Appendix E: Cargo Handling Equipment & Infrastructure Demonstrations, Pilots, Product Launches, and Prototypes

Staff conducted a search and a study of demonstrations, pilot projects, product launches, and prototype announcements for the three zero-emission CHE technologies discussed in this assessment. Staff also researched infrastructure projects in support of these zero-emission CHE technologies. This appendix provides a summary of projects that were active or completed between January 2020 and January 2025.

The term *demonstration* in this appendix refers to a project to test newly developed equipment in a real-world environment to validate its functionality, performance, and suitability for specific applications. In many cases, zero-emission CHE demonstrations use pre-production, custom built, or prototype equipment. The term demonstration is sometimes used as a synonym for pre-production. However, zero-emission CHE demonstrations often use commercially available equipment, as well. Despite meeting the manufacturer's requirements for product development and offering the equipment on the open market, the CHE has not been sufficiently proven for the facility's unique environment, creating the need for a demonstration.[1] Demonstrations are often funded through government grants or incentive programs. Sometimes, a single funding opportunity provides funds for multiple demonstrations. For example, one grant program by the California Air Resources Board, called Sustainable Terminals Accelerating Regional Transformation (START), funded over 100 pieces of equipment at three California seaports.[2] The use of the term demonstration as a project for proving CHE should not be confused with the Technology Readiness Grade of Demonstration.

The term *pilot* in this appendix refers to the use of commercially available, or early-production CHE for small-scale or limited scope deployments to test equipment, validate processes, and identify potential issues before larger scale adoption (i.e., purchasing or manufacturing more of the zero-emission CHE). Unlike demonstrations, pilots are usually funded by the manufacturer or by industry. In this appendix, commercially available CHE used for demonstrations or pilots is identified for each project. Demonstrations and pilots usually have a clearly defined start and end date. At the completion of these projects, the equipment is often returned to the product developers.

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[1] According to Energetics Incorporated, "While the manufacturers consider these EVs commercial models, they are often very early in production, and customers often consider them to be demonstration vehicles since they have not been deployed in significant numbers and are likely to experience some operational issues." (Energetics Incorporated, et al." Final Evaluation Report," California Public Utilities Commission, April 2021. Accessed April 2, 2025. *https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/california-te-prp-final-evaluation-report-presentation.pdf*, page 102.)

[2] California Air Resources Board, "LCTI: Sustainable Terminals Accelerating Regional Transformation (START) Project Phase 1," n.d. Accessed February 26, 2025. *https://ww2.arb.ca.gov/lcti-sustainable-terminals-accelerating-regional-transformation-start-project-phase-1*.

However, in some successful demonstrations and pilots, the equipment is kept by the facility and continues in operation.

The term *product launch* in this appendix refers to an announcement of future commercial availability of a new type of CHE. The announcement is typically made less than a year before the actual availability date. The equipment has completed, or is finishing up, the product development phases (prototype, demonstration, and pre-production testing) and product developers announce future availability to create demand for their soon-to-be released products. Sometimes announcements are made, but the product is not released.[3]

The term *prototype* in this appendix refers to an announcement made by product developers that they are actively working on the development of a new type of equipment. Prototypes differ from product launches as the prototype phase of development involves a limited number of units for product viability testing, sometimes producing only a single unit. As part of the announcement, the developer often unveils the prototype at a major equipment exposition or conference.

This appendix provides a separate table for each demonstration, pilot project, product launch, and prototype. Each project outlines:

1. A specific type of CHE
2. A specific model
3. A specific technology
4. A specific operational environment

If one of these parameters is unique, it constitutes a separate project in this appendix. For example, one battery-electric excavator was moved to three different sites for testing purposes. Each site is listed in this appendix as a separate pilot project. Similarly, a single announcement often reveals multiple products or models. Each one is listed separately.

Each table provides a limited summary of the project. However, additional sources of information are provided for the reader to conduct further study. Each of these projects or announcements is given an identification number (ID) to help staff and the reader track how many projects there are for each type of CHE and associated infrastructure and to easily reference the project. N/A is added when the type of information in the table does not apply to that type of project. For example, for the *Quantity* and the funding-related table elements, demonstrations have a specific number of equipment involved in the project and often receive incentive funding, but product launches do not. When the information may be available, but is not reported in the source information, a note indicating staff's request for the information is added.

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[3] Mohandas, Poornima. "Epic Product Launch Failures and How to Avoid Them." Institute of Product Leadership, August 13, 2024. Accessed May 14, 2025. *https://www.productleadership.com/blog/product-launch-failures-and-how-to-avoid-them*.

The projects are sorted as follows:

1. Alphabetically by CHE Category (i.e. bulk material, container, and facility support)
2. Alphabetically by CHE Type (e.g. excavator, forklift, haul truck, etc.)
3. Alphabetically by zero-emission technology (i.e. battery-electric, grid-electric, hydrogen fuel cell)
4. Alphabetically by CHE OEM or equipment/service provider

Bulk Material CHE Demonstrations, Pilots, Product Launches, and Prototypes

Crane, Material Handling

ID	Crane, Material Handling-1 [Source[4]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Crane, Material Handling
Zero-Emission Technology	Grid-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Sennebogen
Product Name	855 E (Commercially available)
Quantity	1
Project Description	Akij Essentials, one of the largest flour mills in Bangladesh, took delivery of the Sennebogen 855 E grid-electric material handling crane in early 2024 to address stringent emissions regulations. The 855 E runs on a 200-kW e-electric motor and is capable of completing four loading and unloading cycles per minute, offloading approximately 250 tons of raw materials per hour.
Location	Bangladesh, Dhaka, Akij Essentials grain mill (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	2024
End Date	[Staff is seeking information on this pilot.]
Results	[Staff is seeking information on this pilot.]

[4] Nicole Yeong, "Zero-emissions Unloading at Flour Mill," Sennebogen, February 25, 2025. Accessed May 2, 2025. *https://www.sennebogen.asia/news-trade-fairs/zero-emissions-unloading-at-flour-mill*.

ID	Crane, Material Handling-2 [Source[5]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Crane, Material Handling
Zero-Emission Technology	Grid-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Sennebogen
Product Name	825 E (Commercially available)
Quantity	1
Project Description	The Vanheede Environment Group operated a Sennebogen 825 E all-electric material handing crane at its landfill in Rumbeke to support their goal of reducing CO2 emissions in all areas of operation.
Location	Belgium, Rumbeke, Vanheede Environment Group landfill (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	February 2023
End Date	[Staff is seeking information on this pilot.]
Results	Initial reporting indicates: • Savings of approximately 106 tons of CO_2 per year when powered by renewable energy. • 40% lower operating costs compared to diesel models. • Zero-emission operation has improved workplace air quality, benefiting employees. [Staff is seeking information on this pilot.]

[5] Couplez, Valérie, and Lisa-Maria Heigl. "CO2 Reduction in Waste Disposal Management." Sennebogen.com, January 29, 2025. Accessed May 2, 2025. *https://www.sennebogen.com/en/news/news-press/co2-reduction-in-waste-management*.

Crane, Mobile

ID	Crane, Mobile-1 [Source[6]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Crane, Mobile
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Liebherr (mobile crane), Victron (repower)
Product Name	[Staff is seeking information on this demonstration.]
Quantity	1
Project Description	Dynastart repowered a Liebherr diesel-electric mobile crane to use Victron lithium-ion batteries. The diesel engine is used when it is being driven, but the crane operates on batteries at the construction site. New legislation in the Netherlands requires companies to reduce emissions of CO2 and demonstrate their green credentials before construction permits are issued. This has resulted in the demonstration of battery-electric equipment.
Location	Netherlands, Amersfoort construction site (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]
Results	• The crane can operate for two days on a complete charge. • There is no difference in power. • Operators like the reduced noise of the battery-electric equipment.

[6] Victron Energy, "How and why is this crane battery powered?", YouTube video, published on March 26, 2024, 5:54. Accessed April 9, 2025. *https://www.youtube.com/watch?v=QECj2Qa5TWI*.

Crane, Mobile Harbor

ID	Crane, Mobile Harbor-1 [Sources[7]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Crane, Mobile Harbor
Zero-Emission Technology	Grid-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Konecranes
Product Name	Generation 6 (Commercially available)
Quantity	2
Project Description	The Port of San Diego introduced two all-electric Konecranes Generation 6 mobile harbor cranes at its Tenth Avenue Marine Terminal, marking the first of their kind in North America. The cranes provide the heaviest lift capability of port crane systems on the U.S. West Coast, up to 400 metric tons. The project received $2.7 million in grant funding from the San Diego County Air Pollution Control District. This initiative aligns with the Port's Maritime Clean Air Strategy, targeting zero emissions for all cargo handling equipment by 2030.
Location	United States, California, Port of San Diego, Tenth Avenue Marine Terminal
Funding Source (Funding Name)	American Rescue Plan Act and California Coronavirus Fiscal Recovery Funds
Fund Recipient	Port of San Diego
Start Date	September 2024
End Date	[Staff is seeking information on this pilot.]
Results	[Staff is seeking information on this pilot.]

[7] Port of San Diego, "Port of San Diego Demonstrates Tandem-Lift Capability of its New All-Electric Mobile Harbor Cranes, First in North America," September 17, 2024. Accessed April 9, 2025. *https://www.portofsandiego.org/press-releases/general-press-releases/port-san-diego-demonstrates-tandem-lift-capability-its-new.*; Port of San Diego, July "They're Here! Port of San Diego Celebrates Arrival of All-Electric Mobile Harbor Cranes, First in North America," 17, 2023. Accessed April 9, 2025. *https://www.portofsandiego.org/press-releases/general-press-releases/theyre-here-port-san-diego-celebrates-arrival-all-electric*.

ID	Crane, Mobile Harbor-2 [Source[8]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Crane, Mobile Harbor
Zero-Emission Technology	Grid-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Konecranes
Product Name	Repowered Gottwald Model 7 GHMK 7608
Quantity	1
Project Description	The Port of Kalundborg in Denmark converted two Konecranes Gottwald mobile harbor cranes to run on electricity, eliminating the use of diesel fuel. To support the equipment, a transformer station and additional electrical infrastructure were installed, allowing the cranes to operate fully on grid power.
Location	Denmark, Port of Kalundborg, Ny Vesthavn (New West Harbour)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	[Staff is seeking information on this pilot.]
End Date	[Staff is seeking information on this pilot.]
Results	[Staff is seeking information on this pilot.]

[8] World Cargo News, "Port of Kalundborg Electrifies Two Gottwald Cranes," April 9, 2025. Accessed April 10, 2025. *https://www.worldcargonews.com/cargo-handling-equipment/2025/04/port-of-kalundborg-electrifies-two-gottwald-cranes/*.

ID	Crane, Mobile Harbor-3 [Source[9]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Crane, Mobile Harbor
Zero-Emission Technology	Grid-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Konecranes
Product Name	Repowered Gottwald Model 6
Quantity	1
Project Description	The Port of Kalundborg in Denmark converted two Konecranes Gottwald mobile harbor cranes to run on electricity, eliminating the use of diesel fuel. To support the equipment, a transformer station and additional electrical infrastructure were installed, allowing the cranes to operate fully on grid power.
Location	Denmark, Port of Kalundborg, Ny Vesthavn (New West Harbour)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	[Staff is seeking information on this pilot.]
End Date	[Staff is seeking information on this pilot.]
Results	[Staff is seeking information on this pilot.]

[9] World Cargo News, "Port of Kalundborg Electrifies Two Gottwald Cranes," April 9, 2025. Accessed April 10, 2025. *https://www.worldcargonews.com/cargo-handling-equipment/2025/04/port-of-kalundborg-electrifies-two-gottwald-cranes/*.

ID	Crane, Mobile Harbor-4 [Source[10]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Crane, Mobile Harbor
Zero-Emission Technology	Grid-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Liebherr
Product Name	Pactronic 2.0 (Commercially available)
Quantity	1
Project Description	The Port of Hueneme received a Liebherr Pactronic 2.0 zero-emission mobile harbor crane in July 2019. The crane is capable of running on diesel or electricity, but will be plugged into the grid during operation. It was funded by a $3 million Zero- and Near-Zero Emissions Freight Facilities (ZANZEFF) program grant and represents a $7 million investment by Ports America. It aims to enhance cargo handling efficiency while supporting the Port's vision for sustainable operations.
Location	United States, California, Port of Hueneme
Funding Source (Funding Name)	The California Air Resources Board, or CARB (Low Carbon Transportation Incentives (LCTI)/ZANZEFF)
Fund Recipient	Port of Hueneme
Start Date	August 2019
End Date	[Staff is seeking information on this pilot.]
Results	[Staff is seeking information on this pilot.]

[10] The Port of Hueneme, "Port Welcomes First Zero-Emission Crane," July 10, 2019. Accessed April 9, 2025. *https://www.portofhueneme.org/zero-emission-crane*.

ID	Crane, Mobile Harbor-5 [Sources[11]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Crane, Mobile Harbor
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Shanghai Zhenhua Heavy Industries (ZPMC)
Product Name	[Staff is seeking information on this demonstration]
Quantity	1
Project Description	ZPMC launched a demonstration of the world's first hydrogen fuel cell-powered mobile harbor crane. The crane uses a hydrogen fuel cell hybrid power system, achieving net-zero CO2 emissions and only discharging purified water during operation. [Staff is seeking information on this demonstration.]
Location	China, Shanghai, Port of Shanghai
Funding Source (Funding Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	November 2021
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[11] Katherine Si, "ZPMC Launches Trial of World's First Hydrogen Fuel Cell Mobile Crane," Seatrade Maritime News, November 25, 2021. Accessed April 4, 2025. *https://www.seatrade-maritime.com/ports-logistics/zpmc-launches-trial-of-world-s-first-hydrogen-fuel-cell-mobile-crane.*; *https://www.zpmc.com/content/676c11bb0025677d00000108*; Hydrogen Central, "Shanghai Zhenhua Heavy Industries Commissioning Trial Operation of the World's First Hydrogen Fuel Cell Powered Mobile Crane," November 25, 2021. Accessed April 9, 2025. *https://hydrogen-central.com/shanghai-zhenhua-heavy-industries-operation-hydrogen-fuel-cell-powered-mobile-crane.*; H2-View.com, "Shanghai Port Test 'World's First' Hydrogen Fuel Cell Powered Mobile Crane," World Energy, November 26, 2021. Accessed April 9, 2025. *https://www.world-energy.org/article/21392.html*.

Crane, Off-Road

ID	Crane, Off-Road-1 [Source[12]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Crane, Off-Road
Zero-Emission Technology	Battery-electric/Grid-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Liebherr
Product Name	LR 1160.1 unplugged and LR 1250.1 unplugged (Commercially available)
Quantity	2
Project Description	Britain's new high-speed railway project, HS2, has a goal that all construction sites be diesel-free by 2029. Select Plant Hire obtained a Liebherr LR 1160.1 unplugged and a LR 1250.1 unplugged for their lifting operations in support of this goal as well as their own desire to be early adopters.
Location	England, London (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	[Staff is seeking information on this pilot.]
End Date	[Staff is seeking information on this pilot.]
Results	The operator reported smoother operation and less noise. The units can move on battery power and operate for 8 to 10 hours per day. [Staff is seeking information on this pilot.]

[12] Liebherr, "Liebherr – Unplugged crawler cranes, 'The most sustainable future,'" YouTube video, published on September 25, 2022, 3:22. Accessed May 2, 2025. *https://youtu.be/c7mUu9u2S3E?si=s80rydIGTPUlGjBK*.

ID	Crane, Off-Road-2 [Sources[13]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Crane, Off-Road
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Liebherr
Product Name	Custom build using LR1200
Quantity	1
Project Description	Crane rental company, Van Adrighem, and mechanical engineering company, Reedyk, converted a Liebherr LR1200 crawler crane to run on hydrogen. The hydrogen fuel cell crane has comparable power, speed, and safety to similar diesel equipment.
Location	Netherlands, Vierpolders
Funding Source (Funding Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	December 2023
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[13] Infrasite.nl, "Crawler crane converted to hydrogen by Reedyk and Adrighem," December 21, 2023. Accessed March 27, 2025. *https://www.infrasite.nl/bouwen/2023/12/21/rupskraan-omgebouwd-naar-waterstof-door-adrighem-en-reedyk*.; *https://fuelcellsworks.com/subscribers/dutch-firms-showcase-groundbreaking-hydrogen-powered-liebherr-lr1200-crane*; Adrighem Rental, "Liebherr LR1200 Hydrogen Crane," n.d. Accessed April 9, 2025. *https://adrighem.com/liebherr-lr1200-hydrogen-crane/*.; Adrighem Rental, "Liebherr LR12001 Hydrogen Crane," n.d. Accessed March 26, 2025. *https://adrighem.com/rental/liebherr-lr1200-hydrogen-crane/*.

Dozer

Staff is seeking information on demonstrations, pilots, product launches, and prototypes using zero-emission dozers for cargo handling.

Excavator

ID	Excavator-1 [Sources[14]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Excavator/Crawler Excavator
Zero-Emission Technology	Battery-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Volvo
Product Name	EC230 (Commercially available)
Quantity	1
Project Description	This project involved a 90-day trial operation of Volvo's EC230 battery-electric excavator by global construction firm, Skanska, on a transit project in Los Angeles. The battery-electric excavator has a 264-kWh battery that provides 5 hours of runtime.
Location	United States, California, Los Angeles (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	[Staff is seeking information on this pilot.]
End Date	[Staff is seeking information on this pilot.]

[14] Michelle Lewis, "Volvo + Skanska piloted a huge electric excavator in LA – here's how it went," Electrek, February 20, 2024. Accessed February 26, 2025. *https://electrek.co/2024/02/20/volvo-skanska-piloted-a-huge-electric-excavator-in-la-heres-how-it-went/*; Skanska, "Skanska concludes its 90-day pilot program of the zero-emission Volvo EC230 Electric in North America," February 20, 2024. Accessed February 26, 2025. *https://www.usa.skanska.com/who-we-are/media/press-releases/278298/Skanska-concludes-its-90day-pilot-program-of-the-zeroemission-Volvo-EC230-Electric-in-North-America*; Heavy Equipment Guide Staff, "Electric Volvo excavator proves its worth in Skanska pilot with lower emissions, costs, and noise," Heavy Equipment Guide, February 22, 2024. Accessed February 26, 2024. *https://www.heavyequipmentguide.ca/article/41438/electric-volvo-excavator-proves-its-worth-in-skanska-pilot-with-lower-emissions-costs-and-noise*.

Results	The electric excavator successfully loaded trucks with export construction material while maintaining the project schedule. The trial revealed significant benefits, including a 66% reduction in carbon emissions per hour and an estimated 74% decrease in operating costs. The electric machine also enhanced health and safety by minimizing vibrations and noise, resulting in a more comfortable environment for operators and reduced noise pollution in the community. Operators appreciated its ease of use and performance.

ID	Excavator-2 [Source[15]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Excavator/Crawler Excavator
Zero-Emission Technology	Battery-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Volvo
Product Name	EC230 (Commercially available)
Quantity	1
Project Description	The Turner Construction Company conducted a pilot of the Volvo EC230 electric excavator on a manufacturing project for Applied Materials in the Silicon Valley region of Northern California. The excavator was used on the placement of deep utilities, backfilling, building pad excavation, compaction, and material movement. As part of the pilot, Sunbelt Rentals provided a 600-kWh mobile fast charger to provide power to the excavator.
Location	United States, California, Palo Alto (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	[Staff is seeking information on this pilot.]
End Date	October 2024
Results	[Staff is seeking information on this pilot.]

[15] Volvo Construction Equipment, "Turner Construction Company to Pilot Volvo EC230 Electric Excavator as Part of program to Reduce Emissions," August 16, 2023. Accessed February 26, 2024. *https://www.volvoce.com/united-states/en-us/about-us/news/2023/turner-construction-company-to-pilot-volvo-ec230-electric-excavator/*.

ID	Excavator-3 [Source[16]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Excavator/Crawler Excavator
Zero-Emission Technology	Battery-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Volvo
Product Name	EC230 (Commercially available)
Quantity	1
Project Description	WM (formerly Waste Management) is conducting a pilot of the Volvo EC230 battery-electric excavator at one of its facilities on the East Coast. The excavator was planned to perform the same tasks diesel excavators do in waste applications. WM planned to track data and share feedback with Volvo CE.
Location	United States (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	2023
End Date	[Staff is seeking information on this pilot.]
Results	[Staff is seeking information on this pilot.]

[16] Volvo Construction Equipment, "North American Pilot Will Test EC230 Electric Excavator – The Next Step in Volvo Electric Machines," May 3, 2023. Accessed February 26, 2025. *https://www.volvoce.com/united-states/en-us/about-us/news/2023/north-american-pilot-will-test-ec230-electric-excavator/*.

ID	Excavator-4 [Source[17]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Excavator/Wheeled Excavator
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Product launch
OEMs, Equipment, or Service Provider	Hyundai
Product Name	HW155H
Quantity	N/A
Project Description	A static version of Hyundai's 14-ton hydrogen fuel cell excavator debuted at the 2022 Bauma construction trade show. Hyundai plans on releasing the production version in 2025. The excavator can reportedly operate for up to eight hours.
Location	Germany, Munich (Bauma)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	2025
End Date	N/A
Results	[Staff is seeking information on this product launch.]

[17] Jo Borrás, "HD Hyundai set to debut production 14 ton hydrogen wheeled excavator," Electrek, January 27, 2025. Accessed February 26, 2025. *https://electrek.co/2025/01/27/hd-hyundai-set-to-debut-production-14-ton-hydrogen-wheeled-excavator/*.

ID	Excavator-5 [Sources[18]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Excavator/Crawler Excavator
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Prototype
OEMs, Equipment, or Service Provider	JCB
Product Name	220X
Quantity	1
Project Description	JCB developed a 20-ton hydrogen fuel cell powered excavator prototype. At the time of the report, it had undergone more than 12 months of testing.
Location	[Staff is seeking information on this prototype.]
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	[Staff is seeking information on this prototype.]
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[18] JCB, "JBC Leads the Way with First Hydrogen Fuelled Excavator," n.d. Accessed February 26, 2025. *https://www.jcb.com/en-gb/news/2020/07/jcb-leads-the-way-with-first-hydrogen-fuelled-excavator*; JCB, "JCB's Hydrogen Fuel-Cell X Series Excavator – A Zero Emission Industry First," YouTube video, published on July 1, 2020, 0:46. Accessed March 27, 2025. *https://www.youtube.com/watch?v=q1-__SYskjc*.

