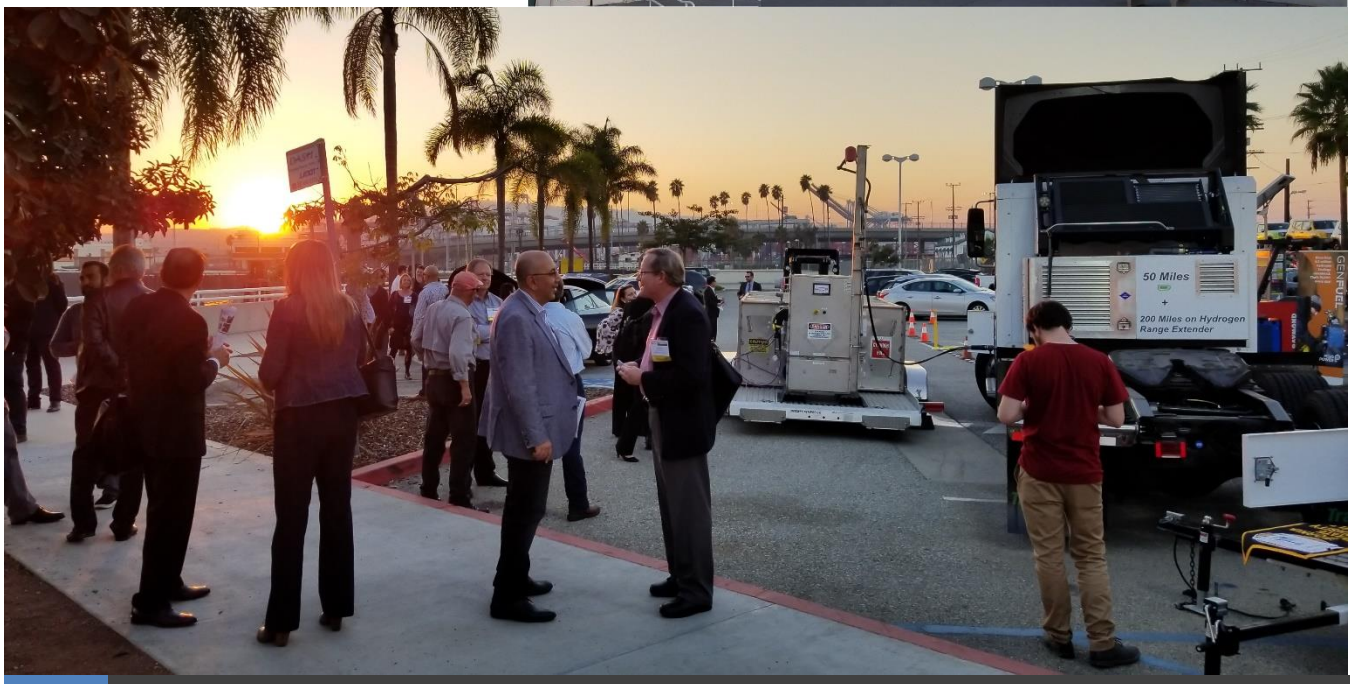
HYDROGEN AND FUEL CELLS IN THE PORTS BRIEFING

DEC. 6, 2017 • BANNING'S LANDING COMMUNITY CENTER • PORT OF LA

CALIFORNIA HYDROGEN BUSINESS COUNCIL

Hydrogen Means Business in California!



CHBC Hydrogen and Fuel Cells in the Ports Briefing Report

California Hydrogen Business Council
1/9/18

Acknowledgements

Planning Committee

The 2017 Hydrogen and Fuel Cells in the Ports Briefing was planned and organized by members of the California Hydrogen Business Council's Goods Movement, Heavy-Duty Transportation, and Clean Ports Sector Action Group. We particularly thank chair Jim Petrecky of Plug Power

Workshop Sponsors

We thank the following organizations for their financial contributions, without which this briefing would not have been possible.

