

HYDROGEN AND FUEL CELLS IN THE PORTS WORKSHOP



CALIFORNIA HYDROGEN
BUSINESS COUNCIL

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BANNING'S LANDING - PORT OF LA



Hydrogen and Fuel Cells in the Ports Workshop Report

California Hydrogen Business Council

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Steering/Planning Committee

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Workshop Sponsors

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For feedback and comments, contact:
Jeff Serfass | CHBC Executive Director
jserfass@californiahydrogen.org
310-455-6095

Executive Summary

The Port of Los Angeles (POLA) and Port of Long Beach (POLB) need to reduce both criteria pollutants and greenhouse gases that originate from activities at the ports, including transporting freight into and out of the port boundaries.

Broadly speaking, this means clean fuels or zero-emission propulsion for anything that moves - trucks, ships, forklifts, container movers – and cleaner fuels or zero-emission electric power systems.

One issue that comes into play is that port management cannot dictate technology choices for the tenants at the ports, only clean air outcomes. While moving to more electrification is part of the solution, bringing more power into the port from the local utilities has its own consequences. Bringing in or making hydrogen from local renewables in the port can provide an important component of electrification.

To accomplish clean air goals with a mix of technologies, including a significant use of hydrogen, will require collaboration among hydrogen industry suppliers, the spectrum of users at the port, funding sources and regulatory agencies. In addition, since much of the pollution arises from idling or slow traffic, both zero-emission technologies and intelligent traffic management can contribute to the solution.

Key take-away messages:

1. Port managers are keenly aware of the need to reduce emissions, and have recently delivered an updated Clean Air Action Plan. They are interested in where hydrogen and fuel cells can play a role. Suppliers need to work closely with the players at the ports to understand operations and to match technology solutions appropriately.
2. Commercial fuel cell and hydrogen systems exist to provide clean mobile power in many types of vehicles and stationary power for onsite operations. The technologies need to be proven in the port environment and available in industrial quantities to move into this market.
3. Funding sources with various agencies can be accessed to move hydrogen technology into the ports, and port managers are willing and welcoming for further discussion.

Key actions that follow from this workshop include this report, a webinar presenting the findings, and a follow-up workshop, to discuss implementation of the findings to develop implementation plans. Perhaps the next workshop should focus on one aspect of the ports, such as freight.

Introduction

The overall purpose of this workshop, held at Banning's Landing Community Center in Los Angeles, and hosted by the Port of Los Angeles, was to develop an understanding of the needs and challenges of California Ports, and the tenants within them, to reduce their emissions footprint and meet California and regional air quality requirements, as well as provide an overview of current hydrogen solutions.

The agenda was arranged to present information on current operations at the ports and review the California requirements for air quality improvements. Opportunities for hydrogen to play a role in meeting these requirements were then reviewed for both the transport / mobility sector and the stationary power sector. Panel discussions allowed for discourse on the on-the-ground situation and highest priorities for finding solutions.

Many of the participants represented activities in the ports and it was particularly valuable to have their perspectives.

This report presents an overview of the discussion topics, along with highlights of the workshop intercourse. The report order generally follows the chronology of the agenda with one exception. The section on "Opportunities and Challenges" appears just before the concluding section, as it contains many of the key points from the workshop. References to materials from the workshop and related activities are included.

Context

This workshop was designed to respond to California Air Resources Board (CARB) and South Coast Air Quality Management District (AQMD) mandates. The California Sustainable Freight Action Plan calls for freight operators to reduce emissions of criteria pollutants and greenhouse gases generated at the ports of Los Angeles and Long Beach. The region has the highest level of toxic emissions in California and related health problems. The primary source is the exhaust from the various modes of transport (drayage, forklifts, container movers) throughout the port. On-site power generation for buildings and vessels also contributes to air emissions.