ID	Excavator-6 [Sources[19]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Excavator/Crawler Excavator
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Prototype
OEMs, Equipment, or Service Provider	Komatsu
Product Name	[Staff is seeking information on this prototype.]
Quantity	1
Project Description	Komatsu developed a concept machine for a medium-sized hydraulic hydrogen fuel cell excavator. The fuel cell system and hydrogen tank were produced by Toyota. Komatsu reports that the fuel cell technology is better for medium and large construction equipment due to a higher energy density and the ability to refuel in a shorter time than recharging batteries.
Location	[Staff is seeking information on this prototype.]
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	May 2023
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[19] Komatsu.com, "Komatsu develops medium-sized hydraulic excavator concept machine with a hydrogen fuel cell," May 12, 2023. Accessed March 27, 2025. *https://www.komatsu.com/en/newsroom/2023/hydraulic-excavator-concept-with-hydrogen-fuel-cell/*; Komatsu.jp, "The Challenge: Carbon Neutrality by 2050," n.d. Accessed April 11, 2025. *https://www.komatsu.jp/en/aboutus/brandcommunication/hydrogen-fuel-cell.*; Komatsu.eu, "Komatsu Announces New Concept Medium-Sized Hydraulic Excavator Equipped with Hydrogen Fuel Cell System," May 16, 2023. Accessed April 11, 2025. *https://www.komatsu.eu/en/news/komatsu-announces-new-concept-hydrogen-excavator*.

ID	Excavator-7 [Source[20]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Excavator/Crawler Excavator
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Liebherr (excavator), Mourik (hydrogen fuel cell)
Product Name	Converted Liebherr R926
Quantity	1
Project Description	Demonstration of a Liebherr excavator converted by Mourik to zero-emissions using hydrogen fuel cells. The 30-ton zero-emission crawler excavator was used on a dyke improvement project.
Location	Netherlands (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	October 2022
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[20] Fuel Cells Works, "Thursday Throwback Story: Mourik Builds First 100% Clean Hydrogen Powered Excavator," October 6, 2022. Accessed February 26, 2024. *https://fuelcellsworks.com/news/mourik-builds-first-100-clean-excavator-on-hydrogen-2*.

ID	Excavator-8 [Sources[21]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Excavator/Wheeled Excavator
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Liebherr (excavator), Terberg Techniek (repower), Zepp.solutions (fuel cell)
Product Name	Repowered 916 Litronic
Quantity	2
Project Description	Demonstration of two fuel cell excavators by the Dutch construction company Jos Scholman. Terberg Techniek repowered Liebherr excavators with Zepp.solutions' 50-kw proton-exchange membrane fuel cells. They were tested for six months.
Location	Netherlands (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]
Results	Project participants stated that the equipment was reliable and performed as expected. [Staff is seeking information on this demonstration.]

[21] Zepp.Solutions, "Liebherr excavator conversion," n.d. Accessed June 10, 2025. *https://zepp.solutions/en/liebherr-hydrogen-excavators/*; Electrive, "Zepp.solutions converts two diesel excavators to hydrogen," October 12, 2023. Accessed June 10, 2025. *https://www.electrive.com/2023/01/03/zepp-solutions-converts-two-diesel-excavators-to-hydrogen/*.

ID	Excavator-9 [Source[22]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Excavator/Crawler Excavator
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Volvo (excavator), Ballard (hydrogen fuel cell)
Product Name	Custom build using a Volvo EC300E hybrid with Ballard's FCmove–XD heavy-duty fuel cell engine
Quantity	1
Project Description	Demonstration of a 30-ton Volvo EC300E excavator that was converted to zero-emissions using a 120-kW Ballard FCmove–XD fuel cell. The excavator is being tested by Norwegian-based construction company, Veidekke, and will also include an on-site mobile refueling station to support the vehicle's operation.
Location	Norway (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	April 2024
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[22] Thomas Davies, "Applied Hydrogen to Deliver 30-ton Excavator to Veidekke AS, Integrating Powerful Ballard Fuel Cell," Ballard, January 29, 2024. Accessed February 26, 2025. *https://blog.ballard.com/truck/ballard-partnership-developing-zero-emission-construction-vehicles*.

Forklift, Heavy-Lift

ID	Forklift-1 [Sources[23]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Forklift
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	DANNAR
Product Name	Model 4.00 (Commercially available)
Quantity	2
Project Description	As part of the California Climate Investments (CCI) program and LCTI, the Port of Stockton demonstrated two battery-electric 30,000-lb forklifts equipped with additional cargo handling attachments, including a multi-purpose truck bed and scissor lift.
Location	United States, California, Port of Stockton
Funding Source (Funding Name)	CARB (CCI/LCTI, San Joaquin Valley Air Pollution Control District Zero-Emission Cargo Handling Demonstration Project)
Fund Recipient	San Joaquin Valley Air Pollution Control District
Start Date	Summer 2018
End Date	Summer 2021
Results	[Staff is seeking information on this demonstration.]

[23] California Air Resources Board, "LCTI: San Joaquin Valley Zero-Emission Cargo Handling Demonstration Project," n.d. Accessed March 27, 2025. *https://ww2.arb.ca.gov/lcti-san-joaquin-valley-zero-emission-cargo-handling-demonstration-project*; Dannar, "DANNAR Partners with the San Joaquin Valley Air Pollution Control District to Deploy Zero-Emission Off-Road Equipment at the Port of Stockton," PR Newswire, June 20, 2018. Accessed March 27, 2025. *https://www.prnewswire.com/news-releases/dannar-partners-with-the-san-joaquin-valley-air-pollution-control-district-to-deploy-zero-emission-off-road-equipment-at-the-port-of-stockton-300668942.html*.

ID	Forklift-2 [Source[24]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Forklift
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Kalmar (forklift), TransPower (repower)
Product Name	Repowered ECG90-180 9-18T (lead-acid)
Quantity	1
Project Description	Demonstration of a 40,000-lb electric forklift at the Port of San Diego. The forklift was manufactured by Kalmar and upgraded with a battery management system by TransPower.
Location	United States, California, Port of San Diego, Terminalift
Funding Source (Funding Name)	California Energy Commission, or CEC (San Diego Port Sustainable Freight Demonstration Project)
Fund Recipient	San Diego Port Tenants Association
Start Date	December 2020
End Date	April 2021
Results	Operator feedback on the electric forklift was generally positive. The overall performance received a rating of 3.5 out of 5. Charging-related aspects including ease of charging and battery life were rated 4 out of 5, though charging time itself scored lower at 2 out of 5. Operator comfort was rated 3.5 out of 5, while equipment-specific performance factors such as lifting speed, maneuverability, and responsiveness also averaged 3.5 out of 5.

[24] Sharon Cloward, et al. "San Diego Port Sustainable Freight Demonstration Project," California Energy Commission, Publication Number: CEC-600-2024-006, March 2024. *https://www.energy.ca.gov/sites/default/files/2024-03/CEC-600-2024-006.pdf* .

ID	Forklift-3 [Sources[25]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Forklift
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	TransPower (repower)
Product Name	[Staff is seeking information on this demonstration.]
Quantity	3
Project Description	The Multisource Green Omni Terminal Project at the Pasha Terminal at the Port of Los Angeles included the demonstration of three 21-ton diesel forklifts that were repowered by TransPower.
Location	United States, California, Port of Los Angeles, Pasha Terminal
Funding Source (Funding Name)	CARB (CCI/LCTI, Multisource Green Omni Terminal Project)
Fund Recipient	Port of Los Angeles
Start Date	June 2016
End Date	December 2021
Results	The forklifts went through several modifications and tests prior to use at the terminal. Due to safety concerns, the forklifts were taken out of service after thermal events occurred with similar repowers of yard trucks.

[25] California Air Resources, "LCTI: Multisource Green Omni Terminal Project," n.d. Accessed March 27, 2025. *https://ww2.arb.ca.gov/lcti-multisource-green-omni-terminal-project*.; Chris Cannon, "Multi-Source Green Omni Terminal Demonstration," The Port of Los Angeles, May 25, 2023. *https://kentico.portoflosangeles.org/getmedia/dadc6610-0a2c-4404-9211-e80f5cb4a4b4/Item-H3_Environmental_Pasha_Presentation*.

ID	Forklift-4 [Sources[26]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Forklift
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Wiggins
Product Name	Wiggins/Thor 36,0000-lb battery-electric forklift (Commercially available)
Quantity	18
Project Description	The Port of Stockton deployed 18 Wiggins and Thor 36,000-lb battery-electric forklifts to pursue zero-emissions and more efficient cargo handling equipment.
Location	United States, California, Port of Stockton, SSA Marine
Funding Source (Funding Name)	CARB (CCI/LCTI, START)
Fund Recipient	Port of Long Beach
Start Date	Winter 2019
End Date	Spring 2024
Results	The Port of Stockton received 8 of 12 heavy forklifts, while SSA Stockton received and commissioned all 6 of their heavy forklifts. The electric forklift fleet at Stockton is actively used to move pallets of rice and bundles of steel throughout the terminal.

[26] California Air Resources Board, "LCTI: Sustainable Terminals Accelerating Regional Transformation (START) Project Phase 1," n.d. Accessed February 26, 2025. *https://ww2.arb.ca.gov/lcti-sustainable-terminals-accelerating-regional-transformation-start-project-phase-1*.; Ghazal Razeghi, Micheal Mac Kinnon, and Scott Samuel, "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission- and Heavy-Duty Vehicles Operating at a Port Terminal, "California Energy Commission, 2023. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*.

ID	Forklift-5 [Source[27]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Forklift
Zero-Emission Technology	Battery-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Wiggins
Product Name	55,000-lb lift capacity Wiggins Yard eBull (Commercially available)
Quantity	6
Project Description	In 2024, the Tenth Avenue Marine Terminal at the Port of San Diego introduced one of the largest zero-emissions heavy-duty forklifts operating in the U.S. Five more battery-electric forklifts were delivered and commissioned in 2025.
Location	United States, California, Port of San Diego, Tenth Avenue Marine Terminal
Funding Source (Funding Name)	CARB (The Clean Off-Road Voucher Incentive Project, or CORE) and U.S. EPA (Clean Ports Initiative)
Fund Recipient	Port of San Diego
Start Date	March 2024
End Date	[Staff is seeking information on this pilot.]
Results	[Staff is seeking information on this pilot.]

[27] World Cargo News, "SSA Marine's electric forklift fleet in San Diego Reaches Five," February 27, 2025. Accessed 27, 2025. *https://www.worldcargonews.com/cargo-handling-equipment/2025/02/ssa-marines-electric-forklift-fleet-in-san-diego-reaches-five/*.

ID	Forklift-6 [Sources[28]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Forklift
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	[Staff is seeking information on this demonstration.]
Product Name	[Staff is seeking information on this demonstration.]
Quantity	8
Project Description	This project establishes a zero-emission goods movement system from the Ports of Long Beach and Los Angeles to four freight facilities in disadvantaged communities, deploying both pre-commercial and commercial zero-emission technologies. As part of the project, NFI Industries, Inc. added eight lithium battery powered forklifts to its Chino facility.
Location	United States, California, Ports of Long Beach and Los Angeles
Funding Source (Funding Name)	CARB (CCI/LCTI, Volvo Low Impact Green Heavy Transport Solutions (LIGHTS) Project)
Fund Recipient	South Coast Air Quality Management District
Start Date	February 2019
End Date	September 2022
Results	[Staff is seeking information on this demonstration.]

[28] California Air Resources Board, "LCTI: Volvo Low Impact Green Heavy Transport Solution (LIGHTS) Projects," n.d. Accessed March 27, 2025. *https://ww2.arb.ca.gov/lcti-volvo-low-impact-green-heavy-transport-solutions-lights-project.*; NFI," NFI Leads Logistics Industry in Sustainability as Early Adopter of Electric Vehicles," October 10, 2019. Accessed March 27, 2025. *https://www.nfiindustries.com/about-nfi/news/nfi-leads-logistics-industry-in-sustainability-as-early-adopter-of-electric-vehicles/*. NFI, "NFI's Ambitious Zero-Emission Commitment Leads the Industry in Sustainable Goods Movement," October 29, 2021. Accessed April 9, 2025. *https://www.nfiindustries.com/about-nfi/insights/zero-emission-goods-movement-commitment/*.

ID	Forklift-7 [Sources[29]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Forklift
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	[Staff is seeking information on this demonstration.]
Product Name	[Staff is seeking information on this demonstration.]
Quantity	20
Project Description	The Nagoya Port demonstrated 20 hydrogen fuel cell forklifts to support more sustainable operations at its terminals and logistics facilities. The hydrogen-powered forklifts operated across multiple terminal operators in Nagoya Port.
Location	Japan, Nagoya Port
Funding Source (Funding Name)	Suzuki Shokan
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	August 26, 2024
End Date	August 30, 2024

[29] Dom Magli, "Port of Nagoya introduces fuel-cell forklifts," Port Technology, January 3, 2025. Accessed March 27, 2025. *https://www.porttechnology.org/news/port-of-nagoya-introducesn-fuel-cell-forklifts/*; Fuel Cells Works, "Nagoya Port Advances Green Logistics with Hydrogen-Powered Forklifts," Fuel Cells Works, January 3, 2025. Accessed March 27, 2025. *https://fuelcellsworks.com/2025/01/03/green-hydrogen/nagoya-port-advances-green-logistics-with-hydrogen-powered-forklifts* ; WorldCargo News. "Hydrogen Refuelling at Nagoya ‣ WorldCargo News." WorldCargo News ‣ Leading Site for Cargo Handling Industry (blog), January 13, 2025. Accessed April 2, 2025. *https://www.worldcargonews.com/cargo-handling-equipment/2025/01/hydrogen-refuelling-at-nagoya/?form=MG0AV3&form=MG0AV3* ; "Hydrogen Refueling Trial at Nagoya Port - Container News." Container News, January 2, 2025. Accessed April 2, 2025. *https://container-news.com/hydrogen-refueling-trial-at-nagoya-port/* ; H2 Energy Group. "H2-View News: Nagoya Port Rolls Out Hydrogen-powered Forklifts for Terminal and Logistics Operations | H2 Energy Group." *H2 Energy Group | Affordable, Sustainable, and Renewable Hydrogen | Fuel for the Future* (blog), January 3, 2025. Accessed April 2, 2025. *https://h2eg.com/h2-view-news-nagoya-port-rolls-out-hydrogen-powered-forklifts-for-terminal-and-logistics-operations/*; H2 News. "Nagoya Port Implements Hydrogen Forklifts," January 7, 2025. Accessed April 2, 2025. *https://h2-news.com/nagoya-port-implements-hydrogen-forklifts/*

Results	During the five-day trial period, all vehicles were refueled with hydrogen while actively in operation, highlighting the practical viability of hydrogen fuel within high-demand logistic environments. The hydrogen forklifts demonstrated several operational efficiencies, notably the quick refueling times of about 3-5 minutes per vehicle.

Forklift, Telehandler

ID	Forklift, Telehandler-1 [Source[30]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Forklift, Telehandler
Zero-Emission Technology	Battery-electric
Project Type	Prototype
OEMs, Equipment, or Service Provider	Manitou (telehandler), DEUTZ (repower),
Product Name	Repowered MT 1135
Quantity	1
Project Description	DEUTZ has incorporated a prototype full-electric drive system into a Manitou telehandler. The full-electric Manitou MT 1135 telehandler is equipped with a 360-volt vehicle power supply, 60-kW electric motor, and a 30-kWh battery.
Location	France, Cologne (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	2018
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[30] DEUTZ, "DEUTZ embarks on electrification of construction equipment with Manitou Group," September 20, 2018. Accessed June 10, 2025. *https://www.deutz.com/en/news/press-releases/news-detail/deutz-embarks-on-electrification-of-construction-equipment-with-manitou-group/*.

ID	Forklift, Telehandler-2 [Sources[31]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Forklift
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Prototype
OEMs, Equipment, or Service Provider	Manitou Group
Product Name	[Staff is seeking information on this prototype.]
Quantity	1
Project Description	In 2022, Manitou introduced its first hydrogen fuel-cell telehandler prototype and plans to launch a 100% hydrogen model by 2026. The design is based on a diesel version with a 46-foot lift height. Manitou is using their hydrogen-powered prototypes to compare against electric versions to gauge their ranges.
Location	France (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	2022
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[31] Don McLoud, "Manitou Reveals its First Hydrogen Telehandler Prototype," Equipment World, December 12, 2022. Accessed March 27, 2025. *https://www.equipmentworld.com/aeriallifting-equipment/telehandlers/article/15304222/manitou-unveils-its-first-hydrogen-telehandler-prototype*; Jeff Pao, "Aerial Lift Makers Adopt Hydrogen Power Sources." Power Progress, January 11, 2025. *https://www.powerprogress.com/news/aerial-lift-makers-adopt-hydrogen-power-sources/8049754.article*.

Haul Truck

ID	Haul Truck-1 [Source[32]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Haul Truck
Zero-Emission Technology	Battery-electric
Project Type	Prototype
OEMs, Equipment, or Service Provider	Komatsu (haul truck), Kuhn (repower)
Product Name	Repowered HD 605-7
Quantity	1
Project Description	Kuhn repowered a Komatsu haul truck to use a 600-kwh battery pack. The haul truck is also equipped with regenerative breaking. Switching to batteries is expected to save approximately 50,000 metric tons of diesel annually. At the time of the prototype announcement, this haul truck was the largest electric vehicle in the world.
Location	Switzerland (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	2019
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[32] Top Gear, "All hail the eDumper, the largest EV in the world," August 28, 2019. Accessed June 16, 2025. *https://www.topgear.com/car-news/electric/all-hail-edumper-largest-ev-world*.

ID	Haul Truck-2 [Source[33]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Haul Truck
Zero-Emission Technology	Battery-electric
Project Type	Prototype
OEMs, Equipment, or Service Provider	Liebherr
Product Name	T 264
Quantity	1
Project Description	Liebherr and Fortescue unveiled a battery-electric T 264 haul truck at MINExpo in Las Vegas. Featuring a 3.2 MWh battery from Fortescue Zero, the truck supports fast charging via a 6 MW system, enabling recharges in 12 to 58 minutes. Equipped with a solution for optimized energy management, the truck will begin onsite validation in late 2025.
Location	United States, Las Vegas (MINExpo)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	September 2024
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[33] Staff Canadian Mining Journal, "Liebherr Reveals Zero Emissions, Autonomous T 264 Haul Truck," MINING.COM, October 18, 2024. Accessed April 2, 2025. *https://www.mining.com/liebherr-reveals-zero-emissions-autonomous-t-264-haul-truck/*.

ID	Haul Truck-3 [Sources[34]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Haul Truck
Zero-Emission Technology	Battery-electric
Project Type	Product launch
OEMs, Equipment, or Service Provider	NHL
Product Name	TR50E
Quantity	N/A
Project Description	NHL has completed the development of battery-electric haul trucks capable of carrying up to 50 tons. These trucks can be powered by fixed-charging or battery-swapping stations. According to NHL, if the trucks charge at the charging station at night and one hour between shifts, they can meet "the requirements of the site."
Location	China (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	2022
End Date	N/A
Results	[Staff is seeking information on this product launch.]

[34] International Mining, "Chinese Mining Truck Leader NHL to Produce Hydrogen Fuel Cell-lithium Battery FCEV 136 T Model by End-2022," August 26, 2022. Accessed June 16, 2025. *https://im-mining.com/2022/08/26/chinese-mining-truck-leader-nhl-to-produce-hydrogen-fuel-cell-lithium-battery-fcev-136-t-model-by-end-2022*.

ID	Haul Truck-4 [Source[35]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Haul Truck
Zero-Emission Technology	Battery-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Sany
Product Name	SKT90E (Commercially available)
Quantity	2
Project Description	Şatır Mining operated two Sany SKT90E electric haul trucks at a lime quarry in Turkey.
Location	Turkey, Izmir lime quarry (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	[Staff is seeking information on this pilot.]
End Date	[Staff is seeking information on this pilot.]
Results	Şatır Mining reports the following after operating the trucks for eight months: • The trucks eliminate fuel consumption and utilize regenerative braking on slopes significantly reducing operational costs. • The trucks required minimal maintenance, with negligible expenses for parts like brake pads and longer intervals between servicing compared to diesel vehicles. • The trucks recoup their costs within approximately 18 months due to savings on electricity and reduced maintenance needs.

[35] Sany Türkiye, "Sany SKT90E %100 Elektrikli Damperli Kaya Kamyonu," YouTube video, published on January 19, 2024, 4:24. Accessed April 22, 2025. *https://youtu.be/4UUwdCbNYRA?si=aUlqTb3SoHBmjGoO*.

	• Kimtaş, the mine operator, is planning on replacing 14 diesel trucks with six electric ones and foresees wider adoption of these vehicles across other quarries.

ID	Haul Truck-5 [Source[36]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Haul Truck
Zero-Emission Technology	Battery-electric
Project Type	Product launch
OEMs, Equipment, or Service Provider	Terra EV
Product Name	The Boss
Quantity	N/A
Project Description	Terra EV, a Canadian company, is developing electric vocational trucks for mining and quarry sites, aiming to provide smaller, 24-hour operational units without diesel consumption or significant emissions. The Boss model, based on the Western Star 4900XD platform, will be a 22-ton truck with two versions: the 310, a straight truck that can be equipped with a dump box, water tank, crane, or service body, or the 466, a tractor configuration with a fifth-wheel. Terra EV claims the load capacity of the 466 model is up to 120 tons.
Location	Canada (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	[Staff is seeking information on this prototype.]
End Date	N/A
Results	[Staff is seeking information on this prototype.]

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[36] Lee Top, "Terra EV Vocational Solution Cuts Carbon in Hauling Applications," Heavy Equipment Guide, March 21, 2022. Accessed April 2, 2025. *https://www.heavyequipmentguide.ca/article/38315/terra-ev-vocational-solution-cuts-carbon-in-hauling-applications*.

