

Hydrogen Fuel Cells for Material Handling

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Target Market: Electric Lift Trucks



Class 3 Rider Pallet Trucks



Class 2 Stand-up Reach Trucks



Class 1 Sit-down Lift Trucks

- North American customers want transparent “Plug and Play” fuel cell products to power the various OEM models in their lift truck fleets

Material Handling in California

- Multi-billion dollar North American market opportunity to supply hydrogen to distribution centers and manufacturing plants
 - California is the single biggest market
- Over 50,000 electric lift trucks operating in large fleets in California
 - Provide California with cost effective, controlled industrial settings for developing and rolling out distributed hydrogen refueling
- Individual warehouses represent commercial scale hydrogen
 - Up to 300 kg per day demand
 - Consistent high utilization
 - Predictable and rapid adoption
 - Options for renewable H₂ and reduce load on grid
- Leverage baseload demands for hydrogen in CA warehouses to build infrastructure for on-road vehicles

H₂ Material Handling Fueling System

➤ Installation

➤ Components

- H₂ Supply
 - Compressed gas
 - Liquid
 - On-site generation

- Compression and Storage
 - Compressors
 - Liquid pumps
 - Linde ionic compressor
 - High pressure storage tanks

- Indoor dispenser

➤ Operation

Hydrogen Fueling - Installation



Hydrogen Fueling - Installation



Hydrogen Supply, Compression and Storage



Hydrogen Supply and/or Generation

Liquid H₂ Supply



On-site generation such as Natural Gas Reforming 9

Hydrogen Storage



Hydrogen Indoor Dispensing

Indoor Fueling Stations – Air Products



Indoor Fueling Stations - Linde



Commercialization Status

- Over one million operating hours of Plug Power fuel cells in lift trucks
- Over 106,000 refuelings to date on Plug Power units
 - No safety incidents
- Average 330 H₂ kg per day. Expect to more than double by March.

Some Current Customers

- Walmart (Washington Courthouse, OH)
- Bridgestone (Warren County, TN & Graniteville, SC)
- Nestle Waters (Dallas, TX)
- GENCO/Kimberly Clark (Graniteville, SC)
- Central Grocers (Joliet, IL)
- Sysco (Canton, MI)
- DLA (Susquehanna, PA)

- Wegmans (Pottsville, PA)
- Whole Foods Markets (Landover, MD)
- Anheuser Busch (Fort Collins, CO)
- FedEx (Springfield, MO)
- Coca-Cola Bottling (Charlotte, NC)
- Sysco (Houston, TX & Philadelphia, PA)

Roll out at Central Grocers – First Greenfields Site



Barriers to Commercialization in California

- Strong interest from prospects in California due to high cost of grid electricity and productivity benefits
- Largest barrier to market is hydrogen – competing against grid electricity; simplicity of doing business with utility companies and “known costs”
- Need first movers - others will follow
- Companies with operations in California make decisions at corporate headquarters, many outside California (Ace Hardware, Kroger, Target, Home Depot, Lowe’s)

Commercialization in California

- Incentive on customer operation and upfront costs of hydrogen at initial sites
- Opportunity to normalize hydrogen business model with volume in California
 - Reduce uncertainty of how to control energy and operating costs
 - Overcome perceived risk/return issue
 - Simplify hydrogen transactions and costs
 - Facilitate hydrogen business model for customer to take initial risk
- Short-term incentive will result in immediate volume of fuel cells in specialty vehicles, fueled by hydrogen in California



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