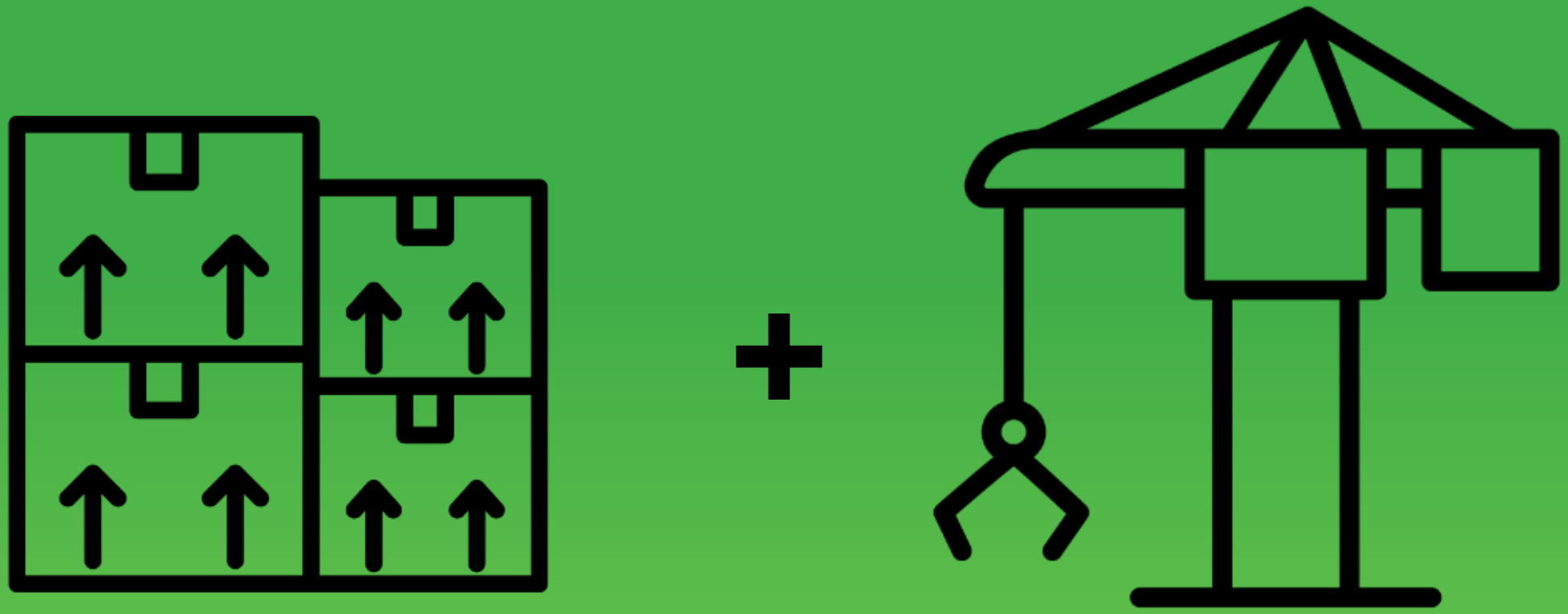
NUVERA®

MAKING THINGS BETTER:
HYDROGEN FUEL CELLS AT SHIPPING PORTS

H_2@PORTS WORKSHOP | 10–12 SEPT 2019 | SAN FRANCISCO

GUS BLOCK | DIRECTOR OF CORPORATE DEVELOPMENT



95% OF EVERYTHING

FIRST EVER MARITIME
GHG REDUCTION TARGETS

IMO

50% BY 2050

SAN PEDRO BAY PORTS

CLEAN AIR ACTION PLAN

GUIDING PRINCIPLES:

- Reduce air emissions and health risks
- Remain competitive
- Support workforce
- Strong partnerships with stakeholders

GOODS MOVEMENT SECTORS:

- Ships
- Trains
- Container Handling Equipment
- Trucks
- Harbor Craft

MAIN GOALS

- Keep the port competitive and financially sustainable
- Minimize emissions of criteria air pollutant and TACs, with a focus on reducing diesel particulate matter
- Reduce GHG emissions
- Build and strengthen partnerships among the port, port tenants, equipment manufacturers, equipment owners and operators, community organizations, regulatory agencies, and the public
- Provide opportunities for meaningful stakeholder engagement