Many of these activities could be rendered pollution-free by converting to clean hydrogen and fuel cell power plants. Engines based on fuel cells or fuel cell/battery hybrids of many types and sizes are commercially available and can replace the current fossil fuel-burning engines. Hydrogen electric 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

The Ports of Los Angeles and Long Beach

The workshop participants were welcomed by Mike DiBernardo, Deputy Executive Director of Marketing and Customer Relations, Port of Los Angeles (POLA). He took the audience on a dazzling video tour through the port. He concluded with his hope that the workshop would produce some good solutions for the ports, as he noted that equipment there needs updating.

Rick Cameron, Managing Director of Planning and Environmental Affairs, Port of Long Beach (POLB), presented a tour of the Port of Long Beach. Together, the two ports form a contiguous Southern California landscape of modern-day shipping, handling nearly half of all goods imported to the US.



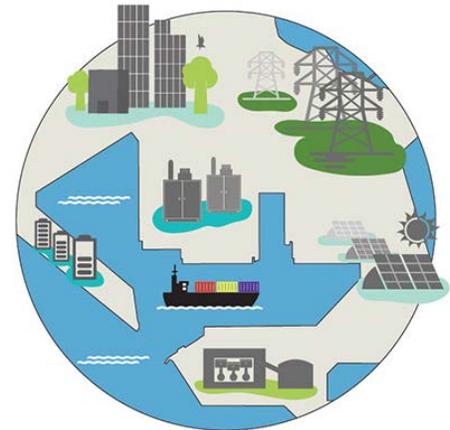
Overview of the Ports of Los Angeles and Long Beach

Key Statistics for Ports of Los Angeles and Long Beach

Parameter	Value
Millions of Twenty-ton units (TEU) in 2015	17
Million metric revenue tons in 2015	177 (LA) / 82.3 (LB)
Terminals	27 (LA) / 22 (LB)
Ship-to-shore container cranes	91 (LA) / 66 (LB)
Employment (San Pedro Bay Port Complex)	
Direct jobs	177,000
Southern California Region	954,000

Mr. Cameron referred participants to the ports Clean Air Action Plan (CAAP), which includes a discussion of actions to be taken and investments to be made. The 2017 update of the CAAP was uploaded just several days after the workshop.¹

An area of the Middle Harbor at the Port of Long Beach (POLB) has been designated as “Energy Island” and is an ideal place to test equipment in the port environment, and suppliers are encouraged to do so.²



Port of Long Beach Energy Island

Regulatory Situation

Governor Brown's Executive Order B-32-15 directs the Secretary of California State Transportation Agency (CALSTA), Secretary of the California Environmental Protection Agency (CalEPA), and the Secretary of the Natural Resources Agency to lead other relevant State departments in developing an integrated action plan by July 2016 that "establishes clear targets to improve freight efficiency, transition to zero-emission technologies, and increase competitiveness of California's freight system." The participating departments are the Air Resources Board (ARB), California Department of Transportation (Caltrans), California Energy Commission (CEC), and the Governor's Office of Business and Economic Development (GO-Biz).

The California Sustainable Freight Action Plan³ was completed in July 2016. Among the topics covered in the plan are 2030 targets for the following:

- **System Efficiency Target:** Improve freight system efficiency 25 percent by increasing the value of goods and services produced from the freight sector, relative to the amount of carbon that it produces by 2030.
- **Transition to Zero Emission Technology Target:** Deploy over 100,000 freight vehicles and equipment capable of zero emission operation and maximize near-zero emission freight vehicles and equipment powered by renewable energy by 2030.
- **Increased Competitiveness and Economic Growth Targets:** Establish a target or targets for increased State competitiveness and future economic growth within the freight and goods movement industry based on a suite of common-sense economic competitiveness and growth metrics and models developed

¹ San Pedro Bay Ports Clean Air Action Plan: <http://www.cleanairactionplan.org>

² <http://www.polb.com/environment/energyisland.asp>

³ <http://www.dot.ca.gov/casustainablefreight/theplan.html>

by a working group comprised of economists, technology experts, and industry. These targets and tools will support flexibility, efficiency, investment, and best business practices through State policies and programs that create a positive environment for growing freight volumes and jobs, while working with industry to mitigate potential negative economic impacts. The targets and tools will also help evaluate the strategies proposed under the Action Plan to ensure consideration of the impacts of actions on economic growth and competitiveness throughout the development and implementation process.

