San Pedro Bay Ports 2024 Accomplishments & 2025 Priorities

April 2, 2025

Jacob Goldberg
Port of Los Angeles

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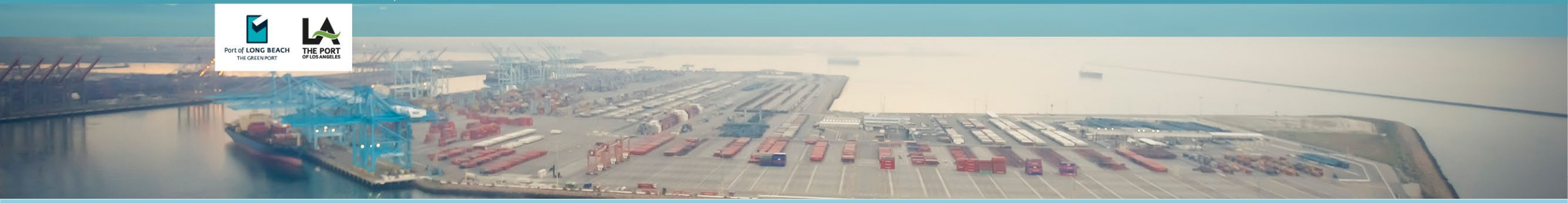
Port of Long Beach



Joint Ports' 2024 Accomplishments

Joint Ports' 2024 Accomplishments

Diesel Particulate Matter

DOWN

91%

2023 Goal 77% ✓

Nitrogen Oxides

DOWN

72%

2023 Goal 59% ✓

Sulfur Oxides

DOWN

98%

2023 Goal 93% ✓

Greenhouse Gases

20%

17%

TEUs

*Compared to 2005 Levels

**GHG emissions (CO_2e) are reported in metric tons per year; all other pollutants are shown in tons per year.

Joint Ports' 2024 Accomplishments

Diesel Particulate Matter
DOWN
20%

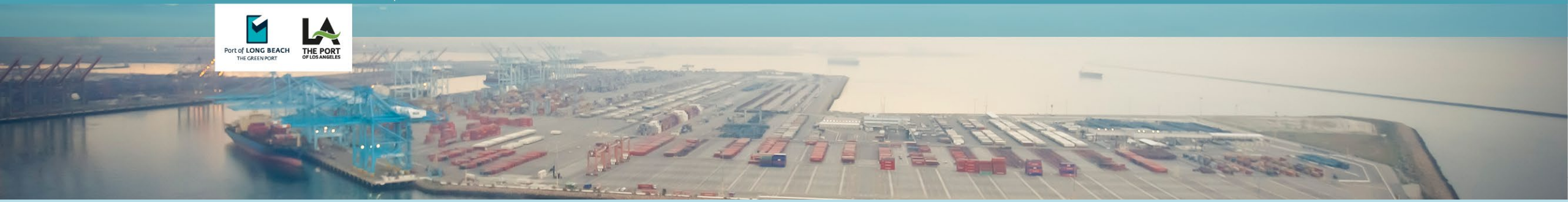
Nitrogen Oxides
DOWN
34%

Sulfur Oxides
DOWN
23%

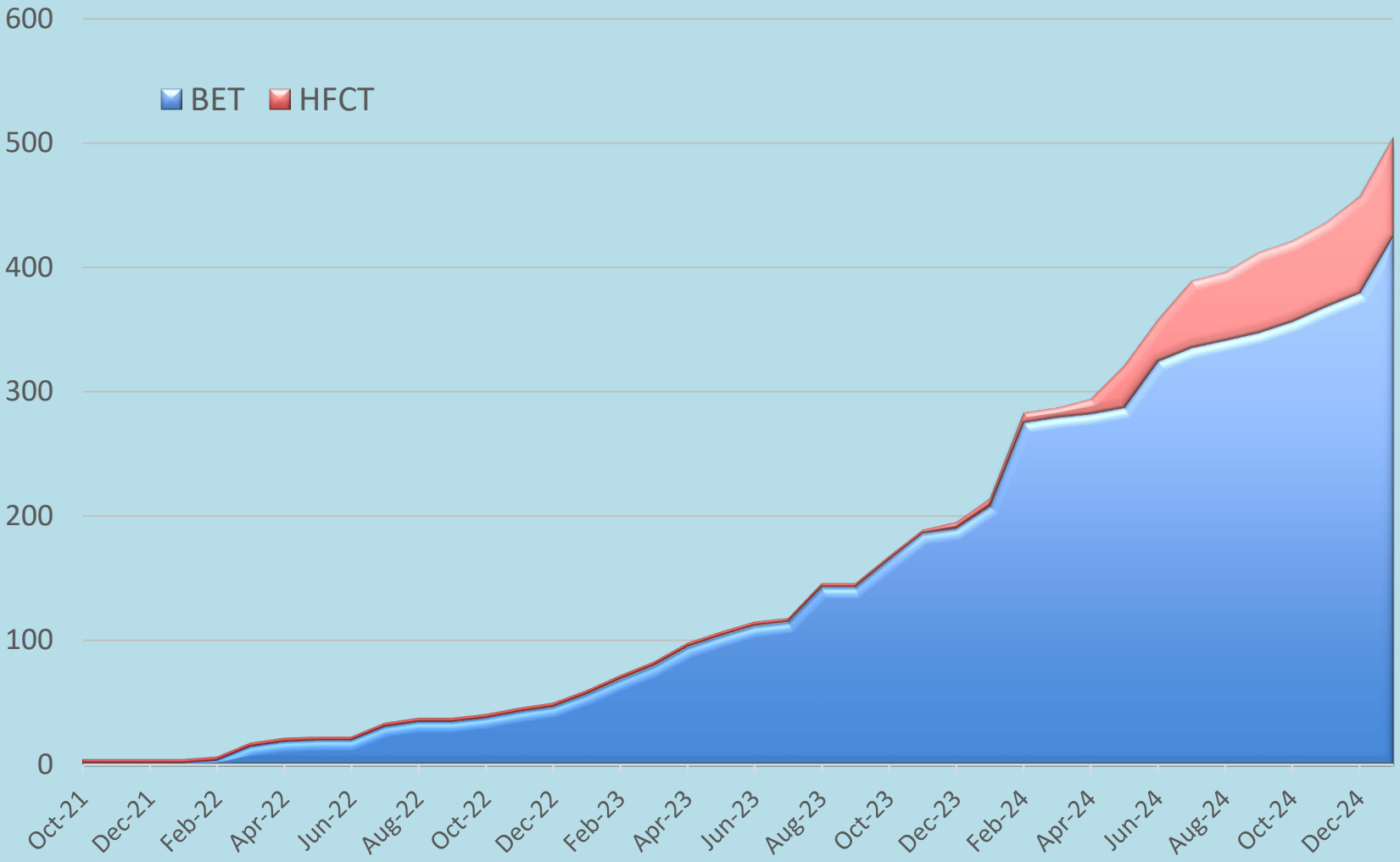
Greenhouse Gases
DOWN
8%

TEUs
1%

*Compared to 2017 Levels
**GHG emissions (CO_2e) are reported in metric tons per year; all other pollutants are shown in tons per year.



Trucks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Trucks

- Funded 800 trucks through the Port Voucher Program, which launched in November 2023 and closed in October 2024
- Collected $85.3 million in CTF Rate dollars and allocated $36.5 million toward the purchase of ZE trucks and infrastructure projects/programs
  - Partnership with Mobile Source Air Pollution Reduction Review Committee for up to 200 charging stations in and around the Ports ($25 million)
  - Partnership with California Energy Commission for charging stations along drayage corridors near the Ports ($12 million)

Trucks

- Progressed development of on-port charging depots
  - Announced first public depot charging infrastructure on POLA property
  - Zeem Solutions Long Beach charging depot will install 42 dual port fast charging stations.
  - Additional charging stations at the Terminal Access Center
  - Charging depot at Pier B and Carrack Avenues
- Grand opening of Forum Mobility charging depot

Cargo Handling Equipment

- Progressed technology advancement though completion of demonstrations
  - Toyota Tsusho Hydrogen Top Handler and Mobile Refueler
  - POLB START Grant: electric forklift, top handler, and railcar mover demonstrations
- Continued development of zero-emission (ZE) infrastructure transition plans for terminal equipment across both Ports

Cargo Handling Equipment

- Ten ZE yard tractors with 12 inductive charging pads and battery storage at West Basin Container Terminal (CEC $7.8 Million)
- Five Commercial ZE top handlers at Yusen Terminal and world's first ZE Hydrogen Fuel Cell RTG
- Advanced contracting for 60 ZE yard tractors and infrastructure at LBCT (MARAD $30.1 million)
- POLB began development of incentive programs for terminal equipment (CALSTA $ 28.7 million)

Port of Los Angeles – SEA CHANGE Project Details

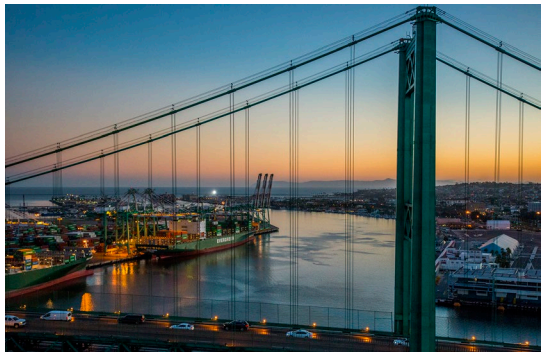
EQUIPMENT

- ~400 battery electric cargo handling equipment (CHE)
- ~250 heavy-duty drayage trucks

INFRASTRUCTURE

Upgrade and expand ZE charging infrastructure

- ~ 300 charging ports for CHE
- 4 power management systems & solar arrays
- Additional shore power for auto terminal



COMMUNITY BENEFITS

$50 million community benefits program

- Workforce development
- Community-directed grant program

Ocean Going Vessels

Shanghai Green Shipping Corridor

- Port of Shanghai added shore power facilities and enhanced their clean marine refueling capacity
- Engaged POLA/POLB fuel and bunkering service providers
- Continued to identify the Corridor clean marine fuel demand/supply status
- Engaged with the Harbor Safety Committee and community stakeholders