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Executive Summary

In a concerted effort to address the harmful effects of local transportation emissions and global climate change, governments around the world have started to transition away from fossil fuels and adopt zero and near-zero emission technologies to significantly curtail greenhouse gas emissions and criteria pollutants. Currently, diesel is the most prevalent fuel in the ports and freight sectors. Reducing emissions in these sectors of the economy is critical because 90% of goods are transported over oceans, into and out of ports.

Many ports are developing and implementing Clean Air Action Plans and adopting technologies to replace diesel for maritime and goods movement applications. As zero emission technologies, hydrogen and fuel cells have generated great interest in ports across the world, including Germany, France, Japan, and Norway. Equipment suppliers are developing hydrogen fuel cell powered equipment, including Laden Container Handlers and top loaders, that can perform in high duty demand cycles and perform for long periods.

In California, the state government has targeted emissions in the ports with a clean air mandate for ports. The goal is to meet aggressive GHG reduction targets and non-attainment requirements through zero emission technologies. While the port authorities in California cannot dictate the technology choices of the tenants at the ports, they can stimulate technology leadership and adoption.

Key actions that follow from the briefing held on December 6, 2017 at the Port of Los Angeles include this report and a webinar presenting the findings from the 2017 Hydrogen and Fuel Cells in the Ports Workshop held in October 2017 in Vallejo and the December briefing. The CHBC plans for 2018 include continued work with the ports and technology providers on this topic.

Introduction

The California Hydrogen Business Council (CHBC) hosted this half-day briefing on December 6, 2017, to provide an update to the 2016 Hydrogen and Fuel Cells in the Ports Workshops at the Port of Los Angeles, and the more recent workshop at the in Vallejo, California. These events discussed current hydrogen and fuel cell activities in ports and maritime, heard the needs and challenges from port and maritime customers (port authorities, terminal operators, trucking companies) of California Ports to reduce their emission footprint and meet California state air quality requirements.

This 2017 Hydrogen and Fuel Cell in the Ports Briefing presented a Show and Tell of hydrogen and fuel cell equipment to be utilized in the ports following the presentation segments. Equipment for the Show and Tell included: Nuvera/Hyster-Yale forklift, Plug Power forklift, TransPower Class 8 truck, Luxfer-GTM Technologies portable generator/ light tower, OneH2 mobile re-fueling unit, and a Toyota Mirai fuel cell electric passenger car. The equipment from the Show and Tell are pictured at the end of this report.

This report presents an overview of the discussion topics, along with highlights and generally follows the chronology of the agenda. References to materials from the workshop and related activities are included.

Context

Seaports and maritime are a growing focus for reducing greenhouse gas emissions and criteria pollutants. Environmental groups are continuing to put more pressure on the ports to enact and enforce more stringent environmental regulations on port tenants such as terminal operators. The Clean Air Action Plan adopted by the Ports of Los Angeles and Long Beach, requires the ports to adopt a zero emission port equipment by 2030. To

meet the growing need for zero emission vehicles and equipment, hydrogen and fuel cell companies will have to work to accelerate the pace of adaptation and adoption, with port vehicle and equipment OEMs. This workshop was created to assist in that effort.

The California Sustainable Freight Action Plan calls for freight operators to reduce emissions of criteria pollutants and greenhouse gases generated at the ports. Ports produce the highest levels of harmful emissions in California, mainly from the exhaust of various modes of transport (drayage, forklifts, and container movers) throughout the port. On-site power generation for buildings and vessels also play a contributing role.

Many of these activities could be rendered pollution-free by converting to zero emission hydrogen and fuel cell powered applications. Fuel cell or fuel cell/battery hybrid applications of many types and sizes are commercially available and can replace the current fossil fuel-burning engines, though currently at higher cost. Hydrogen power generators or other fuel cell technologies are commercially available. Educating potential users on the current products was one of the goals of this workshop.