ID	Haul Truck-6 [Source[37]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Haul Truck
Zero-Emission Technology	Battery-electric
Project Type	Product launch
OEMs, Equipment, or Service Provider	Terra EV
Product Name	The Master
Quantity	N/A
Project Description	Terra EV, a Canadian company, is developing electric vocational trucks for mining and quarry sites, aiming to provide smaller, 24-hour operational units without diesel consumption or significant emissions. The Master model, based on the Western Star 6900XD platform, will be available in two configurations, a straight truck or tractor, with load capacities of 36 and up to 180 tons respectively.
Location	Canada (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	[Staff is seeking information on this prototype.]
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[37] Ibid.

ID	Haul Truck-7 [Source[38]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Haul Truck
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	First Mode (a Cummins Company)
Product Name	[Staff is seeking information on this demonstration.]
Quantity	1
Project Description	First Mode, in collaboration with Anglo American, repowered a haul truck to use hydrogen fuel cell technology. In 2023, the demonstration unit completed year-long testing at a mine site in South Africa.
Location	South Africa, Mogalakwena mine site (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	Anglo American
Fund Recipient	First Mode
Start Date	May 2022
End Date	May 2023
Results	During its year of operation, the hydrogen fuel cell haul truck achieved key milestones: • The first-ever vehicle of its size powered by hydrogen fuel cells and batteries. • Logged 1,245 hours with a peak output of two megawatts. • Successfully commissioned, operator-trained, and deployed alongside diesel trucks for ore and waste haulage.

[38] Fuel Cells Works, "World's Largest Fuel Cell Electric Vehicle Completes Successful Year of Trials | Fuel Cells Works," May 17, 2023. Accessed April 2, 2025. *https://fuelcellsworks.com/news/worlds-largest-fuel-cell-electric-vehicle-completes-successful-year-of-trials*.

	• Matched diesel truck performance, hauling 300 tons over typical mining routes, including 10% grade climbs and 11-kilometer pit runs. • Collected six terabytes of data to enhance performance, reliability, and inform future designs. • The trial demonstrated the viability of zero-emission haulage, with the truck operating at full capacity (300 tons) during pit runs while matching the performance of its diesel counterparts. Its efficiency allowed for high operational speeds without compromising power output, showcasing the potential of hydrogen technology in heavy-duty mining operations.

ID	Haul Truck-8 [Sources[39]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Haul Truck
Zero-Emission Technology	Hydrogen fuel cell/Battery-electric
Project Type	Prototype
OEMs, Equipment, or Service Provider	NHL
Product Name	NTH150
Quantity	1
Project Description	NHL is developing a fuel cell and lithium battery powered haul truck. The NTH150 haul truck will be able to carry a load of 150 tons. NHL plans to establish a comprehensive demonstration mine. The project will include the haul truck plus hydrogen storage.
Location	China (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	2022
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[39] International Mining, "Chinese mining truck leader NHL to produce hydrogen fuel cell-lithium battery FCEV 136 t model by end-2022," August 26, 2022. Accessed June 16, 2025. *https://im-mining.com/2022/08/26/chinese-mining-truck-leader-nhl-to-produce-hydrogen-fuel-cell-lithium-battery-fcev-136-t-model-by-end-2022/*.

ID	Haul Truck-9 [Source[40]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Haul Truck/Articulated Haul Truck
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Prototype
OEMs, Equipment, or Service Provider	Volvo
Product Name	HX04
Quantity	1
Project Description	Volvo is testing the hydrogen fuel cell haul truck at a test track in Braas, Sweden. Hydrogen refueling infrastructure is still in development. The Volvo HX04 can operate for approximately four hours on 12 kg of hydrogen.
Location	Sweden, Braas (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	2022
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[40] Volvo Construction Equipment, "Volvo CE Starts Testing of the World's First Prototype Hydrogen Articulated Hauler," June 13, 2022. Accessed June 16, 2025. *https://www.volvoce.com/global/en/news-and-events/news-and-stories/2022/volvo-ce-starts-testing-of-the-worlds-first-prototype-hydrogen-articulated-hauler/*.

ID	Haul Truck-10 [Sources[41]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Haul Truck
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Prototype
OEMs, Equipment, or Service Provider	Weichai Power
Product Name	[Staff is seeking information on this prototype.]
Quantity	1
Project Description	Weichai Power developed a hydrogen fuel cell haul truck capable of carrying 290 tons. The truck has a 1,100-kW motor and uses a lithium battery pack to store energy. Weichai Power projects the vehicle to save approximately 20 tons of diesel fuel per day.
Location	China (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	2020
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[41] International Mining, "China's Weichai Power and CRRC Yongji Complete Hydrogen-lithium Battery Hybrid 200 Ton Mining Truck," May 8, 2020. Accessed June 16, 2025. *https://im-mining.com/2020/05/08/chinas-weichai-power-crrc-yongji-complete-hydrogen-lithium-battery-hybrid-200-ton-mining-truck/*.

Loader or Loader-Excavator

ID	Loader-1 [Source[42]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Loader/Wheeled Loader
Zero-Emission Technology	Battery-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Caterpillar
Product Name	950 GC
Quantity	1
Project Description	Nouveau Monde Graphite Inc. operated a battery-electric loader at the Matawinie Mine and Bécancour Battery Material Plant. The loader has a 256-kWh battery and an expected run time of up to 8 hours with a mid-shift 45-minute charge. The battery can be charged by either a 22-kW AC, or a 290-kW DC charger.
Location	Canada, Quebec (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	[Staff is seeking information on this pilot.]
Fund Recipient	[Staff is seeking information on this pilot.]
Start Date	[Staff is seeking information on this pilot.]
End Date	[Staff is seeking information on this pilot.]
Results	[Staff is seeking information on this pilot.]

[42] International Mining, "Caterpillar zero emissions fleet at NMG to start with pilot battery electric 950 GC wheel loader," October 6, 2023. Accessed June 10, 2025. *https://im-mining.com/2023/10/06/caterpillar-zero-emissions-fleet-at-nmg-to-start-with-pilot-battery-electric-950-gc-wheel-loader/*; Caterpillar, "Designing Solutions that Help Build a Better, More Sustainable World," n.d. Accessed June 10, 2025. *https://www.cat.com/en_US/by-industry/construction/electric-products.html*.

ID	Loader-2 [Source[43]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material CHE/Loader/Wheeled Loader
Zero-Emission Technology	Battery-electric
Project Type	Product launch
OEMs, Equipment, or Service Provider	Danfoss Editron
Product Name	[Staff is seeking information on this product launch.]
Quantity	N/A
Project Description	Danfoss Editron has developed a fully electric wheel loader. The electric system uses 650V batteries. The batteries supply DC voltage, which is then inverted to AC to control the traction motor.
Location	[Staff is seeking information on this product launch.]
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	2020
End Date	N/A
Results	[Staff is seeking information on this product launch.]

[43] Danfoss, "Danfoss Editron boosts its product portfolio by developing a fully-electric wheel loader system," December 4, 2020. Accessed June 17, 2025. *https://www.danfoss.com/en-us/about-danfoss/news/dps/danfoss-editron-boosts-its-product-portfolio-by-developing-a-fully-electric-wheel-loader-system/*.

ID	Loader-3 [Sources[44]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material/Loader/Wheeled Loader
Zero-Emission Technology	Battery-electric
Project Type	Prototype
OEMs, Equipment, or Service Provider	John Deere
Product Name	310 X-Tier E-Power
Quantity	[Staff is seeking information on this prototype.]
Project Description	At the 2023 CONEXPO-CON/AGG, John Deere introduced the second-generation 310 X-Tier E-Power electric loader-excavator prototype, which features a larger battery. The E-Power technology provides lower daily operating costs, lower jobsite noise, and zero tailpipe emissions.
Location	United States, Nevada, Las Vegas (CONEXPO-CON/AGG)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	2023
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[44] John Deere, "310 X-Tier E-Power Backhoe Walkaround | John Deere Construction," YouTube video, published on April 15, 2023, 2:10. Accessed April 17, 2025. *https://www.youtube.com/watch?v=DmSAMoqFoVg*; "John Deere Expands Options by Introducing New E-Drive and E-Power Machines at CONEXPO-CON/AGG 2023." February 28, 2023. Accessed April 17, 2025. *https://www.deere.com/en/news/all-news/deere-expands-options-with-new-e-drive-and-e-power-machines/*;

ID	Loader-4 [Source[45]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material/Loader/Wheeled Loader
Zero-Emission Technology	Battery-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	SDLG (Volvo)
Product Name	L956HEV (Commercially available)
Quantity	4
Project Description	The Deendayal Port, Kandla, has introduced four SDLG L956HEV electric loaders, supporting the Government of India's Harit Sagar Green Port Guidelines. The guidelines emphasize sustainable, eco-friendly, and energy-efficient port operations. The deployment of the four electric loaders will result in an estimated reduction of 560 tonnes of carbon emissions in a year.
Location	India, Deendayal Port, Kandla
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	February 2025
End Date	[Staff is seeking information on this pilot.]
Results	[Staff is seeking information on this pilot.]

[45] India Shipping News, "Union Budget 2025: DPA Kandla Deploys Electric Wheel Loaders Towards Greener Port Operations," February 4, 2025. Accessed March 17, 2025, *https://indiashippingnews.com/union-budget-2025-dpa-kandla-deploys-electric-wheel-loaders-towards-greener-port-operations/*.

ID	Loader-5 [Sources[46]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material/Loader/Wheeled Loader
Zero-Emission Technology	Hydrogen fuel cell or Battery-electric
Project Type	Prototype
OEMs, Equipment, or Service Provider	HD Hyundai Infracore/Develon
Product Name	DL250 FCEV
Quantity	1
Project Description	HD Hyundai Infracore showcased the Develon DL250 FCEV, a hydrogen fuel cell wheel loader prototype, at Intermat 2024. The hydrogen fuel cell loader can switch between hydrogen fuel cell and battery-electric power sources, offering flexibility in zero-emission operations. The loader maintains over 8 hours of operation on a full charge.
Location	Paris, France (Intermat)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	2024
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[46] Develon, "Prototype Wheel Loader Switched from Fuel Cell to Battery Power," Lectura Press, May 10, 2024. Accessed February 27, 2025. *https://lectura.press/en/article/prototype-wheel-loader-switches-from-fuel-cell-to-battery-power/63326*.; Kang Hyeong-woo, "HD Hyundai Infracore Zeroes in on European Market," The Korean Herald, April 22, 2025. Accessed March 24, 2025. *https://www.koreaherald.com/article/3374229*.

ID	Loader-6 [Sources[47]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material/Loader/Wheeled Loader
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Prototype
OEMs, Equipment, or Service Provider	Nuvera (hydrogen fuel cell), Unknown CHE provider [Staff is seeking information on this prototype.]
Product Name	[Staff is seeking information on this prototype.]
Quantity	1
Project Description	Nuvera Fuel Cells provides power for a heavy-duty wheel loader designed for construction sites. This zero-emission loader operates using a Nuvera E-Series fuel cell engine, enabling sustainable performance.
Location	[Staff is seeking information on this prototype.]
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	2023
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[47] Nuvera Fuel Cells, "Off-Road Applications," n.d. Accessed March 24, 2025. *https://www.nuvera.com/markets/off-road-applications-2/*; Nuvera Fuel Cells, "Hydrogen Fuel Cell-Powered Wheel Loader," YouTube video, published on October 10, 2023, 1:02. Accessed March 27, 2025. *https://www.youtube.com/watch?v=MeYv-6SCytw*.

ID	Loader-7 [Source[48]]
CHE Category/Type/ Subcategory (if applicable)	Bulk Material/Loader/Wheeled Loader
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Pilot
OEMs, Equipment, or Service Provider	XCMG
Product Name	XC968-FCEV (Commercially available)
Quantity	1
Project Description	XCMG launched the XC968-FCEV in collaboration with a Shanxi mining enterprise.
Location	China, Shanxi (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	June 2023
End Date	[Staff is seeking information on this pilot]
Results	The loader has been used extensively in coal yard operations, accumulating over 1,000 hours of use without any breakdowns. Its performance has exceeded expectations, showcasing stable and efficient operation while achieving zero-emissions.

[48]Mark, "World's First! XCMG 6-ton Hydrogen-powered Loader Operated in Shanxi," China Special Vehicle Advisor, June 26, 2023. Accessed August 29, 2024.*https://m.chinaspv.com/news/5549.html*.

Log Stacker

Staff is seeking information on demonstrations, pilots, product launches, and prototypes using zero-emission log stackers for cargo handling.

Container CHE Demonstrations, Pilots, Product Launches, and Prototypes

AGV

Staff is seeking information on demonstrations, pilots, product launches, and prototypes using zero-emission AGVs for cargo handling.

Rail-Mounted Gantry Crane

Staff is seeking information on demonstrations, pilots, product launches, and prototypes using zero-emission rail-mounted gantry cranes for cargo handling.

Reach Stacker

ID	Reach Stacker-1 [Source[49]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Reach Stacker
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Kalmar/Cargotech
Product Name	ERG Series (Commercially available)
Quantity	1
Project Description	Kalmar has delivered its first fully electric reach stacker to the Cabooter Group after a six-month testing period, marking a significant step in sustainable cargo handling operations. The reach stacker is deployed at the Greenport Venlo terminal in the Netherlands.
Location	Netherlands, Greenport Venlo Intermodal Terminal
Funding Source (Funding Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	Cabooter Group
Start Date	[Staff is seeking information on this demonstration.]
End Date	May 2023
Results	[Staff is seeking information on this demonstration.]

[49] Cargotec, "Kalmar Hands Over Its First Fully Electric Reachstacker to Cabooter Group," May 17, 2023. Accessed March 27, 2025. *https://www.cargotec.com/en/nasdaq/trade-press-release-kalmar/2023/kalmar-hands-over-its-first-fully-electric-reachstacker-to-cabooter-group/*.

ID	Reach Stacker-2 [Source[50]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Reach Stacker
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Mi-Jack (reach stacker), TransPower (repower)
Product Name	[Staff is seeking information on this demonstration.]
Quantity	1
Project Description	Demonstration of an electric Mi-Jack reach stacker retrofitted with lithium-ion battery technology designed to increase operating range.
Location	[Staff is seeking information on this demonstration.]
Funding Source (Funding Name)	CEC-Clean Transportation Program (Advanced Battery-Electric Port Vehicles)
Fund Recipient	TransPower
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]
Results	The reach stacker never entered operation due to the failure of its selected battery technology to work reliably.

[50] James Burns and Micheal Simon, "Advanced Battery-Electric Port Vehicles," Transportation Power Inc. California Energy Commission, Publication Number: CEC-600-2021-035, June 2021. *https://www.energy.ca.gov/sites/default/files/2021-06/CEC-600-2021-035.pdf*.

ID	Reach Stacker-3 [Sources[51]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Reach Stacker
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Hyster-Yale (reach stacker), Nuvera (hydrogen fuel cell)
Product Name	[Staff is seeking information on this demonstration.]
Quantity	1

[51] Hyster, "Hyster Begins First-Ever Real-World Pilot of Hydrogen Fuel Cell-Powered Container Handler at CMA CGM-Owned Fenix Marine Terminal in the Port of Los Angeles," Last modified October 11, 2022. Accessed March 24, 2025. *https://www.hyster.com/en-us/north-america/why-hyster/press-releases/2022/hyster-begins-first-ever-real-world-pilot-of-hydrogen-fuel-cell-powered-container-handler-at-cma-cgm-owned-fenix-marine-terminal-in-the-port-of-los-angeles/*; Hyster, "Hyster Ships Hydrogen Fuel Cell Reachstacker to the Port of Valencia," Last modified August 2023. Accessed March 24, 2025. *https://www.hyster.com/en-gb/emea/why-hyster/press-releases/hyster-ships-hydrogen-fuel-cell-reachstacker-to-the-port-of-valencia/*.; Nuvera Fuel Cells, "Nuvera Powers Fuel Cell Shipping Container Handler at the Port of Los Angeles," Last modified November 8, 2022. Accessed March 24, 2025. *https://www.nuvera.com/press-release/nuvera-powers-fuel-cell-shipping-container-handler-at-the-port-of-los-angeles/*.; H2 Ports, "Reach Stacker," Last modified November 28, 2023. Accessed March 24, 2025. *https://h2ports.eu/pilots/#1560789545736-55d48879-d8e2*.; Valencia Port, "Reach Stacker within the Framework of the H2Ports Project Is in Full Development at Hyster," Last modified April 23, 2021. Accessed March 24, 2025. *https://www.valenciaport.com/en/the-hydrogen-reach-stacker-within-the-framework-of-the-h2ports-project-is-in-full-development-at-hyster/*.; Sustainable World Ports, "Port of Valencia-H2Ports/ Fuel Cells and Hydrogen in Ports," 2019. Accessed March 28, 2025. *https://sustainableworldports.org/project/port-of-valencia-h2ports*.; AJOT, "Hyster to Provide CARU Containers B.V. with Electric Empty Container Handler," Last modified May 10, 2023. Accessed March 24, 2025. *https://www.ajot.com/news/hyster-to-provide-caru-containers-b.v-with-electric-empty-container-handler.;H2Ports*, "The H2Ports Hydrogen Project Carries Out a Public Demonstration of Its Pilots in the Port of Valencia." Last modified November 28, 2023. Accessed March 24, 2025. *https://h2ports.eu/the-h2ports-hydrogen-project-carries-out-a-public-demonstration-of-its-pilots-in-the-port-of-valencia/*.

Project Description	Hyster-Yale developed and shipped a hydrogen fuel cell reach stacker for use at the Port of Valencia, Spain. The reach stacker uses Nuvera fuel cells to convert hydrogen to electricity, charging on-board batteries that power the electric motors and hydraulic systems. The reach stacker is expected to support continuous operations while providing zero emissions and achieving comparable full shift performance to a conventional reach stacker powered with a diesel engine. It is also expected that maintenance costs will be reduced thanks to the removal of the engine, transmission and other mechanical-driven components.
Location	Spain, Port of Valencia, MSC Terminal Valencia (MSCTV)
Funding Source (Funding Name)	H2Ports
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

Rubber-Tired Gantry Crane

Project Identifier	RTG-1 [Sources[52]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/RTG
Zero-Emission Technology	Grid-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	ZPMC (RTG) and Cavotec (repower)
Product Name	[Staff is seeking information on this demonstration.]
Quantity	9
Project Description	This project converted nine ZPMC RTGs to grid-electric technology to reduce emissions and improve efficiency. The retrofits included adding components, such as a cable reel system, guidance system, and battery container for off-grid functionality.
Location	United States, California, Port of Long Beach, SSA Marine
Funding Source (Funding Project Name)	CARB (CCI/LCTI, START), CEC (Port of Long Beach (POLB) Zero Emission Terminal Equipment Transition Project)
Fund Recipient	Port of Long Beach
Start Date	November 2020[53]

[52] AJOT, "Fleet of electric cranes operating at Port of Long Beach Terminal," AJOT, October 20, 2022. Accessed February 20, 2025.*https://www.ajot.com/news/fleet-of-electric-cranes-operating-at-port-of-long-beach-terminal.*; Energetics Incorporated, et al." Final Evaluation Report," California Public Utilities Commission, April 2021. *https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/california-te-prp-final-evaluation-report-presentation.pdf.*; California Air Resources Board, "LCTI: Sustainable Terminals Accelerating Regional Transformation (START) Project Phase 1," n.d. Accessed February 26, 2025. *https://ww2.arb.ca.gov/lcti-sustainable-terminals-accelerating-regional-transformation-start-project-phase-1.*; Rose Szoke and Morgan Caswell, "Port of Long Beach Zero-Emission Terminal Equipment Transition Project, "California Energy Commission, April 2024. *https://www.energy.ca.gov/sites/default/files/2024-04/CEC-600-2024-042.pdf.*; Ghazal Razeghi, Micheal Mac Kinnon, and Scott Samuel, "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission- and Heavy-Duty Vehicles Operating at a Port Terminal, "California Energy Commission, 2023. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf.*

[53] On April 4, 2018, the Port of Long Beach held a media event at the SSA Terminal to announce the project's launch.

End Date	October 2022[54]
Results	The 22-month conversion of nine RTG cranes concluded with testing of the first eRTG in May 2020 and implementation of the final guidance system by November 2020. The cranes are grid-powered during operations but can utilize a battery pack for mobility or maintenance, and they have been performing efficiently at the SSA terminal at the Port of Long Beach.

[54] On October 20, 2022, the American Journal of Transportation reported that the nine cranes are in operation.

Project Identifier	RTG-2 [Sources[55]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/RTG
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Mi-Jack (RTG), US Hybrid (repower)
Product Name	[Staff is seeking information on this demonstration]
Quantity	1
Project Description	Mi-Jack and US Hybrid are converting an RTG crane from diesel to hydrogen power. The hydrogen system includes fuel cells from Hyundai.
Location	[Staff is seeking information on this demonstration.]
Funding Source (Funding Project Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	2023
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[55] Marine Log Staff, "Mi-Jack to Convert RTG Crane to Hydrogen Powered," Marine Log, March 6, 2023. Accessed February 27, 2025. *https://www.marinelog.com/inland-coastal/ports-terminals/mi-jack-to-convert-rtg-crane-to-hydrogen-powered/.*; Niamh Marriot, "Mi-Jack Develops Hydrogen-Powered Gantry Crane," Crane & Transport Briefing, Last modified March 29, 2023. Accessed March 24, 2025. *https://www.cranebriefing.com/news/mi-jack-develops-hydrogen-powered-gantry-crane/8027836.article?zephr_sso_ott=RmxnvH*.