NUVERA®

Electrification Value Drivers

Increased Efficiency

Reduced Maintenance Costs

Lower Compliance Costs

Less Noise

Eliminate Diesel Handling

Electrification Value Drivers

CARBON REDUCTION

27.5 lb of CO_2 are produced for every gallon of diesel burned

Average fuel consumption of a top loader:
≈ 3.5 gallons/hour
→ 96.3 lb CO_2/hour

At 3000 hours per year, each diesel top loader produces:

≈ 144 tons CO_2/yr

Nuvera is part of the

HYSTER-YALE GROUP

HYSTER

Yale
People. Products. Productivity.

NUVERA®

UTILEV
THE UTILITY LIFT TRUCK™

BOLZONI
The Material Handling Group

MEYER
seit 1953 Made in QUALITY

ELECTRIFICATION = EFFICIENCY

Application 1a

- Fixed break periods
- Normal power consumption

Option 1a

- Large Li-Ion battery
- Conventional charging
- Low to Medium duty cycle

Application 1b

- Fixed break periods
- Normal power consumption
- Opportunity charging

Option 1b

- Medium to Large Li-Ion battery
- Opportunity charging
- Medium duty cycle

Application 2

- Irregular break periods
- Normal to High power consumption

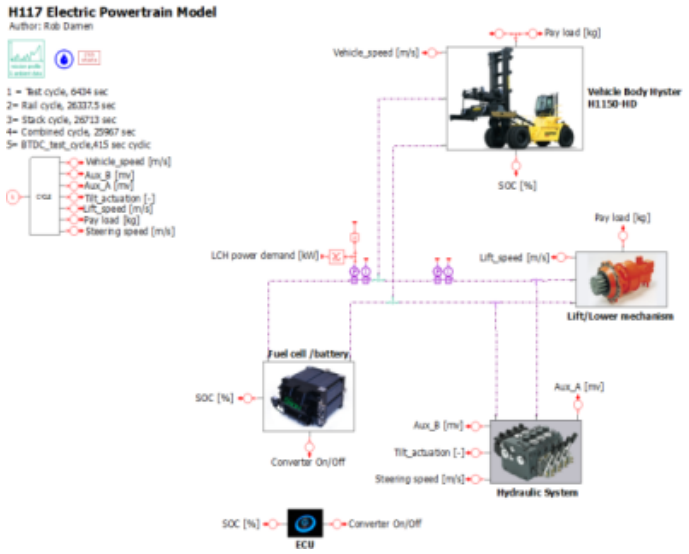
Option 2

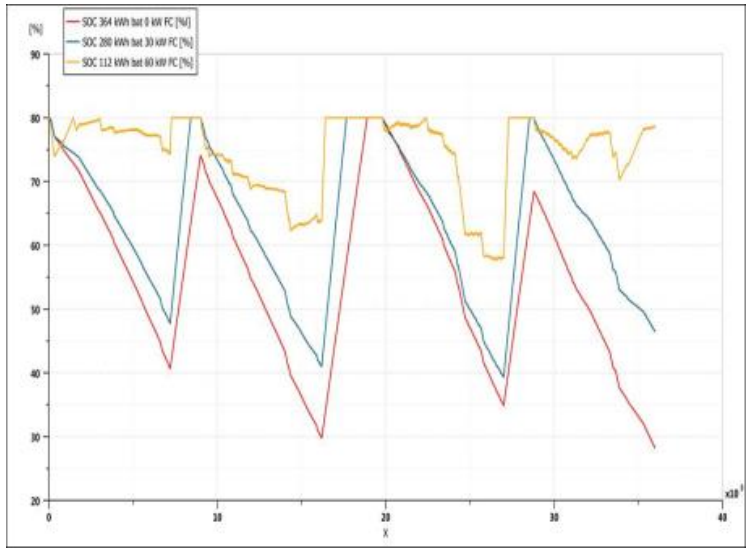
- Fuel Cell with Small Li-ion battery
- Choice of charging system
- Heavy duty cycle: 1 day w/o refill