Discussion Topics – Segments and Summaries

Keynote: Current Hydrogen and Fuel Cell Activities in the Ports and Maritime

Cory Shumaker, Project Coordinator, California Hydrogen Business Council

Hydrogen and fuel cell technologies have been adopted for ports and maritime applications at an increasing rate around the globe, including Germany, France, Japan and Norway. To meet more stringent emission targets, cruise liners and ferries have started to convert to hydrogen and fuel cells. For many, the conversion to hydrogen accomplishes the critical goal to reduce NOx emissions in the goods movement and freight sectors.

Hydrogen has generated considerable interest from ports around the world. The Port of Gothenburg identified hydrogen as a solution for various applications throughout the port, supported by only one hydrogen fueling station. The Port of Hamburg has developed its own Clean Air Action Plan and in the process of testing a PowerPak to provide an LNG containerized solution for shore power at berth, which has proven to be cost effective when considering the required taxes associated with traditional power generation. As a replacement for diesel, the Port of Amsterdam conducted cold ironing for cruise ships and vessels. Amsterdam is also interested in exploring solutions for heavy equipment including trains that cannot utilize overhead catenary power. The Port of Rotterdam is pushing for expanded use of renewable energy. Rotterdam has looked at producing renewable hydrogen from a 70 GW offshore wind park, as well as using hydrogen for refineries , energy islanding, meeting stationary power demands , and fuel cell cargo vessels for inland transport.

California has a Clean Air Focus/ Clean Air Mandate for Ports with the goal of meeting GHG reduction targets and non-attainment requirements through zero emission technologies. There have been six fuel cell electric Class 8 trucks (FCETs) under development for the Department of Energy (DOE) and South Coast Air Quality Management District (SCAQMD) funded Zero Emission Cargo Transport II (ZECT II). A Center for Transportation and the Environment (CTE) fueling solution is needed and under development.

Gus Block, Director, Marketing and Government Business, Nuvera Fuel Cells

Hyster-Yale group is a major equipment supplier for ports. In 2030, zero emission cargo equipment at the ports will become mandatory. There are six value drivers that ports consider when adopting zero emission technologies: productivity, workplace, sustainability, space savings, energy supply, and total cost of ownership.

At the time of this Briefing, Nuvera Fuel Cells offered Class I, II, III electric trucks for warehouse goods movement. Fuel cell electric trucks have advantages over battery electric trucks because of their ability to last longer and perform in high demand duty cycles. Nuvera has been working on a zero emission Laden Container Handler and a fuel cell hybrid top loader. Utilizing a fuel cell on a top loader allows a smaller battery pack on board. Nuvera is exploring solutions for hydrogen delivery and refueling at the ports and currently uses a OneH2 dispenser for mobile fueling. Another option for hydrogen supply is an on-site reformer

Keynote: Opportunities and Barriers to Hydrogen Infrastructure in Ports

Rob Del Core, Director, Business Development, Fuel Cell Power Systems and Hydrogen Fuel Infrastructure, Hydrogenics

Hydrogenics has partnered with Siemens and Daimler to develop a Class 8 fuel cell truck using Hydrogenics' Celerity Plus fuel cell power system and is working with DOE and the CTE on a UPS truck using Hydrogenics's HD30 30kW fuel cell system. Electrolyzers produced by Hydrogenics have operated for thousands of hours and are proven to be durable. Hydrogenics also partnered with StratosFuel on developing renewable hydrogen generation using wind and solar energy in Palm Springs.

Rob Del Core identified cost and footprint as the barriers to hydrogen production at the ports, but not without solutions. Hydrogenics has a preassembled containerized solution that produces up to 200 kg of hydrogen per day for onsite production near ports. California State University, Los Angeles built an onsite hydrogen production facility, producing 65 kg/day from an electrolyzer. Ontario, California has an electrolyzer that produces 130 kg/day. Aberdeen, Scotland has onsite hydrogen production as well, producing 400 kg/day from the local wind farm. Hydrogenics has become increasingly involved in a German power-to-gas project, which will convert excess solar energy into hydrogen and then inject it into the natural gas (NG) pipeline. With increasing demand for hydrogen over time, mass deployments and continuous technology improvement, the economies of scale will reduce cost. The safety of hydrogen has been demonstrated throughout the industry and end users will accumulate experience.