The numerical targets for system efficiency and incorporation of zero-emission vehicles can help frame the discussion of market opportunity and size for the hydrogen and fuel cell industries to participate in this transition.

Another mandate that plays in the ports region is Senate Bill SB350, the “Clean Energy and Pollution Reduction Act of 2015.”⁴ This bill requires that the amount of electricity generated and sold to retail customers per year from eligible renewable energy resources be increased to 50% by December 31, 2030. Activity around this law focuses on renewable energy and is primarily enforced by the South Coast Air Quality Management District.

Finally, SB-1383, the “Short-lived Climate Pollutants” act of 2016 could also be relevant in that biomethane can be a fuel for some types of fuel cells.

California’s Sustainable Freight Landscape: Agencies Working Together

To meet the targets, agencies **MUST** work together. Heather Arias, Chief of the Freight Transport Branch of CARB described the process of how the various agencies contribute to the Sustainable Freight Action Plan. Since this plan is unlike anything that CARB has implemented previously, it will be a new challenge. Some of her specific comments:

- California needs zero emission technologies wherever feasible – this is THE end game where hydrogen and battery technologies are the only solution.
- Freight is under continuing pressure to evolve, both in terms of emissions and overall efficiency of goods and services delivered.
- There are huge needs for improvement across all components of the fleets and infrastructure.
- With new technologies, training needs to be available for operators to become proficient quickly, to maintain and improve current productivity levels.
- There is a need to meet both consumers’ and industry’s demands, and it is becoming more of an instantaneous demand. Stakeholders need to come forward and say what is going to work and what is not going to work in a timely manner, however this needs to be facilitated.
- The end user needs to have a financial incentive for purchasing advanced technologies. This is a challenge and requires that capital and operating costs need to be competitive with existing technologies.

One particular element of the Sustainable Freight Action Plan is to sponsor **pilot projects**. Three current projects are:

⁴ https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350

- Dairy Biomethane for Freight Vehicles
- Advanced Technology for Truck Corridors
- Advanced Technology Corridors at Border Ports of Entry

For the last of these, one concept is to include special truck lanes for zero-emission trucks to reduce the wait in traffic at the border. This is one major source of pollution which can be tackled by both technology and intelligent traffic management.

Ms. Arias also presented the top-level schedule for implementation of the Sustainable Freight Action Plan, which includes

- By July 2017, State agencies work with partners to establish workgroups and work plans for Action Plan implementation
- By July 2018, Provide progress report on Action Plan implementation efforts
- By July 2018, Evaluate Action Plan freight targets to determine if adjustments are needed

Key take-away from this session: The Sustainable Freight Action Plan directs CARB, working with other agencies to meet certain targets by 2030. This provides metrics for both the industry and agencies to work toward, and an opportunity for vendors to illustrate how their technologies help meet these targets. The pilot project element may be the ideal vehicle for hydrogen demonstration in the near term.

Hydrogen Mobile Application Solutions

The panel of mobile solutions featured Ballard, US Hybrid and Plug Power. Ballard, which has been in the fuel cell business for decades, is expanding their product line from bus engines to truck engines. China is a big customer. Another application is truck refrigeration. Ballard seeks opportunities for drayage applications in the Southern California ports.

US Hybrid president, Dr. Abas Goodarzi presented his view of “Integrated Electric, Fuel Cell and Hybrid Powertrain Components Powering Clean Mobility.” US Hybrid’s business focus is heavy duty commercial vehicles. He made it very clear that class 6, 7, and 8 vehicles can all be powered by clean fuel cell engines or hybrid battery/fuel cell engines. He showed interesting data that illustrates how much of the pollution from trucks is due to idling and braking in traffic – more than 50%. An electric powertrain can completely eliminate this pollution.

