges. *Energies*, *16*(5), 2271. https://www.mdpi.com/1996-1073/16/5/2271
- USAID & NREL. (2023). *Grid-Scale Battery Storage*. https://www.nrel.gov/docs/fy19osti/74426.pdf
- Hoyt, M., Amsallem, J., & Clark, C. (2024). *Accelerating Energy Storage Research, Development, and Demonstration: Policy, Programmatic, and Planning Considerations for States*. NASEO. https://www.naseo.org/data/sites/1/documents/publications/NASEO_Energy%20Storage_v2.pdf.

APPENDIX C. Summary of Barriers to BESS

The following sections identify some of the key barriers to BESS deployment in Indiana (as well as elsewhere in the United States).

Cost and Investment Barriers

Obtaining capital typically requires demonstrating stable returns to investors. However, Indiana developers face uncertainty about long-term revenue streams, particularly in the face of changing wholesale market rules.[lxxi] Increased BESS saturation in MISO and PJM can also diminish potential revenue streams, as has been the case in frequency markets.[146] Further, uncertainties regarding the degradation of batteries over time and the associated maintenance costs complicate financial modeling and investment decisions couched on specific estimated returns. Other factors contributing to uncertainty include supply chain constraints, which increase capital costs, and inflation, which raises the cost of capital.

Permitting and Siting Challenges

There is a lack of clear and consistent permitting guidelines across local jurisdictions. Additionally, developers face "chicken and egg" type problems in terms of permit sequencing. For instance, at the state level, IDHS requires specific documentation, such as hazard mitigation plans and foundation specifics. However, gaps in submission protocols, such as limitations in the online portal, result in incomplete applications and delays in approvals. Local governments, meanwhile, often hold back zoning approvals until state-level approvals are issued.[lxxii] Besides sequencing issues, there is an evident unfamiliarity with NFPA 855 standards for decommissioning among local governments, which increases the likelihood of delays.[lxxiii]

Interconnection Issues

Utilities in Indiana are still adapting to the integration of BESS into their planning models. For instance, modeling limitations, such as the inability to simulate battery operation below 5-minute intervals, complicate project evaluations. Moreover, utilities must account for battery degradation and maintenance costs in their IRPs, which can lengthen review timelines.[lxxiv] Developers also frequently encounter long waiting times for interconnection approvals from PJM or MISO, partly due to these modeling and evaluation challenges. The added cost burden of interconnection studies and potential infrastructure upgrades deter investment, as does the uncertainty from delays.[lxxv]

Public Understanding

Public perception and local opposition pose additional challenges for BESS deployment. Concerns about safety risks, such as thermal runaway and fire hazards, generate resistance among community members and local officials. Other concerns include land use and environmental degradation. This opposition is sometimes fueled by a lack of public awareness of BESS technologies.

Other Barriers

Additional general barriers to BESS deployment include:

- Technological constraints, such as limitations in energy density and material availability, which affect scalability and cost;
- Regulatory barriers, such as overlapping responsibilities among state and local authorities that lead to fragmented oversight; and
- Emergency response preparedness, as local fire departments may lack the training or resources to manage BESS-related incidents effectively.

[lxxi] For example, both MISO and PJM are undergoing significant structural changes in how they organize and execute capacity markets. Capacity markets, when functioning appropriately, are intended to send long-term investment signals to developers.
[lxxii] IDHS call (December 11, 2024).
[lxxiii] Ibid.
[lxxiv] IURC call (December 12, 2024).
[lxxv] NREMC call (December 18, 2024).

APPENDIX D. Additional Technology-Specific Resources Regarding BESS

Table 15. Additional Information Regarding Emerging and Established BESS Technologies

Technology	Reference
Lithium iron phosphate (LFP)	Zhao, T., Mahandra, H., Marthi, R., et al. (2024). An overview on the life cycle of lithium iron phosphate: synthesis, modification, application, and recycling. *Chemical Engineering Journal*, 149923. https://www.sciencedirect.com/science/article/pii/S1385894724014086.
Sodium-ion	Glushenkov, A. M. (2023). Recent commentaries on the expected performance, advantages and applications of sodium-ion batteries. *Energy Materials*, *3*(2), N-A. https://www.oaepublish.com/articles/energymater.2022.70.
Zinc-based	Tang, L., Peng, H., Kang, J., et al. (2024). Zn-based batteries for sustainable energy storage: strategies and mechanisms. *Chemical Society Reviews*. Royal Society of Chemistry. https://pubs.rsc.org/en/content/articlepdf/2024/cs/d3cs00295k.
Lead-acid	Babinec, S., Balducci, P., & Liaw, B. (2023). *Technology Strategy Assessment: Findings from Storage Innovations 2030 Lithium-ion Batteries*. U.S. Department of Energy. https://www.energy.gov/sites/default/files/2023-07/Technology%20Strategy%20Assessment%20-%20Lead%20Batteries.pdf.
Flow (vanadium/iron)	Stauffer, N. (2023). Flow batteries for grid-scale energy storage. *MIT News*. Massachusetts Institute of Technology. https://news.mit.edu/2023/flow-batteries-grid-scale-energy-storage-0407.
Solid-state	Kalnaus, S., Dudney, N.J., Westover, A.S., et al. (2023). Solid-state batteries: The critical role of mechanics. *Science*, *381*(6664), eabg5998. https://www.science.org/doi/10.1126/science.abg5998.
Metal-air	Li, Y. & Lu, J. (2017). Metal–air Batteries: Will They Be the Future Electrochemical Energy Storage Device of Choice? *ACS Energy Letters*, *2*(6), 1370-1377. https://pubs.acs.org/doi/10.1021/acsenergylett.7b00119.

APPENDIX E. BESS Deployment Growth Projections

The assumed, logarithmic growth formula is as follows:

$$\frac{K}{1 + e^{-r(t-t_0)}}$$

Where:

- **K** is the expected total capacity of Indiana by 2035. This number is drawn from several different national and state level projections.
- $\boldsymbol{C_0}$ is the starting amount of battery capacity for the model. Exeter estimates there will be roughly 225 MW of battery capacity by the end of 2025.
- **r** is the annual growth rate of the state's battery capacity. Using the assumptions of 225 MW by 2025 and the expected total capacity by 2035, the equation is reworked to:

$$\boldsymbol{r} = \frac{\log\left(\frac{K}{C_{0_{2025}}} - 1\right)}{t_{2028} - t_{2025}}$$

- $\boldsymbol{t_0}$ represents the year where BESS implantation has its peak acceleration. 2028 was calculated to be the midpoint of acceleration due to projects currently under construction coming online in 2028 as well as national trends forecasting annual growth rates to peak between 2028 and 2029.

By 2035, Indiana's battery storage capacity is projected as follows:

- Low Scenario:

$$Capacity(2035) = \frac{2{,}170}{1 + e^{-0.72(2035-2028)}} \approx \mathbf{2,156\ MW}$$

  Total capacity: 1,962-2,351 MW, with average annual additional capacity of roughly 185 MW/year.