Keynote: Customers Being Heard, Hydrogen Industry Taking Note

Fernando Corral, Vice President of Sales, Plug Power

Hydrogen fleets offer many benefits, one being the avoidance of range anxiety. Terminal operators have expressed concern with battery-powered equipment because they are not able to keep up with the duty cycle demand. The port authorities and terminal operators want the OEMs used for zero emission vehicles that already have equipment in the port. As the ports transition to zero emission electric equipment, port service providers will need to be trained, similar to electricians.

Plug Power has 19,000 units in 120 distribution centers and is capable of storing 4,000 kg of hydrogen in a 40' by 40' space. Process fueling has been important and determines how to deliver fuel to the customer. Customers' primary concern has been running out of hydrogen fuel and they must be assured that the fuel will be available at any time. Product demonstrations are critical and must be successful; otherwise a negative experience will create an uphill battle for hydrogen adoption. The importance of having hydrogen refueling infrastructure onsite crates a value proposition for many types of vehicles and equipment. The California Air Resources Board recognizes that much of the equipment going into ports and distribution centers has lithium-ion batteries and is being electrified; fuel cells must be included in the conversation. The utilization of only hydrogen fuel cells in heavy duty vehicles presents a challenge because of the power demand to lift heavy weight. Onboard batteries provide power at peak demand to supplement the sustained energy output of a fuel cell, improving the life of the fuel cell. Hybrid technology will always be used in on and off road equipment. Barriers to entry are easier to be

overcome by battery electric vehicles initially, but may change when hydrogen is scaled up in the future and as the mass use of electric vehicles and equipment creates infrastructure challenges.

Recap and Audience Discussion

Ports stakeholders discussed the complex system at the ports; to start projects on the ground, the right people and conversation must take place. Stakeholders identified Technology Advancement Programs as the main avenue to work with the ports and encouraged the industry to submit applications to partner with the terminal operators. Terminal operators expressed the need to have technology that works right out of the gate and be in operation for 7-25 years.

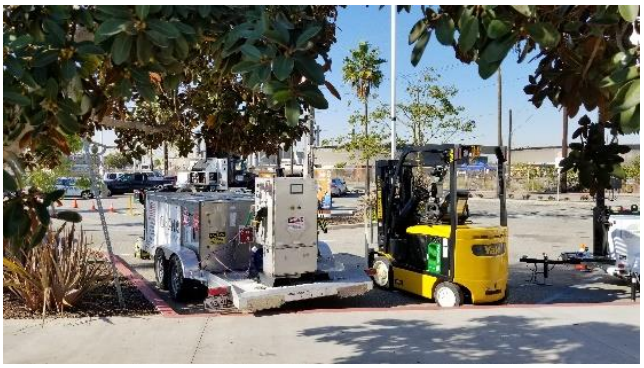
When submitting an application for the Technology Advancement Program, the plan must identify:

- Goals of the project
- Partners and stakeholders
- Data on the equipment (required fuel, equipment operation cycle – ex. one vs. multiple trips increase hydrogen demand)

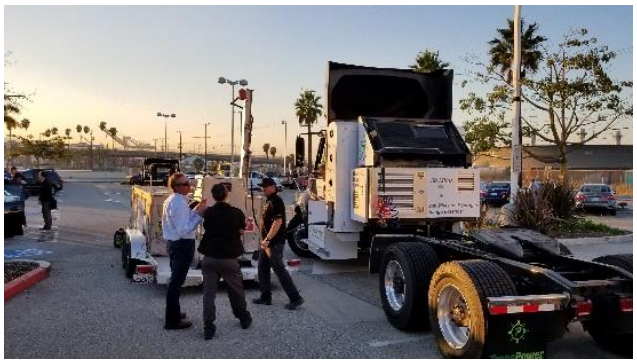
Show and Tell: Hydrogen Technology on Display

Hydrogen fuel cell heavy duty vehicles and equipment were exhibited in the parking lot to provide the opportunity to see, touch and ask questions.