Project Identifier	RTG-3 [Sources[56]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/RTG
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	PACECO Corp.
Product Name	H2-ZE RTG Transtainer Crane
Quantity	1
Project Description	Yusen Terminal at the Port of Los Angeles announced the four-year demonstration of a first-of-its-kind hydrogen fuel cell RTG crane. The RTG crane was developed by PACECO in collaboration with Mitsui E&S.
Location	United States, California, Port of Long Beach, Yusen Terminal
Funding Source (Funding Project Name)	New Energy and Industrial Technology Development Organization
Fund Recipient	Mitsui E&S, PACECO Corp., Toyota Tsusho
Start Date	2024
End Date	2028

[56] Yusen Terminals, "Yusen Terminals Launches World's First Hydrogen Fuel Cell RTG Program," Last modified May 15, 2024. Accessed March 24, 2025. *https://yti.com/2024/05/yusen-terminals-launches-worlds-first-hydrogen-fuel-cell-rtg-program/*.; WorldCargo News, "Refuelling Hydrogen RTG in LA," Last modified October 14, 2024. Accessed March 24, 2025. *https://www.worldcargonews.com/cargo-handling-equipment/2024/10/refuelling-hydrogen-rtg-in-la/*.; Rebecca Moore, "Debut of World's First Hydrogen Fuel Cell RTG Crane at Los Angeles Port," Riviera, Last modified May 21, 2024. Accessed March 24, 2025. *https://www.rivieramm.com/news-content-hub/news-content-hub/debut-of-worlds-first-hydrogen-fuel-cell-rtg-crane-at-los-angeles-port-80850*.; WorldCargo News, "Hydrogen-Powered Transtainer Starts Operations in LA," May 15, 2024. Accessed April 8, 2025. *https://www.worldcargonews.com/news/2024/05/hydrogen-powered-transtainer-starts-operations-in-la/*.; Word Cargo News, "Refuelling Hydrogen RTG in LA," October 14, 2024. Accessed April 8, 2025. *https://www.worldcargonews.com/cargo-handling-equipment/2024/10/refuelling-hydrogen-rtg-in-la/*.

Results	The crane has successfully integrated into terminal operations, demonstrating its ability to reduce emissions and noise pollution while maintaining efficiency. The crane operates entirely on hydrogen fuel cell technology and provides reliable performance. Initial tests confirm that the hydrogen-powered RTG crane's performance is comparable to conventional diesel-powered cranes.

Project Identifier	RTG-4 [Sources[57]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/RTG
Zero-Emission Technology	Hydrogen fuel cell/ Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	TYCROP/H2 Portable
Product Name	[Staff is seeking information on this demonstration.]
Quantity	1
Project Description	The Port of Vancouver converted a rubber-tired gantry crane to run on hydrogen using TYCROP's dual fuel system and Loop Energy's fuel cells. The project aims to decarbonize port operations and reduce emissions.
Location	Canada, Vancouver
Funding Source (Funding Project Name)	Vancouver Fraser Port Authority and the Province of British Columbia (Low-Emission Technology Initiative)
Fund Recipient	TYCROP/H2 Portable
Start Date	2024
End Date	[Staff is seeking information on this demonstration.]
Results	The crane has been successfully integrated into terminal operations, demonstrating its ability to reduce emissions and noise pollution while maintaining efficiency.

[57] Maritime logistics Professional, "Vancouver Crane Powered by Fuel Cell," Last modified September 18, 2023. Accessed March 24, 2025. *https://www.maritimeprofessional.com/news/vancouver-crane-powered-fuel-cell-387943*.; The Maritime Executive "World's Hydrogen Fuel Cell-Powered Rubber-Tyred Gantry to Use Corvus ESS," Published September 17, 2023. Accessed March 27, 2025. *https://maritime-executive.com/corporate/dp-world-s-hydrogen-fuel-cell-powered-rubber-tyred-gantry-to-use-corvus-ess*.

Project Identifier	RTG-5 [Source[58]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/RTG
Zero-Emission Technology	Hydrogen fuel cell/Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	ZPMC
Product Name	[Staff is seeking information on this demonstration.]
Quantity	1
Project Description	ZPMC has developed and launched their first hydrogen fuel cell-powered RTG crane that is estimated to reduce 300 tons of CO2 emissions per year.
Location	China [Staff is seeking information on this demonstration.]
Funding Source (Funding Project Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	[Staff is seeking information on this demonstration.]
Demo Start Date	2021
Demo End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[58] ZPMC, "We Are Proud to Announce That Our Independently Developed Hydrogen Fuel Cell-Powered Mobile Crane Is Now Operational," Facebook, Last modified December 2, 2021. Accessed March 24, 2025. *https://www.facebook.com/ZPMCglobal/posts/we-are-proud-to-announce-that-our-independently-developed-hydrogen-fuel-cell-pow/419912566498808/*.

Ship-to-Shore Crane

Staff is seeking information on demonstrations, pilots, product launches, and prototypes of zero-emission ship-to-shore cranes.

Shuttle and Straddle Carrier

ID	Shuttle and Straddle Carrier-1 [Source[59]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Shuttle and Straddle Carrier/Straddle Carrier
Zero-Emission Technology	Battery-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Kalmar
Product Name	Electric AutoStrads™ (Commercially available)
Quantity	2
Project Description	Deployment of two new Kalmar electric AutoStrads™ at APM Terminals Pier 400 at the Port Los Angeles. The project also involves retrofitting two existing hybrid straddle carriers to fully electric ones. The initiative is part of APM Terminals' $60 million electrification pilot, aiming to decarbonize supply chains and achieve net-zero emissions at the terminal by 2030. The electric straddle carriers will feature high-power batteries with quick charging capabilities, supported by Kalmar FastCharge™ stations.
Location	United States, California, Port of Los Angeles, APM Terminals Pier 400
Funding Source (Funding Name)	APM Terminals Electrification Pilot
Fund Recipient	N/A
Start Date	2024
End Date	[Staff is seeking information on this pilot.]
Results	[Staff is seeking information on this pilot.]

[59] Cargotec Corporation, "Kalmar and APM Terminals Join Forces for Straddle Carrier Electrification Pilot at Pier 400 Terminal in Los Angeles," Kalmar Global, March 5, 2024. Accessed April 14, 2025. *https://www.kalmarglobal.com/news--insights/press_releases/2024/kalmar-and-apm-terminals-join*.

Side Handler

Project Identifier	Side Handler-1 [Source[60]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Side Handler
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Hyster-Yale
Product Name	Electric equivalent to the Hyster H10XD-ECD8
Quantity	1
Project Description	Hyster-Yale plans on demonstrating a battery-electric empty container handler at the Port of Rotterdam. The handler will be used at the CARU depot and is expected to operate for approximately 2,000 hours per year.
Location	Netherlands, Port of Rotterdam, CARU Depot
Funding Source (Funding Project Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[60] AJOT, "Hyster to Provide CARU Containers B.V. with Electric Empty Container Handler," Last modified May 10, 2023. Accessed March 24, 2025. *https://www.ajot.com/news/hyster-to-provide-caru-containers-b.v-with-electric-empty-container-handler*.

Project Identifier	Side Handler-2 [Source[61]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Side Handler
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Taylor Machine Works
Product Name	ZLC-974 (Commercially available)
Quantity	1
Project Description	Demonstration of a Taylor electric side handler with a 922-kW-hour capacity battery pack at BNSF San Bernardino Intermodal Railyard.
Location	United States, California, San Bernardino, BNSF Intermodal Railyard
Funding Source (Funding Project Name)	CARB (LCTI/ZANZEFF, Flexible Solutions for Freight Facilities - San Joaquin Valley Zero and Near-Zero Emission Enabling Freight Project)
Fund Recipient	San Joaquin Valley Air Pollution Control District
Start Date	March 2019
End Date	Fall 2021
Results	A single charge could perform approximately 288 lifts over 25 hours of continuous operation. The typical daily use was observed to be 3.8 hours. A charge once a day or night was sufficient to keep the battery charged. The electric side handler needed to be brought back to the charging station once per day. The side handler required up to 5 hours to fully recharge, but typically required less time. Data showed that the performance of the electric side handler was equivalent to its diesel counterpart.

[61] California Air Resources Board, "LCTI: Flexible Solutions for Freight Facilities – San Joaquin Valley Zero and Near-Zero Emission Enabling Freight Project," Last modified August 15, 2021. Accessed March 24, 2025. *https://ww2.arb.ca.gov/lcti-flexible-solutions-freight-facilities-san-joaquin-valley-zero-and-near-zero-emission-enabling*

Project Identifier	Side Handler-3 [Sources[62]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Side Handler
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Hyster-Yale, Nuvera
Product Name	Electric H10XD-ECD8
Quantity	1
Project Description	Demonstration of a Nuvera powered hydrogen fuel cell container handler combining two E-45 fuel cell engines with a lithium-ion battery to achieve zero-emissions and eight to ten hours of continuous operation.
Location	United States, California, Port of Los Angeles
Funding Source (Funding Project Name)	"Clean Port and Logistic" program/HHLA's H2LOAD project
Fund Recipient	HHLA
Start Date	2023
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[62] Nuvera Fuel Cells, "Nuvera Powers Fuel Cell Shipping Container Handler at the Port of Los Angeles," November 8, 2022. Accessed March 24, 2025. *https://www.nuvera.com/press-release/nuvera-powers-fuel-cell-shipping-container-handler-at-the-port-of-los-angeles/*.; Hyster, "Hyster Begins First-Ever Real-World Pilot of Hydrogen Fuel Cell-Powered Container Handler at CMA CGM-Owned Fenix Marine Terminal in the Port of Los Angeles," Last modified October 11, 2022. Accessed March 24, 2025.; *https://www.hyster.com/en-us/north-america/why-hyster/press-releases/2022/hyster-begins-first-ever-real-world-pilot-of-hydrogen-fuel-cell-powered-container-handler-at-cma-cgm-owned-fenix-marine-terminal-in-the-port-of-los-angeles/*.; Hyster, "Hyster to Provide Hamburger Hafen UND Logistik AG with Hydrogen Fuel Cell-Powered Empty Container Handler and terminal Tractor," May 5, 2022. Accessed April 1, 2025. *https://www.hyster.com/en-us/north-america/why-hyster/press-releases/2022/hyster-to-provide-hamburger-hafen-und-logistik-ag-with-hydrogen-fuel/*.; AJOT, "Hyster to Provide CARU Containers B.V. with Electric Empty Container Handler," Last modified May 10, 2023. Accessed March 24, 2025. *https://www.ajot.com/news/hyster-to-provide-caru-containers-b.v-with-electric-empty-container-handler*.

Top Handler

ID	Top Handler-1 [Sources[63]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Top Handler
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Taylor Machine Works
Product Name	ZLC-976 (Commercially available)
Quantity	2
Project Description	Demonstration of two Taylor Machine Works battery-electric ZLC top handlers at the Port of Los Angeles on a 12-month trial.
Location	United States, California, Port of Los Angeles, Everport Terminal
Funding Source (Funding Project Name)	[Staff is seeking information on this demonstration]
Fund Recipient	Everport Terminal Services
Start Date	2019
End Date	2020
Results	The ZLC top handlers can work two full shifts and can charge in two hours. This equipment is commercially available.

[63] Port of Los Angeles, "Port of Los Angeles Unveils World's First Zero-Emissions Top Handlers," YouTube video, published on October 2, 2019, 2:06. Accessed April 9, 2025. *https://www.youtube.com/watch?v=WB_T804vQSE*; Port of Los Angeles, "Demonstration Electric Equipment Operating Daily at Everport Terminal," Last modified August 6, 2020. Accessed May 20, 2025. *https://www.portoflosangeles.org/references/news_080520_top_handlers_performing_well* ; Ghazal Razeghi, Micheal Mac Kinnon, and Scott Samuel, "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission- and Heavy-Duty Vehicles Operating at a Port Terminal, "California Energy Commission, 2023. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*

ID	Top Handler-2 [Sources[64]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Top Handler
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Taylor Machine Works
Product Name	ZLC-906 (First generation was commercially available, but is no longer available)
Quantity	2
Project Description	Demonstration of two battery-electric Taylor Machine Works top handlers at the Port of Long Beach SSA Marine. The top handlers were deployed with a 931-kWh lithium iron phosphate battery pack and 200-kW charger.
Location	United States, California, Port of Long Beach, SSA Marine
Funding Source (Funding Project Name)	CARB (CCI/LCTI, The Commercialization of POLB Off-Road Technology "C-PORT" Demonstration)
Fund Recipient	Port of Long Beach
Start Date	2020
End Date	2021
Results	Data from the demonstration showed that the battery-electric top handlers were able to perform over a work shift comparable to that of diesel equipment.

[64] California Air Resources Board, "LCTI: The Commercialization of POLB Off-Road Technology 'C-PORT' Demonstration," n.d. Accessed March 28, 2025. *https://ww2.arb.ca.gov/lcti-commercialization-polb-road-technology-c-port-demonstration*.; Port of Long Beach, "Zero-Emissions Yard Equipment Enters Port Service," February 25, 2020. Accessed March 28, 2025.*https://polb.com/port-info/news-and-press/zero-emissions-yard-equipment-enters-port-service-02-25-2020/*.; Ghazal Razeghi, Micheal Mac Kinnon, and Scott Samuel, "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission- and Heavy Duty Vehicles Operating at a Port Terminal, "California Energy Commission, 2023. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*.

ID	Top Handler-3 [Sources[65]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Top Handler
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Taylor Machine Works
Product Name	ZLC-906 (1st generation product, was commercially available, but is no longer offered)
Quantity	1
Project Description	Demonstration of one battery-electric Taylor Machine Works top handler at Long Beach Container Terminal (LBCT) at the Port of Long Beach. The top handler was deployed with a 931- h lithium iron phosphate battery pack and 200-kW charger.
Location	United States, California, Port of Long Beach, LBCT
Funding Source (Funding Project Name)	CARB (CCI/LCTI, The Commercialization of POLB Off-Road Technology "C-PORT" Demonstration)
Fund Recipient	Port of Long Beach
Start Date	2018
End Date	2021
Results	Data from the demonstration showed that the battery-electric top handler was able to perform over a work shift comparable to that of diesel equipment.

[65] California Air Resources Board, "LCTI: The Commercialization of POLB Off-Road Technology 'C-PORT' Demonstration," n.d. Accessed March 28, 2025. *https://ww2.arb.ca.gov/lcti-commercialization-polb-road-technology-c-port-demonstration*.; Port of Long Beach, "Zero-Emissions Yard Equipment Enters Port Service," February 25, 2020. Accessed March 28, 2025.*https://polb.com/port-info/news-and-press/zero-emissions-yard-equipment-enters-port-service-02-25-2020/*.; Ghazal Razeghi, Micheal Mac Kinnon, and Scott Samuel, "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission- and Heavy Duty Vehicles Operating at a Port Terminal, "California Energy Commission, 2023. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*.

ID	Top Handler-4 [Sources[66]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Top Handler
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Taylor Machine Works
Product Name	ZLC-906 (1st generation product, was commercially available, but is no longer offered)
Quantity	2
Project Description	As part of the ZANZEFF program, the Port of Oakland received two first-generation ZLC-906 EV top handlers. The top handlers are expected to operate in standard applications for two full shifts (16 hours) without the need for opportunity charging.
Location	United States, California, Port of Oakland
Funding Source (Funding Project Name)	CARB (LCTI/ZANZEFF, START)
Fund Recipient	Port of Long Beach
Start Date	May 2023
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[66] California Air Resources Board, "LCTI: Sustainable Terminals Accelerating Regional Transformation (START) Project Phase 1," n.d. Accessed February 26, 2025. *https://ww2.arb.ca.gov/lcti-sustainable-terminals-accelerating-regional-transformation-start-project-phase-1*; "Zero Emissions Top Handlers Land in Oakland." 2023. World Cargo News. May 1, 2023. Accessed April 14, 2025. *https://www.worldcargonews.com/environment/2023/01/zero-emissions-top-handlers-land-in-oakland/*; "Taylor was instrumental in pioneering dedicated container handlers over 50 years." *Facebook.Com*, January 15, 2020. Accessed May 19, 2025. *https://www.facebook.com/photo/?fbid=2786530691403887&set=taylor-was-instrumental-in-pioneering-dedicated-container-handlers-over-50-years*.

ID	Top Handler-5 [Source[67]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Top Handler
Zero-Emission Technology	Battery-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Taylor Machine Works
Product Name	ZLC-996 (Commercially available)
Quantity	5
Project Description	The Port of Los Angeles deployed five battery-powered electric cargo top handlers at Yusen Terminals, replacing diesel-powered equipment to reduce emissions. These zero-emission top handlers, developed by Taylor Machine Works, can operate for two full shifts.
Location	United States, California, Port of Los Angeles, Yusen Terminal
Funding Source (Funding Project Name)	[Staff is seeking information on this pilot]
Fund Recipient	Port of Los Angeles
Start Date	2019
End Date	2024
Results	[Staff is seeking information on this pilot.]

[67] AAPA Powers Program, "Electric Cargo Top Handlers Enter Service at Port of Los Angeles," June 26, 2024. Accessed March 28, 2025. *https://aapapowers.com/electric-cargo-top-handlers-enter-service-at-port-of-los-angeles/*.

ID	Top Handler-6 [Sources[68]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Top Handler
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Hyster-Yale
Product Name	H1050-1150XD-CH top loader
Quantity	1
Project Description	Demonstration of an electric Hyster-Yale top loader with two 45-kW Nuvera hydrogen fuel cells and wireless charging in regular container handling service at the Port of Los Angeles. The loader can be refueled in approximately 15 minutes and provides eight to ten hours of continuous operation. The project aligns with the Clean Air Action Plan 2030 objectives and demonstrates the potential of hydrogen as a sustainable energy source for port operations.
Location	United States, California, Port of Los Angeles, Fenix Marine Services
Funding Source (Funding Project Name)	CARB (CCI/LCTI)
Fund Recipient	Center for Transportation and the Environment
Start Date	May 2018
End Date	May 2022

[68] American Journal of Transportation, "Hyster to Provide CARU Containers B.V. With Electric Empty Container Handler," May 10, 2023. Accessed March 28, 2025. *https://www.ajot.com/news/hyster-to-provide-caru-containers-b.v-with-electric-empty-container-handler*; California Air Resources Board, "LCTI: Demonstration of Zero-Emission Technologies for Freight Operations at Ports," n.d. April 1, 2025. *https://ww2.arb.ca.gov/lcti-demonstration-zero-emission-technologies-freight-operations-ports*.; Hyster, "Hyster Begins First-Ever Real-World Pilot of Hydrogen Fuel Cell-Powered Container Handler at CMA CGM-Owned Fenix Marine Terminal in the Port of Los Angeles," Last modified October 11, 2022. Accessed March 24, 2025. *https://www.hyster.com/en-us/north-america/why-hyster/press-releases/2022/hyster-begins-first-ever-real-world-pilot-of-hydrogen-fuel-cell-powered-container-handler-at-cma-cgm-owned-fenix-marine-terminal-in-the-port-of-los-angeles/*; Nuvera, "Nuvera Powers fuel cell shipping container handler at the Port of Los Angeles," Last modified March 30, 2023. Accessed May 20, 2025. *https://www.nuvera.com/press-release/nuvera-powers-fuel-cell-shipping-container-handler-at-the-port-of-los-angeles/* .

Results	[Staff is seeking information on this pilot.]

ID	Top Handler-7 [Source[69]]
CHE Category/Type/ Subcategory (if applicable)	Top Handler
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Taylor Machine Works
Product Name	[Staff is seeking information on this demonstration.]
Quantity	2
Project Description	Taylor Machine Works in partnership with SSA Marine was to design, manufacture and demonstrate two hydrogen fuel cell top handlers. The top handlers would be primarily fuel-cell powered, with onboard batteries to support peak power demands and capture regenerative energy. The design included the use of liquid hydrogen fuel cooled to -250°F. This configuration would enable top handlers to operate for more than 16 hours, meeting the daily duty cycle of two shifts.
Location	United States, California, Port of Long Beach, SSA Marine
Funding Source (Funding Project Name)	Port of Long Beach, Port of Los Angeles, SSA Marine, Taylor Machine Works and a hydrogen fuel supplier
Fund Recipient	SSA Marine
Start Date	2021
End Date	2024

[69] San Pedro Bay Ports Clean Air Action Plan, "2024 Annual Report and 2025 Priorities Technology Advancement Program," May 2025. *https://cleanairactionplan.org/wp-admin/admin-ajax.php?juwpfisadmin=false&action=wpfd&task=file.download&wpfd_category_id=230&wpfd_file_id=5342&token=&preview=1*.

Results	Taylor Machine Works faced several challenges during the design phase that hindered completion of the final design. The primary issues included the availability, safety, and storage of liquid hydrogen fuel, as well as uncertainties in the supply chain for third-party fuel cell integrators. These challenges prevented the development of top handlers capable of achieving successful software integration across key components such as hybrid powertrains, fuel cell controls, hybrid battery power management, and hydrogen safety systems. Therefore, the project was cancelled.

ID	Top Handler-8 [Source[70]]
CHE Category/Type/ Subcategory (if applicable)	Top Handler
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Toyota Tsusho
Product Name	[Staff is seeking information on this demonstration.]
Quantity	1
Project Description	Demonstration of Toyota Tsusho America's newly remanufactured hydrogen fuel cell top handler with sustainable hydrogen fuel.
Location	United States, California, Port of Los Angeles, Fenix Marine Services
Funding Source (Funding Project Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	Port of Los Angeles
Start Date	2023
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[70] Fuel Cells Works,"OneH2 Partners with Toyota Tsusho America to Demonstrate Zero-Emissions Hydrogen Fuel," Last modified November 15, 2022. Accessed March 24, 2025. *https://fuelcellsworks.com/news/oneh2-partners-with-toyota-tsusho-america-to-demonstrate-zero-emissions-hydrogen-fuel/*.

Yard Truck

ID	Yard Truck-1 [Source[71]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	Yard tractor (Commercially available) [Staff is seeking information on this demonstration.]
Quantity	2
Project Description	Demonstration of two battery-electric BYD yard trucks to facilitate the development and demonstration of clean technologies at the Port of Los Angeles.
Location	United States, California, Port of Los Angeles
Funding Source (Funding Name)	CARB (CCI/LCTI, Multisource Green Omni Terminal Project)
Fund Recipient	Port of Los Angeles
Start Date	June 2016
End Date	December 2021
Results	One of the BYD yard trucks continues to work well. The other yard truck is being evaluated for charging issues.

[71] California Air Resources Board, "LCTI: Multisource Green Omni Terminal Project," n.d. Accessed March 27, 2025. *https://ww2.arb.ca.gov/lcti-multisource-green-omni-terminal-project*.