- Average Scenario:

$$Capacity(2035) = \frac{2{,}713}{1 + e^{-0.80(2035-2028)}} \approx \mathbf{2,703MW}$$

  Total capacity: 2,439-2,967 MW, with average annual additional capacity of roughly 236 MW/year.

- High Scenario:

$$Capacity(2035) \ = \frac{2{,}984}{1 + e^{-0.84(2035-2028)}} \approx \mathbf{2,975}$$

  Total capacity: 2,675– 3,276 MW, with annual additions of 261 MW/year.

APPENDIX F. Production, Reserves, and Ownership of Major BESS Minerals

Table 16 through Table 20 summarize global production and reserves for lithium, cobalt, nickel, manganese, and graphite, respectively, using data from the 2025 USGS Report,[147] and ownership distribution information based on a study conducted by Greitemeier, et al. (2025)[148] for the same minerals except graphite. The Greitemeier et al. study uses the 2020 USGS Report to identify the largest mines for each mineral,[149] and then sources mineral ownership data from various websites and company reports from years 2019-2025. Using these findings, the last column of the below tables (other than Table 20, graphite) shows the percent ownership of mines. Because this is based on a sampling, some smaller mines included in the 2025 USGS Report are not included in the ownership column.

Table 16. Lithium Production, Reserves, and Ownership

Production Country	2023 (tons)	2024 (tons)	% of 2024 Prod.	Reserves (tons)	Ownership Country
Argentina	8,630	18,000	7.65%	4,000,000	USA: 77.27%; China: 22.37%
Australia	91,700	88,000	37.39%	7,000,000	Australia: 41.91%; USA: 31.14%; China: 2.94%; Chile: 3.99%
Brazil	5,260	10,000	4.25%	390,000	Canada: 100%
Canada	3,240	4,300	1.83%	1,200,000	Not included
Chile	41,400	49,000	20.82%	9,300,000	Chile: 75.63%; USA: 24.37%
China	35,700	41,000	17.42%	3,000,000	China: 100%
Namibia	2,700	2,700	1.15%	14,000	Not included
Portugal	380	380	0.16%	60,000	United Kingdom: 100%
United States	Not available	Not available	Not available	1,800,000	Not included
Zimbabwe	14,900	22,000	9.35%	480,000	China: 100%
Other countries	-	-	-	2,800,000	
World Total	**203,910**	**235,380**		**30,044,000**	

Notes: "Not available" refers to the fact that the 2025 USGS Report did not provide this data for this country. "Not included" means that this country was not included in the sample used for the Greitemeier et al. study.

Table 17. Cobalt Production, Reserves, and Ownership

Production Country	2023 (tons)	2024 (tons)	% of 2024 Prod.	Reserves (tons)	Ownership Country
Australia	5,220	3,600	1.25%	1,700,000	Canada: 55.37%; Switzerland: 44.63%
Canada	4,220	4,500	1.56%	220,000	Switzerland: 51.22%; Brazil: 43.43%
Congo (Kinshasa)	175,000	220,000	76.34%	6,000,000	Europe: 47.76%; China: 47.16%; Congo: 5.08%
Cuba	3,300	3,500	1.21%	500,000	Canada: 50%; Cuba: 50%
Indonesia	19,000	28,000	9.72%	640,000	China: 100%
Madagascar	4,000	2,600	0.90%	100,000	Japan: 54.18%; South Korea: 45.82%
New Caledonia	2,570	1,500	0.52%	Not available	Not included
Papua New Guinea	3,070	2,800	0.97%	62,000	China: 85%; Canada: 8.56%; Papua New Guinea: 6.44%
Philippines	3,800	3,800	1.32%	260,000	Philippines: 62.5%; Canada: 37.5%
Russia	8,700	8,700	3.02%	250,000	Russia: 100%
Turkey	2,500	2,700	0.94%	91,000	Not included
United States	500	300	0.10%	70,000	Australia: 100%
Other countries	6,080	6,200	2.15%	800,000	Not included
World Total	**237,960**	**288,200**		**10,693,000**	

Notes: "Not available" refers to the fact that the 2025 USGS Report did not provide this data for this country. "Not included" means that this country was not included in the sample used for the Greitemeier et al. study.

Table 18. Nickel Production, Reserves, and Ownership					
Production Country	2023 (tons)	2024 (tons)	% of 2024 Prod.	Reserves (ton)	Ownership Country
Australia	149,000	110,000	3.01%	24,000,000	Australia: 40.17%; Europe: 35.04%; Canada: 24.79%
Brazil	82,700	77,000	2.11%	16,000,000	Europe: 86.77%; Brazil: 13.23%
Canada	159,000	190,000	5.20%	2,200,000	Europe: 54.17%; Brazil: 33.06%; China: 12.77%
China	117,000	120,000	3.28%	4,400,000	China: 100%
Indonesia	2,030,000	2,200,000	60.19%	55,000,000	China: 86.73%; Brazil: 8.5%; Indonesia: 4.77%
New Caledonia	231,000	110,000	3.01%	7,100,000	Europe: 76.84%; Brazil: 23.16%
Philippines	413,000	330,000	9.03%	4,800,000	Philippines: 100%
Russia	210,000	210,000	5.75%	8,300,000	Russia: 100%
United States	16,400	8,000	0.22%	310,000	Canada: 100%
Other countries	340,000	300,000	8.21%	>9,100,000	
World Total	**3,748,100**	**3,655,000**		**>131,210,000**	

Table 19. Manganese Production, Reserves, and Ownership					
Production Country	2023 (tons)	2024 (tons)	% of 2024 Prod.	Reserves (tons)	Ownership Country
Australia	2,860	2,800	14.11%	500,000	Australia: 61.58%; Europe: 27.82%; Singapore: 10.60%
Brazil	580	590	2.97	270,000	Brazil: 92.64%; Europe: 7.36%
China	767	770	3.88	280,000	China: 100%
Côte d’Ivoire	357	360	1.81	Not available	Dubai: 90%; Côte d’Ivoire: 10%
Gabon	4,490	4,600	23.17	61,000	Europe: 40.89%; Gabon: 40.41%; China: 18.71%
Ghana	818	820	4.13	13,000	Jersey: 90%; Ghana: 10%
India	744	800	4.03	34,000	India: 100%
Malaysia	410	410	2.07	Not available	Mexico: 100%
South Africa	7,300	7,400	37.28	560,000	South Africa: 57.78%; Australia: 42.22%
Other countries	1,230	1,300	6.55	Not available	
World Total	**19,556**	**19,850**		**1,718,000**	

Note: “Not available” refers to the fact that the 2025 USGS Report did not provide this data for this country.