Ocean Going Vessels

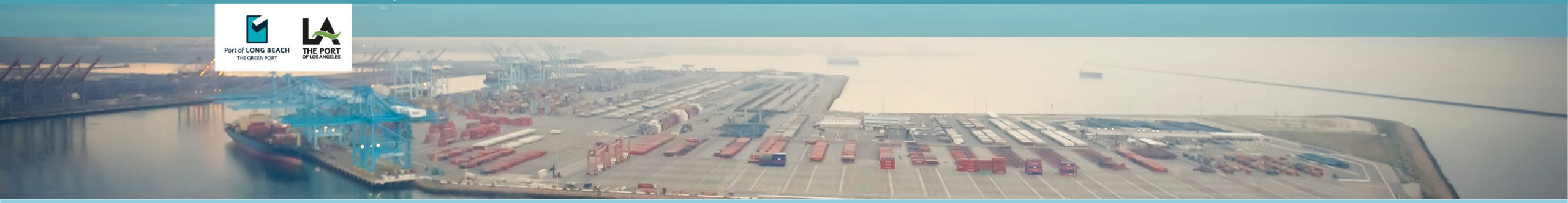
Singapore Green Shipping Corridor

- Released a Baseline Study of maritime trade flows between Singapore, Los Angeles, and Long Beach
- Nominated carrier services that will be part of the Corridor
- Singapore began bunkering clean marine fuels
- Engaged POLA/POLB fuel and bunkering service providers*
- Engaged with the Harbor Safety Committee and community stakeholders*

Ocean Going Vessels

Locomotives

- Broke ground on new $1.5bn Pier B On-Dock Rail Support Facility to increase efficiency and shift cargo from trucks to trains
- Completed Pacific Harbor Line ZE Switcher Demonstration Project
- Continued implementation of ZE Switcher Project with Union Pacific (DERA $2 million)



Harbor Craft

- POLA awarded $31 million award from CARB for the LA MER Project
  - Catalina Express
  - Harbor Breeze
  - Technology assessment and infrastructure planning

- POLB began development of incentive programs for harbor craft engine replacements (CALSTA $ 28.7 million)

2025 Priorities

Truck Priorities

- Develop strategies to accelerate the deployment of zero emission trucks in the Ports' fleet
  - Increased funding toward zero emission truck purchases
  - Complete funding cycle for truck infrastructure projects
  - Explore innovative concepts to reward early adopters
- Complete Drayage Truck 2024 Feasibility Assessment

CHE Priorities

- Develop and publicly present zero emission terminal transition plans for each port
- Accelerate ZE CHE technology development through demonstrations
- Complete 2024 CHE Feasibility Assessment
- POLB to provide financial incentives for ZE CHE

OGV Priorities

- Update Green Ship Incentive Program (ESI 2.0)
- Support tanker and RoRo terminals in installing shore power
- Progress development and implementation of Green Shipping Corridors
  - Clean marine fuel efforts
- Continue to implement OGV demonstration projects
- POLB to implement ship-to-shore power projects under CalSTA
- Accelerate deployment of at-berth emission control systems

Harbor Craft

- Advance innovative harbor craft technologies through demonstrations
- Begin development of harbor craft technology and complex-wide zero emission infrastructure assessment
- POLB to provide financial incentives for cleaner harbor craft

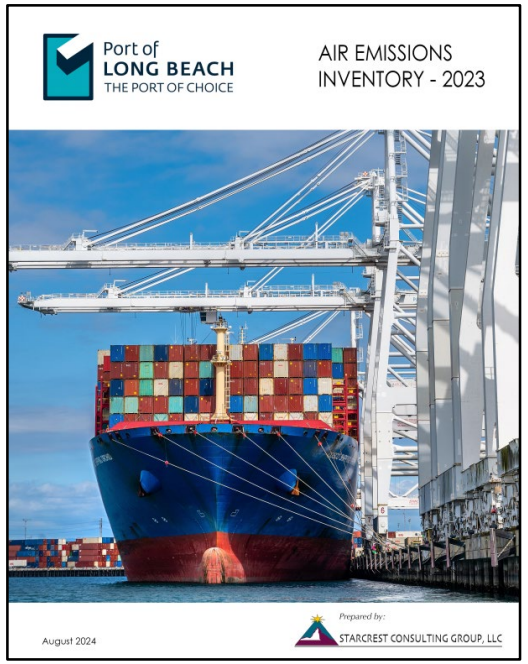
Locomotives

- POLB to provide financial incentive for zero emission locomotives
- POLA to continue EPA DERA grant to implement zero emission switcher locomotive project with Union Pacific

Emission Inventories and Air Monitoring

- 2024 Emissions Inventories
  - Air - Port of Long Beach (polb.com)
  - Air Emissions Inventory | Air Quality | Port of Los Angeles

- 2024 Air Monitoring Reports
  - Clean Air Action Plan Reports - San Pedro Bay Ports Clean Air Action Plan



Grants

- Continue monitoring local, state, and federal funding opportunities to support the CAAP
- Noteworthy programs for consideration:
  - EPA Diesel Emission Reduction Act (DERA)
  - MARAD Port Infrastructure Development Program (PIDP)
  - South Coast AQMD
    - Carl Moyer Program
    - Prop 1B
    - Climate Pollution Reduction Grant Program
  - CEC Clean Transportation Program
    - Port ZEV Infrastructure Solicitation

Thank you!

Update on 2024 Feasibility Assessment for Class 8 Drayage Trucks

April 2, 2025

Class 8 Truck Feasibility Assessment

Assess the current feasibility of zero-emission (ZE) technologies for drayage operations

Examine the readiness of supporting infrastructure and evaluate economic considerations

Analyze the operational feasibility and requirements for implementing ZE technology in port operations

Engage with various stakeholders, including port personnel, technology developers, regulatory agencies, and industry associations

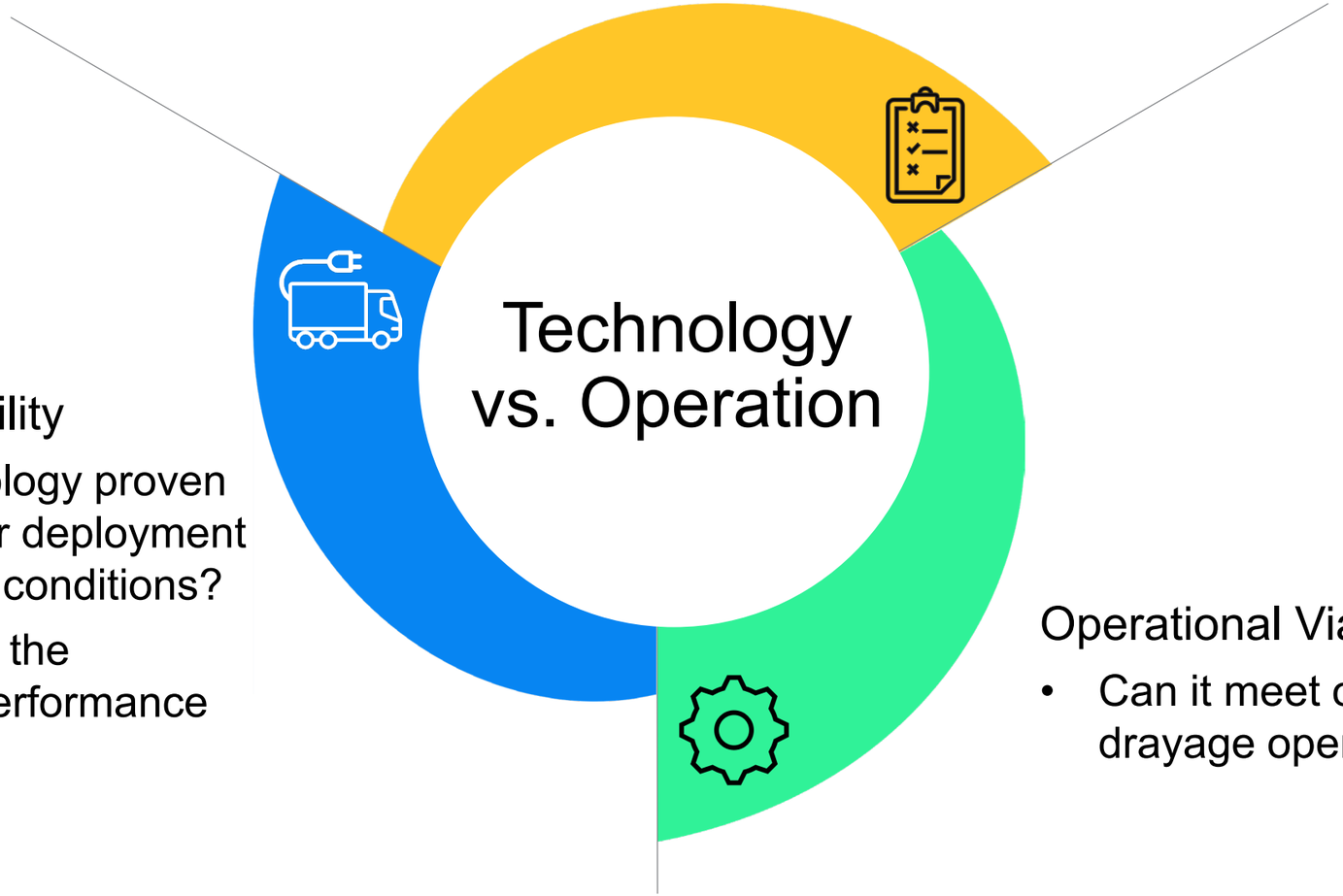
Port's Clean Air Action Plan – Feasibility Assessments

PHASE 1

June – October 2024

Commercial Viability

- Manufacturing Capability
- Production Timelines
- Support Services



Technical Viability

- Is the technology proven and ready for deployment in real-world conditions?
- Does it meet the necessary performance standards?

Operational Viability

- Can it meet operational needs of drayage operators?