Dr. Goodarzi highlighted the benefits of a hydrogen fuel cell engine:

- Fast fueling, which is critical for productive operations
- 24/7 operations
- No range compromises
- Not only no emissions, but the most efficient no-emission transportation option



US Hybrid Fuel Cell Class 8 Hybrid Fuel Cell Truck

The supply chain for fuel cell powered heavy duty vehicles is already in place. The fuel cell is just a combustion-less engine. It uses a lot of the existing engine components.

Plug Power Vice President, Strategic Marketing and Investor Relations, John Cococcia presented their view of a complete hydrogen and fuel cell solution for ports, including both material handling equipment and hydrogen infrastructure. Plug Power has installed over 13,000 fuel cells in forklifts to replace batteries which are slow to charge and have limited life. Currently, Plug Power is delivering 10,000 kilograms of hydrogen per day via 150 dispensers to fuel the forklifts in a variety of manufacturing and goods movement facilities. This successful commercial enterprise represents an obvious solution for goods movement at the ports. A key issue is the reliable availability of fuel. Another is operation in the harsh marine environment of the port, which would be a new challenge for hydrogen fuel cells.

To make sure the ports are green and build a sustainable market for hydrogen fuel, consider the following “hydrogen city” concept, comprised of:

- a captive fleet – vehicles within the port
- a tethered local fleet – intermodal along the I-710 corridor, for example – vehicles that always return to the port
- a regional fleet – private vehicles within the LA basin



Plug Power Fuel Cell Forklifts

Key take-away from this session: Hydrogen fuel cell propulsion systems and vehicles are already commercially available and will provide clean exhaust from mobile equipment. There is no reason to wait to invest in these technologies.

Discussion point: Where to locate hydrogen dispensing? A single central location is not workable because the port is too large. Fueling points would need to be distributed. Fuel specifications are end-use dependent (SAE J2719, ISO 14687-1,2,3) and compliance will be required.

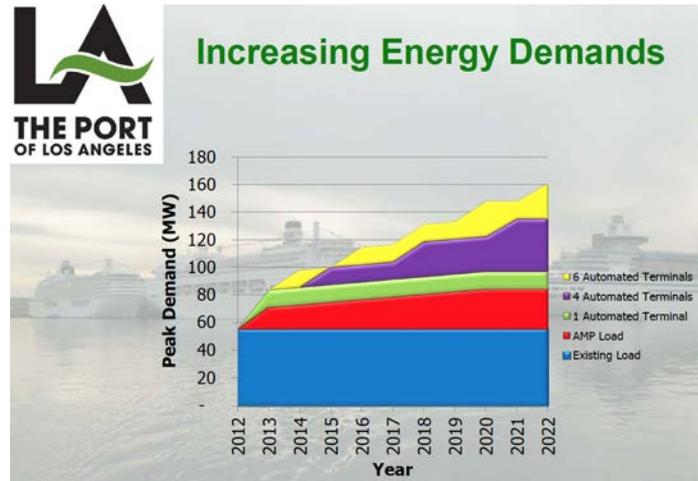
Hydrogen Stationary Application Solutions

In this session, presenters reviewed the powered stationary equipment at the port. This included the Cargo Handling Equipment (i.e., cranes, container movers), refrigerated units (reefers), and shore-to-ship power while docked. Stationary power also includes all the hotel power for buildings, lights, HVAC, and anything else that needs electricity to operate.

Each terminal operator contracts individually for power from the local utility companies (Los Angeles Department of Water and Power or Southern California Edison). As a result, the actual electric load of the port is not known in detail.

Ben Chavdarian, Senior Electrical Engineer, Port of Long Beach, presented port power demand, strategies and security planning. New proven technology, such as hydrogen fuel cells, can be implemented quickly into multiple terminals once one port/terminal implements it. The terminals have multiple energy metering points with separate services provided by the utilities, each terminal has its own power. Port of Long Beach sees energy demands increasing overall while having requirements to reduce air emissions. These are the trends. Alternative maritime power (AMP)

demands, port electrification and renewables all have impacts, plus operation growth and terminal automation. The current electricity consumption is 55 MW baseload today, and is projected to grow to 160 MW by 2022. Cranes make up a large portion of electrical loads at 40%, while container refrigeration is another large percentage. Ports are on the cutting edge of new technology due to regulatory and community pressures to clean up the air. Cold ironing (powering the ship from shore power, not onboard power) is now the norm, typically 6.6 kV, 7.5 kW per container ship; hydrogen can be used as the power source for this application. A critical competitive advantage would be to convert a substation to hydrogen supply, if costs are less. Increasing electrical energy demands are due to both growths in traffic and a move to more electrification to reduce emissions.