Table 20. Graphite Production and Reserves				
Production Country	2023 (tons)	2024 (tons)	% of 2024 Prod.	Reserves
Austria	500	500	<.01%	Not available
Brazil	66,300	68,000	0.54	74,000,000
Canada	5,470	20,000	0.16	5,900,000
China	1,210,000	1,270,000	97.12	81,000,000
Germany	180	170	<.01	Not available
India	25,600	27,800	0.22	8,600,000
Korea, North	8,100	8,100	0.06	200,000
Korea, South	9,620	9,600	0.08	1,800,000
Madagascar	63,000	89,000	0.71	27,000,000
Mexico	1,300	900	0.01	3,100,000
Mozambique	98,000	75,000	0.60	25,000,000
Norway	6,480	7,000	0.06	600,000
Russia	15,000	20,000	0.16	14,000,000
Sri Lanka	3,000	3,300	0.03	1,500,000
Tanzania	13,200	25,000	0.20	18,000,000
Turkey	2,800	3,100	0.02	6,900,000
Ukraine	1,670	1,200	0.01	Not available
Vietnam	2,500	2,000	0.02	9,700,000
World Total	**1,532,720**	**1,630,670**		**277,300,000**

Note: "Not available" refers to the fact that the 2025 USGS Report did not provide this data for this country.

APPENDIX G. BESS Safety Codes, Standards, and Guides

BESS safety is informed by a collection of codes, standards, and guides, each serving a distinct purpose:

- A *code* is a set of requirements developed by a governing body or standards organization (e.g., NFPA, International Code Council [ICC]). Codes become legally enforceable once they are adopted, often with amendments, into state or local statutes or administrative rules. They provide mandatory safety requirements for BESS installations.
- A *standard* is a set of technical specifications developed by an officially recognized organization that provides detailed requirements for design, performance, and testing of BESS components and systems to ensure a minimum level of safety.
- A *guide* provides recommended best practices and methodologies to assist stakeholders in ensuring appropriate safety and risk management. Guides are not legally enforceable.

Table 21 identifies national codes and standards applicable to BESS safety, and each is described further in the subsequent pages. This list, although not comprehensive, is intended to provide a starting point for state officials and local planners hoping to learn more about best practice requirements for BESS safety.

Table 21. National Codes and Standards for BESS Safety

BESS Component	National Codes and Standards
Interconnection	IEEE 1547, IEEE 2800
Overall Installation	NFPA 70, NFPA 855, IFC, UL 9540, IEEE C2
Fire/Gas Detection	IFC, NFPA 72, NFPA 855
Fire/Explosion Detection	IFC, NFPA 13, NFPA 15, NFPA 68, NFPA 69, NFPA 855
Battery Rack	UL 9540A
Power Conversion System	UL 1741
Cell/Battery	UL 1642, UL 1973, UL 9540A
Communications, Battery Management System (BMS)	UL 1741, UL 9540, CSA/ANSI C22.2 No. 340, IEEE 2686, IEEE 2688

Codes

- *International Fire Code (IFC):* Establishes minimum regulations for fire prevention and fire protection systems. Addresses general fire safety precautions, emergency planning and preparedness, fire department access and water supplies, sprinkler systems, fire alarm systems, special hazards, and storage and use of hazardous materials.
- *IFC Sec. R328:* Establishes safety standards for residential energy storage systems, including requirements for equipment listings, installation locations, energy ratings, electrical installations, fire detection, impact protection, and ventilation.
- *NFPA 1, Fire Code:* Provides comprehensive requirements that provide a reasonable level of fire and life safety, as well as property protection from hazards created by fire, explosion, and dangerous conditions.

Standards

- *NFPA 800 (Proposed):* NFPA is in the process of drafting NFPA 800, Battery Safety Code, to provide uniform minimum requirements to address fire, electrical, life safety, and property protection from battery hazards. It will cover fire, explosion, and other hazardous conditions throughout the lifecycle of a battery.
- *NFPA 855, Standard for the Installation of Stationary Energy Storage Systems:* Provides limitations on maximum threshold quantities, capacities for a given system, footprint, and separation, with breakdowns for specific BESS technologies. Requirements for commissioning, O&M, as well as decommissioning of systems with information for Authorities Having Jurisdiction and first responders are also detailed. NFPA 855 is the key BESS NFPA standard, and an effort is underway to synchronize all BESS-related inputs in other NFPA standards with NFPA 855.
- *CSA/ANSI C22.2 No. 340: Battery Management Systems:* Applies to BMS's consisting of hardware and software designed to monitor, control, and regulate electrical and thermal parameters of battery packs to prevent thermal runaway and other potentially hazardous conditions.
- *IEC/ISO 27000: Information Security Management:* Standard for information security management systems and their requirements.
- *IEC 61850:* International standard defining communication protocols for intelligent electronic devices at electrical substations.
- *IEC 62351:* An international cybersecurity standard for Smart Grid communication and control systems.
- *IEC 62443:* Series of standards that address security for operational technology in automation and control systems.
- *IEEE C2: ANSI standard for the National Electrical Safety Code, published by IEEE.* Contains voluntary standards for protection against electrical hazards during installation, operation, and maintenance of electric supply and communication lines.
- *IEEE 1547, Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces:* Establishes uniform requirements for the performance, operation, testing, safety, and maintenance of distributed energy resources (DERs) interconnected with electric power systems.

- *IEEE 1686-2022, IEEE Standard for Intelligent Electronic Devices Cybersecurity Capabilities:* Defines the functions and features to be provided in intelligent electronic devices to accommodate cybersecurity programs.
- *IEEE 2686, Recommended Practice for Battery Management Systems in Stationary Energy Storage Applications:* Provides comprehensive guidelines on the design, configuration, and interoperability of BMS's in stationary applications.
- *IEEE 2688, Recommended Practice for Energy Storage Management Systems in Grid Applications:* Provides guidelines for the development and deployment of energy storage management systems in grid applications.
- *IEEE 2800, Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems:* Establishes minimum technical requirements for connecting IBRs (wind, solar, BESS) to transmission and sub-transmission networks.
- *NFPA 13, Standard for the Installation of Sprinkler Systems:* Addresses sprinkler system design approaches, system installation, and component options to prevent fire deaths and property loss.
- *NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection:* Provides minimum requirements for the design, installation, and system acceptance testing of water spray fixed systems used for fire protection.
- *NFPA 68, Standard on Explosion Prevention:* Applies to the design, location, installation, maintenance, and use of devices and systems that vent the combustion gases and pressures resulting from a deflagration within an enclosure so that structural and mechanical damage is minimized.
- *NFPA 69, Standard on Explosion Prevention Systems:* Provides requirements for installing systems for the prevention and control of explosions in enclosures that contain flammable concentrations of flammable gases, vapors, mists, dusts, or hybrid mixtures. It is intended for use by design engineers, operating personnel, and Authorities Having Jurisdiction.
- *NFPA 70 (National Electrical Code):* A set of standards for safe electrical installation and maintenance.
- *NFPA 72, National Fire Alarm and Signaling Code:* Provides the latest safety provisions to meet society's changing fire detection, signaling, and emergency communications demands.
- *NFPA 780, Standard for the Installation of Lightning Protection Systems:* Provides lightning protection system installation requirements to safeguard people and property from fire risk and related hazards associated with lightning exposure.
- *UL 1642, Standard for Lithium Batteries:* Specifies testing requirements for non-rechargeable and rechargeable lithium batteries.
- *UL 1741, Safety Standard for Inverters and Power Converter Equipment:* Safety standard for inverter and power converter equipment used in renewable energy systems, including solar, wind, and fuel cell systems.
- *UL 1973, Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail (LER) Applications:* Establishes safety requirements for stationary battery systems (e.g., BESS), as well as vehicle auxiliary power systems and LER applications. Addresses electrical performance, mechanical integrity, environmental resilience, and fire safety for BESS.
- *UL 2272, Standard for Electrical Systems for Personal E-Mobility Devices:* Details requirements related to the construction of e-Mobility devices, and prescribes electrical, mechanical and environmental testing to assess electrical safety.
- *UL 2849, Standard for Electrical Systems for eBikes:* Evaluates the safety of electrical drive train systems, battery systems, and charger system combinations for eBikes.
- *UL 2900, Series of standards that present general software cyber security requirements for network-connectable products.*
- *UL 9540, UL 9540 is considered the key product safety standard for BESS and is mandated by both the IFC and NFPA 855*. UL 9540 ensures compatibility among system components while addressing functional safety, enclosures, ventilation, cooling, communications, and fire protection. In addition to UL 9540, UL 9540a is required to evaluate thermal runaway risks through testing. This involves the intentional triggering of a battery failure to assess fire spread and propagation. These tests are used to establish fire safety features and safe separation distances between units to minimize the risk of fire propagation and cascading battery failures (e.g., thermal runaway). UL 9540-certified systems are designed to contain internal failures, limit fire propagation, and reduce the risk of explosion.
- *CIP-002-5.1a, Cyber systems and Asset Categorization:* Requires organizations to identify and categorize their Bulk Electric System (BES) cyber assets. The standard also requires that organizations apply cybersecurity requirements based on the potential impact of a cyberattack on the BES.
- *CIP-003-6, Security Management Controls:* Requires the initial identification and categorization of BES Cyber Systems and require organizational, operational, and procedural controls to mitigate risk to BES Cyber Systems.

