DRIVING THE BLUE ECONOMY
TEXAS A&M UNIVERSITY AT GALVESTON

BREAKBULK EDUCATION DAY

HOUSTON MARITIME Center & Museum

Abstract

Maritime ports have been an essential part of global trade for many years. However, the challenges that they face have been increasing due to grid instability, escalating energy demands, and weather-related disruptions. Diesel backup generators have been heavily relied upon which has led to a large contribution to greenhouse gas emissions, along with poor air quality that offers limited resilience. In modern day, maritime ports are prompted to shift over to clean energy directives as well as expanded electricity grids. New solutions are needed to both minimize environmental impacts and streamline operations. Battery Energy Storage Systems (BESS) and microgrids are both prime examples of how these sustainability goals can be achieved. Ports that use BESS are now able to store renewable energy and use it as a contingency plan for when disaster hits, while microgrids provide ports with on site control and the ability to use diverse energy sources like wind and solar. Our poster will implore the challenges, examples, and best practices to integrate these technological advances that will transform the worlds ports into sustainable, clean, and resilient energy hubs.

Objectives

Our project demonstrates how Battery Energy Storage Systems and Microgrids will be the future of decarbonizing ports while strengthening their resilience worldwide.
Specific topics on the poster are as follows:

- **Analyzing the roles that both BESS and Microgrids** are tasked with during critical disruptions in port operations.
- **Assess energy challenges** that ports must overcome including high energy demand, the reliance on diesel backup, and grid instability.
- **Evaluate case studies** from U.S. ports such as Alaska and Long Beach that show the learnings from decarbonization and resilience.
- **Develop guidelines to achieve these practices** that will contribute to more domestic and international ports adopting microgrids as well as BESS.

Port of Long Beach

The Port of Long Beach's $18 million microgrid project showcases how BESS and microgrids bolster port resilience and aid decarbonization. The system includes a 300-kW rooftop solar PV array, a 1 MW/2 MWh stationary BESS, and a mobile BESS (mBESS) capable of supporting remote assets like pump stations and stranded Remote Communication Units (RCUs). Funded in part by a $5 million grant from the California Energy Commission, the microgrid primarily supports the Joint Command and Control Center which is critical for overseeing port security, including the harbor patrol and port police.
The port's diesel generator remains in use due to equipment with high inrush currents, which may draw up to four times their normal current briefly. These spikes cannot yet be managed by the inverter-based systems alone. To comply with safety codes, the port upgraded an existing wall to a two-hour fire rating because the mBESS was located within 10 feet. Additional setbacks from vehicles and structures were required based on battery size. Space limitations also impacted solar deployment, with typical solar PV requiring about 1 kW per 100 sq ft or 1 MW per 5 acres. The project faced multiple permitting and infrastructure challenges, including a mandatory two-hour fire-rated wall for battery proximity, abatement of asbestos on a 1960s warehouse roof, and compliance with seismic and hazardous material codes. Despite these challenges, the microgrid supports port decarbonization while enhancing energy reliability.
The benefits of implementing BESS and a microgrid include uninterrupted operation of critical infrastructure during outages, increased energy independence, and support for faster recovery during emergencies. The integration of solar PV and BESS reduces reliance on fossil fuels, contributing to the port's decarbonization goals and compliance with emissions regulations. The mobile BESS adds flexibility by powering remote or stranded assets when needed. Additionally, the system can reduce operational costs over time through load shifting and potential participation in grid services during normal ("blue sky") operations, making it both a resilient and economically strategic investment for the port.

Port of Alaska

The Meter Study and Microgrid Options Evaluation profiled at PNNL analyzes the Don Young Port of Alaska's real power needs, then uses those measured load profiles to test microgrid designs that pair solar, BESS, and existing diesel for extended outages. The work emphasizes right-sizing a grid-forming BESS to provide fast ride-through, black-start, and islanding so critical port functions can continue through hazards like earthquakes or tsunamis, and it flags that planning is multi-year and iterative. The study also notes operational interdependence with the adjacent Joint Base Elmendorf-Richardson (JBER), so resilience options consider both the port and nearby defense loads.
Building on that analysis, Anchorage documents and federal filings show the port moving forward with a dedicated microgrid/BESS: the municipality approved a sole-source contract with Chugach Electric Association for a Port of Alaska "microgrid BESS project," and a NEPA categorical exclusion states the system is intended to reduce emissions, smooth demand swings, and provide resilient power that can support JBER during disruptions. Earlier Sandia/DOE concept work for this site outlined the same architecture of PV, BESS, and diesel configured to island critical port loads and black start after a grid failure. In short, the port's BESS anchors a resilience-first microgrid strategy: batteries deliver instantaneous stability and reduce diesel burn, while diesel remains as long-duration contingency for Alaska's worst-case outages.

Methodology

Our methodology contains mixed-methods research to explore BESS integration with microgrids at port facilities, focusing on resilience enhancement and decarbonization. We began by conducting a thorough literary analysis on case studies and research from government publications, technical documentation, peer-reviewed scholarship, and documented cases of port electrification initiatives. Key resources were the Pacific Northwest National Laboratory's Port Electrification Handbook, produced in collaboration with the Department of Energy, along with academic studies on microgrid design that incorporate the usage of BESS. We also examined economic viability assessments and comprehensive case analyses from ports across different continents. Our data collection consisted of system specifications, financial metrics, carbon emissions data, and power reliability statistics sourced from published studies and industry documentation.

Discussion

Maritime ports continue to grapple with operational and environmental challenges that are growing by the hour: grid instability, increasing energy demands, and climate-induced disruptions. Diesel generators were historically the mainstay of port backup power, resulting in greenhouse gas emission and degrading air quality in the local environment. The appropriateness of this solution, which holds only short-term potency, however, becomes ever more questionable in the wake of resilience considerations and modern sustainability goals.
The Battery Energy Storage Systems (BESS) and microgrid solutions have now become core to the decarbonization and further electrification paths being charted by ports. While BESS should ensure storing excess renewable energy, reducing peak demand charges, and serving as reliable backup for outages, microgrids ensure localized control over the distribution and integration of renewable sources-from solar to wind-enhancing energy security and sustainability.

Conclusion

The integration of Battery Energy Storage Systems (BESS) and microgrids goes beyond a simple technology upgrade. It represents a strategic transformation of how maritime ports operate in response to climate and energy challenges. These systems enhance energy resilience, reduce greenhouse gas emissions, and support the seamless incorporation of renewable energy sources such as solar and wind. By doing so, ports can shift from being major energy consumers to proactive players in the global clean energy transition. Despite ongoing financial, technical, and regulatory challenges, early adopters are demonstrating that success is possible with careful planning, stakeholder engagement, and supportive policy frameworks. BESS and microgrids offer scalable, cost-effective solutions that not only reduce dependence on fossil fuels but also ensure continuity during grid disruptions. As more ports follow these emerging best practices, the industry is poised to evolve into a network of clean, resilient, and sustainable energy hubs, aligned with long-term environmental and operational goals.

Battery Energy Storage & Microgrids for Port Resilience & Decarbonization

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