Transforming ENERGY

Electrification Analysis: Container Ports' Cargo Handling Equipment

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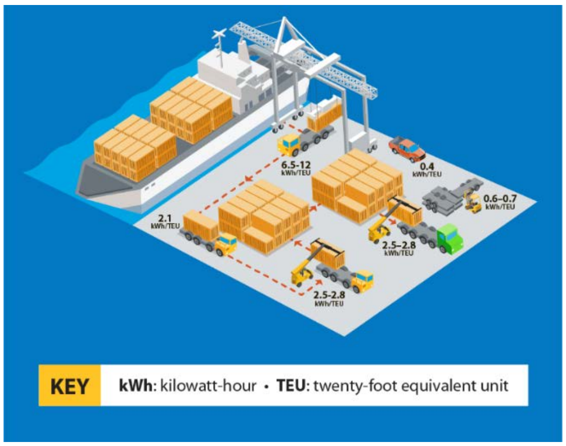

Figure 1. Estimating port terminal loads. *Illustration Cameron Nelson, NREL*

Maritime decarbonization is an integral part of reducing emissions from freight transportation. The Electrification Analysis of Container Ports' Cargo Handling Equipment developed by the National Renewable Energy Laboratory (NREL) in partnership with the Electric Power Research Institute provides a scalable solution to model energy demand per container moved (kilowatt-hour [kWh]/twenty-foot equivalent unit [TEU]) for an all-electric cargo handling equipment fleet.

Container Movements (Equipment Used)	Energy Consumed Per Container
Vessel to Dockside (Ship-to-Shore Crane)	6.5–12 kWh/TEU
Dockside to Container Stack (Yard Tractor)	2.1 kWh/TEU
Yard Tractor to Container Stack (Reach Stacker)	2.5–2.8 kWh/TEU
Container Stack to Drayage Truck (Reach Stacker)	2.5–2.8 kWh/TEU
Forklifts: Light, Medium, and Heavy Duty	0.6–0.7 kWh/TEU
Personnel Vehicles: Light Duty	0.4 kWh/TEU

Table 1. Energy Demand per Container Moved for Each Equipment Type

Data Collection

NREL's Fleet Research, Energy Data, and Insights (FleetREDI) commercial vehicle data collection and analysis platform provided the bulk of the cargo handling equipment data. The equipment energy consumption profile was calculated using FleetREDI's analysis of the vehicle miles traveled along with second-by-second data from NREL's Fleet DNA data clearinghouse.

NREL also collaborated with a container port, Port of Honolulu, that provided data for an electric ship-to-shore crane, personnel vehicles, and reach stackers. The container port also provided crucial operational data of the port, including container throughput and shift hours.

Electrification Analysis

NREL calculated the hourly energy consumption for each equipment type. Using the operational profile and hourly equipment energy consumption (kWh/hr), we evaluated the energy per shift. Subsequently, we calculated the amount of energy drawing from the grid during operation and downtime.

Next, we took the kWh/hr of each equipment type and the number of containers unloaded per hour to calculate the energy consumed per container moved (kWh/TEU), shown in Table 1. Finally, we scaled the overall kWh/TEU for all equipment based on annual container throughput for the top-25 U.S. container ports to estimate the annual energy consumed at these ports with an all-electric cargo handling equipment inventory.

Electric Cargo Handling Equipment Adoption Rates

The team estimated the adoption rates of electric cargo handling equipment by leveraging data provided by the Port of Long Beach's Electric Vehicle (EV) Blueprint. We took the port's target of a 100% EV fleet by 2030 as the most aggressive target.

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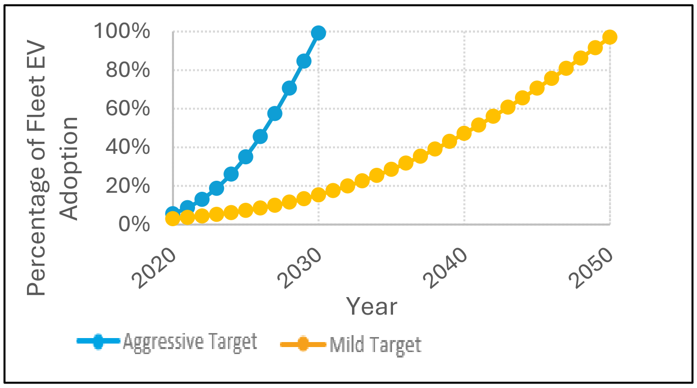

Figure 2. Electric vehicle stock projections for the Port of Long Beach

We fit the adoption rates provided by the port to an S-curve. To characterize the mild EV adoption target, this curve was stretched to assume 100% adoption by 2050, shown in Figure 2. We then applied these adoption rates to the annual energy consumption calculated for the top-25 U.S. ports.

In a 100% electrification scenario in 2035, the annual energy consumption for all top-25 ports ranges from 1.61 to 2.03 TWh.

Conclusion

This project developed a model to understand energy demand at each EV equipment level that is easily scalable to container demand and EV adoption rate projections.

Stakeholders—including the U.S. Department of Energy and its Vehicle Technologies Office and Office of Energy Efficiency and Renewable Energy, plus external parties—will be able to utilize the results of this project to facilitate fleet electrification at ports across the nation. This model could be refined further in future work with data collection and analysis of a variety of container ports around the United States.

Acknowledgment

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