- *CIP-004-7, Personnel training and Security Awareness:* focuses on mandatory personnel training and security awareness requirements, aiming to ensure that individuals with access to critical BES cyber assets receive proper training to minimize cyber risks by maintaining a high level of cybersecurity awareness through annual training sessions covering best practices for safeguarding BES assets.
- *CIP-005-7, Cyber Security – Electronic Security Perimeter(s):* Manages electronic access to BES Cyber Systems by specifying a controlled Electronic Security Perimeter in support of protecting BES Cyber Systems against compromise that could lead to misoperation or instability in the BES.
- *CIP-006-6, Physical security of BES Cyber Systems:* Outlines physical security requirements for cyber systems. Part of a group of NERC CIP standards that are related to cybersecurity.
- *CIP-007-6, System Security Management:* Manages system security by specifying select technical, operational, and procedural requirements in support of protecting BES Cyber Systems against compromise that could lead to misoperation or instability in the BES.
- *CIP-008-6, Incident Reporting and Response Planning:* Mitigates the risk to the reliable operation of the BES as the result of a Cyber Security Incident by specifying incident response requirements.
- *CIP-009-6, Recovery Plans for BES Cyber Systems:* Establishes standards to recover reliability functions performed by BES Cyber Systems by specifying recovery plan requirements in support of the continued stability, operability, and reliability of the BES.
- *CIP-010-2, Configuration Change Management and Vulnerability Assessments:* Establishes requirements to prevent and detect unauthorized changes to BES Cyber Systems by specifying configuration change management and vulnerability assessment requirements in support of protecting BES Cyber Systems from compromise that could lead to misoperation or instability in the BES.
- *CIP-011-2, Information Protection:* Aims to prevent unauthorized access to BES Cyber System Information by specifying information protection requirements in support of protecting BES Cyber Systems against compromise that could lead to misoperation or instability in the BES.
- *NERC CIP-014-2,* Identifies and protects transmission substations and stations. It also protects primary control centers.

Guides

- *Electrical Energy Storage Data Submission Guidelines, Version 3:* Sandia report that informs stakeholders on what data are needed for given functions, how to prescribe access to those data and the considerations impacting data architecture design and provides insight into the data and data systems necessary to ensure storage can meet growing expectations in a safe and cost-efficient manner.
- *Cybersecurity Capability Maturity Model (C2M2):* DOE model to assess and improve cybersecurity capabilities in the energy sector.
- *NIST Cybersecurity Framework 2.0:* Provides guidance to industry, government agencies, and other organizations to manage cybersecurity risks.
- *Sandia Energy Storage Handbook 2020, Chapter 18:* Provides high-level technical discussions of current technologies, industry standards, processes, best practices, guidance, challenges, lessons learned, and projections about energy storage as an emerging and enabling technology.
- *IEEE 693, Recommended Practice for Seismic Design of Substations:* Discusses seismic design recommendations for substations, including qualification of different equipment types.
- *IEEE 1547.3 – 2023, Cybersecurity of Distributed Energy Resources:* Provides security recommendations for DER stakeholders and clarifies the broad requirements of cybersecurity.
- *NIST 800-82, Guide to Operational Technology (OT) Security:* provides guidance on how to improve the security of OT systems while addressing their unique performance, reliability, and safety requirements.
- *NIST SP 800-37 (Rev. 2), Guide for Applying the Risk Management Framework to Federal Information Systems, A Security Life Cycle Approach:* Describes the Risk Management Framework (RMF) and provides guidelines for applying the RMF to information systems and organizations.
- *NIST SP 800-39, Managing Information Security Risk – Organization, Mission, and Information System View:* Provides guidance for an integrated, organization-wide program for managing information security risk to organizational operations (i.e., mission, functions, image, and reputation), organizational assets, individuals, other organizations, and the Nation resulting from the operation and use of federal information systems.
- *NIST SP 800-53, Security and Privacy Controls for Federal Information Systems and Organizations:* Provides a catalog of security and privacy controls for information systems and organizations to protect organizational operations and assets, individuals, other organizations, and the nation from a diverse set of threats and risks, including hostile attacks, human errors, natural disasters, structural failures, foreign intelligence entities, and privacy risks.
- *NIST SP 800-82 (Rev. 3), Guide to Industrial Control Systems Security:* Provides guidance on how to

secure OT while addressing their unique performance, reliability, and safety requirements.

- *NIST SP 800-209, Security Guidelines for Storage Infrastructure:* Provides a comprehensive set of security recommendations to address evolving threats in storage technology, covering both general IT security management areas (e.g., physical security, authentication, incident response) and storage-specific concerns (e.g., data protection, isolation, encryption) as storage systems transition from traditional models to cloud-based architectures.
- *DOE Energy Storage Handbook (Chapter 18), Physical Security and Cybersecurity of Energy Storage Systems:* Addresses the risks and consequences of physical and cyberattacks on energy storage systems, emphasizing the need for robust security measures. It discusses current research, standards, and industry best practices to enhance the physical protection and cybersecurity of energy storage systems.