OEM Approach for Ports and Terminal Operators

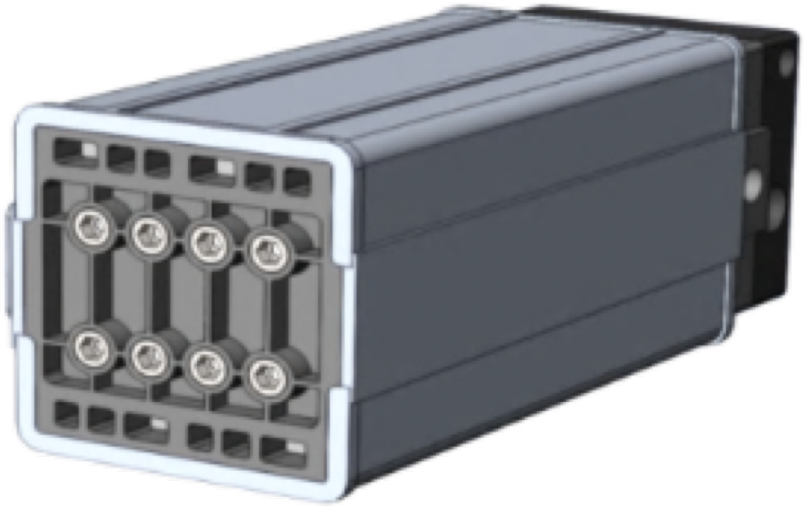
Data Collection Power & Energy → Virtual Vehicle Model → Sizing of Energy Source

Average:	Value:	Minimum:	Maximum:
[text]	[hr]	[hr]	[hr]
Run time per shift	3.4	1.3	4.2
Amount of shifts per day	3.1	1	4
Run time per day	10.6	1.3	15.7
Run time per week day	9.6	1.3	15
Run time per weekend day	12.7	7.6	15.7
Break time	3.7	0.6	15.9
Break during day	1.5	0.6	2.1
Break over night	8.5	3.5	15.9





DIVERSITY IN APPLICATIONS REQUIRE TAILORED TRUCK CONFIGURATIONS



Li-Ion Battery

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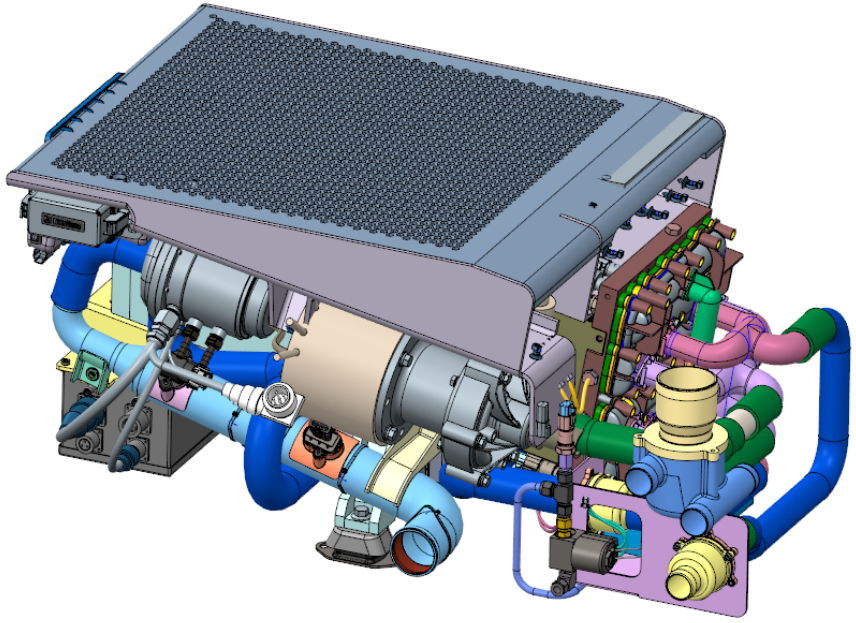
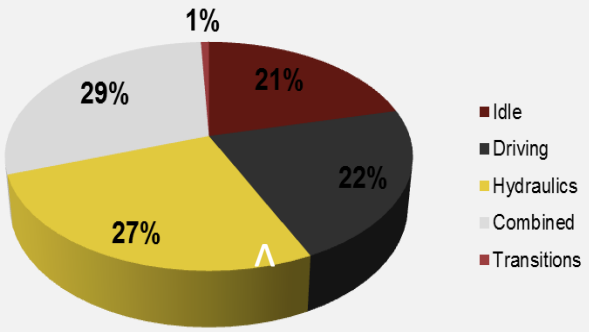