Fuel Cell Energy Power Plant

a PPA agreements, has an around-the-clock global technical assistance center, and has been able to provide cost savings of up to 20% compared to what the utility grids typically charge.

Robert Nielsen, Director of Business Development, FuelCell Energy presented on primary power solutions using hydrogen fuel cells. He described two main applications: electrical grid support and onsite supply (behind the meter). Fuel cells can be operated in grid connected mode, grid independent mode, and micro-grid mode. The company is responsible for the world's largest fuel cell park consisting of 21 units providing 59MW of power. FuelCell Energy provides project financing using

Ryan Sookhoo, Director of Business Development, Hydrogenics presented on backup power solutions using their maritime fuel cell system (MarFC). It is a containerized solution capable of providing critical power, peak power, shore-to-ship power, and portable power in addition to backup power. The MarFC has been deployed at Hickam Air Force base and Raglan Mine. Hydrogenics recently went into a joint venture with Kolon Water and Energy in South Korea using the containerized fuel cell solution to provide 1 MW of continuous power from excess hydrogen produced at a refinery. The company is also in the business of hydrogen production and fueling stations, as well as fuel cells for transportation. Hydrogenics is building the largest wind to hydrogen facility in the world in the desert of California.

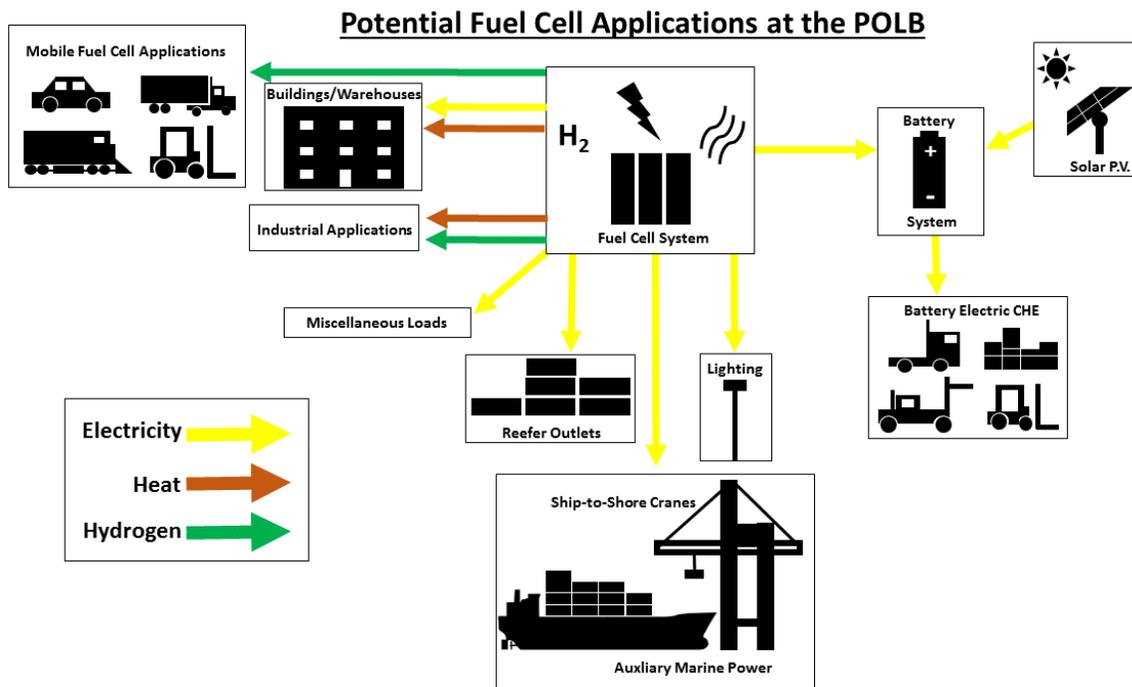


Hydrogenics MarFC (Maritime Fuel Cell System)