APPENDIX H. BESS Overnight Capital and O&M Costs

Table 22. BESS Overnight Capital Costs Apportioning

NREL Category	IMPLAN 528 Sector	Cost ($/kW) (AVG)	% of Total OCC Costs	In-State Attribution	Indiana Final Demand
Construction					
Developer Cost (Contingency, Profit, Overhead, & EPC Overhead)	Architectural, engineering, and related services	$207.48	13.74%	67.67%	9.30%
Installation Labor & Equipment	Construction of new power and communication structures	$49.99	3.31%	100.00%	3.31%
Subtotal:		**$257.47**	**17.05%**		**12.61%**
Manufacturing					
Electrical BOS - Wiring	Other communication and energy wire manufacturing	$45.69	3.03%	2.95%	0.09%
Electrical BOS – Switchgear & Circuit Breakers	Switchgear and switchboard apparatus manufacturing	$54.83	3.63%	0.22%	0.01%
Electrical BOS – SCADA & EMS	Relay and industrial control manufacturing	$45.69	3.03%	1.24%	0.04%
Electrical BOS – Transformers & Inverters	Power, distribution, and specialty transformer manufacturing	$131.61	9.05%	0.21%	0.02%
Structural BOS	Fabricated structural metal manufacturing	$14.65	0.97%	25.56%	0.25%
LI Battery Cabinet	Storage battery manufacturing	$928.38	61.49%	2.04%	1.25%
Subtotal:		**$1,225.84**	**81.19%**		
Services					
Permitting, Inspection and Interconnection (PII)	Legal Services	$26.51	1.76%	58.10%	1.02%
Subtotal:		**$26.51**	**1.76%**		
Total:		**$1,509.82**	**100.00%**	**28.67% (avg)**	**15.29%**

BOS = Balance of System; EMS = Energy Management System; EPC = Engineering, Procurement, and Construction; SCADA = Supervisory Control and Data Acquisition.

Note: Sales tax is excluded from analysis. Based on a standalone utility-scale Li-ion battery storage system (60 MW - 240 MWh)

Table 23. BESS O&M Costs Apportioning

NREL Category	IMPLAN 528 Sector	% of Total O&M Costs	In-State Attribution	Indiana Final Demand
Administrator/Asset Management/In-House Security	Office and administrative services	14.00%	48.90%	6.34%
Contracted Site Security	Investigation and security services	6.00%	100.00%	6.00%
Scheduled/Unscheduled Maintenance	Commercial and industrial machinery and equipment repair and maintenance	80.00%	100.00%	80.00%
Total:		**100.00%**	**82.96% (avg)**	**92.84%**

Note: Property taxes and land lease payments excluded as it represents a transfer payment rather than additional economic activity for an industry. Additionally, battery augmentation, which represents a large share of O&M costs would occur beyond the time period analyzed for this report and is therefore excluded.

APPENDIX I. Indiana County Assignments for Regional Economic Analysis

Table 24. List of Counties by Assigned Region in Regional Economic Analysis

Region	County	Region	County	Region	County
1 – NORTHWEST	Jasper	5 – CENTRAL	Boone	8 – SOUTH CENTRAL	Brown
	LaPorte		Hamilton		Daviess
	Lake		Hancock		Greene
	Newton		Hendricks		Lawrence
	Porter		Johnson		Martin
	Pulaski		Madison		Monroe
	Starke		Marion		Orange
2 – NORTH CENTRAL	Elkhart		Morgan		Owen
	Fulton		Shelby	9 – SOUTH	Clark
	Kosciusko	6 – EAST	Bartholomew		Crawford
	Marshall		Blackford		Floyd
	St. Joseph		Dearborn		Harrison
3 – NORTHEAST	Adams		Decatur		Scott
	Allen		Delaware		Washington
	DeKalb		Fayette	10 – SOUTHWEST	Dubois
	Grant		Franklin		Gibson
	Huntington		Henry		Knox
	LaGrange		Jackson		Perry
	Noble		Jay		Pike
	Steuben		Jefferson		Posey
	Wabash		Jennings		Spencer
	Wells		Ohio		Vanderburgh
	Whitley		Randolph		Warrick
4 – WEST CENTRAL	Benton		Ripley		
	Carroll		Rush		
	Cass		Union		
	Clinton		Wayne		
	Fountain	7 – WEST	Clay		
	Howard		Parke		
	Miami		Putnam		
	Montgomery		Sullivan		
	Tippecanoe		Switzerland		
	Tipton		Vermillion		
	Warren		Vigo		
	White				

APPENDIX J. Regional Economic Analysis Assumptions

Table 25. Factors Used When Developing Region Assignments for Regional Economic Analysis

Factor	Metric Evaluated	Justification
POPULATION	Total Population and Population Growth	Population is one contributor to peak load. Additionally, more populated areas are generally less suitable for generation and transmission facilities with a larger footprint. BESS are a common resource to meet grid needs grid requirements in more populous regions.
RENEWABLE ENERGY ACTIVITY	Generation Capacity (MW)	Renewable energy is a strong driver for storage. BESS can provide firming capability and help time-shift intermittent energy to more productive dispatch periods. BESS can also increase utilization of interconnection capacity.
TRANSMISSION INTERCONNECTIVITY	Distance from transmission stations	BESS must be connected to the grid through substations/transmission lines, and the availability of related infrastructure is a key factor in deployment location. Moreover, BESS proximity to transmission lines lower costs by reducing distribution losses.
ANNOUNCED PROJECTS	Planned capacity (MW)	IRP commitments help indicate where and when deployment is likely to occur. Additionally, areas reliant on utilities that have not publicly committed to BESS projects have lower weights. Moreover regions with large BESS projects in the MISO/PJM queues received higher weights.
SKILLED WORKFORCE	Number of highly skilled workers (engineering, research centers, etc.)	Regions that host high-skilled talent pools received higher weights. With their expertise and technical skills, these regions can implement projects at a more efficient rate, lowering possible economic risks associated with utility-scale projects. Additionally, regions with energy-focused institutions or technical colleges (e.g., Greene County's Battery Innovation Center) offer lower labor risks and faster project implementation, making them more attractive.
EV MANUFACTURING	Presence of EV manufacturing centers	Co-location with gigafactories or EV supply chains signals regional energy tech investment. These regions often have workforce overlap, and infrastructure that support BESS deployment.

APPENDIX K. Public Awareness Survey for Indiana BESS

Methodology

This survey was conducted by Dynata LLC among 1,000 adult residents of Indiana, aged 18 and older. Respondents were initially screened for residency, with participants from outside Indiana or those under 18 terminated from the survey. The survey achieved 1,000 complete responses, with an incidence rate of 69.1%. The median length of the interview was approximately 2 minutes and 53 seconds, and the survey had an abandonment rate of 4%, resulting in 269 terminated interviews and 342 respondents exceeding demographic quotas.

To ensure the representativeness of the survey, demographic quotas were established for gender, age groups, and residential location based on predefined target stratifications. Actual responses were slightly adjusted through weighting to align with these original targets.

For gender, the original target was 470 males (47%) and 530 females (53%). Actual collected responses were 450 males (45%) and 548 females (55%). Weighting adjustments were made accordingly to correct this imbalance and match the predefined stratifications.[lxxvi]

Regarding age distribution, the targets included 290 respondents (29%) aged 18-34, 320 respondents (32%) aged 35-54, and 390 respondents (39%) aged 55 or older. The collected data closely matched these targets, with actual responses of 290, 321, and 389, respectively, requiring minimal adjustments through weighting.