ID	Yard Truck-2 [Sources[72]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	Terminal tractor (Commercially available) [Staff is seeking information on this demonstration.]
Quantity	5
Project Description	The Port of Los Angeles demonstrated zero-emission equipment including five BYD yard trucks. The yard trucks were equipped with BYD's first-generation zero-emission propulsion technology.
Location	United States, California, Port of Los Angeles
Funding Source (Funding Name)	Alternative and Renewable Fuels and Vehicle Technology Program
Fund Recipient	Port of Los Angeles
Start Date	March 10, 2020
End Date	December 31, 2021
Results	There were several issues requiring periodic transport of the yard trucks back to the BYD Lancaster facility that adversely impacted the in-service demonstration.

[72] Teresa Pisano and Kerry Cartwright, "The Port of Los Angeles Advanced Yard Tractor Deployment and Eco-Drive Freight Advanced Traveler Information System Drayage Truck Efficiency Project," California Energy Commission, March 2024. *https://www.energy.ca.gov/sites/default/files/2024-03/CEC-600-2024-007.pdf*. ; The Port of Los Angeles, "Advanced Yard Tractor Deployment & Eco-FRATIS Drayage Truck Efficiency Project," n.d.*https://kentico.portoflosangeles.org/getmedia/5f3562b1-68ba-488f-9b22-4b4c00d4c287/cec-2015-fact-sheet.pdf*.

ID	Yard Truck-3 [Source[73]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	8Y (Commercially available)
Quantity	10
Project Description	Demonstration of 10 battery-electric yard trucks at the BNSF Railway intermodal facility in Los Angeles, California.
Location	United States, California, Los Angeles, BNSF intermodal facilities
Funding Source (Funding Name)	CARB (CCI)
Fund Recipient	San Bernardino County Council of Governments
Start Date	June 20, 2016
End Date	December 21, 2019
Results	The fleet took ownership of the vehicles and will continue operating them in regular service.

[73] California Air Resources Board, "LCTI: Multi-Class Heavy Duty Zero Emission Truck Development Project for Intermodal and Warehouse Facilities," n.d. Accessed March 28, 2025. *https://ww2.arb.ca.gov/lcti-multi-class-heavy-duty-zero-emission-truck-development-project-intermodal-and-warehouse*.

ID	Yard Truck-4 [Source[74]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	8Y (Commercially available)
Quantity	10
Project Description	Demonstration of 10 battery-electric yard trucks at the BNSF Railway intermodal facility in San Bernardino, California.
Location	United States, California, San Bernadino, BNSF intermodal facilities
Funding Source (Funding Name)	CARB (CCI)
Fund Recipient	San Bernardino County Council of Governments
Start Date	June 20, 2016
End Date	December 21, 2019
Results	The fleet took ownership of the vehicles and will continue operating them in regular service.

[74] California Air Resources Board, "LCTI: Multi-Class Heavy Duty Zero Emission Truck Development Project for Intermodal and Warehouse Facilities," n.d. Accessed March 28, 2025. *https://ww2.arb.ca.gov/lcti-multi-class-heavy-duty-zero-emission-truck-development-project-intermodal-and-warehouse*.

ID	Yard Truck–5 [Source[75]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	8Y (Commercially available)
Quantity	3
Project Description	Demonstration of 3 battery-electric yard trucks at Daylight Transport intermodal facility in Fontana, California.
Location	United States, California, Fontana, Daylight Transport intermodal facility
Funding Source (Funding Name)	CARB (CCI)
Fund Recipient	San Bernardino County Council of Governments
Start Date	June 20, 2016
End Date	December 21, 2019
Results	The fleet took ownership of the vehicles and will continue operating them in regular service.

[75] California Air Resources Board, "LCTI: Multi-Class Heavy Duty Zero Emission Truck Development Project for Intermodal and Warehouse Facilities," n.d. Accessed March 28, 2025. *https://ww2.arb.ca.gov/lcti-multi-class-heavy-duty-zero-emission-truck-development-project-intermodal-and-warehouse*.

ID	Yard Truck-6 [Source[76]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	8Y second generation (Commercially available)
Quantity	2
Project Description	Dole Food Company demonstrated two battery-electric BYD yard trucks. The yard trucks evolved in response to feedback from users in areas such as cab comfort, ergonomics, height of cab, and foot area.
Location	United States, California, Port of San Diego, Dole Terminal
Funding Source (Funding Name)	Clean Transportation Program
Fund Recipient	San Diego Port Tenants Association
Start Date	June 1, 2018
End Date	[Staff is seeking information on this demonstration.]
Results	The electric yard tractors had battery issues and stopped operations multiple times for repair and maintenance. The two yard tractors drove nearly 9,900 miles combined with reported savings of about 2,250 gallons of diesel fuel.

[76] Sharon Cloward, et al. "San Diego Port Sustainable Freight Demonstration Project," California Energy Commission, Publication Number: CEC-600-2024-006, March 2024. *https://www.energy.ca.gov/sites/default/files/2024-03/CEC-600-2024-006.pdf* .

ID	Yard Truck-7 [Sources[77]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	8Y second generation (Commercially available)
Quantity	1
Project Description	Pasha demonstrated one battery-electric BYD yard truck. Pasha chargers were installed next to the transformer to minimize the trenching.
Location	United States, California, Port of San Diego, Pasha Terminal
Funding Source (Funding Name)	Clean Transportation Program
Fund Recipient	San Diego Port Tenants Association
Start Date	December 1, 2018
End Date	[Staff is seeking information on this demonstration.]
Results	The demonstration ran into multiple challenges, including issues with vehicle design and performance.

[77] Energetics Incorporated, et al." Final Evaluation Report," California Public Utilities Commission, April 2021. *https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/california-te-prp-final-evaluation-report-presentation.pdf*.; Sharon Cloward, et al. "San Diego Port Sustainable Freight Demonstration Project," California Energy Commission, Publication Number: CEC-600-2024-006, March 2024. *https://www.energy.ca.gov/sites/default/files/2024-03/CEC-600-2024-006.pdf* .

ID	Yard Truck-8 [Sources[78]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	8T (Commercially available)
Quantity	7
Project Description	Demonstration of seven battery-electric BYD yard trucks at ITS Marine Terminal at the Port of Long Beach. BYD was able to customize the electric yard trucks to accommodate terminal preferences. These customizations did not alter the battery-electric drivetrain or performance.
Location	United States, California, Port of Long Beach, ITS Marine Terminal
Funding Source (Funding Name)	Clean Transportation Program
Fund Recipient	The Port of Long Beach
Start Date	July 1, 2020
End Date	September 1, 2021
Results	The BYD electric yard tractors' ability to perform both work shifts at ITS was inconsistent due to the availability of mid-shift and end-of-shift opportunity charging.

[78] Energetics Incorporated, et al." Final Evaluation Report," California Public Utilities Commission, April 2021. *https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/california-te-prp-final-evaluation-report-presentation.pdf*; Ghazal Razeghi, Micheal Mac Kinnon, and Scott Samuel, "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission- and Heavy-Duty Vehicles Operating at a Port Terminal, "California Energy Commission, 2023. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*.; Rose Szoke and Morgan Caswell, "Port of Long Beach Zero-Emission Terminal Equipment Transition Project," California Energy Commission, April 2024. *https://www.energy.ca.gov/sites/default/files/2024-04/CEC-600-2024-042.pdf* .

ID	Yard Truck-9 [Sources[79]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	8Y (Commercially available)
Quantity	1
Project Description	LBCT required modifications to BYD's yard truck to meet operational needs. Changes included adapting the frame for sharp turns, integrating a compatible navigation system, and modifying the fifth wheel coupling system.
Location	United States, California, Port of Long Beach, LBCT
Funding Source (Funding Name)	Clean Transportation Program
Fund Recipient	The Port of Long Beach
Start Date	January 1, 2021
End Date	June 9, 2022
Results	BYD opted out of the demonstration project due to resource limitations and unresolved engineering challenges.

[79] Rose Szoke and Morgan Caswell, Port of Long Beach Zero-Emission Terminal Equipment Transition Project, "California Energy Commission, April 2024. *https://www.energy.ca.gov/sites/default/files/2024-04/CEC-600-2024-042.pdf* .; Ghazal Razeghi, Micheal Mac Kinnon, and Scott Samuel, "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission- and Heavy-Duty Vehicles Operating at a Port Terminal, "California Energy Commission, 2023. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*.

ID	Yard Truck-10 [Sources[80]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD (yard truck), WAVE (inductive charging system)
Product Name	Yard Tractor (second generation, commercially available) with inductive charging capability [Staff is seeking information on this demonstration]
Quantity	10
Project Description	The Port of Los Angeles demonstrated 10 battery-electric BYD yard trucks. WAVE's wireless inductive charging systems were used to supply power to the yard trucks.
Location	United States, California, Port of Los Angeles, West Basin Container Terminal
Funding Source (Funding Name)	Alternative and Renewable Fuel Vehicle Technology Program, Targeted Airshed Grant
Fund Recipient	Port of Los Angeles
Start Date	[Staff is seeking information on this demonstration]
End Date	[Staff is seeking information on this demonstration]
Results	Wireless charging added complexity and cost to the initial design and build of the project, but also provided terminal operators with enhanced safety, efficiency, and reduced labor cost over the life of the equipment.

[80] The Port of Los Angeles, "Advanced Yard Tractor Deployment & Eco-FRATIS Drayage Truck Efficiency Project," n.d. *https://kentico.portoflosangeles.org/getmedia/5f3562b1-68ba-488f-9b22-4b4c00d4c287/cec-2015-fact-sheet.pdf.*; Jason Barlow, "The Push for Zero-Emissions: Lessons Learned from California Port's Decarbonization Projects as Ports Eye Leveraging Green Technology into a Commercial Advantage," American Association of Port Authorities, October 2022. *https://aapa.cms-plus.com/files/PPM%20Residency%20Report%20-%20B%20Jason%20Barlow.pdf* .

ID	Yard Truck-11 [Sources[81]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	DINA, TransPower, Meritor
Product Name	Yard Tractor (Commercially available) [Staff is seeking information on this demonstration.]
Quantity	5
Project Description	Five DINA and TransPower Battery-Electric Yard Tractors were demonstrated at the Port of Oakland as part of the START program. START was a pioneering demonstration of a multi-region, zero-and near-zero-emission supply chain that advances the California Sustainable Freight Action Plan and showcases emission reduction strategies replicable throughout freight facilities.
Location	United States, California, Port of Oakland
Funding Source (Funding Name)	CARB (CCI/LCTI, START)
Fund Recipient	Port of Long Beach
Start Date	December 21, 2019
End Date	March 19, 2024
Results	Fueling and charging infrastructure timelines are heavily impacted by utility requirements and permitting milestones, driving both equipment delivery schedules and service contracts.

[81] California Air Resources Board, "LCTI: Sustainable Terminals Accelerating Regional Transformation (START) Project Phase 1," n.d. Accessed February 26, 2025. *https://ww2.arb.ca.gov/lcti-sustainable-terminals-accelerating-regional-transformation-start-project-phase-1*.; Ghazal Razeghi, Micheal Mac Kinnon, and Scott Samuel, "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission- and Heavy-Duty Vehicles Operating at a Port Terminal, "California Energy Commission, 2023. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*.

ID	Yard Truck-12 [Sources[82]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	DINA, TransPower, Meritor
Product Name	Yard Tractor (Commercially available) [Staff is seeking information on this demonstration.]
Quantity	33
Project Description	33 DINA and TransPower Battery-Electric Yard Tractors were demonstrated at the Port of Long Beach as part of the START program. START was a pioneering demonstration of a multi-region, zero-and near-zero-emission supply chain that advances the California Sustainable Freight Action Plan and showcases emission reduction strategies replicable throughout freight facilities.
Location	United States, California, Port of Long Beach
Funding Source (Funding Name)	CARB (CCI/LCTI, START)
Fund Recipient	Port of Long Beach
Start Date	December 21, 2019
End Date	March 19, 2024
Results	Fueling and charging infrastructure timelines are heavily impacted by utility requirements and permitting milestones, driving both equipment delivery schedules and service contracts.

[82] California Air Resources Board, "LCTI: Sustainable Terminals Accelerating Regional Transformation (START) Project Phase 1," n.d. Accessed February 26, 2025. *https://ww2.arb.ca.gov/lcti-sustainable-terminals-accelerating-regional-transformation-start-project-phase-1*.; Sustainable World Ports, "Fact Sheet: Sustainable Terminals Accelerating Regional Transformation Project," October 2018. *https://sustainableworldports.org/wp-content/uploads/Sustainable-Terminals-Accelerating-Regional-Transformation-Project.pdf*.

ID	Yard Truck-13 [Sources[83]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Kalmar (yard truck), TransPower (drive system)
Product Name	T2E (Commercially available)
Quantity	1
Project Description	The C-PORT project included the deployment of one battery-electric yard truck. This project was intended to demonstrate zero-emission equipment under tough duty cycles in a rigorous seaport setting comparing performance of an electric yard truck with a hydrogen fuel cell yard truck (see Yard Truck-26).
Location	United States, California, Port of Long Beach
Funding Source (Funding Name)	Clean Climate Investments (C-PORT)
Fund Recipient	Port of Long Beach
Start Date	March 20, 2018
End Date	June 20, 2021
Results	The battery-electric yard truck needed to be charged twice per day.

[83] California Air Resources Board, "LCTI: The Commercialization of POLB Off-Road Technology 'C-PORT' Demonstration," n.d. Accessed March 28, 2025. *https://ww2.arb.ca.gov/lcti-commercialization-polb-road-technology-c-port-demonstration*; Ghazal Razeghi, Micheal Mac Kinnon, and Scott Samuel, "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission- and Heavy-Duty Vehicles Operating at a Port Terminal, "California Energy Commission, 2023. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*; World Cargo News, "More funding for clean equipment," July 11, 2018, Accessed July 30, 2025. *https://www.worldcargonews.com/mobile-che/2018/07/more-funding-for-clean-equipment/*.

ID	Yard Truck-14 [Sources[84]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Kalmar
Product Name	Yard Tractor (Commercially available) [Staff is seeking information on this demonstration.]
Quantity	2
Project Description	As part of the Shore to Store Project, The Port of Hueneme demonstrated two electric yard tractors. These were the first pieces of zero-emission equipment at the facility.
Location	United States, California, Port of Hueneme
Funding Source (Funding Name)	CARB (CCI)
Fund Recipient	Port of Los Angeles
Start Date	January 24, 2022
End Date	January 25, 2023
Results	[Staff is seeking information on this demonstration.]

[84] California Air Resources Board, "LCTI: Port of Los Angeles 'Shore to Shore' Project," n.d. Accessed March 27, 2025. *https://ww2.arb.ca.gov/lcti-port-los-angeles-shore-store-project*.; The Port of Los Angeles, "Zero- and Near Zero-Emission Freight Facilities (ZANZEFF) Shore to Shore Project," n.d. Accessed March 28, 2025. *https://kentico.portoflosangeles.org/getmedia/db7c41ac-59b3-4491-8bb4-8a02d63b495d/zanzeff-fact-sheet*.; *https://cleanairactionplan.org/technology-advancement-program/reports/*.

ID	Yard Truck-15[Sources[85]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Kalmar (Commercially available)
Product Name	(Commercially available models) [Staff is seeking information on this demonstration.]
Quantity	2
Project Description	Two Kalmar yard trucks were demonstrated by two southern California fleets as part of the Volvo LIGHTS project. The project goal was to maintain efficiency in freight facilities while reducing emissions and operating costs.
Location	United States, California
Funding Source (Funding Name)	CARB (CCI/LCTI, Volvo LIGHTS Project)
Fund Recipient	South Coast Air Quality Management District
Start Date	February 19, 2019
End Date	September 30, 2022
Results	[Staff is seeking information on this demonstration.]

[85] CALSTART, "Volvo LIGHTS: Zero-Emission Goods Movement," May 2023. *https://calstart.org/wp-content/uploads/2023/05/Volvo-LIGHTS-Zero-Emission-Goods-Movement_new.pdf*; California Air Resources Board, "LCTI: Volvo Low Impact Green Heavy Transport Solution (LIGHTS) Projects," n.d. Accessed March 27, 2025. *https://ww2.arb.ca.gov/lcti-volvo-low-impact-green-heavy-transport-solutions-lights-project*; NFI," NFI Leads Logistics Industry in Sustainability as Early Adopter of Electric Vehicles," October 10, 2019. Accessed March 27, 2025. *https://www.nfiindustries.com/about-nfi/news/nfi-leads-logistics-industry-in-sustainability-as-early-adopter-of-electric-vehicles/*.

ID	Yard Truck-16 [Source[86]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Kalmar Ottawa
Product Name	Yard Tractor (Commercially available) [Staff is seeking information on this demonstration.]
Quantity	1
Project Description	The Multisource Green Omni Terminal Project demonstrated a battery-electric Kalmar-Ottawa yard truck. The objective of the project was to deploy equipment and infrastructure, conduct emission testing, and practical demonstration of zero and near-zero emission technologies with a high potential to be commercialized.
Location	United States, California, Port of Los Angeles, Pasha Terminal
Funding Source (Funding Name)	CARB (CCI/LCTI, Multisource Green Omni Terminal Project)
Fund Recipient	Port of Los Angeles
Start Date	June 2016
End Date	December 2021
Results	Some of the technology partners adjusted their next generation of equipment based on lessons learned from this demonstration.

[86] California Air Resources, "LCTI: Multisource Green Omni Terminal Project," n.d. Accessed March 27, 2025. *https://ww2.arb.ca.gov/lcti-multisource-green-omni-terminal-project*.

ID	Yard Truck-17 [Source[87]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Kalmar (yard truck), TransPower (repower)
Product Name	Yard Tractor
Quantity	2
Project Description	Dole demonstrated two Kalmar yard trucks converted to battery-electric by TransPower. Each yard truck operated for about 140 hours per month.
Location	United States, California, Port of San Diego, Dole Terminal
Funding Source (Funding Name)	Clean Transportation Program
Fund Recipient	Transportation Power Inc.
Start Date	March 1, 2018
End Date	February 1, 2019
Results	As of the end of the project, the two Dole yard tractors continued to accrue mileage and hours at an excellent rate

[87] James Burns and Micheal Simon, "Advanced Battery-Electric Port Vehicles," Transportation Power Inc. California Energy Commission, Publication Number: CEC-600-2021-035, June 2021. *https://www.energy.ca.gov/sites/default/files/2021-06/CEC-600-2021-035.pdf*.

ID	Yard Truck-18 [Sources[88]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	MAFI
Product Name	T230e (Commercially available)
Quantity	4
Project Description	The Port of Virginia is demonstrating four new MAFI T230e battery-electric yard trucks at Norfolk International Terminals. These are the first zero-emission vehicles in use at the terminals.
Location	United States, Virgina, Port of Virginia, Norfolk International Terminals
Funding Source (Funding Name)	State of Virginia
Fund Recipient	Port of Virginia
Start Date	December 1, 2022
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[88] Associated Press, "Port gets Funding for Electric Ship-to-Shore Cranes, Trucks," U.S. News, July 11, 2020. Accessed March 28, 2025. *https://www.usnews.com/news/best-states/virginia/articles/2020-07-11/port-gets-funding-for-electric-ship-to-shore-cranes-trucks*.; Syed Rakin Rahman, "Port of Virginia Employs All-Electric Yard Tractors," Port Technology International, February 13, 2023. Accessed March 28, 2025. *https://www.porttechnology.org/news/port-of-virginia-employs-all-electric-yard-tractors/*.

ID	Yard Truck-19 [Source[89]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	OrangeEV
Product Name	Terminal Tractor (Commercially available) [Staff is seeking information on this demonstration.]
Quantity	6
Project Description	Rail Management Services demonstration of six battery-electric OrangeEV yard trucks. Six diesel-powered yard trucks are being replaced by battery-electric versions at the South Intermodal Yard in Tacoma.
Location	United States, Washington, Tacoma, South Intermodal Yard
Funding Source (Funding Name)	Diesel Emissions Reduction Act Grant Program
Fund Recipient	Rail Management Services
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[89] The Northwest Seaport Alliance, "NWSA Accepts EPA and Tacoma Power Grants to Install First Permanent Fleet of Electric Cargo-Handling Equipment," December 17, 2020. Accessed April 2, 2025. *https://www.nwseaportalliance.com/newsroom/nwsa-accepts-epa-and-tacoma-power-grants-install-first-permanent-fleet-electric-cargo*.

ID	Yard Truck-20 [Sources[90]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	OrangeEV
Product Name	Yard Tractors (Commercially available) [Staff is seeking information on this demonstration.]
Quantity	2
Project Description	Through the Volvo LIGHTS project, DHE replaced all freight equipment being used in its Ontario facility with battery-electric models. The battery-electric equipment included two OrangeEV yard trucks.
Location	United States, California, Ontario (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	CARB (CCI/LCTI, Volvo LIGHTS Project)
Fund Recipient	South Coast Air Quality Management District
Start Date	February 25, 2019
End Date	September 30, 2022
Results	[Staff is seeking information on this demonstration.]

[90] California Air Resources Board, "LCTI: Volvo Low Impact Green Heavy Transport Solution (LIGHTS) Projects," n.d. Accessed March 27, 2025. *https://ww2.arb.ca.gov/lcti-volvo-low-impact-green-heavy-transport-solutions-lights-project*.; CALSTART, "Volvo LIGHTS: Zero-Emission Goods Movement," May 2023. *https://calstart.org/wp-content/uploads/2023/05/Volvo-LIGHTS-Zero-Emission-Goods-Movement_new.pdf*; Volvo, "Volvo Trucks' Customer Dependable Highway Express Reduces Carbon Footprint by Electrifying Southern California Distribution Facility," January 14, 2021. Accessed March 27, 2025. *https://www.volvotrucks.us/news-and-stories/press-releases/2021/january/customer-dependable-highway-express-reduces-carbon-footprint-by-electrifying/*.