Beyond the immediate discussion that took place at the workshop, another study by CHBC member University of California – Irvine is relevant to this topic.⁵ That study, *Assessment of Fuel Cell Technologies to Address Power Requirements at the Port of Long Beach*, sponsored by POLB and available as a white paper, focuses on a comprehensive evaluation of alternative energy sources. It presents power generation options at multiple scales by solid oxide fuel cell (SOFC), molten carbonate, and phosphoric acid fuel cell systems. Additionally, it states that “combined cooling, heat, and power applications from the same systems can further enhance environmental and energy benefits and reduce costs.” The value of combined heat and power (CHP) was not discussed at the workshop, but represents another opportunity for some hydrogen and fuel cell technologies.

⁵ MacKinnon, Michael A. and Samuelson, Scott, “Assessment of Fuel Cell Technologies to Address Power Requirements at the Port of Long Beach,” Report prepared for the Port of Long Beach, June 28, 2016.

<http://polb.com/civica/filebank/blobdload.asp?BlobID=13597>



Overview of Potential Fuel Cell Applications at the POLB Including the Provision of Electricity, Heat and Hydrogen

Key take-away from this session: The multiple stationary power needs for base load cargo handling power, shore-to-ship power, refrigeration units, and automated terminals, including the anticipated increase in these requirements, can be met with clean, renewable energy using a variety of technologies and fuel cells. The solutions are flexible, green, secure and reliable, and provide energy independence. Once one terminal proves the technology can work in the port environment other terminals will be quick to implement to duplicate the success.

Hydrogen Supply Solutions for Ports

In this session presenters overviewed the ways hydrogen can be provided to the ports in a variety of ways, different solution providers discussed solutions for hydrogen refueling and storage.

Dwight Zuck, Hydrogen Energy, Advanced Business and Technologies US, Air Liquide presented on hydrogen delivery. Air Liquide has acquired AirGas and added its services to Air Liquide’s portfolio. They have been involved in hydrogen for over 40 years, and currently have hydrogen activities all over the world. There’s a lot of opportunities for hydrogen in every level of



Air Liquide liquid hydrogen delivery

the supply chain. Air Liquide also operates an electrolyzers sourced from other companies. Fuel cell commercialization is here. There are various H2 delivery options including the most common of tube trailer delivery.

Steve Szymanski, Director of Business Development, Proton Onsite presented on onsite electrolysis. There are two predominate electrolyzer commercial technologies, alkaline and Proton Exchange membrane (PEM). Transportation fuel and large scale energy storage are the emerging markets for electrolyzers. A lot of work is being done on what is called power-to-methane, where a hydrogen created from electrolysis is combined with carbon to create a synthetic methane. The cost of hydrogen from an electrolyzer really depends on the price of electricity and the cost per kW of capital equipment. Proton Onsite has a project in Hawaii that provides hydrogen fuel for buses and a shuttle. Proton Onsite also supplied the electrolyzer for the Washington DC fueling station.



Proton M200 Fuel Cell

Jennifer Hunt, FuelCell Energy presented on onsite tri-generation. The tri-gen plant uses FuelCell Energy's fuel cell to produce hydrogen, heat, and power from renewable or non-renewable fossil fuels. On site hydrogen production is a good solution when there isn't a pipeline. It can operate on biogas or natural gas and is a water independent system. Various issues and regulations have changed the utility view and strategies with regard to self-generation power, making it more useful.

Key take-away from this session: Hydrogen production and delivery has been around for a long time. Diverse approaches are available. The key is matching the technology with the need. PEM fuel cells and electrolyzers, for example, can be the zero-emission solution at the ports. Alternatives are tri-generation approaches.