Previous presentation can be found at:
https://cleanairactionplan.org/about-the-plan/stakeholder-advisory-group/

PHASE 2

November – December 2024

$ Economic Viability

- Evaluate costs associated with adopting ZE technologies compared to traditional diesel baselines

Charging & Refueling Infrastructure Accessibility

- Identify infrastructure gaps and estimate necessary charging and refueling needs

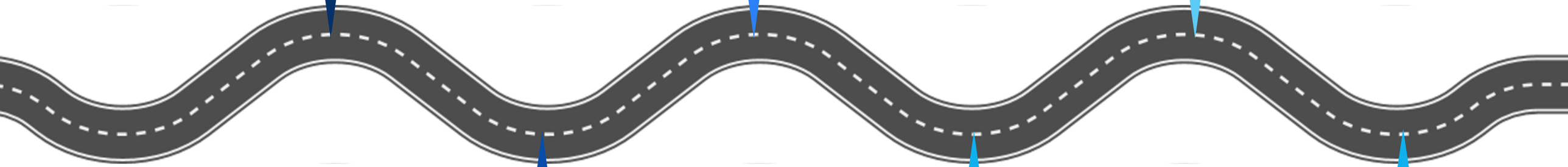
PHASE 3

January - June 2025

Combine All Viability Assessments

Assess Overall Feasibility

Engage Stakeholders for Feedback



Connect Insights

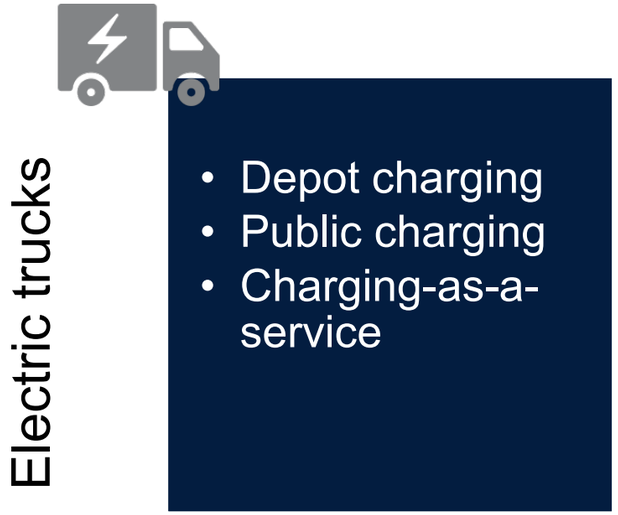
Peer Review for Accuracy

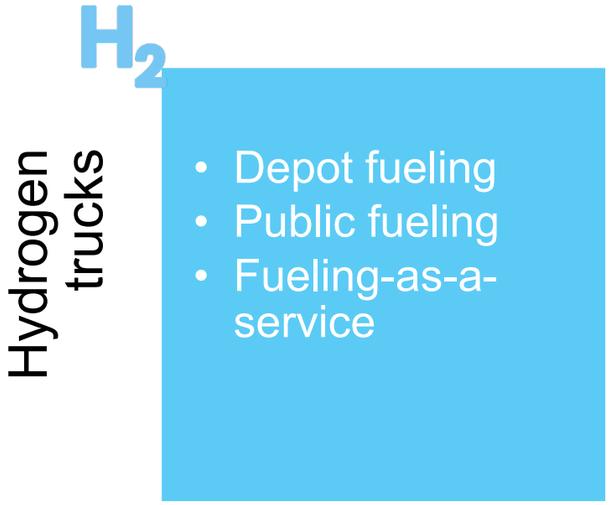
We are here!

Publish Final Report Publicly
June 2025

Economic Viability Approach

- Develop a total cost of ownership (TCO) analysis
- TCO was evaluated with and without incentives
- Establish distinct scenarios to compare costs of ZE technologies with diesel baselines





Scenarios are informed by discussions/survey with fleet operators

Economic Viability Components and Key Assumptions

Cost Category	Cost Component
Vehicle Capital Costs	Purchase Price
	State Sales and Federal Excise Tax
	Resale Value
Vehicle Operation and Maintenance (O&M) Costs	Fuel Cost
	Vehicle Maintenance Cost
	Insurance Cost
	Labor Costs for Extended Shifts
Infrastructure Costs	Infrastructure Capital and Installation Cost
	Infrastructure Make-ready
	Infrastructure O&M

Incentive Type*	Incentive Name
Regulatory, Market-Based	Low Carbon Fuel Standard (LCFS) Credits
State, Point-of-Sale Rebate	Clean Truck and Bus Voucher Incentive Project
Federal, Tax Credit	Commercial Clean Vehicle Credit
Utility, Infrastructure Rebate	SCE Charge Ready Transport (CRT)-Customer-Built
State, Infrastructure Grant	EnergIIZE Commercial Vehicles - EV fast track & Hydrogen

**Notes: The incentive values reflect base amounts and do not include any additional enhancements*

Class 8 Truck Average Operating Assumptions

1.5 shifts per day

120 miles per shift per day

5 operational days per week

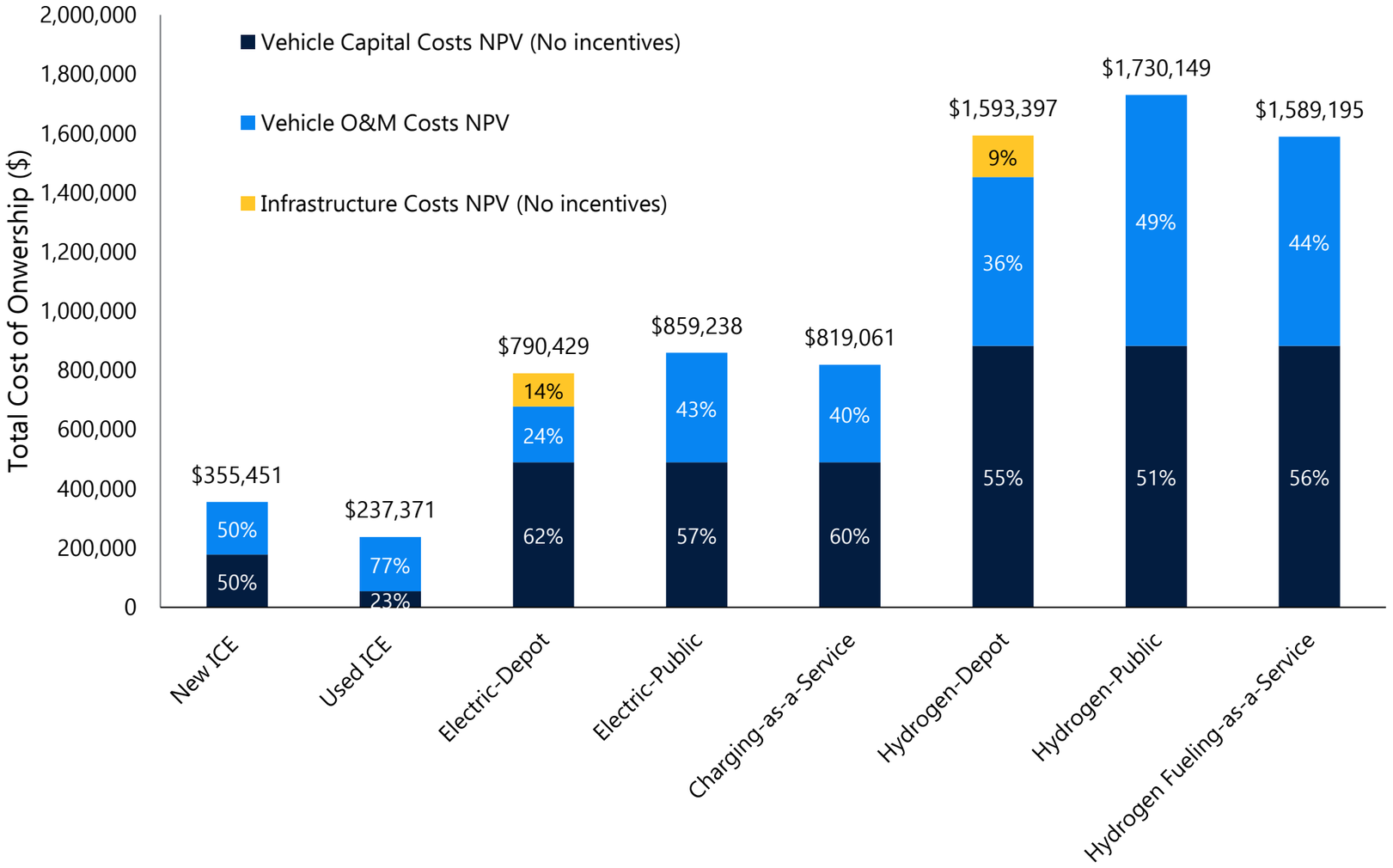
180 miles per day

46,800 miles per year

5-year ownership

Source: Operator Interviews and Survey

Total Cost of Ownership Results (No Incentives)



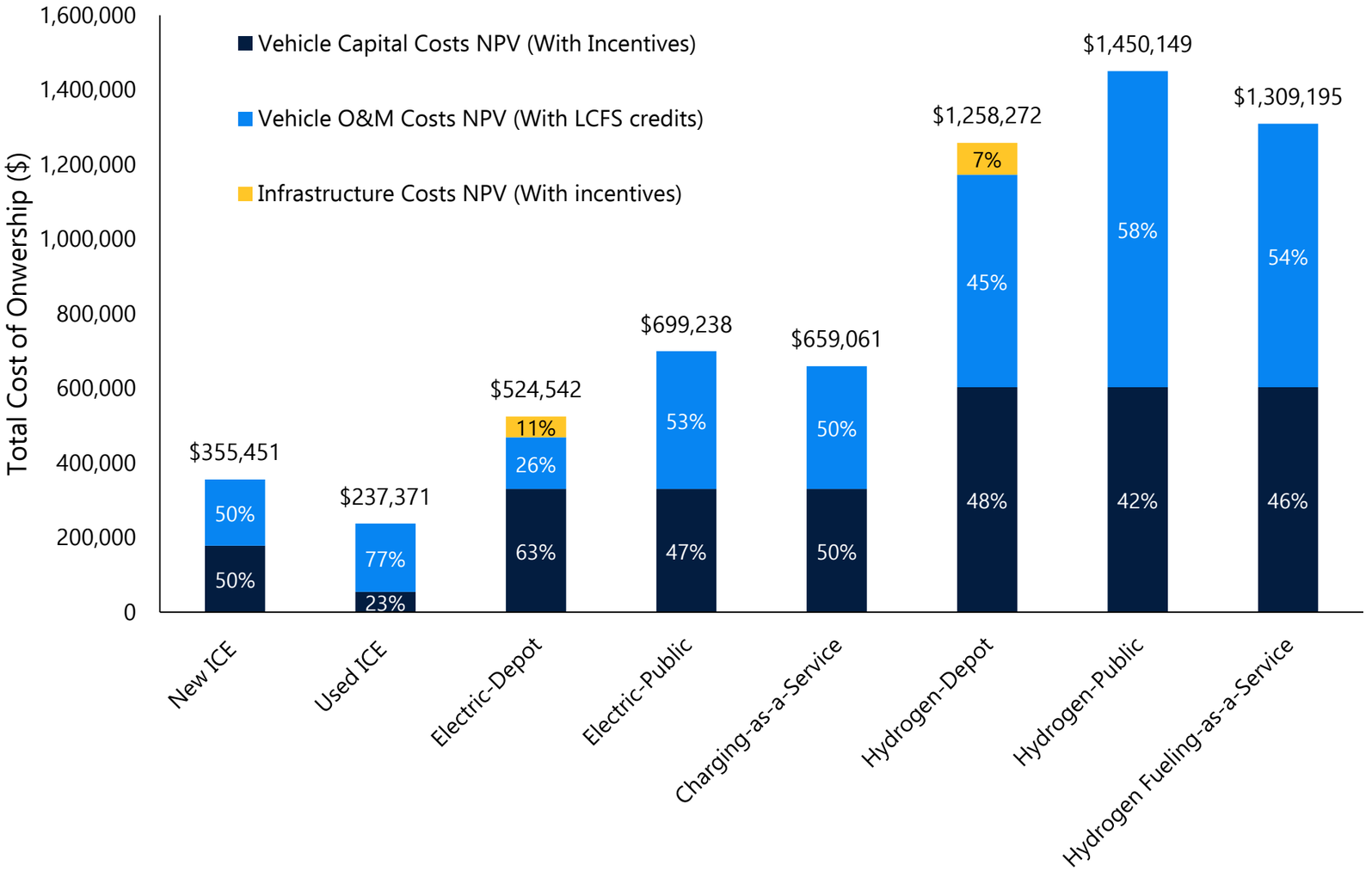
TCO:
Used ICE = Lowest
Electric = 2–2.4x New ICE
Hydrogen = 4.5–5x New ICE and 2x Electric

