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Sustainable Port Operations: Powered by NREL

World-Class Capabilities to Accelerate Low- and Zero-Emissions Seaport Operation

Seaports are vital economic hubs that allow the United States to compete on a global scale. But the heavy vehicles and cargo equipment that enable their operations also emit harmful air pollutants and greenhouse gas emissions.

For nearly two decades, National Renewable Energy Laboratory (NREL) researchers have worked toward comprehensive seaport decarbonization. They fuse world-class analysis with deep vehicle and transportation systems knowledge to guide strategic deployment of low- and zero-emissions vehicles, charging and refueling infrastructure, and grid improvements. Together, these capabilities can enable sustainable port operations.

NREL's research spans:

Fleet Research, Energy Data, and Insights for Decarbonization

NREL researchers dispatch to ports across the nation to install data loggers on vehicles operating in and around ports. This high-resolution—once per second (1Hz)—data feeds into NREL's Fleet DNA data clearinghouse and FleetREDI, the world's only secure, public, and anonymized data analysis and insights pipeline for commercial vehicle decarbonization.

The FleetREDI analysis pipeline enables our research teams to conduct deep engineering analysis into port vehicle operations: performing detailed charging analysis, determining optimal vehicle operations, and modeling viable clean-energy solutions.

Then, we provide fast, customized recommendations for the low- and zero-emissions solutions of best fit. Site-specific recommendations pinpoint opportunities to transition to battery-electric, hydrogen fuel cell, and biofuel technologies for port vehicle operations—including drayage vehicles, port yard tractors, harbor cranes, forklifts, and other material handling equipment.

NREL analysis supported the single largest deployment of heavy-duty, zero-emissions terminal tractors in Eastern United States at the Port Authority of New York and New Jersey (PANYNJ)'s Red Hook Terminal.

Portfolio: ZANZEFF Shore to Store Project | Zero Emission Cargo Transport (ZECT I) Battery-Electric Drayage Project | PANYNJ Yard Tractor Electrification Study | PANYNJ Drayage Truck Electrification Study | Ports of Long Beach and Los Angeles Drayage Drive Cycle Characterization and Development Project | Dallas Fort Worth (DFW) International Airport Route Optimization for Energy-Efficient Airport Shuttle Operations



Comprehensive Hydrogen Infrastructure Deployment

NREL's trusted, unbiased infrastructure analysis has formed the backbone of some of the world's largest real-world demonstrations of hydrogen fuel-cell drayage operations. Our end-to-end infrastructure planning spans hydrogen generation, storage, infrastructure requirements, and fueling for trucks and other large port vehicles such as marine vessels.

NREL analysis demonstrated that hydrogen fuel cell trucks in the Port of Los Angeles' Shore to Store project can transport goods from the nation's ports to their final destinations without producing vehicle emissions.

Portfolio: Zero Emission Cargo Transport (ZECT II) Hydrogen Fuel-Cell Drayage Project | ZANZEFF Shore to Store Project

Optimized Charging through Grid Integration

Our researchers conduct comprehensive research on the integration of EVs with port facilities, energy storage systems, and the electrical grid. By identifying the impacts of EV charging on the grid and implementing managed charging strategies, we can reduce the barriers associated with deploying charging systems at scale, support the integration of renewable energy sources, and reduce the cost of charging—even at large, interconnected port facilities. NREL researchers can also evaluate shore power solutions for safe and reliable power transfer from the grid to vessels docked at port.

NREL analysis is helping the Port of Long Beach to replace 100% of its cargo handling equipment with electrified alternatives by 2030.

Portfolio: ZECT I Battery-Electric Drayage Project | DFW International Airport ZEV Blueprint | DFW International Airport Athena ZEV | Port of Long Beach Port Community Electric Vehicle Blueprint | ZANZEFF Shore to Store Project | PANYNJ Drayage Truck Electrification Study

Strategic Blueprinting for Clean, Optimized Technology Deployment

NREL experts combine vehicle-, infrastructure-, and grid-level analysis to chart a path to clean, cost-effective, optimized technology deployments for the busiest air- and seaports in the United States. These solutions support the electrical, physical, and cyber resilience of the power grid.

NREL's work doesn't stop at the port's gates: Our researchers can help to plan regional infrastructure to support port activities, infrastructure for interconnected port facilities, and mobility solutions for urban planners.

NREL's strategic EV blueprinting is helping the PANYNJ to reach an established goal of net-zero carbon emissions by 2050 across all port facilities.

Portfolio: Port of Long Beach Port Community Electric Vehicle Blueprint | ZANZEFF Shore to Store Project | DFW EV Blueprint

Integrating Diversity, Equity, Inclusion, and Accessibility

Our researchers can quantify the impacts of deploying low- and zero-emissions technologies on the communities surrounding sea and inland ports. Their research focuses on emissions reduction strategies and their impact on air quality and noise pollution, as well as opportunities to close equity gaps in disadvantaged communities through engagement with new development and technology advancements.

NREL researchers are helping develop an action plan for corridor electrification along Utah's Wasatch Front, where severe air pollution disproportionately affects underserved communities.

Portfolio: ZANZEFF Shore to Store Project | Port of New York and New Jersey Drayage & Terminal Tractor Electrification Projects | National Zero-Emission Freight Corridor Strategy | Utah Inland Port Drayage Electrification

Recent Partners

California Air Resources Board | Honolulu Harbor | Port Authority of New York and New Jersey | Port of Hueneme | Port of Long Beach | Port of Los Angeles | South Coast Air Quality Management District

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