Luxfer-GTM Technologies Portable Generator and Light tower (Left), Nuvera Hyster Yale Forklift (Middle), OneH2 Mobile Re-fueling Unit (Right)



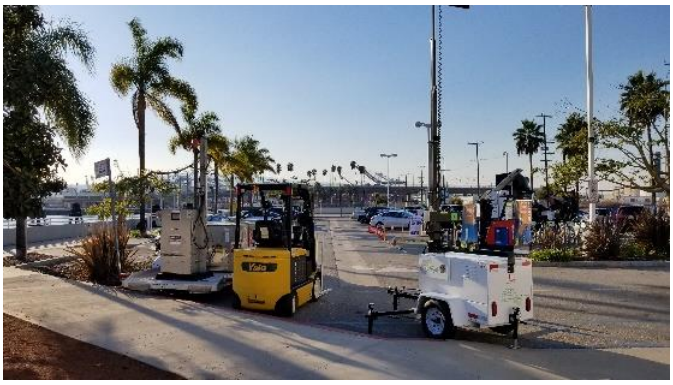
Luxfer-GTM Technologies Portable Generator and Light tower (Left), Nuvera Hyster Yale Forklift (Right)



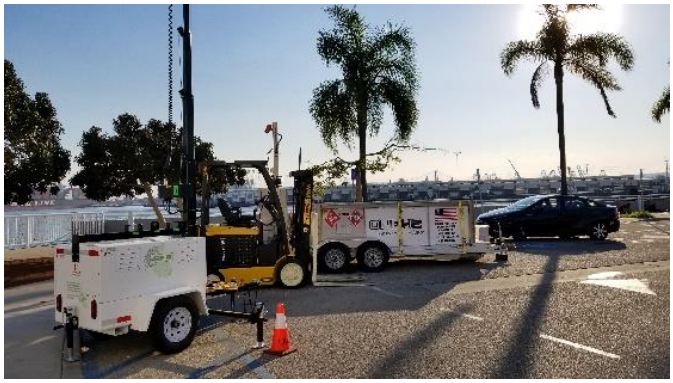
OneH2 Mobile Re-fueling Unit (Left), TransPower Class 8 Truck (Right)

OneH2 Mobile Re-fueling Unit (Left), TransPower Class 8 Truck (Right)

TransPower Class 8 Truck



On H2 Mobile Re-Fueling Unit (Left), Nuvera Hyster-Yale Forklift (Middle) Luxfer-GTM Technologies Portable Generator and Light Tower (Right)



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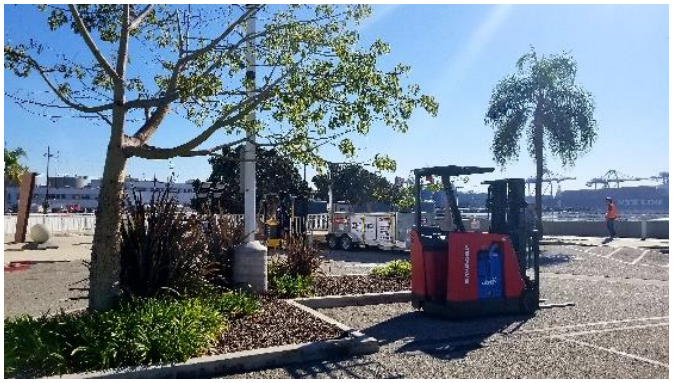

Plug Power Forklift