Vehicle Capital and Infrastructure:
ZE Trucks = 2.8–5x New ICE
Hydrogen Infrastructure = ↑ 25% than Electric

O&M:
Electric = Maintenance ↓ 20% than New ICE, but
Extra Labor Cost & Insurance = 3x New ICE
Hydrogen = Fuel cost ↑ 6x New ICE

Notes: Net Present Value (NPV) at 5% discount rate; Costs adjusted to 2024 dollars.
NPV is a financial metric that calculates the profitability of an investment by subtracting the present value of cash outflows from the present value of cash inflows, accounting for the time value of money

Total Cost of Ownership Results (With Incentives)



TCO with Incentives

Electric trucks:
Up to 34% *

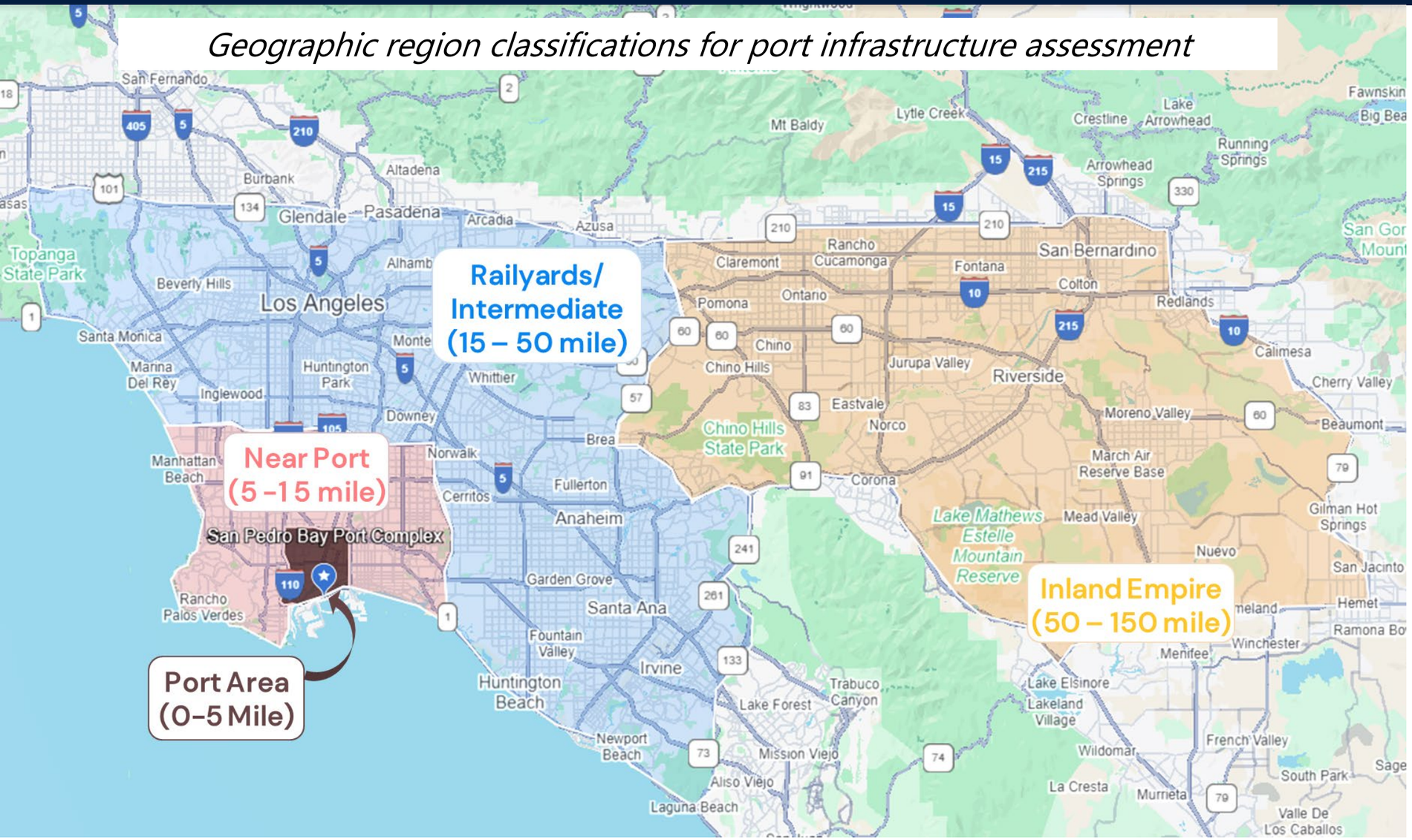
Hydrogen trucks:
Up to 21% *

**Lower compared to the TCO with no incentives*

Notes: Net Present Value (NPV) at 5% discount rate; Costs adjusted to 2024 dollars.
NPV is a financial metric that calculates the profitability of an investment by subtracting the present value of cash outflows from the present value of cash inflows, accounting for the time value of money

Charging & Refueling Infrastructure Accessibility Approach

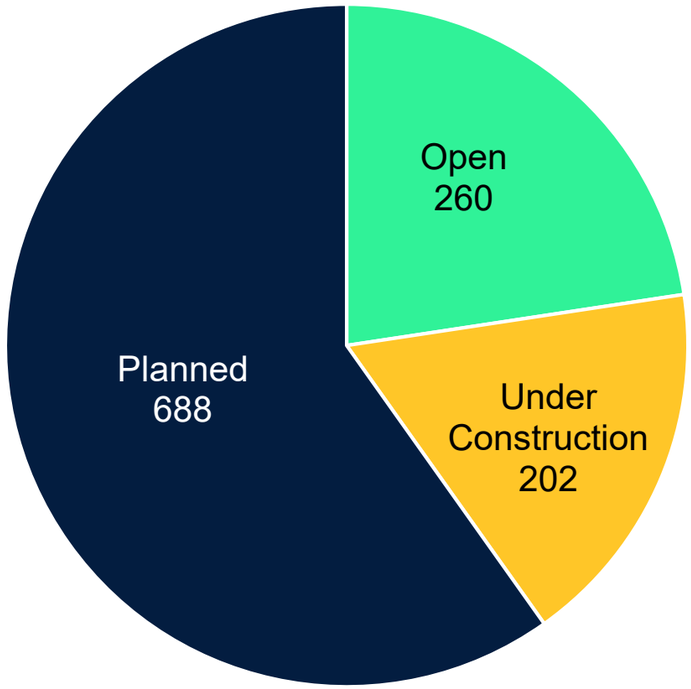
Geographic region classifications for port infrastructure assessment



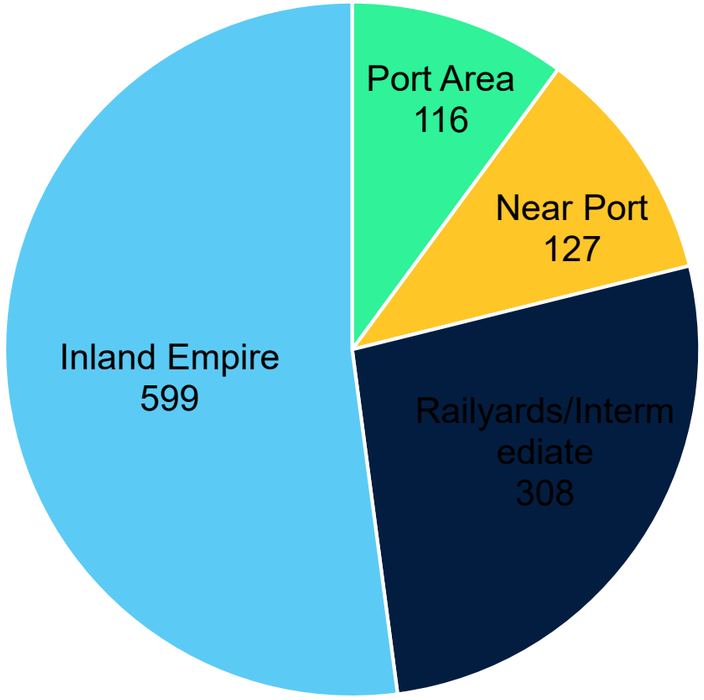
Charging and hydrogen infrastructure needs were assessed based on survey data from 42 drayage operators (1,030 trucks), factoring in trip distances, charging/refueling patterns, energy consumption rates, and infrastructure utilization.