Fuel Cell

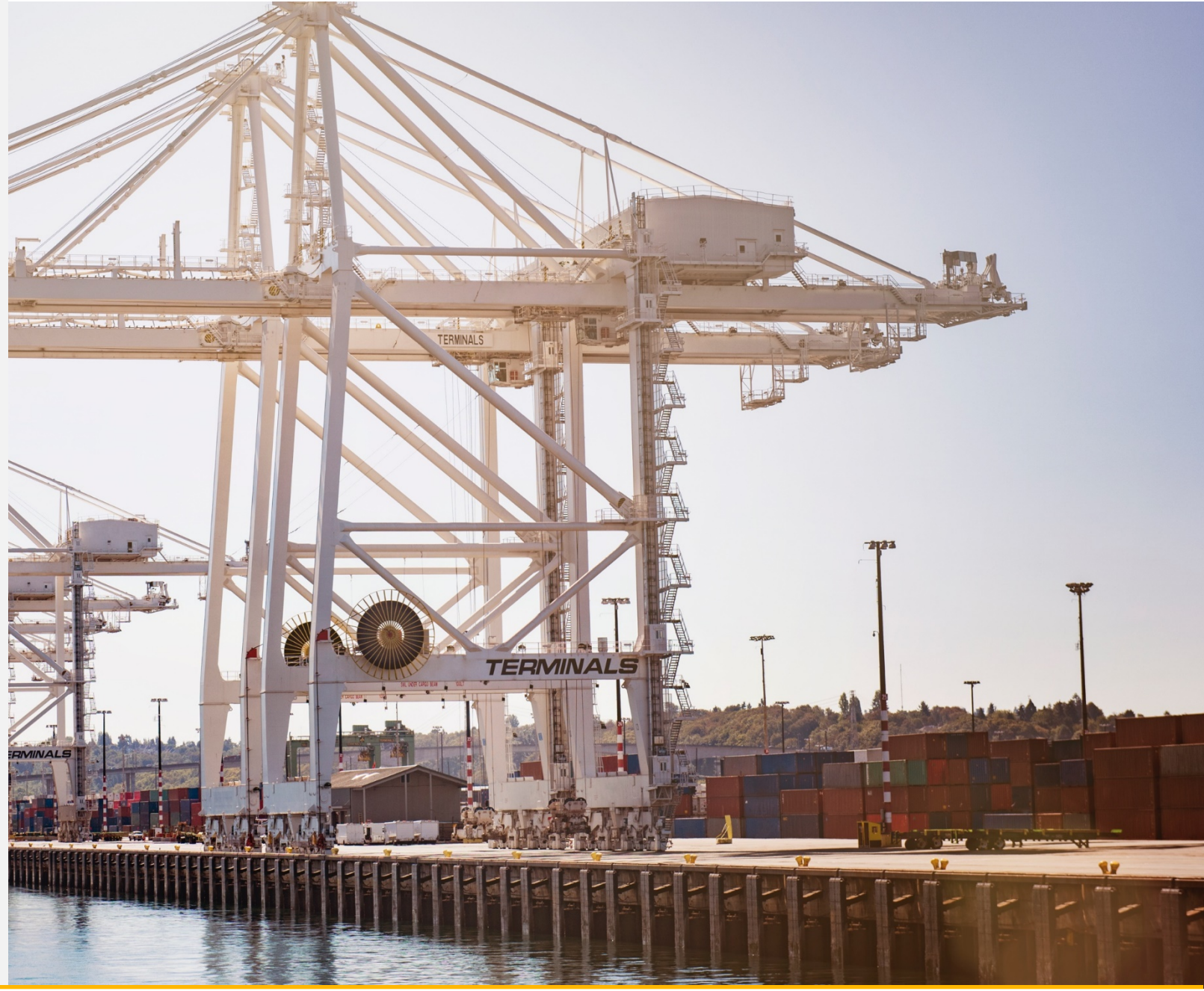
Port Operations Duty Cycles: *Yard & Dock*