ID	Yard Truck-21 [Source[91]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Prototype
OEMs, Equipment, or Service Provider	Terberg
Product Name	RT-EV 4×4
Quantity	1
Project Description	Terberg has developed a prototype RT-series battery-electric yard truck specifically for roll-on, roll-off ocean-going vessels. Currently, the company is conducting use-trials across Europe with key ro-ro terminal operators, planning a formal product launch later in 2025. The initiative is designed to demonstrate how an all-electric, purpose-built ro-ro yard truck can meet the requirements of modern cargo handling.
Location	Europe [Staff is seeking information on this prototype.]
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	[Staff is seeking information on this prototype.]
End Date	N/A
Results	Users reported that the yard truck performs robustly in real world terminal conditions and offers smooth, responsive maneuverability on challenging ship ramps. It operates with significantly reduced noise and emissions compared to its diesel counterparts. These results suggest that the battery-electric truck is capable of handling the demands of ro-ro operations while delivering benefits in efficiency and sustainability.

[91] Avery, Paul, "On the road to an electric Ro-Ro tractor," World Cargo News, April 24, 2025. Accessed April 26, 2025. *https://www.worldcargonews.com/cargo-handling-equipment/2025/04/on-the-road-to-an-electric-ro-ro-tractor/*.

ID	Yard Truck-22 [Sources[92]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/AGV
Zero-Emission Technology	Battery-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Terberg, Embotech
Product Name	YT203EV ATT (Commercially available)
Quantity	30
Project Description	APM Terminals Maasvlakte II ordered 30 electric terminal trucks from Terberg.
Location	Netherlands, Port of Rotterdam, APM Terminals Maasvlakte II
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	The fleet is expected to enter service in 2027.
End Date	[Staff is seeking information on this pilot.]
Results	[Staff is seeking information on this pilot.]

[92] Terberg Special Vehicles, "Next Generation Electric Terminal Tractors," n.d. Accessed April 9, 2025. *https://www.terbergspecialvehicles.com/en/development/electric/*.; Terberg Special Vehicles, "APM Terminals Maasvlakte II Signs Unique cooperation Contract with Embotech and Terberg for the Purchase and Implementation of 30 Electric Automated Terminal Tractor," Royal Terberg Group, January 9, 2025. Accessed April 9, 2025. *https://prod.royalterberggroup.com/en/news/news-template-page/206716*.; International Transport Journal, "Terminal operator Orders Electric Automated Trucks," January 2025. Accessed April 9, 2025. *https://www.transportjournal.com/en/home/news/artikeldetail/terminal-operator-orders-electric-automated-trucks.html*.; Fox59, "APM Terminals Maasvlakte II Signs Unique Cooperation Contract with Embotech and Terberg for 30 ATTs," January 9, 2025. Accessed April 9, 2025. *https://fox59.com/business/press-releases/ein-presswire/775436212/apm-terminals-maasvlakte-ii-signs-unique-cooperation-contract-with-embotech-and-terberg-for-30-atts/*.

ID	Yard Truck-23 [Source[93]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	TransPower (repower), CHE (Unknown) [Staff is seeking information on this demonstration.]
Product Name	[Staff is seeking information on this demonstration.]
Quantity	2
Project Description	The Multisource Green Omni Terminal Project demonstrated two TransPower yard trucks. The purpose of the project was to deploy equipment and infrastructure, conduct emission testing, and practical demonstration of zero and near-zero emission technologies with a high potential to be commercialized.
Location	United States, California, Port of Los Angeles, Pasha Terminal
Funding Source (Funding Name)	CARB (CCI/LCTI, Multisource Green Omni Terminal Project)
Fund Recipient	Port of Los Angeles
Start Date	June 2016
End Date	December 2021
Results	Some of the technology partners adjusted their next generation of equipment based on lessons learned from this demonstration.

[93] California Air Resources, "LCTI: Multisource Green Omni Terminal Project," n.d. Accessed March 27, 2025. *https://ww2.arb.ca.gov/lcti-multisource-green-omni-terminal-project*.

ID	Yard Truck-24 [Sources[94]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Atena
Product Name	[Staff is seeking information on this demonstration.]
Quantity	1
Project Description	This demonstration project involves the repower of a diesel-electric hybrid yard truck to use hydrogen fuel cell technology at Valencia Terminal Europa. The H2Ports Initiative aims to develop these tractors to enhance the range of zero-emission yard trucks in port operations. This truck consists of a 12-kg hydrogen storage at 350 bar and a 25-kWh battery. The fuel cell module provides 70 kW of power and can operate for at least six hours before refueling.
Location	Spain, Port of Valencia
Funding Source (Funding Name)	Fuel Cells and Hydrogen 2 Joint Undertaking
Fund Recipient	Spain, Port of Valencia
Start Date	April 21, 2023
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[94] H2 Ports, "Yard Tractor," n.d. Accessed March 28, 2025. *https://h2ports.eu/pilots/*.; Valencia Port, "The Hydrogen Terminal Tractor of the H2PORTS Project Disembarks at the Port of Valencia," April 22, 2023. Accessed March 28, 2025. *https://www.valenciaport.com/en/the-hydrogen-terminal-tractor-of-the-h2ports-project-disembarks-at-the-port-of-valencia/*.; Sustainable World Ports, "Port of Valencia- H2Ports/ Fuel Cells and Hydrogen in Ports," 2019. Accessed March 28, 2025. *https://sustainableworldports.org/project/port-of-valencia-h2ports*.

ID	Yard Truck-25 [Source][95]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Capacity (yard truck), BAE (traction motor), Ballard (hydrogen fuel cell)
Product Name	Yard Truck
Quantity	2
Project Description	Demonstration of two hydrogen fuel cell yard trucks at the TraPac Terminal at the Port of Los Angeles. The objective of this project is to validate the commercial viability of zero-emissions hybrid fuel cell-electric yard trucks operating in a demanding, real-world cargo-handling application at the Port of Los Angeles. These trucks feature a 9.1-kg hydrogen storage system at 350 bar and an 85-kWh battery with plug-in charging capability.
Location	United States, California, Port of Los Angeles, TraPac Terminal
Funding Source/Funding Name	CARB (CCI/LCTI, Zero Emissions for California Ports (ZECAP))
Fund Recipient	Gas Technology Institute
Start Date	March 20, 2019
End Date	September 22, 2022
Results	• The trucks performed equal to, or greater than, their internal combustion counterparts. • The range was greater than expected. • Refueling took about 15 minutes providing "near perpetual operational capability." • Very smooth operation provided positive feedback from operators.

[95] California Air Resources Board, "LCTI: Zero Emissions for California Ports (ZECAP)," n.d. Accessed April 1, 2025. *https://ww2.arb.ca.gov/lcti-zero-emissions-california-ports-zecap*.

ID	Yard Truck-26 [Source[96]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	China National Heavy Duty Truck Group Co./Sinotruk (CHE), Loop Energy (technology developer)
Product Name	Yard Tractor
Quantity	1
Project Description	Demonstration of a hydrogen fuel cell yard truck at LBCT at the Port of Long Beach.
Location of Demonstration or Operation	United States, California, Port of Long Beach, LBCT
Location	CARB (CCI/LCTI, C-PORT)
Fund Recipient	The Port of Long Beach
Start Date	N/A
End Date	N/A
Results	The hydrogen fuel cell yard truck was delivered to LBCT. However, in October 2019, the Port and terminal, after consulting with CARB, decided against commissioning and demonstrating the vehicle.

[96] Matt Hart, et al.," The Commercialization of POLB Off Road Technology (C-PORT) Demonstration Final Report, (C-PORT POLB Final Report 2021-0822 Compiled)" Clean Air Action Plan, August 19, 2021. *https://cleanairactionplan.org/technology-advancement-program/reports/#*

ID	Yard Truck-27 [Sources[97]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Hyster-Yale (terminal tractor), Nuvera (hydrogen fuel cell)
Product Name	Terminal tractor [Staff is seeking information on this demonstration.]
Quantity	2
Project Description	Demonstration of two Hyster-Yale terminal tractors, powered by 45-kW Nuvera fuel cells at the HHLA Container Terminal Tollerort. They will run on hydrogen fuel produced locally at the HHLA Hamburg Green Hydrogen Hub. The project is part of a joint initiative of HHLA and other European companies that aims to operationalize and test hydrogen-powered port equipment to reduce emissions in port handling and associated logistics chains.
Location	Germany, Hamburg, HHLA Container Terminal Tollerort
Funding Source (Funding Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	2022
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[97] Hyster, "Hyster Begins First-Ever, Real-World Pilot of Hydrogen Fuel Cell-Powered Container Handler at CMA CGM-Owned Fenix Marine Terminal in the Port of Los Angeles," Last modified October 11, 2022. Accessed April 1, 2025.*https://www.hyster.com/en-us/north-america/why-hyster/press-releases/2022/hyster-begins-first-ever-real-world-pilot-of-hydrogen-fuel-cell-powered-container-handler-at-cma-cgm-owned-fenix-marine-terminal-in-the-port-of-los-angeles/*; Hyster, "Hyster to Provide Hamburger Hafen UND Logistik AG with Hydrogen Fuel Cell-Powered Empty Container Handler and terminal Tractor," May 5, 2022. Accessed April 1, 2025. *https://www.hyster.com/en-us/north-america/why-hyster/press-releases/2022/hyster-to-provide-hamburger-hafen-und-logistik-ag-with-hydrogen-fuel/.*; Nuvera Fuel Cells, "Nuvera Powers Fuel Cell Shipping Container Handler at the Port of Los Angeles," November 8, 2022. Accessed March 24, 2025. *https://www.nuvera.com/press-release/nuvera-powers-fuel-cell-shipping-container-handler-at-the-port-of-los-angeles/* .

ID	Yard Truck-28 [Source[98]]
CHE Category/Type/ Subcategory (if applicable)	Container CHE/Yard Truck
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Prototype
OEMs, Equipment, or Service Provider	Terberg, Zepp.solutions
Product Name	YT203-H2
Quantity	1
Project Description	In 2020, Terberg began testing its first concept hydrogen fuel cell yard truck in Rotterdam, Netherlands. Equipped with four 350-bar hydrogen fuel tanks containing 14.4 kg of hydrogen, it can be used for a full day in heavy-duty applications.
Location	Netherlands, Rotterdam, United Waalhaven Terminals
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	October 2020
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[98] Terberg Special Vehicles, "Terberg Starts Intensive Testing of Hydrogen Terminal Tractor in the Port of Rotterdam," October 28, 2020. Accessed February 20, 2025. *https://www.terbergspecialvehicles.com/en/news/terberg-starts-intensive-testing-of-hydrogen-terminal-tractor/*.

Facility Support CHE Demonstrations, Pilots, Product Launches, and Prototypes

Aerial Lift

Staff is seeking information on demonstrations, pilots, product launches, and prototypes using zero-emission aerial lifts.

Cone Vehicle

Staff is seeking information on demonstrations, pilots, product launches, and prototypes using zero-emission cone vehicles.

Railcar Mover

ID	Railcar Mover-1 [Sources[99]]
CHE Category/Type/ Subcategory (if applicable)	Facility Support CHE/Railcar Mover
Zero-Emission Technology	Battery-electric
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Zephir
Product Name	(Several Zephir models are commercially available. It is not clear from the available literature which model is part of the demonstration.) [Staff is seeking information on this demonstration.]
Quantity	1
Project Description	Demonstration of a Zephir battery-electric rail car mover with range extender at the Port of Stockton. [Staff is seeking information on this demonstration.]
Location	United States, California, Port of Stockton
Funding Source (Funding Project Name)	CARB (CCI/LCTI, START)
Fund Recipient	Port of Long Beach
Start Date	Winter 2019
End Date	Spring 2024
Results	[Staff is seeking information on this demonstration.]

[99] California Air Resources Board, "LCTI: Sustainable Terminals Accelerating Regional Transformation (START) Project Phase 1," n.d. Accessed February 26, 2025. *https://ww2.arb.ca.gov/lcti-sustainable-terminals-accelerating-regional-transformation-start-project-phase-1*; Pacific Ports. "Port of Stockton Moves Toward Zero-Emissions Goal." May 20, 2021. Accessed April 14, 2025. *https://pacificports.org/port-of-stockton-moves-toward-zero-emissions-goal*.

Utility Truck, Other

ID	Utility Truck-1 [Sources[100]]
CHE Category/Type/ Subcategory (if applicable)	Facility Support CHE/Utility Truck
Zero-Emission Technology	Battery-electric
Project Type	Product launch
OEMs, Equipment, or Service Provider	Komatsu and Dimaag
Product Name	4WD Mobile Megawatt Charger
Quantity	N/A
Project Description	Komatsu, in collaboration with Dimaag, announced a mobile megawatt mobile charging vehicle at Bauma 2025. It is designed to fast-charge battery-powered construction and mining equipment. It is designed for off-road use with four-wheel steering, allowing it to navigate rugged terrain. It includes a modular DC-DC converter capable of delivering charging power from 1 MW up to 6 MW, paired with a 295-kWh battery pack.
Location	Germany, Munich (Bauma)
Funding Source (Funding Project Name)	N/A
Fund Recipient	N/A
Start Date	[Staff is seeking information on this product launch.]
End Date	N/A
Results	[Staff is seeking information on this product launch.]

[100] Dimaag EV, "Megawatt Charging System – Fast & Flexible Power," n.d. Accessed May 19, 2025. *https://dimaag-ev.com/mwcs/*; Don McLoud, "Komatsu, Dimaag Unveil 4WD Mobile Megawatt Charger for Electric Construction Equipment," Equipment World, May 12, 2025. Accessed May 19, 2025. *https://www.equipmentworld.com/alternative-power/battery-electric/article/15745149/komatsu-dimaag-unveil-mobile-megawatt-charging-system*; The EV Report, "Komatsu Unveils Mobile Megawatt Charger at BAUMA 2025," April 7, 2025. Accessed May 19, 2025. *https://theevreport.com/komatsu-unveils-mobile-megawatt-charger-at-bauma-2025*.

ID	Utility Truck-2 [Sources[101]]
CHE Category/Type/ Subcategory (if applicable)	Facility Support CHE/Utility Truck
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Prototype
OEMs, Equipment, or Service Provider	Ford
Product Name	F-550 Super Duty
Quantity	5
Project Description	Ford is collaborating with SoCalGas and Plastic Omnium to develop a hydrogen fuel cell-powered Ford F-550 Super Duty truck as part of the U.S. Department of Energy's SuperTruck 3 program. Ferguson Enterprises will test the trucks in real-world conditions and provide feedback. The trucks will feature 700-bar hydrogen high-pressure vessels, enabling rapid refueling and extended range. The trucks will be tested in many configurations including being equipped with lift buckets for working on power and telecom lines.
Location	[Staff is seeking information on this prototype.]
Funding Source (Funding Project Name)	DOE (SuperTruck 3)
Fund Recipient	Ford
Start Date	[Staff is seeking information on this prototype.]
End Date	N/A
Results	[Staff is seeking information on this prototype.]

[101] Brett Foote, "Ford F-550 Super Duty Hydrogen Fuel Cell Supply Plans Revealed." Ford Authority, September 14, 2022. Accessed March 24, 2025. *https://fordauthority.com/2022/09/ford-f-550-super-duty-hydrogen-fuel-cell-supply-plans-revealed/*; Stephane Babcock, "U.S. DOE Announces More than $127 Million for SuperTruck 3," Advanced Clean Tech News, November 3, 2021. Accessed April 14, 2025. *https://www.act-news.com/news/u-s-doe-announces-more-than-127-million-for-supertruck-3/*.

ID	Utility Truck-3 [Sources[102]]
CHE Category/Type/ Subcategory (if applicable)	Facility Support CHE/Utility Truck
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Prototype
OEMs, Equipment, or Service Provider	General Motors
Product Name	Built on a similar frame to the 2024 Chevrolet Silverado 5500 MD
Quantity	4
Project Description	General Motors has announced the development of medium-duty fuel cell fleet trucks. The prototype trucks are expected to have an estimated range greater than 300 miles and a 19,500-lb gross vehicle weight rating. The trucks will operate in a native 800V architecture and are expected to produce more than 300 kW of peak power. Southern Company, one of the largest utility companies in the United States, will receive the trucks to be used as shop vehicles at its worksites. Southern Company will also demonstrate an integrated hydrogen microgrid for fueling, including a stationary fuel cell-based mobile power generator.
Location	Multiple Southern Company worksites (non-seaport/intermodal railyard project).
Funding Source (Funding Project Name)	DOE (SuperTruck 3, Hydrogen and Fuel Cell Technologies Office)
Fund Recipient	General Motors
Start Date	[Staff is seeking information on this prototype.]
End Date	[Staff is seeking information on this prototype.]
Results	[Staff is seeking information on this prototype.]

[102] Green Car Congress, "GM Piloting Medium-Duty Fuel Cell Trucks and Low-Emissions Worksites," March 6, 2024. Accessed April 9, 2025. *https://www.greencarcongress.com/2024/03/20240306-gm.html*.; Stephane Babcock, "U.S. DOE Announces More than $127 Million for SuperTruck 3," Advanced Clean Tech News, November 3, 2021. Accessed April 14, 2025. *https://www.act-news.com/news/u-s-doe-announces-more-than-127-million-for-supertruck-3/*.

ID	Utility Truck-4 [Source[103]]
CHE Category/Type/ Subcategory (if applicable)	Facility Support CHE/Utility Truck
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Product launch
OEMs, Equipment, or Service Provider	Hexagon Purus, Ballard
Product Name	Class 6 & 7 Fuel Cell Electric Trucks
Quantity	N/A
Project Description	Hexagon Purus and Ballard Power Systems announced plans to produce a Class 6 fuel cell electric truck. This vehicle will feature Hexagon Purus's hydrogen storage systems and Ballard's FCmove™ fuel cell module, offering a range of over 400 miles and refueling times comparable to conventional fossil-fuel-powered trucks. Designed for zero-emission commercial transport, the truck will support California's air quality regulations and the broader adoption of hydrogen fuel cell technology in heavy-duty transport.
Location	United States, California, Long Beach (2021 ACT Expo)
Funding Source (Funding Project Name)	N/A
Fund Recipient	N/A
Start Date	2022
End Date	N/A
Results	[Staff is seeking information on this product launch.]

[103] Hexagon Purus, "Class 6 Fuel Cell Electric Truck Powered by Hexagon Purus and Ballard Launched at ACT Expo," Last modified August 31, 2021. Accessed March 24, 2025. *https://hexagonpurus.com/news/class-6-fuel-cell-electric-truck-powered-by-hexagon-purus-and-ballard-launched-at-act-expo*.

ID	Utility Truck-5 [Sources[104]]
CHE Category/Type/ Subcategory (if applicable)	Facility Support CHE/Utility Truck
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Product launch
OEMs, Equipment, or Service Provider	Stellantis
Product Name	Dodge Ram 5500
Quantity	N/A
Project Description	Stellantis has announced plans to produce a hydrogen fuel cell-powered Dodge Ram 5500 in their Mexico factory as a chassis cab for the North American market.
Location	N/A
Funding Source (Funding Project Name)	N/A
Fund Recipient	N/A
Start Date	[Staff is seeking information on this product launch.]
End Date	N/A
Results	[Staff is seeking information on this product launch.]

[104] Andre Smirnov, "Report: Stellantis Says Hydrogen-Powered Ram HD 5500 EV Trucks Are Coming Soon to the U.S. Market," TFLTruck, May 1, 2024. Accessed April 8, 2025. *https://tfltruck.com/2024/05/report-stellantis-says-hydrogen-powered-ram-hd-5500-ev-trucks-are-coming-soon-to-the-u-s-market/*; Carla Westerheide, "Stellantis significantly expands FCEV production," Electrive, April 30, 2024. Accessed April 8, 2025. *https://www.electrive.com/2024/04/30/stellantis-significantly-expands-fcev-production/*; Stephen Edelstein, "Fuel-cell Ram HD Pickup Included in Stellantis Hydrogen Rollout," Green Car Reports, May 7, 2024. Accessed April 8, 2025. *https://www.greencarreports.com/news/1143092_hydrogen-fuel-cell-ram-hd-pickup-stellantis*.

Utility Truck, Sweeper

ID	Sweeper-1 [Sources[105]]
CHE Category/Type/ Subcategory (if applicable)	Facility Support CHE/Utility Truck, Sweeper
Zero-Emission Technology	Battery-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Global
Product Name	M4 (Commercially available)
Quantity	1
Project Description	The New York City Department of Sanitation unveiled its first all-electric street sweeper, developed in collaboration with Global Environmental Products and US Hybrid. This initiative is part of the city's goal to reduce greenhouse gas emissions by 80% by 2035. It features advanced lithium-ion batteries and a 120-kW traction motor.
Location	United States, New York (non-seaport/intermodal railyard project)
Funding Source (Funding Project Name)	New York City Department of Sanitation
Fund Recipient	N/A
Start Date	May 2021
End Date	[Staff is seeking information on this pilot.]
Results	The electric sweeper is expected to save 89 metric tons of carbon emissions over its lifetime. [Staff is seeking information on this pilot.]

[105] Keith Kerman, "DSNY Introduces All-Electric Sweeper," *NYC Fleet Newsletter - Issue 344*. May 10, 2021. Accessed April 17, 2025. *https://www.nyc.gov/assets/dcas/downloads/pdf/fleet/NYC-Fleet-Newsletter-344-DSNY-Introduces-All-Electric%20Sweeper.pdf*; Waste 360, "New York City Department of Sanitation Unveils All-Electric Street Sweeper," May 6, 2021. Accessed April 17, 2025. *https://www.waste360.com/fleet-technology/new-york-city-department-of-sanitation-unveils-all-electric-street-sweeper*.

ID	Sweeper-2 [Sources[106]]
CHE Category/Type/ Subcategory (if applicable)	Facility Support CHE/Utility Truck, Sweeper
Zero-Emission Technology	Battery-electric
Project Type	Pilot
OEMs, Equipment, or Service Provider	Equipment (unknown) [Staff is seeking information on this pilot.]
Product Name	[Staff is seeking information on this pilot.]
Quantity	[Staff is seeking information on this pilot.]
Project Description	In 2020, the City of Oslo launched the "Pioneering City for Zero-Emission Heavy Transport" project to reduce emissions from heavy transport. In 2022, Oslo implemented a pilot program for sweepers involving battery-swapping capability.
Location	Norway, Oslo (non-seaport/intermodal railyard project)
Funding Source (Funding Project Name)	[Staff is seeking information on this pilot.]
Fund Recipient	[Staff is seeking information on this pilot.]
Start Date	2022
End Date	[Staff is seeking information on this pilot.]
Results	The battery swapping capability reduced the operational carbon footprint by 34% compared to fixed-battery models.