Existing Charging Infrastructure

Total of **1,150** Charging Ports within 150-mile Radius

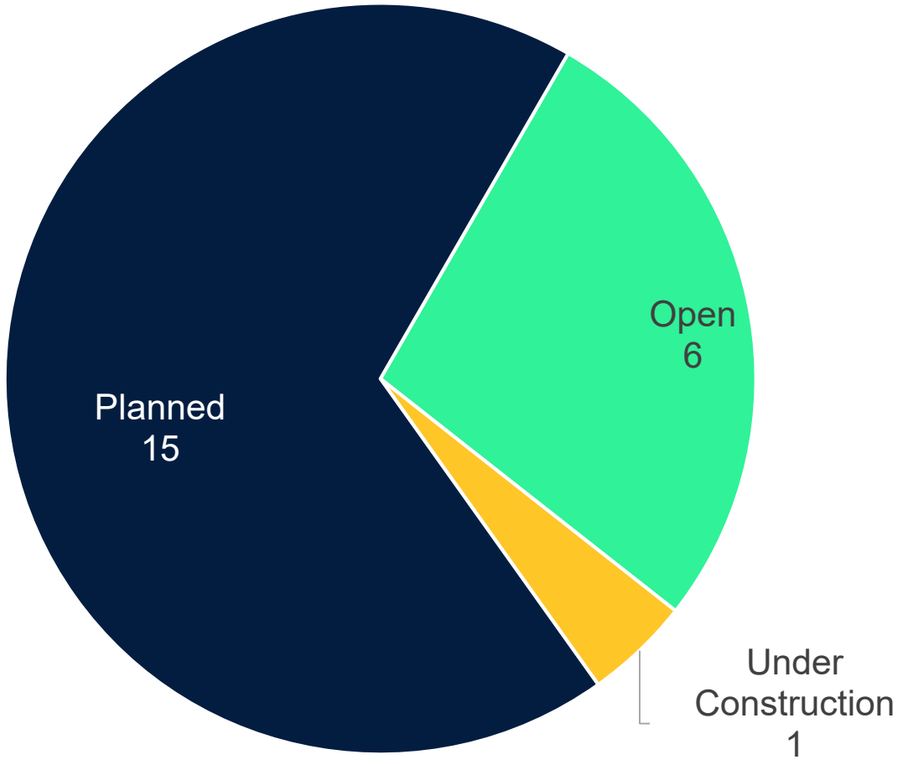


Majority within Inland Empire

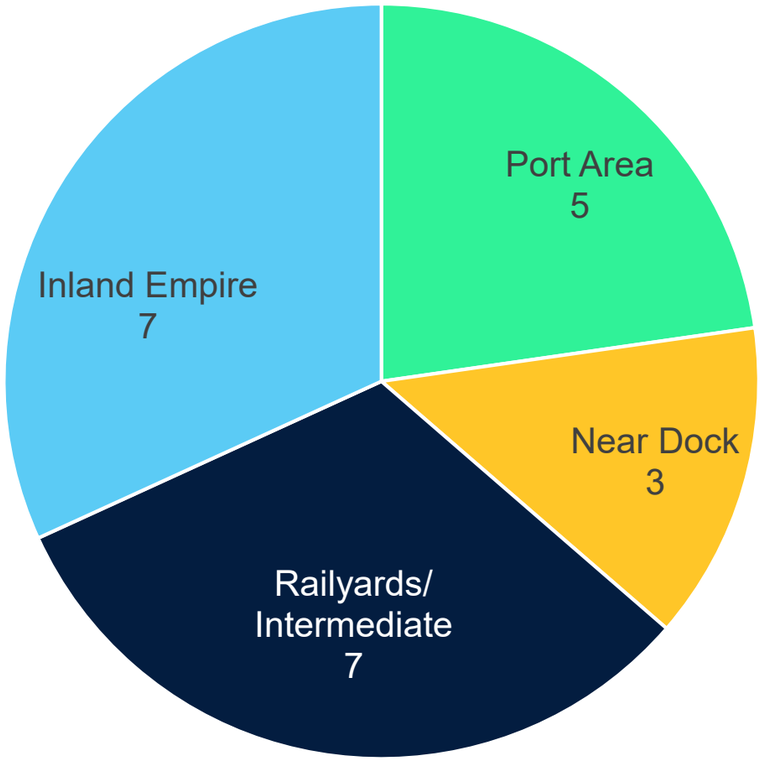


Existing Hydrogen Refueling Infrastructure

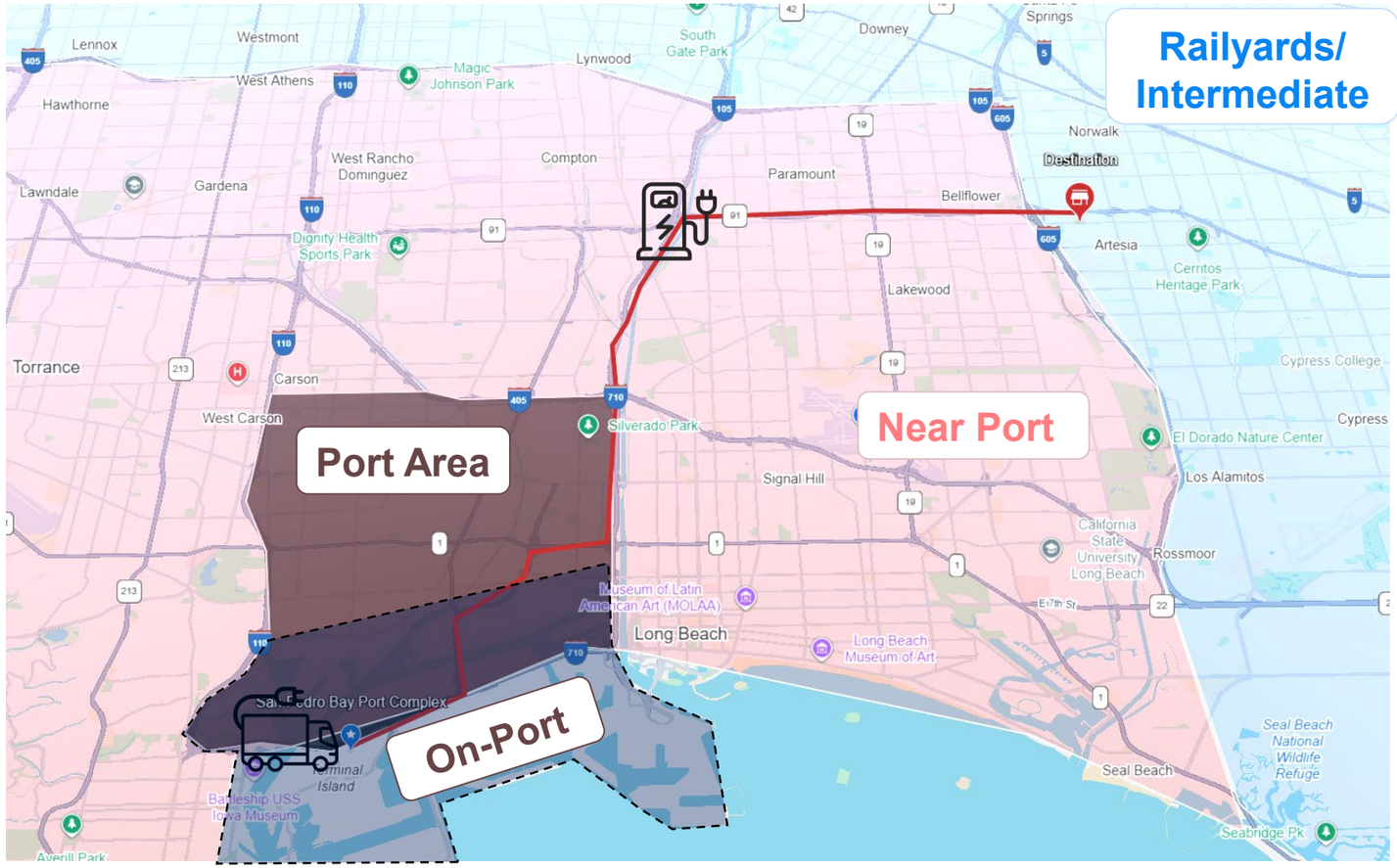
Total of **22** Hydrogen Refueling Stations



Distributed throughout the region

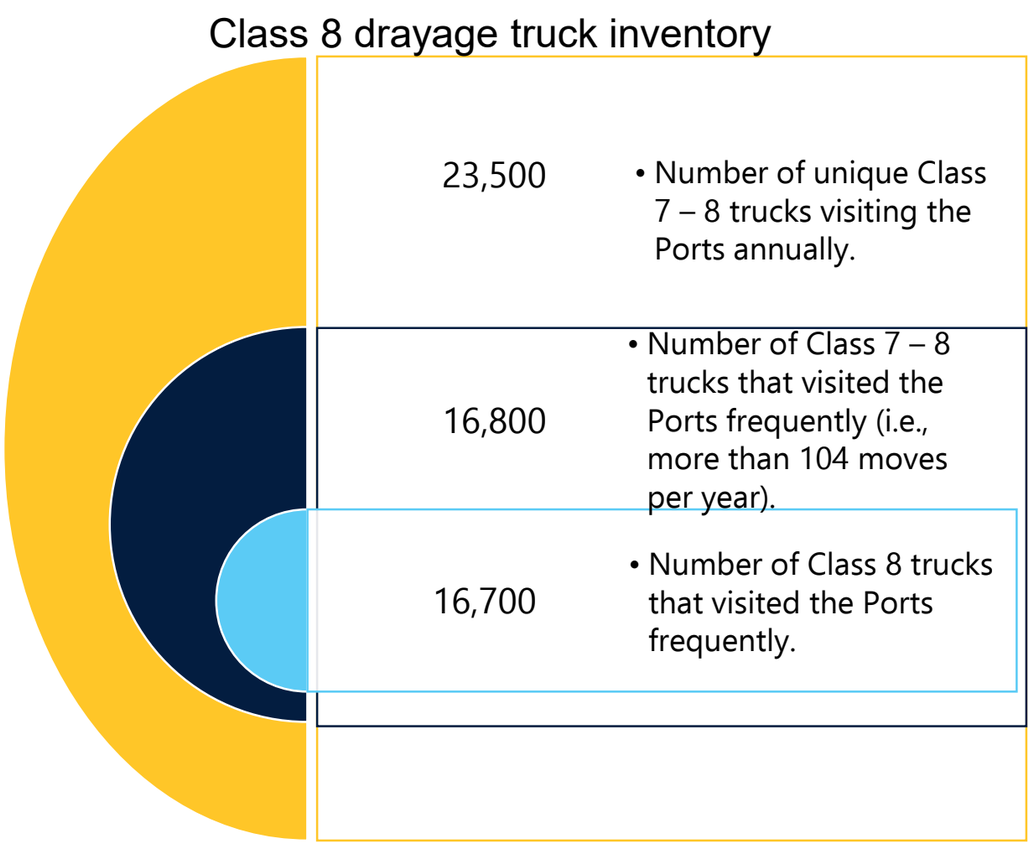


Charging Infrastructure Needs Assessment



- Analysis used survey data
- Considered truckers with and without depot charging access.
- Identified charging locations, timing, and concurrency needs.
- Determined required ports per region for sampled trucks.
- Extrapolated results to estimate total chargers for four segmented areas.

Charging and Refueling Infrastructure Needed for Full Transition to ZE



There is a need for a total of **6,200 Charging Ports** and **32 Hydrogen Refueling Stations** in the region for a full transition to ZE trucks

Fuel type	Number of Class 8 ZE trucks	**Existing** operational or in development infrastructure	Number of charging ports / hydrogen refueling stations **Needed** in the region
Battery electric trucks (BETs)	15,000	462 charging ports *(can support up to 800 BETs)*	6,200 charging ports
Hydrogen fuel cell electric trucks (FCETs)	1,700	7 hydrogen refueling stations *(with a total of 25,200 kg/day refueling capacity can support up to 350 FCETs)*	32 hydrogen refueling stations *(with a total of 123,200 kg/day refueling capacity)*

Overall Feasibility

- **ZE Trucks Are Commercially Available** – Several ZE models exist, but are best suited for specific drayage applications. BETs work well for short routes, while FCETs may support longer hauls.

- **Technology Limitations Remain** – ZE trucks are heavier, impacting payload capacity. BETs also have slow charging rates, requiring megawatt-level charging for better performance and efficiency.