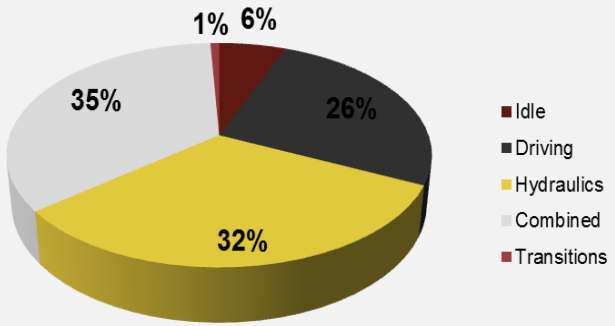
21% Idle
78% Driving & Hydraulics

Three breaks per eight-hour shift:
15 minutes | 90 minutes | 15 minutes

Requires 400 kWh



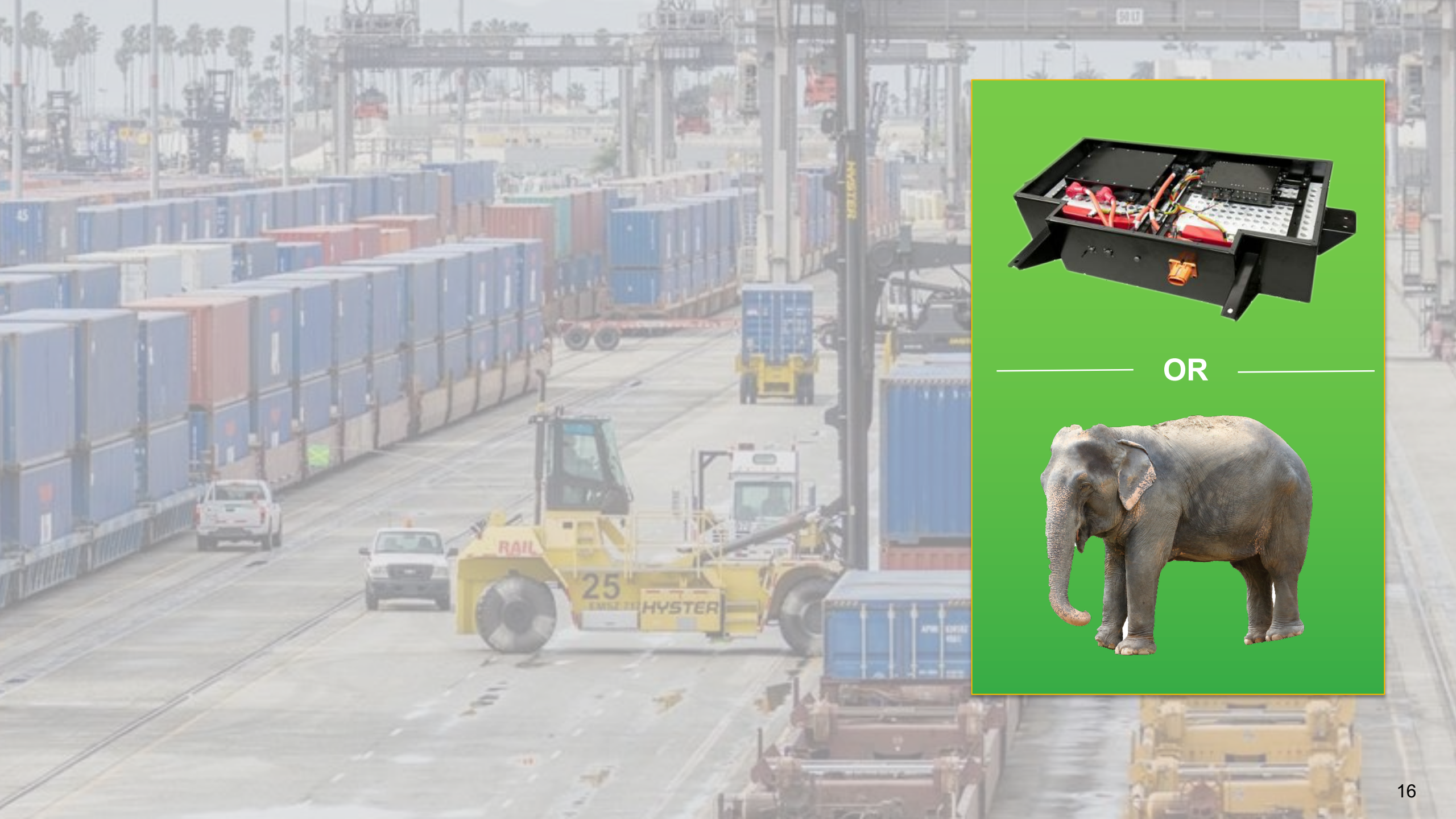
Port Operations Duty Cycles: *Rail*



3-6% Idle
93% Driving & Hydraulics

Up to seven hours no break

Requires 925 kWh



OR

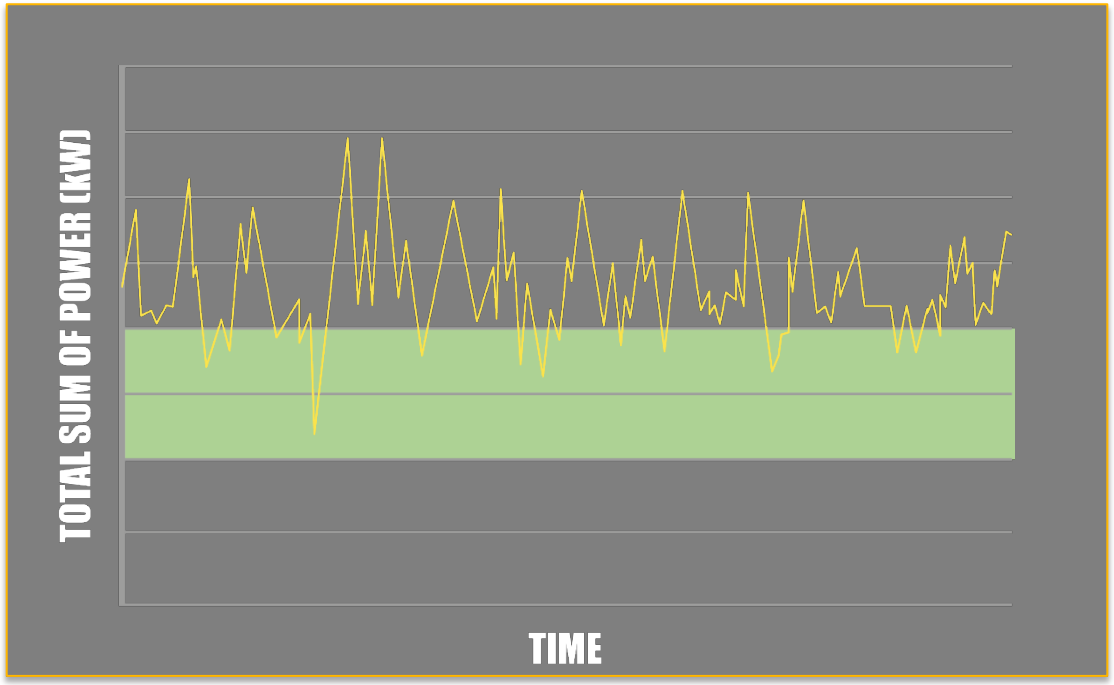
Electrification = Efficiency

Traction Energy Recovery

- 80 ton vehicle travelling at 14 mph
- ➢ 0.45 kWh kinetic energy