Government Programs and Funding Opportunities for Hydrogen Applications in Ports and in Freight

In this session a summary of the funding landscape for the next 1 – 5 years from various government funding agencies, such as the DOE, ARB, CEC, and SCAQMD, was provided for technology providers and participants

Fred Minassian, Assistant Deputy Executive Officer, Technology Advancement Office, South Coast Air Management Quality District, presented on some of the insights from SCAQMD. The population of the South Coast Air Quality basin would be the fifth largest state in the country, and therefore there is a large dependency

on clean air in their air district. There is no longer a “black box” to achieve the goal of NO_x reductions. We now have commercially viable solutions available. SCAQMD has worked a lot with fuel cell buses and has seen their successes. SCAQMD is also doing projects for delivery trucks and heavy duty trucks using fuel cells.

Heather Arias, Freight Transport Branch Chief, California Air Resources Board, presented on the insights and opportunities from CARB. They are doing a variety of projects with trucks, truck refrigeration units (TRUs), locomotives, ships at berth, and commercial harbor craft. CARB is working with SCAQMD to distribute Prop1B money of about \$137M to projects that will contribute to lower greenhouse gas emissions. There are a variety of fuel cell projects where different levels of funding are available. The Carl Moyer program will be updated in 2017; it currently requires a large amount of paperwork which CARB is trying to streamline to make it a more user friendly process. A total of \$1.1 billion has been distributed since 1999-2000 by SCAQMD to clean up transportation.

Andre Freeman, Supervisor – Medium- and Heavy-Duty Vehicle Technology Unit, California Energy Commission, presented on the insights and opportunities from the CEC. The Alternative and Renewable Fuel and Vehicle Technology Program has funding areas for alternative fuel production, alternative fuel infrastructure, alternative fuel and advanced technology vehicles, and related needs and opportunities. There is a significant amount of funding for demonstrations. An allocation of \$20M a year is specifically for hydrogen fueling stations in CA. There have been questions about heavy duty fueling and what funding will be available for it in the future. Specific heavy duty fueling infrastructure is needed; large trucks are not able to fill up at normal passenger car stations. The CEC is fuel agnostic, there is no one size fits all solution. Now there is an increased focus on the freight sector. Thus far there has been \$93.7M in advanced medium duty and heavy duty vehicle demonstration projects. The CEC has workforce development training funding. They are currently in the process of updating the revised investment plan for the Alternative and Renewable Fuel and Vehicle Technology Program; the CEC is looking for advice on where they should put money and why.

Pete Devlin, Market Transformation and Intergovernmental Coordination Manager, Hydrogen and Fuel Cells Technologies Office (FCTO), U.S. Department of Energy, presented on the insights and opportunities from the DOE. Durability for fuel cells is basically solved; it can run as long as a conventional car engine, 5,000 hours. That target will be raised to 8,000 hours in the near future. The number of fuel cell shipments has risen dramatically worldwide. Fuel cells are a better option for Class 2+ vehicles because of the increase in range. That includes heavy duty trucks which are a great application for fuel cells and can help make a big improvement in reducing greenhouse gas emissions. DOE wants CARB and CEC to do the heavy lifting on funding for deployments. Deployments can be: heavy duty (buses, trucks), medium duty (shuttle buses, baggage tow tractors, delivery vehicles), and light duty (commercial vans and tactical vehicles). “Clustering” FCEVs can drive up demand. DOE-MARAD has been doing projects with fuel cells using a container deployed in Hawaii that may be coming to Long Beach. Ground support equipment at airports is another good application for fuel cell vehicles. Class 8 fuel cell trucks are designed to have more torque than a diesel. Since more diesel is used in refrigeration of containers than driving the trucks they are on, this is a great application for fuel cells; Nuvera and Ballard are creating solutions for this. The FedEx Delivery van is great for the neighborhood but they must work more than a full shift. Auxiliary power units (APUs) can be seen in the very near future in ports.