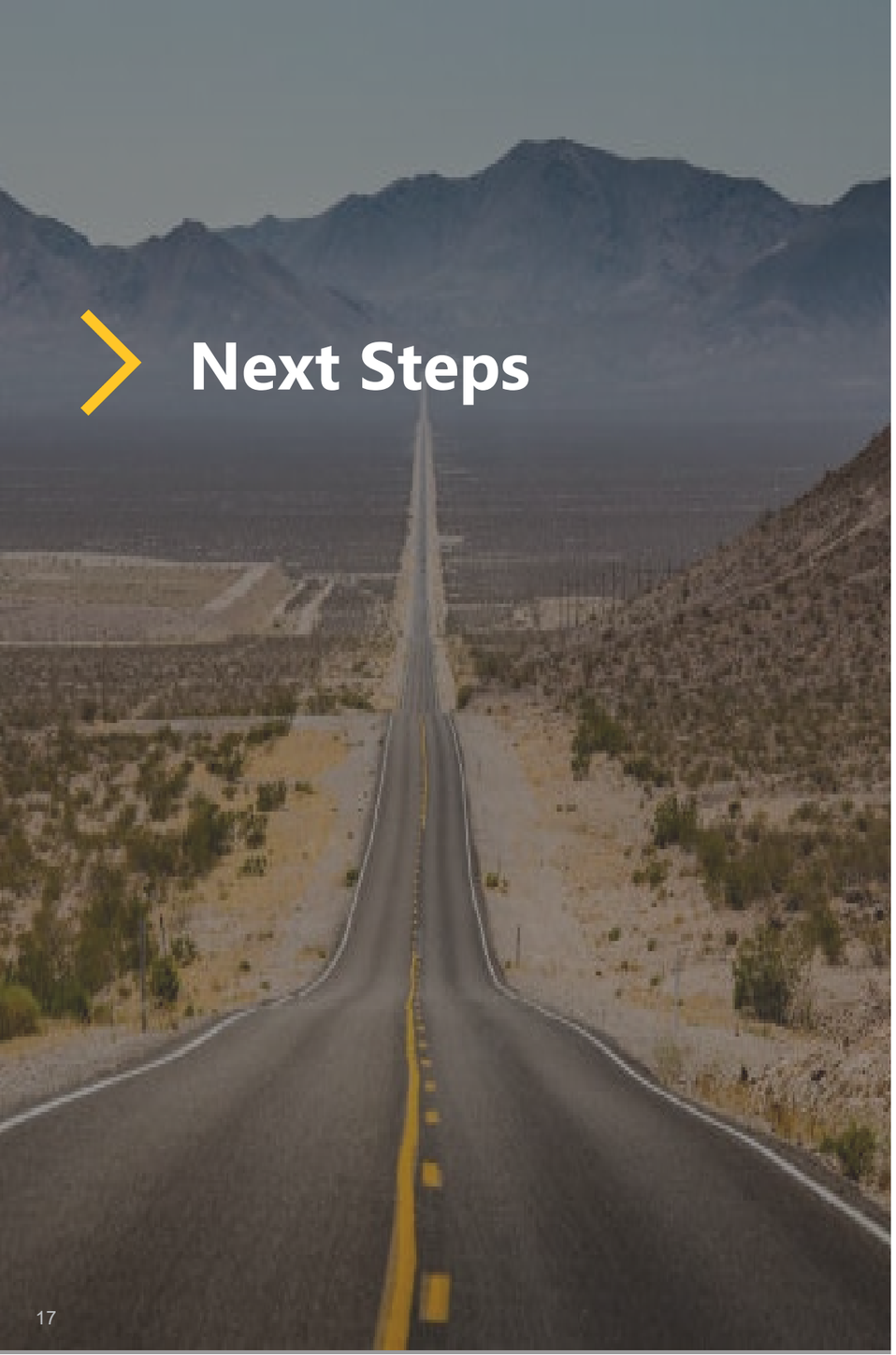
- **Operational Viability Varies** – 75% of operators could use BETs for short-haul trips, but only 67% can manage the payload constraints. FCETs offer quick refueling but face infrastructure shortages.

- **High Costs Are a Barrier** – BETs cost 2–2.5x and FCETs 4.5–5x more than new diesel trucks. Incentives help but don’t close the gap completely.

- **Infrastructure Gaps** – Current infrastructure can only support ~1,000 ZE trucks, while full adoption requires a 14x increase in charging ports and 5x increase in hydrogen capacity.

- **Major Investments Needed** – Advancing technology, lowering costs, and scaling up infrastructure are essential for achieving full ZE drayage operations, with regional support and funding for both infrastructure and trucks playing a crucial role.

Next Steps



Next Steps

Peer review for accuracy.

Draft report for public review.

Future updates to CAAP stakeholders.

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Questions?

Thank you!

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- facebook.com/ThisIsICF
- #thisisicf

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SAN PEDRO BAY PORTS

2024 CARGO HANDLING EQUIPMENT FEASIBLITY ASSESSMENT

CAAP Stakeholder Meeting
April 2, 2025

AGENDA

CAAP Stakeholder Meeting

APRIL 2, 2025

1. Approach
2. Feasibility Assessment Initial Results
    1. Yard Tractors
    2. Top Handlers
    3. Large-Capacity Forklifts
    4. Rubber-Tired Gantry Cranes
3. Schedule / Next Steps

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Feasibility Assessment Approach

In-Scope Equipment

> Develop an updated **Feasibility Assessment of Zero-Emissions (ZE) Cargo Handling Equipment (CHE)** to inform the San Pedro Bay Ports' deployment strategy in meeting their 2030 ZE targets.

> Assessment of the following battery-electric (BE) and hydrogen fuel cell (HFC) CHE:

- Rubber-tired gantry crane (RTG)

  (*Grid-electric in addition to BE and HFC)*
- Top Handler
- Large-Capacity Forklift (36,000+ lbs)
- Yard Tractor

Feasibility Assessment Approach

Evaluation Criteria

Commercial Availability

Technical Viability

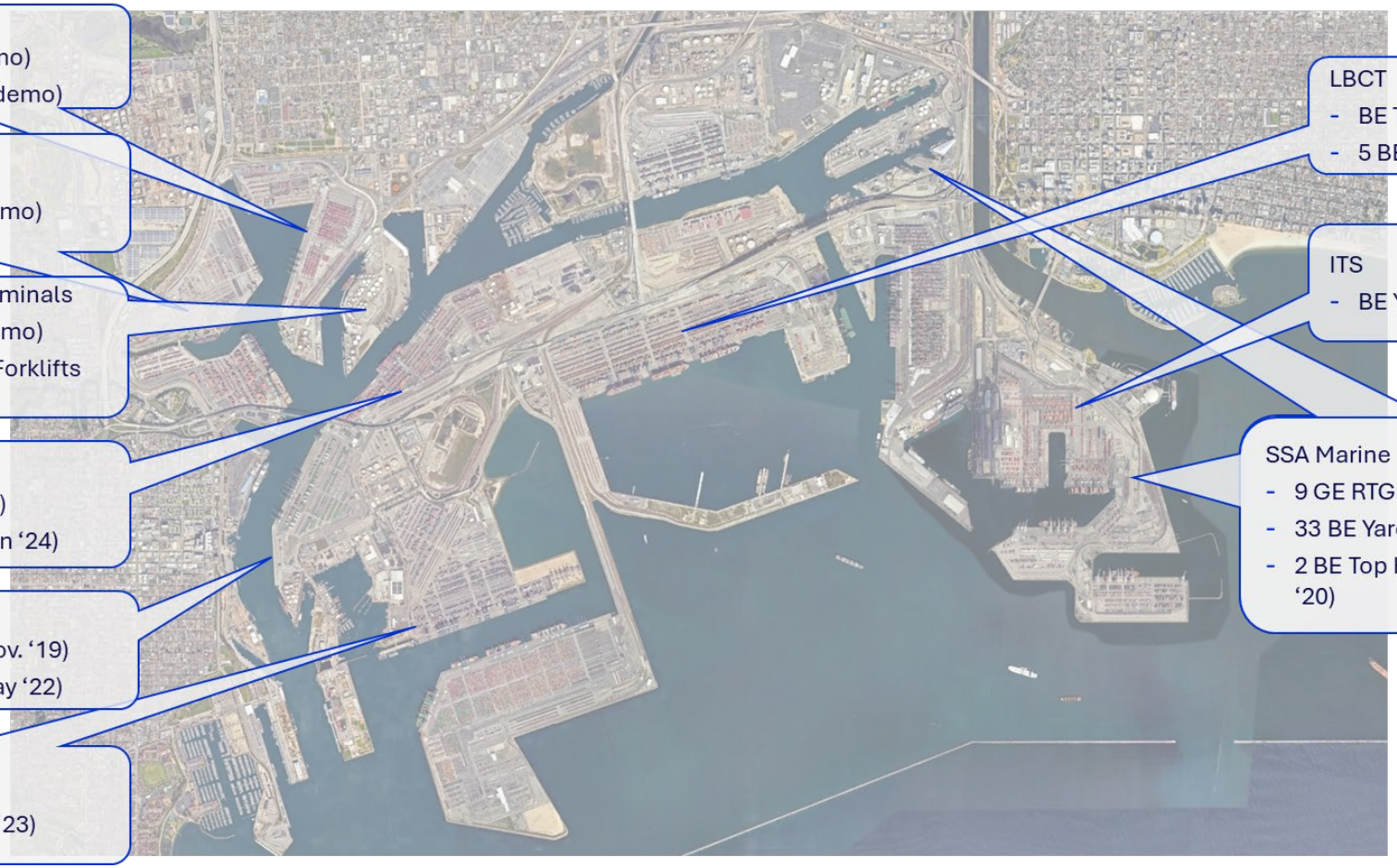
Infrastructure Availability

Operational Feasibility

Economic Workability

Ports ZE CHE Deployments

SPBP and MTO Surveys



TRAPAC
- 1 BE Yard Tractor (demo)
- 2 HFC Yard Tractors (demo)

WBCT Ports America
- 10 BE Yard Tractors (demo)

Pasha Stevedoring & Terminals
- 4 BE Yard Tractors (demo)
- 3 BE Large-Capacity Forklifts (demo)

Yusen Terminals
- 1 HFC RTG (May 2024)
- 5 BE Top Handlers (Jun '24)

Everport
- 2 BE Top Handlers (Nov. '19)
- 3 BE Yard Tractors (May '22)

Fenix Marine Services
- 2 HFC Top Handlers ('23)

LBCT
- BE Top Handler (3 yr demo)
- 5 BE Yard Tractors (demos)

ITS
- BE Yard Tractors ('20-'21)

SSA Marine
- 9 GE RTG: 3+yrs full operation
- 33 BE Yard Tractors (demo)
- 2 BE Top Handlers (demo since '20)

2021: 46 of 2,711 CHE were ZE (1.7%)
2023: 105 of 2,968 CHE were ZE (3.5%)

Industry Outreach

Equipment and Charging/Fueling Original Equipment Manufacturers (OEMs)