Hydraulic Energy Recovery

- 43 feet of lifting with 52 ton total load
- ➢ 1.8 kWh potential energy



Nuvera ® 45 kW Fuel Cell Engine

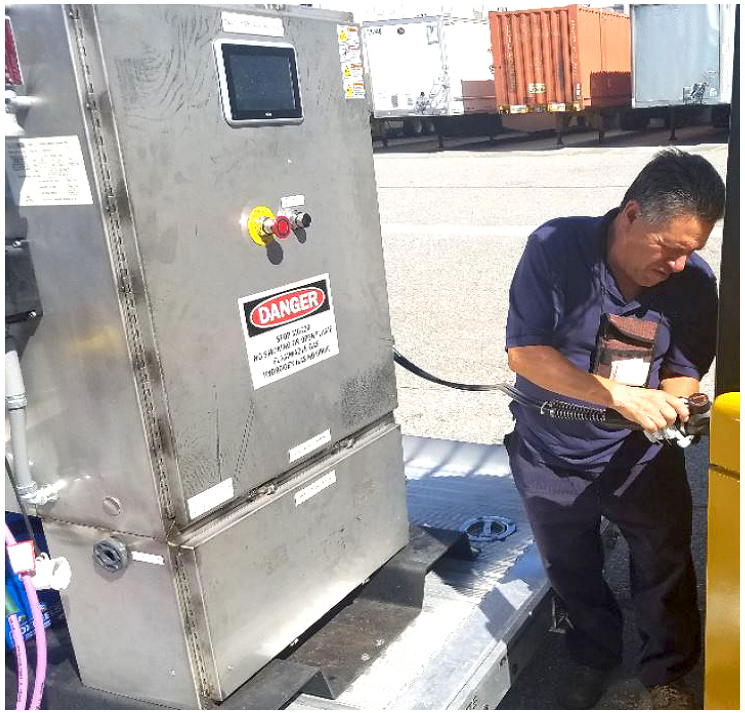
cu

Fuel Cell Electric Hyster® Top Loader

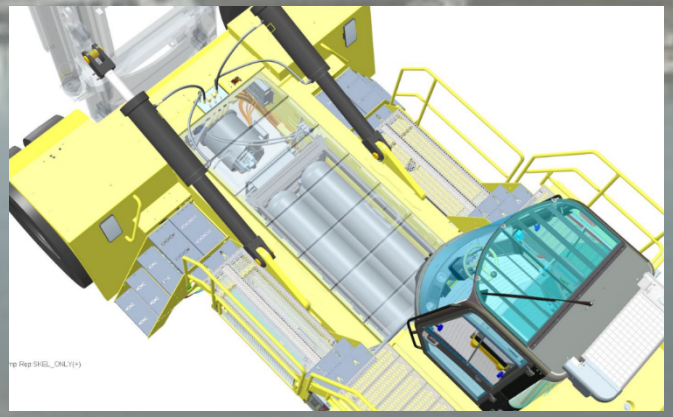
Fuel Cell Electric Hyster® Top Loader

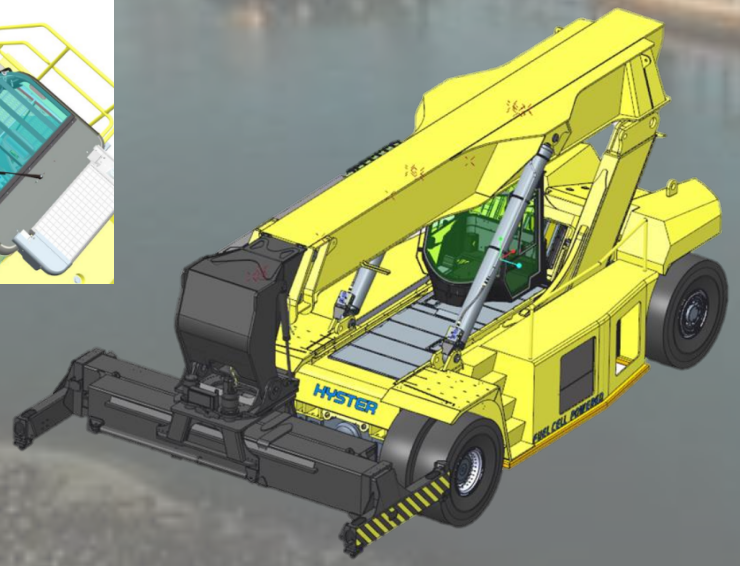
Funded in part by the California Air Resources Board
supported by California Climate Investments
www.caclimateinvestments.ca.gov

Hydrogen Fast Fueling



Fuel Cell Electric Hyster® Reachstacker





ELECTRIFICATION = EFFICIENCY

- Diversity in applications require tailored truck configurations
- Battery and fuel cell hybrid trucks will be fit for every application
- Optimized sizing of batteries and hydrogen system linked with charging/refill strategy
- Smart energy recovery for maximum efficiency

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ZERO EMISSIONS – LIMITLESS POSSIBILITIES

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