[106] City of Oslo, "Summary in English: Oslo – Pioneering City for Zero-Emission Heavy Transport." n.d. Accessed April 17, 2025. *https://www.klimaoslo.no/rapport/oslo-pioneering-city-for-zero-emission-heavy-transport/summary-pioneering-city-zero-emission-heavy-transport*; PW Consulting, "Electric Autonomous Street Sweeper Market," PW Consulting Automotive & Machinery Research Center, October 9, 2024. Accessed April 17, 2025. *https://pmarketresearch.com/auto/electric-autonomous-street-sweeper-market/*.

ID	Sweeper-3 [Sources[107]]
CHE Category/Type/ Subcategory (if applicable)	Facility Support CHE/Utility Truck, Sweeper
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Global
Product Name	M4 HSD (Commercially available)
Quantity	1
Project Description	Demonstration of a hydrogen fuel cell street sweeper by the California Department of Transportation (Caltrans) in Los Angeles County. The South Coast Air Quality Management District does not allow the use of diesel street sweepers.
Location	United States, California, Los Angeles County (non-seaport/intermodal railyard project)
Funding Source (Funding Project Name)	Caltrans' Division of Equipment and Division of Maintenance
Fund Recipient	N/A
Start Date	January 1, 2019
End Date	September 19, 2021
Results	The final report from Caltrans concludes that hydrogen fuel cell street sweepers are a viable alternative to current street sweeper technologies and found the following:

[107] Caltrans Division of Research, Innovation and System Information. "Research Results - Evaluation of Hybrid Electric Street Sweepers." Task Number: 3130. *Caltrans*. Caltrans. Accessed April 17, 2025. *https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/research-results/task3130-rrs-06-22-a11y.pdf*; University of California at Riverside. "Evaluation of Hybrid Electric Street Sweepers: Final Report." CA 22-3130. *Caltrans*. California Department of Transportation. Accessed April 17, 2025. *https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/final-reports/ca22-task-3130-dor.pdf*.

	• The sweeper demonstrated significant emission reductions, producing only water and warm air, and offering cold-start emission benefits over diesel and compressed natural gas models. • Operators appreciated the improved broom and driving performance due to the electric motor's instant torque and the ability to independently adjust broom speed. • The regenerative braking system also contributed to energy efficiency. • The sweeper's operational range was limited to 51-66 miles per tank, depending on usage, which may not always meet the requirements of longer routes compared to diesel or compressed natural gas sweepers. • Refueling infrastructure for hydrogen was challenging with limited availability. • The reliability of the fuel cell sweeper showed room for improvement, with offline hours and work orders exceeding those of diesel and compressed natural gas models. • Some operators expressed safety concerns about refueling and maintenance due to high-pressure hydrogen tanks.

ID	Sweeper-4 [Sources[108]]
CHE Category/Type/ Subcategory (if applicable)	Facility Support CHE/Utility Truck, Sweeper
Zero-Emission Technology	Hydrogen fuel cell
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Equipment (unknown), Holthausen, Visedo (repower) [Staff is seeking information on this demonstration.]
Product Name	[Staff is seeking information on this demonstration.]
Quantity	1
Project Description	Dutch firm Holthausen and Finnish manufacturer Visedo in cooperation with the municipality of Groningen, converted a diesel-powered sweeper utility vehicle to use a hydrogen fuel cell.
Location	Netherlands, Hoogezand (non-seaport/intermodal railyard project)
Funding Source (Funding Project Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	July 2017
End Date	N/A
Results	The hydrogen fuel cell sweepers operate at 60 decibels as compared to the 120 decibels for diesel equipment. A full filling of the hydrogen tanks allows for a day and a half of operation before needing refueling. Similar battery-electric sweepers used at Vatican City can only operate for 4.5 hours before needing a charge.

[108] Danfoss Editron, "Visedo powers revolutionary hydrogen street-sweeper," YouTube video, published on July 14, 2017, 0:24. Accessed April 18, 2025. *https://youtu.be/fkjtfdjDN1I?si=DSWwMi62uwQxR7ds*.; Wiseman, Ed, "Clean Sweep: Dutch Town Gets Hydrogen Fuel Cell Street Cleaner," *The Telegraph*, July 19, 2017. Accessed April 17, 2025. *https://www.telegraph.co.uk/cars/news/clean-sweep-dutch-town-gets-hydrogen-fuel-cell-street-cleaner/?ICID=continue_without_subscribing_reg_first*.

Infrastructure/Charging Solution Demonstrations

Charging Infrastructure

ID	Charging Infrastructure-1 [Source[109]]
Category/Type	Infrastructure/Wireless Charging Station (Inductive Charging)
Project Type	Demonstration
OEMs, Equipment, or Service Provider	A35
Product Name	Dynamic Wireless Power Transfer system
Quantity	1
Project Description	Demonstration of the "Arena of the Future'" circuit built by A35, Stellantis, and other partners, to field test electric charging with dynamic induction. The 1,050-meter-long circuit is located in a private area of the A35 autostrada, near the Chiari Ovest exit, and is powered with an electrical output of 1 MW. Using dynamic wireless power transfer, electric vehicles can charge wirelessly, by driving in wired lanes with an innovative system of turns installed under the tarmac.
Location	Italy, Lombardy (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	A35, Stellantis, and other partners
Fund Recipient	A35, Stellantis, and other partners
Start Date	2021
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[109] Stellantis, "'Arena del Futuro,' Innovative Dynamic Induction Charging Becomes a Reality," December 2, 2021. Accessed February 13, 2025. *https://www.stellantis.com/en/news/press-releases/2021/december/arena-del-futuro-innovative-dynamic-induction-charging-becomes-a-reality?adobe_mc_ref=&adobe_mc_ref=*.

ID	Charging Infrastructure-2 [Sources[110]]
Category/Type	Infrastructure/Fast Charger
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	BYD Charger
Quantity	2
Project Description	Demonstration of one 200-kW BYD charging station and one 70-kW BYD charging station. The charging stations provided power for one battery-electric top handler and one battery-electric yard truck, respectively, at LBCT at the Port of Long Beach.
Location	United States, California, Port of Long Beach, LBCT
Funding Source (Funding Name)	CARB (CCI/LCTI, C-PORT)
Fund Recipient	Port of Long Beach
Start Date	Spring 2018
End Date	Summer 2021

[110] Ghazal Razeghi, Micheal Mac Kinnon, and Scott Samuel, "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission- and Heavy-Duty Vehicles Operating at a Port Terminal, "California Energy Commission, 2023. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf.*; California Air Resources Board, "LCTI: The Commercialization of POLB Off-Road Technology 'C-PORT' Demonstration," n.d. Accessed March 28, 2025. *https://ww2.arb.ca.gov/lcti-commercialization-polb-road-technology-c-port-demonstration.*; Port of Long Beach "Zero-Emissions Yard Equipment Enters Port Service,", February 25, 2020. Accessed March 28, 2025.*https://polb.com/port-info/news-and-press/zero-emissions-yard-equipment-enters-port-service-02-25-2020/.*

Results	• Data from the demonstration showed that the battery-electric top handler was able to perform over a work shift comparable to that of diesel equipment. • The battery-electric yard tractor was equipped with battery packs ranging from 150 to 240 kWh. According to C-PORT demonstration reports, the average energy consumption was 15.2 kWh per hour (±5 kWh), with daily usage averaging 5.4 hours (±3.1 hours), resulting in a daily energy use of approximately 85 kWh (±50 kWh). On average, these tractors used about 50% (±30%) of their state of charge each day. However, in some cases, daily energy demand exceeded battery capacity, requiring the tractors to be charged twice per day.

ID	Charging Infrastructure-3 [Source[111]]
Category/Type	Infrastructure/Battery Storage System
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	BYD 2.6-Megawatt Battery Storage System
Quantity	1
Project Description	The project aims to deploy equipment and infrastructure, conduct emissions testing, and demonstrate zero and near-zero emission technologies with commercialization potential. The project includes a 2.6 MW battery storage system from BYD.
Location	United States, California, Port of Los Angeles
Funding Source (Funding Name)	CARB (CCI/LCTI, Multisource Green Omni Terminal Project)
Fund Recipient	Port of Los Angeles
Start Date	June 2016
End Date	December 2021
Results	As of 2020, the battery storage system is being permitted and the solar panel array installation has been delayed.

[111] California Air Resources, "LCTI: Multisource Green Omni Terminal Project," n.d. Accessed March 27, 2025. *https://ww2.arb.ca.gov/lcti-multisource-green-omni-terminal-project*.

ID	Charging Infrastructure-4 [Sources[112]]
Category/Type	Infrastructure/Fast Charger
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	[Staff is seeking information on this demonstration.]
Quantity	1
Project Description	One charger was installed to support charging for one BYD electric yard truck.
Location	United States, California, Port of San Diego
Funding Source (Funding Name)	CEC (San Diego Port Sustainable Freight Demonstration Project)
Fund Recipient	San Diego Port Tenants Association
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]
Results	• This provided San Diego Gas & Electric (SDG&E) with additional experience in installing EV charging, along with more accurate cost information. • This experience will help SDG&E and the Port to support future electrification of Port District tenants' cargo handling equipment and vehicles.

[112] Energetics Incorporated, et al." Final Evaluation Report," California Public Utilities Commission, April 2021. Accessed April 2, 2025. *https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/california-te-prp-final-evaluation-report-presentation.pdf*; San Diego Port Tenants Association, Sharon Cloward, Chelsea Bernie, Andrea Swanson, Anna Yee, Build Momentum, Inc., and San Diego Port Tenants Association. "San Diego Port Sustainable Freight Demonstration Project." *California Energy Commission*, March 2024. Accessed April 2, 2025. *https://www.energy.ca.gov/sites/default/files/2024-03/CEC-600-2024-006.pdf*

ID	Charging Infrastructure-5 [Sources[113]]
Category/Type	Infrastructure/Fast Charger
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	BYD Charger
Quantity	2
Project Description	This demonstration project, funded by the 2016–2017 Off-Road Advanced Technology Demonstration Program, evaluated the performance of pre-commercial zero-emission cargo handling equipment in demanding duty cycles at two terminal locations. Two 200-kW BYD charging stations were deployed to support charging for two battery-electric top handlers at the Port of Long Beach SSA Marine.
Location	United States, California, Port of Long Beach, SSA Marine
Funding Source (Funding Name)	CARB (CCI/LCTI, C-PORT)
Fund Recipient	Port of Long Beach
Start Date	Spring 2018
End Date	Summer 2021
Results	The C-PORT demonstration showed that two battery-electric top handlers used 60±13 kWh of energy per hour while operating 5 to 7 hours daily.

[113] Ghazal Razeghi, Micheal Mac Kinnon, and Scott Samuel, "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission- and Heavy-Duty Vehicles Operating at a Port Terminal, "California Energy Commission, 2023. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*.; California Air Resources Board, "LCTI: The Commercialization of POLB Off-Road Technology 'C-PORT' Demonstration," n.d. Accessed March 28, 2025. *https://ww2.arb.ca.gov/lcti-commercialization-polb-road-technology-c-port-demonstration*.

ID	Charging Infrastructure-6 [Sources[114]]
Category/Type	Infrastructure/Fast Charger
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	BYD Charger
Quantity	7
Project Description	As part of Clean Air Action Plan for the Port of Long Beach, International Transportation Service Terminal deployed seven BYD chargers to support charging for battery-electric yard trucks. Southern California Edison (SCE) is responsible for deploying utility side infrastructure to serve up to 20 battery-electric terminal yard trucks.
Location	United States, California, Port of Long Beach, International Transportation Service Terminal
Funding Source (Funding Name)	CEC/ZE Terminal Equipment Transition Project
Fund Recipient	Port of Long Beach
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]

[114] Energetics Incorporated, et al." Final Evaluation Report," California Public Utilities Commission, April 2021. Accessed April 2, 2025. *https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/california-te-prp-final-evaluation-report-presentation.pdf* ; California Energy Commission, "Port of Long Beach Zero-Emissions Terminal Equipment Transition Project," n.d. Accessed April 2, 2025. *https://www.energy.ca.gov/publications/2024/port-long-beach-zero-emissions-terminal-equipment-transition-project*; Razeghi, Ghazal, Michael Mac Kinnon, Scott Samuelsen, University of California, Irvine, and Advanced Power and Energy Program, University of California, Irvine. "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission Medium- and Heavy-Duty Vehicles Operating at a Port Terminal." *Prepared for: California Energy Commission*, 2021. Accessed April 2, 2025. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*

Results	Infrastructure construction was completed. However, charger and tractor issues caused delays outside the project scope. SCE spent $1.63 million, exceeding the approved $450,000, to install charging infrastructure for seven chargers supporting BYD electric yard tractors. The setup can support 13 more chargers. Over five months of demonstration, the tractors consumed over 10 MWh monthly.

ID	Charging Infrastructure-7 [Sources[115]]
Category/Type	Infrastructure/Fast Charger
Project Type	Demonstration
OEMs, Equipment, or Service Provider	BYD
Product Name	BYD Charger
Quantity	4
Project Description	As part of the Clean Air Action Plan for the Port of Long Beach, LBCT deployed four BYD chargers supporting battery-electric yard trucks.
Location	United States, California, Port of Long Beach, LBCT
Funding Source (Funding Name)	CEC/ZE Terminal Equipment Transition Project
Fund Recipient	Port of Long Beach
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]
Results	The terminal underwent significant renovation and had sufficient electrical capacity to support the installation of the EV chargers; therefore, SCE upgrades were not required.

[115] Energetics Incorporated, et al." Final Evaluation Report," California Public Utilities Commission, April 2021. Accessed April 2, 2025. *https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/california-te-prp-final-evaluation-report-presentation.pdf* ; "Port of Long Beach Zero-Emissions Terminal Equipment Transition Project," n.d. Accessed April 2, 2025. *https://www.energy.ca.gov/publications/2024/port-long-beach-zero-emissions-terminal-equipment-transition-project* ; Razeghi, Ghazal, Michael Mac Kinnon, Scott Samuelsen, University of California, Irvine, and Advanced Power and Energy Program, University of California, Irvine. "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission Medium- and Heavy-Duty Vehicles Operating at a Port Terminal." *Prepared for: California Energy Commission*, 2021. Accessed April 2, 2025. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*

ID	Charging Infrastructure-8 [Sources[116]]
Category/Type	Infrastructure/Hands-Free Charger
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Cavotec
Product Name	Hands-Free Charger
Quantity	1
Project Description	As part of Clean Air Action Plan for the Port of Long Beach, one Cavotec smart charger was installed to support charging for battery-electric yard trucks at LBCT.
Location	United States, California, Port of Long Beach, LBCT
Funding Source (Funding Name)	CEC (Zero-Emission Terminal Equipment Transition Project)
Fund Recipient	Port of Long Beach
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[116] Energetics Incorporated, et al." Final Evaluation Report," California Public Utilities Commission, April 2021. Accessed April 2, 2025. *https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/california-te-prp-final-evaluation-report-presentation.pdf* ; "Port of Long Beach Zero-Emissions Terminal Equipment Transition Project," n.d. Accessed April 2, 2025. *https://www.energy.ca.gov/publications/2024/port-long-beach-zero-emissions-terminal-equipment-transition-project* ; Razeghi, Ghazal, Michael Mac Kinnon, Scott Samuelsen, University of California, Irvine, and Advanced Power and Energy Program, University of California, Irvine. "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission Medium- and Heavy-Duty Vehicles Operating at a Port Terminal." *Prepared for: California Energy Commission*, 2021. Accessed April 2, 2025. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*

ID	Charging Infrastructure-9 [Source[117]]
Category/Type	Infrastructure/Grid-Electric Charging System
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Cavotec
Product Name	Grid Connected Electric Conversion System
Quantity	Connect/disconnect system for 9 RTG grid-electric repowers
Project Description	SSA Marine installed a grid-connected electric system. The system allows electric RTG cranes to disconnect from the grid using a battery container for block changes and movement to maintenance. One battery container will serve all nine cranes, stored and charged in the maintenance area and delivered by yard truck. SSA Marine will connect the cranes to SCE via four 4,000V termination points. SCE supported infrastructure upgrades including a new 12kV circuit, distribution substations, transformers, switchgears, conduit and cable, capacitor bank, etc.
Location	United States, California, Port of Long Beach, SSA Marine
Funding Source (Funding Name)	CARB (CCI/LCTI, START), CEC (POLB Zero Emission Terminal Equipment Transition Project)
Fund Recipient	Port of Long Beach
Start Date	November 2020
End Date	October 2022
Results	• While SSA Marine might have been able to accelerate the project timeline by doing multiple actions in parallel (procuring the conversion components, installing the switchgear pads, ordering the battery module, and cutting the trenches), management chose to verify each activity was completed before progressing to the next. • Port terminal space is expensive. Using it for electrical infrastructure can reduce tenant revenue.

[117] Energetics Incorporated, et al." Final Evaluation Report," California Public Utilities Commission, April 2021. *https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/california-te-prp-final-evaluation-report-presentation.pdf*.

ID	Charging Infrastructure-10 [Sources[118]]
Category/Type	Infrastructure/Mobile Power Station
Project Type	Demonstration
OEMs, Equipment, or Service Provider	DANNAR
Product Name	Mobile Power Station
Quantity	2
Project Description	DANNAR, in partnership with the San Joaquin Valley Air District, deployed California's first Mobile Power Stations at the Port of Stockton. The Mobile Power Station is a durable, battery-electric off-road mobile platform designed for multiple functions, allowing it to replace various single-purpose diesel-powered equipment. The project supports the commercial rollout of zero-emission off-road technologies and aims to significantly cut greenhouse gases, criteria pollutants, and diesel emissions—particularly benefiting nearby disadvantaged communities.
Location	United States, California, Port of Stockton
Funding Source (Funding Name)	CARB (California Climate Investment)
Fund Recipient	San Joaquin Valley Air Pollution Control District
Start Date	Summer, 2018
End Date	Summer, 2021
Results	DANNAR completed the assembly of the Mobile Power Stations and delivered them to the Port of Stockton for data collection.

[118] Dannar, "DANNAR Partners with the San Joaquin Valley Air Pollution Control District to Deploy Zero-Emission Off-Road Equipment at the Port of Stockton," PR Newswire, June 20, 2018. Accessed March 27, 2025. *https://www.prnewswire.com/news-releases/dannar-partners-with-the-san-joaquin-valley-air-pollution-control-district-to-deploy-zero-emission-off-road-equipment-at-the-port-of-stockton-300668942.html*.; California Air Resources Board, "LCTI: San Joaquin Valley Zero-Emission Cargo Handling Demonstration Project," n.d. Accessed March 27, 2025. *https://ww2.arb.ca.gov/lcti-san-joaquin-valley-zero-emission-cargo-handling-demonstration-project*

ID	Charging Infrastructure-11 [Source[119]]
Category/Type	Infrastructure/Wireless Charging Station (Inductive Charging)
Project Type	Demonstration
OEMs, Equipment, or Service Provider	InductEV
Product Name	Hands-free Charging for Battery Electric Cargo Handling Equipment
Quantity	5
Project Description	International Transportation Service Terminal at the Port of Long Beach was selected as a grant project partner to provide its high-power wireless inductive charging system for five battery-electric cargo handling units while parked, marking its first installation at a West Coast port. InductEV offers high-power wireless charging systems that utilize inductive charging pads. Current InductEV systems support wireless charging from 75 kW to 450 kW. These systems require no additional space compared to traditional wired chargers and enhance safety through fully hands-free operation.
Location	United States, California, Port of Long Beach, International Transportation Service Terminal
Funding Source (Funding Name)	CEC
Fund Recipient	International Transportation Service
Start Date	January, 2025
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[119] InductEV, "Port of Long Beach to Install Hands-Free Chargers for Electric Cargo Handling Equipment," January 29, 2025. Accessed February 3, 2025. *https://www.inductev.com/press-releases/port-of-long-beach-to-install-hands-free-chargers-for-electric-cargo-handling-equipment*.

ID	Charging Infrastructure-12 [Source[120]]
Category/Type	Infrastructure/Conductive Charging
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Kalmar and Elonroad
Product Name	Dynamic Charging
Quantity	1
Project Description	Elonroad's conductive charging technology uses a vehicle-mounted current collector that connects to charging rails on the road. This method achieves 97% energy transfer efficiency and is more cost-effective to install than inductive systems, which can lose up to 30% of energy as heat. The project will involve building a 200-meter-long electric road at Kalmar's Innovation Centre in Ljungby, Sweden. Special rails will be embedded in the ground to enable vehicles to charge dynamically.
Location	Sweden, Ljungby (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[120] John Hills, "Kalmar and Elonroad Trial Potential Dynamic Charging Breakthrough for Heavy Electric Vehicles," Electric Drives, November 28, 2024. Accessed January 3, 2025. *https://electricdrives.tv/kalmar-and-elonroad-trial-potential-dynamic-charging-breakthrough-for-heavy-electric-vehicles/*.

ID	Charging Infrastructure-13 [Sources[121]]
Category/Type	Infrastructure/Charging Station (Conductive Charging)
Project Type	Demonstration
OEMs, Equipment, or Service Provider	[Staff is seeking information on this demonstration.]
Product Name	[Staff is seeking information on this demonstration.]
Quantity	37
Project Description	The Port of Long Beach Port Advance Vehicle Electrification Project includes the installation of charging infrastructure to support battery-electric yard trucks and forklifts at Total Terminals International. The project includes a heavy-duty off-road DC fast charging system for electric yard hostlers.
Location	United States, California, Port of Long Beach, Total Terminals International
Funding Source (Funding Name)	CEC/Port Advance Vehicle Electrification Project
Fund Recipient	Port of Long Beach
Start Date	August, 2018
End Date	March, 2022
Results	[Staff is seeking information on this demonstration.]