Equipment Vendor	Equipment Type	Electric (Grid-Tied)	Battery Electric	HFC	Charging Solution	Changing/Fueling Vendor
AutoCar, BYD, Capacity, Hyster-Yale, Kalmar, Konecranes, Mafi, OrangeEV, Sany, Taylor / Terberg	**UTR**		X		**Plug-in / hands-free** (*Static*)	Kempower, RocSys
			X		**Conductive** (*Static / Dynamic*)	ElonRoad
			X		**Inductive** (*Static*)	InductEV, WAVE
Hyster-Yale, Kalmar, Toyota, Terberg				X	**Refueling**	...
Taylor, Hyster-Yale, Kalmar, Konecranes	**Top / Side Handler**		X		**Plug-in / hands-free** (*Static*)	RocSys, Kempower
			X		**Conductive** (*Static / Dynamic*)	ElonRoad
			X		**Inductive** (*Static*)	InductEV, WAVE
Hyster-Yale, Toyota/Tsusho				X	**Refueling**	...
Hyster-Yale, Kalmar, Konecranes, Taylor, Wiggins	**Heavy Forklift**		X		**Plug-in / hands-free** (*Static*)	RocSys, Kempower
			X		**Conductive** (*Static / Dynamic*)	ElonRoad
			X		**Inductive** (*Static*)	InductEV, WAVE
Wiggins				X	**Refueling**	...
Kalmar, Konecranes, Paceco-Mitsui, Rainbow	**RTG / Yard Crane**	X			**Grid-Tied connection** (*Cable-reel / Busbar*)	Vendor Support
Konecranes		X			**Conductive** (*Dynamic*)	ElonRoad
Paceco-Mitsui, Konecranes				X	**Refueling**	...

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Infrastructure

Infrastructure Investments

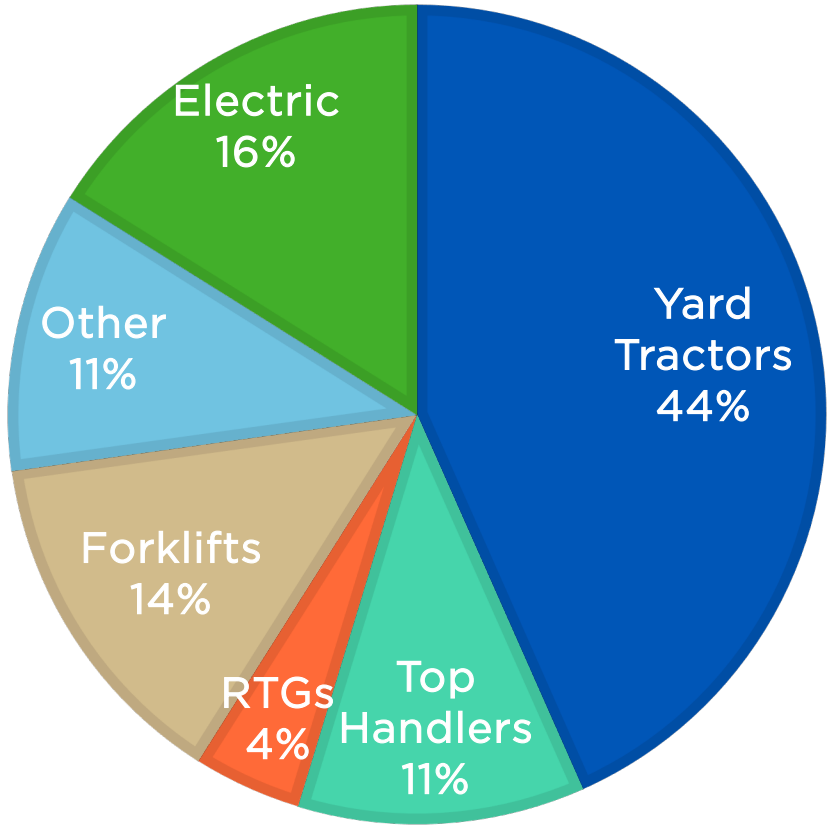
3,639 Cargo Handling Equipment in San Pedro Bay Ports

Electrification

- **On-Terminal Upgrades:** chargers, transformers, switchgear, conduits, etc.
- **Utility Upgrades:** transmission and distribution lines, substations

Hydrogen

- **On Terminal Upgrades:** storage system, compressor, dispenser, mobile refueler
- **Distribution and Delivery:** pipeline, transport trucks
- **Production:** electrolyzer, reformer



ZE CHE Operational Feasibility

Marine Terminal Operators

- **Desired:** Ability to complete two 8-hour shifts WITHOUT inter-shift charging / fueling
- **Minimum:** Ability to complete two WITH inter-shift charging / fueling

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Battery-Electric

TICO

OrangeEV

BYD

MAFI

Hydrogen Fuel Cell

Kalmar

Gaussin

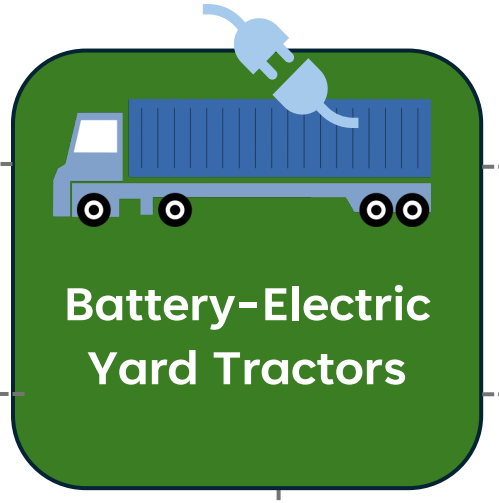
Capacity

Terberg

Yard Tractors

Battery Electric Yard Tractors

Feasibility Assessment Summary



Technical Viability

- **Operating under full range of container terminal operating conditions**
- Improvements needed to achieve comparable diesel performance (single tank endurance: 20 hrs)

Operational Feasibility

- **Complete 2 shifts <u>WITH</u> opportunity charging (30-60 minutes)**
- 210-250 kWh batteries demonstrated ability to complete 1 shift without charging
- Full charging during hoot shift (150 kW)

Commercial Availability

- **7 OEMs offer Early-Full Commercial models**
- BABA models available
- Preferred ZE technology of MTOs

Economic Workability

- **Purchase price 2X diesel yard tractors**
- Terminal and utility infrastructure upgrade costs required
- Potential operational cost savings due to:
  - Lower fuel costs (electricity v. diesel)
  - Reduced maintenance costs

Infrastructure Readiness

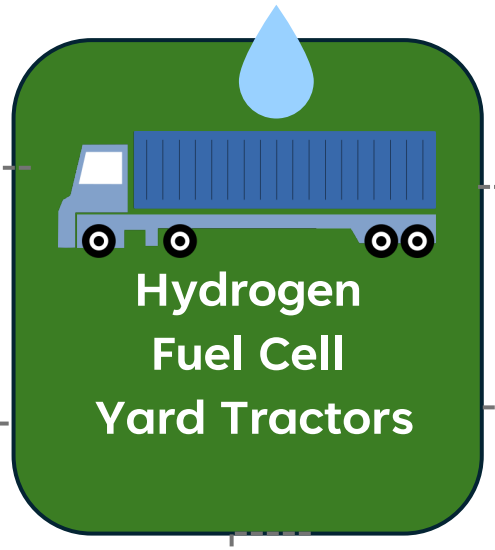
- **Planning Stage / Full Buildout: 4-5 yrs**
- Electric utility upgrades required
- Terminals electrical upgrades required
  Charging infrastructure installation required
- Charging options include:
  - manual, robotic-arm, and inductive
  - Level 2 and DCFC

Hydrogen Fuel Cell Yard Tractors

Feasibility Assessment Summary

Technical Viability

- **Prototype models, completed demonstrations at SPBP terminals**
- Improvements needed to achieve comparable diesel performance (single-tank endurance: 20 hrs)



Operational Feasibility

- **Complete 2 shifts <u>WITH</u> inter-shift fueling**
- 10 hours of operations
- Refueling times: 15 minutes

Economic Workability

- **Purchase price: HFC 3X diesel**
- **Green hydrogen fuel costs are ~ 2-3x diesel per unit of energy**

Commercial Availability

- **No OEMs** offer commercial U.S. models

Infrastructure Readiness

- **Early Planning Stage**
- Small-scale deployments with mobile solutions
- **Hydrogen fuel supply is limited**
- Transportation systems to be planned and developed
- Refueling and storage equipment required

BURNS McDONNELL

Battery-Electric

Taylor ZLC Series

Kalmar Empty Container Handler

Hydrogen Fuel Cell

Hyster-Yale

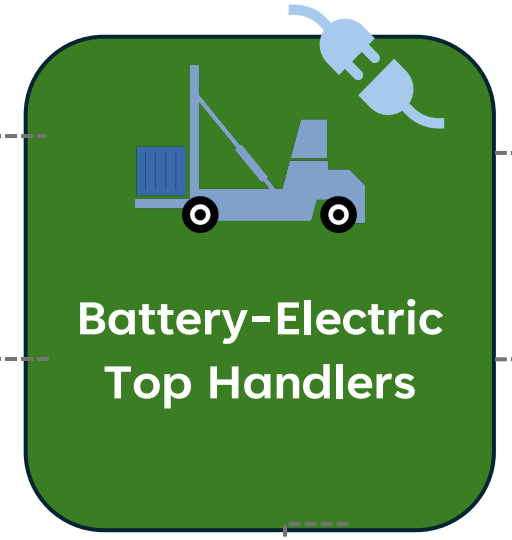
Top Handlers

Battery Electric Top Handlers

Feasibility Assessment Summary

Technical Viability

- **Operating under full range of container terminal operating conditions**
- Limited improvements needed to achieve diesel equivalent performance



Operational Feasibility:

- **Complete 2 shifts <u>WITHOUT</u> opportunity charging (yard operations)**
- **Rail operations require opportunity charging**
- Full charging during hoot shift
- Lifting capacity up to 100,000 lbs

Commercial Availability

- **5 OEMs** offer commercial models
- Early-full commercial
- BABA models available

Economic Workability

- **Purchase price 2X diesel top handlers**
- Terminal and utility infrastructure upgrade costs required
- Potential operational cost savings due to:
  - Lower fuel costs (electricity v. diesel)
  - Reduced maintenance costs