Respondents' residential locations were stratified as follows: 590 respondents (59%) in urban areas, 235 respondents (20%) in suburban areas, and 220 respondents (21%) in rural areas. Actual number of responses included 518 urban respondents (54%), 221 suburban respondents (23%), and 220 rural respondents (23%).

Quality check questions were included in the survey to ensure data consistency and reliability. These questions verified respondents' answers against previous questions on their year of birth, access to reliable internet, and commute length. Responses inconsistent with earlier answers were flagged to maintain data integrity. The answers to these questions are not included in this topline.

All survey responses were weighted to precisely align with the demographic stratifications originally set. This weighting ensures that survey findings accurately reflect the demographic characteristics of Indiana's adult population.

[lxxvi] To calculate the weight for each quota, the target population percentage is divided by the observed sample percentage. If certain quota groups are underrepresented in the responses, they were applied a weight greater than 1. This formula is used for each of the three quotas. After, the weights are multiplied together to get a combined weight for each respondent. This final number is used to adjust the original results to achieve the original quotes. Lastly, the weights are normalized to have an average of 1. This ensures that the weighted total is equal to the original sample size.

Question Results

QFAMILIARITY: How familiar are you with Battery Energy Storage Systems?

	Weighted	Percent	Unweighted	Percent
Extremely familiar	46	4.6%	45	4.5%
Very familiar	67	6.7%	65	6.5%
Moderately familiar	173	17.3%	171	17.1%
Slightly familiar	249	24.9%	250	25.0%
Not familiar at all	465	46.5%	469	46.9%

QINFORMATION: Where do you typically obtain information about energy technologies like Battery Energy Storage Systems? (Select all that apply)

	Weighted	Percent	Unweighted	Percent
Social media	302	30.2%	297	29.7%
Academic and research groups	86	8.6%	83	8.3%
Industry professionals	146	14.6%	144	14.4%
Local electric utilities	201	20.1%	199	19.9%
Government agencies	76	7.6%	74	7.4%
News media	284	28.4%	281	28.1%
Word of mouth (neighbors, family, friends)	259	25.9%	260	26.0%
Environmental groups	114	11.4%	113	11.3%
Do not know or actively research those technologies	365	36.5%	368	36.8%
Other (please specify)	25	2.5%	24	2.4%

QSUPPORT: How much do you support or oppose the use of Battery Energy Storage Systems on Indiana's electric grid?

	Weighted	Percent	Unweighted	Percent
Strongly support	118	11.8%	116	11.6%
Support	234	23.4%	232	23.2%
Neutral	608	60.8%	612	61.2%
Oppose	25	2.5%	25	2.5%
Strongly oppose	15	1.5%	15	1.5%

QCONCERNS: What concerns do you have about the use of Battery Energy Storage Systems on Indiana's electric grid? (Select up to three)

	Weighted	Percent	Unweighted	Percent
Impacts on viewshed	38	3.8%	37	3.7%
Environmental impact, including battery disposal	360	36.0%	359	35.9%
Lack of clear information about this technology	296	29.6%	296	29.6%
Risk of fire or safety hazards	233	23.3%	231	23.1%
Land use (impact on land availability, encroachment on farmland)	173	17.3%	176	17.6%
Impact on taxes	245	24.5%	246	24.6%
Reliance on critical minerals like cobalt	100	10.0%	98	9.8%
Effectiveness during extreme weather events	263	26.3%	260	26.0%
Impact on electricity rates	309	30.9%	309	30.9%
Other (please specify)	49	4.9%	50	5.0%

QBENEFITS: What benefits do you see from the use of Battery Energy Storage Systems on Indiana's electric grid? (Select up to three)

	Weighted	Percent	Unweighted	Percent
Supporting renewable energy like solar and wind	313	31.3%	311	31.1%
Lowering electricity costs over time	413	41.3%	412	41.2%
Providing backup power during emergencies	425	42.5%	426	42.6%
Reducing air pollution and carbon emissions	264	26.4%	262	26.2%
Improving power reliability and reducing outages	379	37.9%	378	37.8%
Creating local jobs and economic opportunities	245	24.5%	243	24.3%
Other (please specify)	52	5.2%	52	5.2%

QECONBENEFITS: Which economic benefits of Battery Energy Storage Systems do you think are most important? (Select up to three)

	Weighted	Percent	Unweighted	Percent
New job creation	412	41.2%	409	40.9%
Ongoing local employment opportunities	322	32.2%	319	31.9%
Support for small businesses	218	21.8%	216	21.6%
Increased tax revenue for local communities	194	19.4%	190	19.0%
Lower energy costs for consumers	710	71.0%	711	71.1%
Other (please specify)	35	3.5%	36	3.6%

QENVIRCONCERNS: How concerned are you about the environmental impact of battery energy storage, such as battery disposal and mining practices?

	Weighted	Percent	Unweighted	Percent
Extremely concerned	100	10.0%	99	9.9%
Very concerned	184	18.4%	182	18.2%
Somewhat concerned	477	47.7%	478	47.8%
Not very concerned	169	16.9%	170	17.0%
Not at all concerned	71	7.1%	71	7.1%

QINVOLVEMENT: How important is it for local communities to be involved in decisions about battery energy storage projects?

	Weighted	Percent	Unweighted	Percent
Extremely important	242	24.2%	241	24.1%
Very important	379	37.9%	377	37.7%
Somewhat important	295	29.5%	297	29.7%
Not very important	45	4.5%	46	4.6%
Not at all important	40	4.0%	39	3.9%

Full Responses to Open-Ended Questions

QINFORMATION: Where do you typically obtain information about energy technologies like Battery Energy Storage Systems? *(Select all that apply)*

- Google (4)
- Online searches (3)
- Websites, Online
- General internet exposure
- Internet research
- Google n siri
- Online
- Web search
- ChatGPT to search everywhere
- Personal research
- IBEW
- Investing articles about companies that produce these systems
- Trade Journals
- Company financial reports
- YouTube
- Son in law is electrician
- Podcasts
- Work

QCONCERNS: What concerns do you have about the use of Battery Energy Storage Systems on Indiana's electric grid? *(Select up to three)*

- Battery storage is simply virtue signaling for the wind and solar renewables, it really won't have an impact besides more cost
- Energy bills
- Battery life would make the cost savings just go into new replacements
- Total cost, bad GOP laws that strip Hoosiers of benefits of using solar
- I'm really unfamiliar but checked concerns regarding any change
- None (14)
- Not sure (2)
- Don't know what it is (16)
- Don't know enough about it (9)
- Need more information
- Not interested/don't care (2)
- NA

QBENEFITS: What benefits do you see from the use of Battery Energy Storage Systems on Indiana's electric grid? *(Select up to three)*

- Sounds like it would save money on electricity bills
- None (3)
- I really don't see any of this benefitting the economy tbh
- Nothing significant, it is all virtue signaling
- It would help if I were aware of what the item does
- Don't know (16)
- Don't know what it is (15)
- Don't know enough about it (12)
- Don't care
- NA