[121] Sustainable World Ports, "Fact Sheet: Port Advanced Vehicle Electrification (PAVE) Project," August 2018. *https://sustainableworldports.org/wp-content/uploads/CEC-PAVEprojectFactSheet_8_10_18.pdf* ; Razeghi, Ghazal, Michael Mac Kinnon, Scott Samuelsen, University of California, Irvine, and Advanced Power and Energy Program, University of California, Irvine. "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission Medium- and Heavy-Duty Vehicles Operating at a Port Terminal." *Prepared for: California Energy Commission*, 2021. Accessed April 2, 2025. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*

ID	Charging Infrastructure-14 [Sources[122]]
Category/Type	Infrastructure/Renewable Microgrid
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Schneider Electric
Product Name	Microgrid
Quantity	1
Project Description	Schneider Electric was awarded the contract to design, engineer, and construct the Port of Long Beach's microgrid, which includes a 300-kW solar panel array and a 250-kW battery energy storage system. The system generates 520 MWh annually, reducing reliance on diesel backup generators and cutting the port's electricity costs by over $60,000 a year. An important element of the port's microgrid is its inclusion of both stationary and mobile battery storage.
Location	United States, California, Port of Long Beach
Funding Source (Funding Name)	CEC
Fund Recipient	Port of Long Beach and Schneider Electric
Start Date	2018
End Date	2022
Results	[Staff is seeking information on this demonstration.]

[122] Kathy Hitchens, "Port of Long Beach, Schneider Electric Start Construction on $12.2 Million Microgrid Project," Microgrid Knowledge, March 14, 2022. Accessed April 1, 2025. *https://www.microgridknowledge.com/google-news-feed/article/11427396/port-of-long-beach-schneider-electric-start-construction-on-122-million-microgrid-project*.; Darell Proctor, "Pot's Microgrid Could Be Sea Change for Industry," Power, July 1, 2019. Accessed April 1, 2025. *https://www.powermag.com/ports-microgrid-could-be-sea-change-for-industry/* ; "Charging Ahead: The Port Community Electric Vehicle Blueprint | Moving Forward Network," n.d. Accessed April 2, 2025. *https://www.movingforwardnetwork.com/project/charging-ahead-the-port-community-electric-vehicle-blueprint/* ; Energize Innovation, "Port of Long Beach Microgrid - Resilience for Critical Facilities | CEC," April 23, 2018. Accessed April 2, 2025. *https://www.energizeinnovation.fund/projects/port-long-beach-microgrid-resilience-critical-facilities*

ID	Charging Infrastructure-15 [Source[123]]
Category/Type	Infrastructure/Battery Storage System
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Sunbelt Rentals
Product Name	Battery Energy Storage System
Quantity	1
Project Description	A 600-kWh battery energy storage system will power a mobile fast charger connected to the Volvo EC230 electric excavator, allowing it to recharge during a lunch break for a full day's work. The battery energy storage system offers an emissions-free, noise-free power solution, making it ideal for portable site charging, supplementing combustion generators and providing standby power for jobsites.
Location	United States, California, Silicon Valley (non-seaport/intermodal railyard project)
Funding Source (Funding Name)	[Staff is seeking information on this demonstration.]
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[123] Press Information, "Turner Construction Company to Pilot Volvo EC230 Electric Excavator as Part of program to Reduce Emissions," Volvo Construction Equipment, August 16, 2023. Accessed February 26,2024. *https://www.volvoce.com/united-states/en-us/about-us/news/2023/turner-construction-company-to-pilot-volvo-ec230-electric-excavator/.*

ID	Charging Infrastructure-16 [Source[124]]
Category/Type	Infrastructure/Hands-Free Charger
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Tritium DCFC Limited
Product Name	DC Fast Charger
Quantity	33
Project Description	Demonstration of 175-kW chargers featuring mechanized connectors to power electric terminal tractors that move shipping containers and enhance port efficiency. This is the first large-scale port electric vehicle charging project in North America to use mechanized connectors. Stäubli Electrical Connectors supplied the hands-free, high-power Quick Charging Connector systems for the terminal's Tritium charger fleet. This advanced technology enables automatic connection between Tritium chargers and the terminal tractors' charge ports, creating a seamless, zero-touch charging process. The system enhances operational safety and efficiency while reducing labor time and overall charging costs for the port.
Location	United States, California, Port of Long Beach, SSA Marine
Funding Source (Funding Name)	CARB Zero- and Near Zero-Emission Freight Facilities Project
Fund Recipient	Port of Long Beach, SSA Marine
Start Date	[Staff is seeking information on this demonstration.]
End Date	November 2023
Results	Tritium has completed the installation and operationalization of 33 of its chargers at SSA.

[124] Tritium, "Tritium Completes Installation of North America's First Mechanized Large-Scale Port EV Charging Program at Port of Long Beach," November 29, 2023. Accessed February 13, 2025. *https://tritiumcharging.com/tritium-completes-installation-of-north-americas-first-mechanized-large-scale-port-ev-charging-program-at-port-of-long-beach/*.

ID	Charging Infrastructure-17 [Source[125]]
Category/Type	Infrastructure/Wireless Charging Station (Inductive Charging)
Project Type	Demonstration
OEMs, Equipment, or Service Provider	WAVE
Product Name	WAVE Wireless System
Quantity	1
Project Description	The Port of Los Angeles demonstrated an electric top loader with a fuel cell range extender. WAVE provided a 250-kW wireless inductive charging system to support charging.
Location	United States, California, Port of Los Angeles, Fenix Marine Services
Funding Source (Funding Name)	CARB (CCI/LCTI)
Fund Recipient	Center for Transportation and the Environment
Start Date	May 2018
End Date	May 2022
Results	[Staff is seeking information on this demonstration.]

[125] California Air Resources Board, "LCTI: Demonstration of Zero-Emission Technologies for Freight Operations at Ports," n.d. April 1, 2025. *https://ww2.arb.ca.gov/lcti-demonstration-zero-emission-technologies-freight-operations-ports*.

ID	Charging Infrastructure-18 [Sources[126]]
Category/Type	Infrastructure/Wireless Charging Station (Inductive Charging)
Project Type	Demonstration
OEMs, Equipment, or Service Provider	WAVE
Product Name	Inductive Charging System
Quantity	12
Project Description	The project will deploy ten BYD second-generation battery-electric yard trucks and charging infrastructure at West Basin Container Terminal. WAVE will be responsible for designing and demonstrating inductive charging technology to support charging for battery-electric yard trucks. The project also includes a battery energy storage system to minimize peak-demand charges.
Location	United States, California, Port of Los Angeles, West Basin Container Terminal
Funding Source (Funding Name)	CEC (Advanced Infrastructure Demonstration), South Coast Air Quality Management District
Fund Recipient	Port of Los Angeles
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[126] The Port of Los Angeles, "Zero Emission Freight Vehicle Advanced Infrastructure Demonstration (AID) Project," n.d. Accessed April 2, 2025. *https://kentico.portoflosangeles.org/getmedia/ffe04622-f7bc-47b4-afbd-5d385531a4d3/aid-cec-fact-sheet.*; Jason Barlow, "The Push for Zero-Emissions: Lessons Learned from California Port's Decarbonization Projects as Ports Eye Leveraging Green Technology into a Commercial Advantage," American Association of Port Authorities, October 2022. Accessed April 2, 2025. *https://aapa.cms-plus.com/files/PPM%20Residency%20Report%20-%20B%20Jason%20Barlow.pdf*; Chris, "Reports | Clean Air Action Plan." Clean Air Action Plan, n.d. Accessed April 2, 2025. *https://cleanairactionplan.org/technology-advancement-program/reports/*

ID	Charging Infrastructure-19 [Source[127]]
Category/Type	Infrastructure/Fast Charger
Project Type	Demonstration
OEMs, Equipment, or Service Provider	[Staff is seeking information on this demonstration.]
Product Name	[Staff is seeking information on this demonstration.]
Quantity	56
Project Description	This project establishes a zero-emission goods movement system from the Ports of Long Beach and Los Angeles to four freight facilities in disadvantaged communities. It includes 56 non-proprietary Level 2 chargers, along with both 50-kW and 150-kW DC fast charging units, designed to support battery-electric trucks and yard tractors.
Location	United States, California, Port of Long Beach and Port of Los Angeles
Funding Source (Funding Name)	CARB (CCI/LCTI, Volvo LIGHTS Project)
Fund Recipient	South Coast Air Quality Management District
Start Date	February 2019
End Date	September 2022
Results	• Infrastructure deployment showed longer lead times, making it challenging to align with equipment delivery. • The project faced challenges in utility interconnection approvals for integrated solar/energy storage at fleets due to different requirements.

[127] California Air Resources Board, "LCTI: Volvo Low Impact Green Heavy Transport Solution (LIGHTS) Projects," n.d. Accessed March 27, 2025. *https://ww2.arb.ca.gov/lcti-volvo-low-impact-green-heavy-transport-solutions-lights-project*.

ID	Charging Infrastructure-20 [Sources[128]]
Category/Type	Infrastructure/Battery Storage System
Project Type	Demonstration
OEMs, Equipment, or Service Provider	[Staff is seeking information on this demonstration.]
Product Name	[Staff is seeking information on this demonstration.]
Quantity	1
Project Description	As part of the Zero-Emission Freight Vehicle Advanced Infrastructure Demonstration Project at the Port of Los Angeles, a battery storage system will be installed to receive and store energy from the electrical grid. The battery storage system targets the issues of energy costs and grid reliability by "trickle charging" the battery system during off-peak hours when energy costs less and using that energy to charge yard trucks during peak energy periods when costs and demand are high.
Location	United States, California, Port of Los Angeles, West Basin Container Terminal
Funding Source (Funding Name)	CEC (Advanced Infrastructure Demonstration), South Coast Air Quality Management District
Fund Recipient	Port of Los Angeles
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[128] The Port of Los Angeles, "Zero Emission Freight Vehicle Advanced Infrastructure Demonstration (AID) Project," n.d. *https://kentico.portoflosangeles.org/getmedia/ffe04622-f7bc-47b4-afbd-5d385531a4d3/aid-cec-fact-sheet*.; Jason Barlow, "The Push for Zero-Emissions: Lessons Learned from California Port's Decarbonization Projects as Ports Eye Leveraging Green Technology into a Commercial Advantage," American Association of Port Authorities, October 2022.*https://aapa.cms-plus.com/files/PPM%20Residency%20Report%20-%20B%20Jason%20Barlow.pdf*; "San Pedro Bay Ports Technology Advancement Program, 2024 Annual Report and 2025 Priorities." San Pedro Bay Ports Clean Air Action Plan, May 2025. *https://cleanairactionplan.org/wp-admin/admin-ajax.php?juwpfisadmin=false&action=wpfd&task=file.download&wpfd_category_id=230&wpfd_file_id=5342&token=&preview=1*.

ID	Charging Infrastructure-21 [Source[129]]
Category/Type	Infrastructure/Renewable Microgrid
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Schneider Electric
Product Name	Renewable Microgrid
Quantity	1
Project Description	This project received $5 million from the CEC to demonstrate a microgrid at a facility at the Port of Long Beach to increase resiliency of future zero-emission terminals. The microgrid includes photovoltaic solar and energy storage and will be capable of operating in island mode.
Location	United States, California, Port of Long Beach
Funding Source (Funding Name)	CEC
Fund Recipient	Port of Long Beach
Start Date	March 2022
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[129] Razeghi, Ghazal, Michael Mac Kinnon, Scott Samuelsen, University of California, Irvine, and Advanced Power and Energy Program, University of California, Irvine. "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission Medium- and Heavy-Duty Vehicles Operating at a Port Terminal." *Prepared for: California Energy Commission*, 2021. Accessed April 2, 2025. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*

ID	Charging Infrastructure-22 [Sources[130]]
Category/Type	Infrastructure/Renewable Microgrid
Project Type	Demonstration
OEMs, Equipment, or Service Provider	[Staff is seeking information on this demonstration.]
Product Name	Renewable Microgrid
Quantity	1
Project Description	Port of San Diego received a $4.9M grant from the CEC to install a renewable microgrid at the Tenth Avenue Marine Terminal. The microgrid reduces greenhouse gas emissions, cut utility bills by 60%, and enhances resiliency by providing backup power to critical port facilities. The 700-kW solar photovoltaic array generates renewable energy, which is stored in a 2,700-kWh lithium-ion battery energy storage system.
Location	United States, California, Port of San Diego, Tenth Avenue Marine Terminal
Funding Source (Funding Name)	CEC
Fund Recipient	Port of San Diego
Start Date	[Staff is seeking information on this demonstration.]
End Date	[Staff is seeking information on this demonstration.]
Results	The microgrid provides load shifting and peak shaving during normal daily operations and supports utility demand response needs. The solar photovoltaic offsets energy loads on the terminal, when there is excess solar photovoltaic generation, the battery storage is charged. When the battery storage is fully charged, excess solar photovoltaic production is exported to the grid.

[130] Ghazal Razeghi, Micheal Mac Kinnon, and Scott Samuel, "A Comprehensive and Replicable Infrastructure Blueprint for Zero-Emission- and Heavy-Duty Vehicles Operating at a Port Terminal, "California Energy Commission, 2023. *https://cleanenergy.uci.edu/PDF_White_Papers/PortTerminalBlueprint2023.pdf*.; Port of San Diego, "About the Microgrid Infrastructure Project," n.d. Accessed April1, 2025. *https://www.portofsandiego.org/microgrid*.

Hydrogen Refueling Stations

ID	Hydrogen Refueling Station-1 [Source[131]]
Category/Type	Infrastructure/On-Site Hydrogen Fueling System
Project Type	Demonstration
OEMs, Equipment, or Service Provider	HTEC
Product Name	N/A
Quantity	1
Project Description	Demonstration of a stationary HTEC mobile tube-trailer hydrogen fueling system to support zero-emission hybrid fuel cell-electric yard trucks at the Port of Los Angeles. The fueling station stored up to 182 kg of hydrogen at 450 bar and provided 2 kg per minute fill without pre-cooling of the hydrogen. The station was refilled via tanker delivery.
Location	United States, California, Port of Los Angeles, TraPac Container Terminal
Funding Source (Funding Name)	CARB (CCI/LCTI, ZECAP)
Fund Recipient	Port of Los Angeles
Start Date	Spring 2019
End Date	Fall 2022
Results	• Permitting took much longer than expected. Need to engage with regulators early. • Fueling time was longer than expected. The target was three minutes, but it took longer without a cooling system.

[131] California Air Resources Board, "LCTI: Zero Emissions for California Ports (ZECAP)," n.d. Accessed April 1, 2025. *https://ww2.arb.ca.gov/lcti-zero-emissions-california-ports-zecap*.

ID	Hydrogen Refueling Station-2 [Source [132]]
Category/Type	Infrastructure/Mobile Hydrogen Refueler
Project Type	Demonstration
OEMs, Equipment, or Service Provider	IGX Group
Product Name	N/A
Quantity	1
Project Description	Demonstration of a hydrogen mobile refueler provided by IGX Group to support an electric top loader with a fuel cell range extender at the Port of Los Angeles.
Location	United States, California, Port of Los Angeles, Fenix Marine Services
Funding Source/Funding Name	CARB (CCI/LCTI)
Fund Recipient	Center for Transportation and the Environment
Start Date	May 2018
End Date	May 2022
Results	[Staff is seeking information on this demonstration.]

[132] California Air Resources Board, "LCTI: Demonstration of Zero-Emission Technologies for Freight Operations at Ports," n.d. April 1, 2025. *https://ww2.arb.ca.gov/lcti-demonstration-zero-emission-technologies-freight-operations-ports*.

ID	Hydrogen Refueling Station-3 [Sources[133]]
Category/Type	Infrastructure/Mobile Hydrogen Refueler
Project Type	Product Launch
OEMs, Equipment, or Service Provider	JBC
Product Name	N/A
Quantity	N/A
Project Description	To support hydrogen equipment, JCB has developed a mobile hydrogen fuel tanker that can be driven to equipment, allowing refueling in a similar way to diesel. It only takes minutes to fill up, which is comparable with diesel fuels.
Location	[Staff is seeking information on this demonstration.]
Funding Source (Funding Name)	N/A
Fund Recipient	N/A
Start Date	N/A
End Date	N/A
Results	[Staff is seeking information on this demonstration.]

[133] JCB, "Hydrogen. Fueling. The Future." n.d. Accessed April 1, 2024. *https://www.jcb.com/en-us/campaigns/hydrogen/hydrogen-refuelling* ; Fuel Cells Works "JCB Unveils Industry First Mobile Hydrogen Refueller," October 24, 2022. *https://fuelcellsworks.com/news/jcb-unveils-industry-first-mobile-hydrogen-refueller*.; JCB, "Wraps Come Off Hydrogen Refueller as JCB Unveils Industry First," October 21, 2022. Accessed April 9, 2025. *https://www.jcb.com/en-gb/news/2022/10/wraps-come-off-hydrogen-refueller-as-jcb-unveils-industry-first*.

ID	Hydrogen Refueling Station-4 [Source [134]]
Category/Type	Infrastructure/Hydrogen Refueling Station
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Shell Oil Products USA
Product Name	N/A
Quantity	1
Project Description	Demonstration of one of two large capacity renewable hydrogen fueling stations.
Location	United States, California, Ontario
Funding Source/Funding Name	CARB (CCI/LCTI, Port of Los Angeles "Shore to Store" Project)
Fund Recipient	Port of Los Angeles
Start Date	Spring 2019
End Date	Spring 2023
Results	The Ontario Hydrogen Station began operation in July 2021

[134] California Air Resources Board, "LCTI: Port of Los Angeles 'Shore to Shore' Project," n.d. Accessed March 27, 2025. *https://ww2.arb.ca.gov/lcti-port-los-angeles-shore-store-project*.

ID	Hydrogen Refueling Station-5 [Source [135]]
Category/Type	Infrastructure/Hydrogen Refueling Station
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Shell Oil Products USA
Product Name	N/A
Quantity	1
Project Description	Demonstration of one of two large capacity renewable hydrogen fueling stations.
Location	United States, California, Wilmington
Funding Source/Funding Name	CARB (CCI/LCTI, Port of Los Angeles "Shore to Store" Project)
Fund Recipient	Port of Los Angeles
Start Date	Spring 2019
End Date	Spring 2023
Results	The Wilmington Hydrogen Station began operation in September 2021

[135] California Air Resources Board, "LCTI: Port of Los Angeles 'Shore to Shore' Project," n.d. Accessed March 27, 2025. *https://ww2.arb.ca.gov/lcti-port-los-angeles-shore-store-project*.

ID	Hydrogen Refueling Station-6 [Sources [136]]
Category/Type	Infrastructure/Hydrogen Refueler
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Suzuki Shokan, Toyota
Product Name	N/A
Quantity	[Staff is seeking information on this demonstration.]
Project Description	The Nagoya Port demonstrated hydrogen fuel cell forklifts and hydrogen refuelers to support more sustainable operations at its terminals and logistics facilities. The hydrogen-powered forklifts operated across multiple terminal operators in Nagoya Port and were refueled with hydrogen refuelers during the five-day trial that took place in August 2024.
Location	Japan, Nagoya Port
Funding Source/Funding Name	Suzuki Shokan
Fund Recipient	[Staff is seeking information on this demonstration.]
Start Date	August 26, 2024
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[136] Dom Magli, "Port of Nagoya Introduces Fuel-cell Forklifts." Port Technology International, January 3, 2025. Accessed April 2, 2025. *https://www.porttechnology.org/news/port-of-nagoya-introducesn-fuel-cell-forklifts/*; WorldCargo News, "Hydrogen Refuelling at Nagoya ‣ WorldCargo News," January 13, 2025. Accessed April 2, 2025. *https://www.worldcargonews.com/cargo-handling-equipment/2025/01/hydrogen-refuelling-at-nagoya/?form=MG0AV3&form=MG0AV3*.; Container News, "Hydrogen Refueling Trial at Nagoya Port - Container News." January 2, 2025. Accessed April 2, 2025. *https://container-news.com/hydrogen-refueling-trial-at-nagoya-port/*.

ID	Hydrogen Refueling Station-7 [Source[137]]
Category/Type	Infrastructure/Mobile Hydrogen Refueler
Project Type	Demonstration
OEMs, Equipment, or Service Provider	Toyota Tsusho
Product Name	N/A
Quantity	1
Project Description	Toyota Tsusho developed and deployed a mobile hydrogen refueler mounted on a truck chassis. The refueler includes nine cylinders, each holding 27.5 kg of hydrogen, with a total capacity of 247.5 kg at 930 bar. It will deliver hydrogen at approximately 2 kg per minute.
Location	United States, California, Port of Los Angeles, Fenix Marine Services
Funding Source (Funding Name)	San Pedro Bay Ports Technology Advancement Program
Fund Recipient	Port of Los Angeles
Start Date	December 2023
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[137] Clean Air Action Plan, "2023 Annual Report and 2024 Priorities Technology Advancement Program," July 2024. *https://cleanairactionplan.org/wp-content/uploads/wpfd/preview_files/2023-TAP-Annual-Report(7e8750d4a701596732953c160d2ae096).pdf*.

ID	Hydrogen Refueling Station-8 [Source[138]]
Category/Type	Infrastructure/Mobile Hydrogen Refueler
Project Type	Demonstration
OEMs, Equipment, or Service Provider	[Staff is seeking information on this demonstration.]
Product Name	N/A
Quantity	1
Project Description	The project aims to deploy and demonstrate fuel cell-powered port equipment and hydrogen as a zero-emission fuel, preparing for market adoption. The hydrogen refueling system will consist of two main parts. The land-based part will be dedicated to the reception of and storage of hydrogen from an external supplier and the compression of hydrogen up to the delivery pressure (450 bar). The mobile part will store the compressed hydrogen and will include a hydrogen dispenser for the refueling of port equipment.
Location	Spain, Port of Valencia, MSC Terminal Valencia and Valencia Terminal Europe
Funding Source/Funding Name	Fuel Cells and Hydrogen Joint Undertaking
Fund Recipient	Port of Valencia
Start Date	2019
End Date	[Staff is seeking information on this demonstration.]
Results	[Staff is seeking information on this demonstration.]

[138] Sustainable World Ports, "Port of Valencia- H2Ports/ Fuel Cells and Hydrogen in Ports," 2019. Accessed March 28, 2025.*https://sustainableworldports.org/project/port-of-valencia-h2ports.*; H2 Ports," Hydrogen Refuelling Station," n.d. Accessed April 1, 2025. *https://h2ports.eu/pilots/#1560789549136-9427f977-771c*.