Infrastructure Readiness

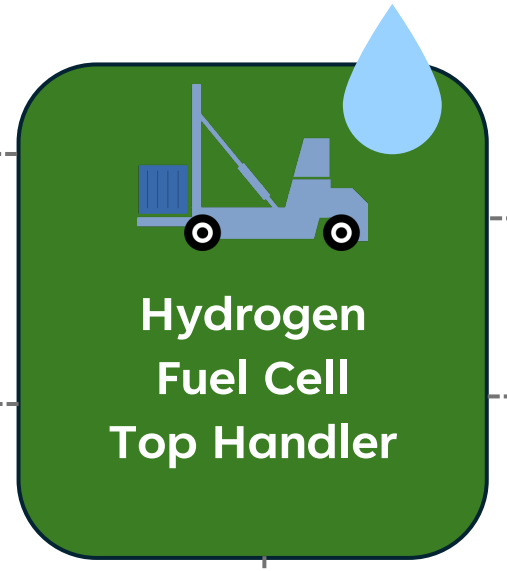
- **Planning Stage**
- Electric utility upgrades required
- Terminals electrical upgrades required Charging infrastructure installation required
- Charging options include:
  - manual, robotic-arm, and inductive
  - Level 2 and DCFC

Hydrogen Fuel Cell Top Handler

Feasibility Assessment Summary

Technical Viability

- **Full-scale prototype demonstrations**
- Improvements needed to achieve diesel equivalent performance



Operational Feasibility

- **Complete 2 shifts <u>WITH</u> inter-shift fueling**
- 10 hours of operations
- Refueling times: 15 minutes

Commercial Availability

- **No OEMs** offer commercial models
- **Pre-Commercial**
- Limited demand from MTOs

Economic Workability

- **Purchase price: HFC 3X diesel**
- **Green hydrogen fuel costs are ~ 2-3x diesel per unit of energy**

Infrastructure Readiness

- **Early Planning Stage**
- Small-scale deployments with mobile solutions
- **Hydrogen fuel supply is limited**
- Transportation systems to be planned and developed
- Refueling and storage equipment required

BURNS McDONNELL

Battery-Electric

Taylor

Wiggins

Hydrogen Fuel Cell

Wiggins

High-Capacity Forklifts (36,000+ lbs)

Battery Electric Large-Capacity Forklift

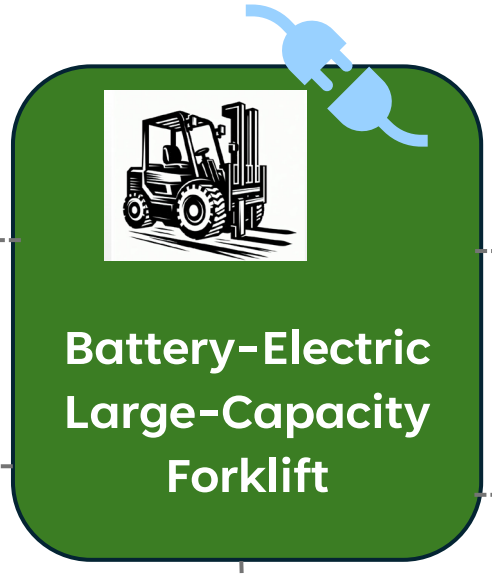
Feasibility Assessment Summary

Technical Viability

- **Operating under full range of terminal operating conditions**
- Achieved diesel equivalent performance

Operational Feasibility

- **Complete 2 shifts <u>WITHOUT</u> charging**
- Lifting capacity up to 100,000 lbs
- Full charging during hoot shift (180 kW)



Commercial Availability

- **6 OEMs** offer commercial models
- Fully Commercial
- BABA models available

Economic Workability

- **Purchase price 2X diesel forklifts**
- Terminal and utility infrastructure upgrade costs required
- Potential operational cost savings due to:
  - Lower fuel costs (electricity v. diesel)
  - Reduced maintenance costs

Infrastructure Readiness

- **Planning Stage**
- Electric utility upgrades required
- Terminals electrical upgrades required Charging infrastructure installation required
- Charging options include:
  - manual, robotic-arm, and inductive
  - Level 2 and DCFC

Hydrogen Fuel Cell Large-Capacity Forklift

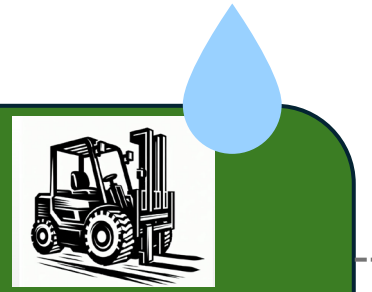
Feasibility Assessment Summary

Technical Viability

- **Operating under terminal operating conditions**
- Improvements needed to achieve diesel equivalent performance

Operational Feasibility

- **Complete 2 shifts <u>WITH</u> inter-shift fueling**
- 10-12 hours of operations
- Refueling times: 15 minutes



Hydrogen Fuel Cell Large-Capacity Forklift

Commercial Availability

- **1 OEM** offers commercial model
- Early Commercial
- Limited demand from terminal operators

Economic Workability

- **Purchase price: HFC 3X diesel**
- **Green hydrogen fuel costs are ~ 2-3x diesel per unit of energy**

Infrastructure Accessibility

- **Early Planning Stage**
- Small-scale deployments with mobile solutions
- **Hydrogen fuel supply is limited**
- Transportation systems to be planned and developed
- Refueling and storage equipment required

BURNS McDONNELL

Grid-Tied Electric

PACECO-Mitsui

Battery-Electric

Konecranes

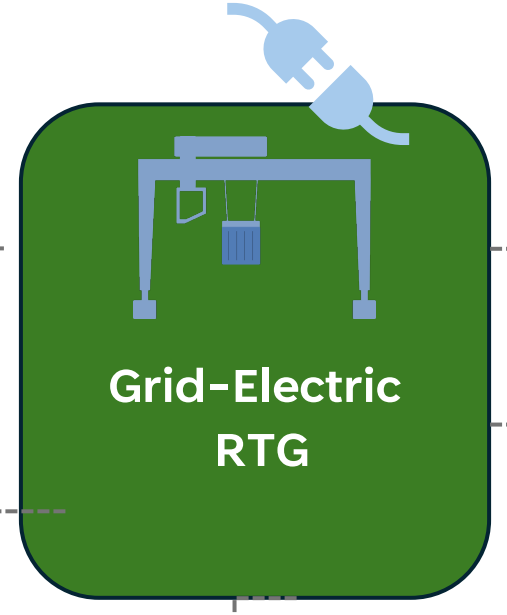
Hydrogen Fuel Cell

PACECO

Rubber-Tired Gantry Cranes

Grid-Electric Rubber-Tired Gantry Cranes

Feasibility Assessment Summary



Technical Viability

- **Operating under full range of container terminal operating conditions**
- Achieved diesel equivalent performance

Operational Feasibility

- **24/7 operational capabilities**
- Maneuverability is reduced due to the constant grid connection requirement
- Lane changes for cable reel RTG possible using batteries

Commercial Availability

- **6 OEMs** offer commercial models
- Fully Commercial
- Cable reel or busbar options

Economic Workability

- **Purchase price of grid-tied RTGs is 1.1-1.2X diesel RTGs**
- Additional costs for electrical infrastructure
- Operational cost savings due to:
  - Lower fuel costs (electricity v. diesel)
  - Reduced maintenance costs

Infrastructure Readiness

- **Planning Stage**
- **Requires dedicated trenches or collector poles for connections**
- More consistent loads and lower peak demand than BE models
- Full deployment requires terminal and grid electrical upgrades

Battery-Electric Rubber-Tired Gantry Crane

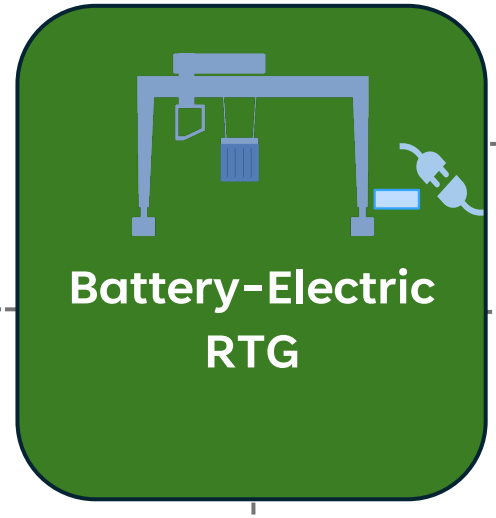
Feasibility Assessment Summary

Technical Viability

- **System completed and tested through demonstration in Europe**
- Improvements needed to achieve diesel equivalent performance

Operational Feasibility

- **Complete 2 shifts <u>WITH</u> charging**
- 296-kWh battery provides 8 hrs of ops (1 shift)
- Charging in 1 hour
- Flexible maneuverability equivalent to diesel RTGs



Commercial Availability

- **1 OEM** offers commercial model
- **Early Commercial**
- Proven technology and deployed in European terminals, but needs to be proven in U.S.

Economic Workability

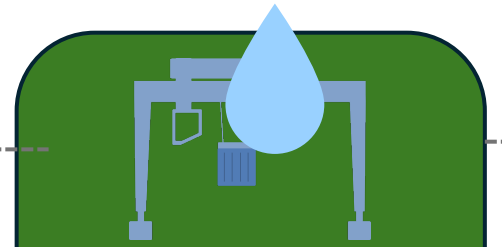
- **Purchase price similar to grid-tied RTGs (1.1-1.2X diesel RTGs)**
- Terminal and utility infrastructure upgrade costs required for chargers
- Potential operational cost savings due to:
  - Lower fuel costs (electricity v. diesel)
  - Reduced maintenance costs

Infrastructure Readiness

- **Planning Stage**
- Electric utility upgrades required
- Terminals electrical upgrades required Charging infrastructure installation required
- Charging options include:
  - Manual
  - Robotic arm

Hydrogen Fuel Cell Rubber-Tired Gantry

Feasibility Assessment Summary



Hydrogen Fuel-Cell RTG

Technical Viability

- **Full-scale demonstration at SPBP terminal**
- Achieved diesel equivalent performance

Operational Feasibility

- **Capable to operate for 2 shifts** WITHOUT **refueling**
- Refueling performed during hoot shift
- Retrofit of diesel RTGs to HFC possible

Commercial Availability

- **1 OEM** performing operational demo in POLA
- **Pre-Commercial**

Economic Workability

- Purchase price expected to be **1.25X** grid-tied RTGs
- **Green hydrogen fuel costs are ~ 2-3x diesel per unit of energy**
- Generation, transport, storage, and fueling infrastructure costs required

Infrastructure Readiness

- **Early Planning Stage**
- Small-scale deployments with mobile refuelers
- **Hydrogen fuel availability is limited**
- Transportation systems to be planned and developed
- Refueling and storage equipment required

Schedule / Next Steps

Milestones

- Research/Data Reviews: **July - September 2024**
- OEM/Operator Interviews: **September - November 2024**
- Develop Assessment: **December 2024 - April 2025**
- Peer Review Period: **April-May 2025**
- Drafts for Public Comment: **May-June 2025**
- Public Review Period: **June 2025**
- Final Assessment: **July 2025**