QECONBENEFITS: Which economic benefits of Battery Energy Storage Systems do you think are most important? *(Select up to three)*

- All of the above
- Not having climate disasters is also an economic issue!
- A trivial amount of energy storage for peak load
- Power in power outages
- I'm guessing lower costs would be a benefit
- Reduced carbon emissions
- Environmental
- None (2)
- Don't know (14)
- Don't know what it is (6)
- Don't know enough about it (5)
- Don't have any information
- Don't care

APPENDIX L. Additional Resources Regarding Community Engagement

- NREL. (2022). *Community Energy Planning: Best Practices and Lessons Learned in NREL's Work with Communities*. https://docs.nrel.gov/docs/fy22osti/83846.pdf.
- Romero-Lankao, P., Rosner, N., Efroymson, R. A., et al. (2023). *Community Engagement and Equity in Renewable Energy Projects: A Literature Review*. National Renewable Energy Laboratory. https://docs.nrel.gov/docs/fy23osti/87113.pdf.
- DOE Office of Energy Efficiency & Renewable Energy. *Reliable Energy Siting through Technical Engagement and Planning (R-STEP™)*. https://www.energy.gov/eere/reliable-energy-siting-through-technical-engagement-and-planning-r-steptm.
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- Vallaincourt, L. & Qureshi, M. (2023). *Best Practices Guide for Community Engagement in Energy Projects*. Conservation Council of New Brunswick. https://www.conservationcouncil.ca/wp-content/uploads/2023/09/Best-Practices-Guide-for-Community-Engagement-in-Energy-Projects.pdf.
- Beshouri, I., Hobbs, J., Konishi, R., et al (2024). *Power in Partnership: Insights for Siting Utility-Scale Renewables in Michigan*. University of Michigan – Taubman College of Architecture and Urban Planning. https://www.michigan.gov/mpsc/-/media/Project/Websites/mpsc/workgroups/2023-Energy-Legislation/Renewable-Energy-and-Energy-Storage-Siting/PowerInPartnershipReport.pdf.

APPENDIX M. Briefing Materials to Support Community Engagement

Battery Development in Indiana: Regulatory Steps

Developing a utility-scale Battery Energy Storage System (BESS) in Indiana involves coordination with state, federal, and local authorities. This handout outlines the regulatory steps applicable to developers and other stakeholders.

Local Planning and Zoning Review

Entity: Jurisdictional government entities, typically local planning and/or zoning board

Timing: Varies

Major Reviews:

- Zoning and re-zoning
- Site plan, fire safety, road use, & environmental permits or reviews
- Decommissioning agreement & bonding
- Other construction & building permits

Local governments have final say on land use approvals

Regional Grid Interconnection

Entity: Midcontinent Independent System Operator (MISO) or PJM Interconnection, LLC (PJM)

Timing: >3 years

Major Reviews:

- Feasibility Study
- System Impact Study
- Facilities Study
- Generator Interconnection Agreement

A Generator Interconnection Agreement is required to connect systems to the bulk power system

State Environmental Permitting

Entity: Indiana Department of Natural Resources (IDNR) & Indiana Department of Environmental Management (IDEM)

Timing: Varies

Major Reviews:

- Wetland & floodplain permits
- Stormwater permits
- Environmental compliance

Permits required if site overlaps with sensitive environmental zones

Fire Safety and Emergency Planning

Entity: Indiana Dept. of Homeland Security (IDHS)

Timing: 30 days

Major Reviews:

- Site, fire/emergency, & training plan
- Commissioning & decommissioning procedures
- Fire safety standards compliance

Compliance with NFPA 855 is mandatory

State Utility Regulation

Entity: Indiana Utility Regulatory Comm. (IURC)

Timing: 90-240 days

Major Reviews:

- Standalone BESS: Clean Energy Project Application
- Paired BESS: Certificate of Convenience & Necessity (CPCN)
- Declination of Full IURC Jurisdiction Application (for Ind. Power Producers)

Application depends on system ownership & configuration

Battery Planning: Siting and Other Considerations

Local planners and zoning officials oversee the siting of most energy facilities, including utility-scale Battery Energy Storage Systems (BESS), in their respective jurisdiction. This document provides additional information to help planning officials in Indiana understand the siting, land use, environmental, and fire safety implications of BESS, especially in jurisdictions with no existing facilities.

Land Use and Ecological Impacts

Footprint and siting flexibility: Unlike most other energy generation technologies, BESS do not need to be sited in areas with direct access to any specific natural (e.g., water, sun, wind) or infrastructural (e.g., gas pipeline, highway) resource. As a result, developers generally look to site BESS wherever it is the most economic and easiest to interconnect to the grid. Utility-scale BESS generally require approximately 0.03-0.1 acres per megawatt (MW), as compared to 0.2-0.3 acres/MW for natural gas plants.[1]

Land use zoning: Utility- or energy-related projects are typically allowed within agricultural, commercial and/or industrial land use zones, with special exemptions. BESS are likely compatible with land-use zones that allow utility- or energy-related technologies per current zoning ordinances. Best practice is for zoning ordinances to provide technology-neutral frameworks that are adaptable to innovations in energy and grid technologies.

Environmental regulation: Indiana Department of Natural Resources and Indiana Department of Environmental Management review is required for projects sited in floodways and wetlands, respectively.

Disturbance mitigation: Common strategies to address potential disturbances from BESS are similar to those for other energy technologies.

Disturbance Type	Example	Mitigation
Ground disturbance	Site grading, access roads, cement pads	Siting BESS on former industrial or power plant sites (i.e., brownfield) or co-locating with other energy facilities preserves unaltered land (i.e., greenfield)
Viewshed	Fencing, nighttime lighting	Reducing visibility with landscape buffers or engineered screening can mitigate viewshed and aesthetic impacts
Traffic	Higher local road use during construction	Traffic plans can mitigate traffic to schools and/or commuters
Noise	Construction noise	Constrained work hours can reduce noise interruption

Fire Safety and Setback Requirements

Safety guidelines: National Fire Protection Association (NFPA) 855 standards include setbacks and other conditions that establish minimum requirements for BESS safety.

Egress and vegetation clearance: Best practice is to maintain 10-foot clearances from building exits and flammable vegetation.

Site access: BESS access roads must be wide enough and adequately constructed and maintained to accommodate construction, maintenance, and emergency vehicles.

Safety regulation: The Indiana Department of Homeland Security reviews NFPA 855 compliance, commissioning plans, decommissioning plans, and emergency response plans for BESS projects.

Other setback considerations: NFPA 855 standards differentiate requirements by location and design.

