MAKING THINGS BETTER:
HYDROGEN FUEL CELLS AT SHIPPING PORTS

H₂@PORTS WORKSHOP | 10–12 SEPT 2019 | SAN FRANCISCO
GUS BLOCK | DIRECTOR OF CORPORATE DEVELOPMENT
Solutions that DRIVE Productivity

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
- Support workforce
- Remain competitive
- 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
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 CO₂ are produced for every gallon of diesel burned

Average fuel consumption of a top loader:
≈ 3.5 gallons/hour
→ 96.3 lb CO₂/hour

At 3000 hours per year, each diesel top loader produces:
≈ 144 tons CO₂/yr
**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

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**ELECTRIFICATION = EFFICIENCY**
Solutions that DRIVE Productivity

OEM Approach for Ports and Terminal Operators

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

DIVERSITY IN APPLICATIONS REQUIRE TAILORED TRUCK CONFIGURATIONS
Li-Ion Battery

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
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
Fuel Cell Electric Hyster® Top Loader
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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
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