	Remote	Near Exposure	Reduced Setbacks
Applicability	100 feet or more from property lines, roads, and structures	Less than 100 feet from property lines, roads, and structures	When (1) fire-rated barriers or enclosures are used; (2) fire test data shows no harmful heat radiation sufficient to ignite nearby exposures; and (3) system has noncombustible, fire-rated outer walls
Requirement	Exempt from added spacing requirements	Additional 10-foot setbacks and other design considerations	Reductions from 10-ft to 3 ft setback permitted with approval from the Authority Having Jurisdiction (Indiana Department of Homeland Security in Indiana)

Best Practice and Frameworks

NYSERDA Guidebook: The Battery Energy Storage System Guidebook developed by the New York State Energy Research and Development Authority (NYSERDA), last updated in November 2024, offers details on permitting and siting guidance that can serve as a valuable reference.

Codes and standards: A variety of resources exist to help state officials and local planners learn more about best practice requirements for BESS safety, including:

BESS Component	National Codes and Standards
Interconnection	IEEE 1547, IEEE 2800
Overall Installation	NFPA 70, NFPA 855, IFC, UL 9540, IEEE C2
Fire/Gas Detection	IFC, NFPA 72, NFPA 855
Fire/Explosion Detection	IFC, NFPA 13, NFPA 15, NFPA 68, NFPA 69, NFPA 855
Battery Rack	UL 9540A
Power Conversion System	UL 1741
Cell/Battery	UL 1642, UL 1973, UL 9540A
Communications, Battery Management System (BMS)	UL 1741, UL 9540, CSA/ANSI C22.2 No. 340, IEEE 2686, IEEE 2688

Key: IEEE =Institute of Electrical and Electronics Engineers; IFC = International Fire Code ; UL = Underwriters Laboratories; CSA/ANSI = Canadian Standards Association / American National Standards Institute.

For additional information, see Hoyt, M., Kuykendall, O., Cotton, W. et al. (2025). *Utility-Scale Battery Energy Storage System Applications and Impacts in Indiana*. Indiana Office of Energy Development.

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Frequently Asked Questions: Battery Safety

As utility-scale Battery Energy Storage System (BESS) installations expand across Indiana, residents and local officials may have questions about their safety. This FAQ provides additional information about the risks involved and the systems in place to protect citizens and property.

Does Indiana specifically regulate BESS safety?

Yes. On July 1, 2023, Indiana enacted House Enrolled Act (HEA) 1173 (Indiana Code § 22-14-8-6) establishing safety requirements for new and expanded utility-scale BESS in Indiana. Key provisions include:

- Adoption of National Fire Protection Association (NFPA) 855 standards for fire safety, which specify fire protection, installation, spacing, and emergency response requirements.
- Delegation of safety evaluation and enforcement to the Indiana Department of Homeland Security (IDHS), which reviews and approves safety and commissioning plans.
- Requirements for developers to implement emergency response plans and offer annual training to local fire departments.

What causes BESS to fail?

BESS can fail due to various conditions:

Failure Mode	Example
Thermal Abuse	Battery overheating from poor ventilation
Electrical Abuse	Battery overcharging, external short circuits
Mechanical Abuse	Puncturing or crushing a battery
Internal Faults	Manufacturing defects in a battery
Environmental Impacts	Extreme temperature exposure, flooding, pests, and other natural disruptions

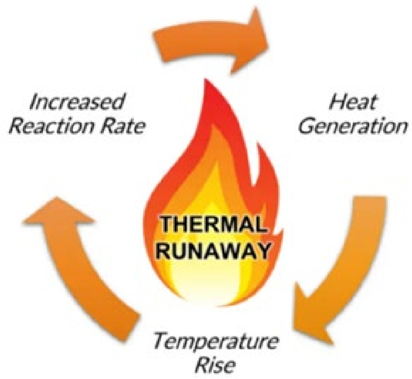
What risks are there when a BESS fails?

Hazards associated with BESS installations include:

- Stranded energy: Damaged batteries may still contain stored energy. This poses the risk of delayed fires and electrical shock.
- Off-gassing: Damaged batteries may emit flammable/toxic gases. These gases pose potential health, fire, and explosion hazards, particularly in enclosed spaces.
- Deep-seated fires: Fires contained in protective casings and enclosures can be particularly difficult to extinguish. Emergency responders may decide to handle such fires using non-intervention strategies (e.g., letting the fire burn itself out) to avoid personnel risk.
- Thermal runaway: Occurs when internal heat build-up exceeds the battery's ability to release heat, resulting in a rapid rise in temperature. Thermal runaway can cause a battery to rupture, catch fire, and, in some cases, explode.

How often do BESS installations fail?

BESS failures are rare. According to data from the Energy Information Administration (EIA) and the Electric Power Research Institute (EPRI), the failure rate of BESS installations is approximately 0.32%.[1]



Who is responsible for BESS safety and preventing failures?

BESS safety is a shared responsibility among multiple entities and individuals. These include:

Stakeholder	Responsibilities
Manufacturers	Design and produce batteries that meet safety standards
Operators	Maintain systems, train staff and first responders
Local planning authorities	Approve siting, zoning, and decommissioning plans
IDHS	Enforces NFPA 855 standards and reviews site plans
Regional grid operators	Oversee grid-level reliability and integration
Emergency responders	Respond to BESS safety incidents and undertake training

How are BESS designed to detect early signs of failure?

BESS incorporate multiple hazard detection and protection systems to preemptively identify failures:

- Battery Management System: Continuously monitors conditions (e.g., voltage, temperature).
- Smoke and heat detectors: Conventional and very early smoke detection apparatus (VESDA) are used to detect smoke before flames arise.
- Off-gas detection systems: Identify volatile gases released during early cell degradation, helping operators intervene before a failure escalates.
- Thermal imaging and flame detectors: Allow external monitoring of multiple BESS enclosures.
- Internal camera systems: Provide real-time visual confirmation without risk to personnel.

How are BESS designed to address failure?

Fire suppression in BESS combines design features and extinguishment systems:

System/Feature	Description
Continuous ventilation systems	Remove flammable gases before they reach dangerous levels
Deflagration vents / blast panels	Release built-up pressure and prevent enclosure ruptures
Water-based systems	When appropriately targeted (e.g., in-rack nozzles), water can prevent fire propagation. Water must be used with caution to avoid electrical short circuits and adverse chemical reactions
Dry-pipe systems	Allow firefighters to inject water without opening the enclosure
Gaseous suppression agents	These agents (e.g., FM-200 or Novec 1230) extinguish fires by starving them of oxygen

Can fires involving thermal runaway be extinguished?

Not always. Once thermal runaway begins, suppression agents may be ineffective and could even increase explosion risk by displacing oxygen while flammable gases accumulate. Best practice is a containment strategy that focuses on preventing a fire from spreading to nearby enclosures, letting the fire burn itself out, and using water only as a last resort.

How are firefighters trained to handle a BESS failure?

Under Indiana Code §22-14-8-6, BESS operators must provide annual training to local fire departments. Firefighting strategies increasingly emphasize containment over extinguishment, especially during a thermal runaway event. Emergency response plans, provided by the operator of the BESS, also play a critical role by providing emergency responders with detailed site-specific information about potential hazards, system layouts, battery chemistries, and recommended tactics.

For additional information, see Hoyt, M., Kuykendall, O., Cotton, W. et al. (2025). *Utility-Scale Battery Energy Storage System Applications and Impacts in Indiana*. Indiana Office of Energy Development.

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