Francisco Donez, Air Quality, Environmental Protection Agency presented on the insights and opportunities from the EPA. The Diesel Emissions Reduction Act (DERA) is national funding competition with state allocations and has up to \$100M allocated annually, but it needs to be renewed after FY2016. The purpose of the program is to clean up diesel engines through a clean diesel rebate program. The EPA is looking at ports for greenhouse gas reduction and criteria pollutant reduction. There are 39 million people that live near the ports and that have to

deal with the air pollution. The EPA has a ports initiative that mentions zero emission technologies. The EPA is part of a West Coast Collaborative that is a public-private partnership. The Collaborative is part of the National Clean Diesel Campaign (NCDC), which seeks to advance strategies to reduce diesel emissions and move toward cleaner air.

Mark Glaze, Air Quality Specialist, Federal Highway Administration presented on the insights and opportunities from FHWA. CMAQ is Congestion Mitigation and Air Quality Improvement Program established in 1991 that has provided \$30 B in 20,000 transportation projects nationwide. There are a wide range of eligible projects under CMAQ, with a couple that hydrogen projects may fall into; 12 hydrogen fuel cell projects have been submitted recently. Los Angeles area has not yet gone through their project selection process for 2017 with part of the \$254 M for Southern California Area Governments.

Key take-away from this session: There are numerous sources of funding available for procurement, demonstration and deployment. Vendors need to coordinate between users in the ports and funding agencies to accelerate infusion of hydrogen and fuel cells into the ports.

Purpose for Zero Emission Technologies: Community/Environmental Perspective

Nidia Erceg, Deputy Policy Director, Coalition for Clean Air (CCA), gave the audience an insight to the reasoning for implementing zero emission technology. For decades, California has been at the forefront of the environmental policy. “The Californians who live near ports, rail yards, and along high traffic corridors, are subsidizing the goods movement sector with their health.” There will be a doubling or tripling of goods movement numbers going into the next few decades, and the increase in emissions from this must be addressed. Coalition for Clean Air is focused on zero emissions to make the transportation system more sustainable. The highest source of NO_x emissions are heavy-duty diesel trucks. The sad fact is race and social class are largely the determinates of where the air quality issues are. Environmental justice requires that no community should be burdened with more environmental impacts than any other. CCA does toxic tours to show the neighborhoods that are negatively affected the most. Particulate matter 2.5 leads to 2,000 premature deaths per year. “Right now is the time for opportunity and all of you have a chance to make an impact.” Advocacy groups can be a resource. First listen to them, respect them, then express a different perspective if there is one. We need to expand the stakeholders and speak up when there are noticeable groups missing. We need to focus on getting the costs down and increasing zero emission demonstrations. One task for the state of California and its leadership is to gather federal funding for this initiative.

Key take-away from this session: Moving forward with clean hydrogen technologies in the ports and surrounding areas is not only good for business, but the also the right thing to do for the people who live in the region.

Opportunities and Challenges

Panel Discussion Opportunities and Challenges for Hydrogen in the Ports

Ports, trucking companies, terminal operators, and environmental groups identified their concerns and needs so that technology providers can be informed. This panel produced a lively discussion both from the panelists and the workshop participants.

Thomas Jelenic, Vice President, Pacific Merchant Shipping Association provided insights from the perspective of the shipping companies. In the future there will be more consolidation and more turmoil as terminals deal with very low freight rates. It was very surprising to see Hanjin Terminal go bankrupt. There is a transformation going on in the harbor to move to it greener technologies. A lot of people have focused on electrification, but we need multiple pathways to get to the clean air goals; one solution will not fit all industries. The maritime industry is very complex. Hydrogen has been predominately absent in the ports. Even with substantial investment in natural gas over the last 10 years, diesel still dominates which shows the resistance to change by the ports. Can hydrogen be a cost-effective solution in the time frame needed to meet the standards set by the State? One of the troubles with alternative technologies is that they tend to have a gas station approach with a central fueling station and the terminals are expected to adopt that strategy. That's not realistic. The hydrogen industry needs to educate the maritime industry. Reliability and performance are key. Diesel is the workhorse and is what they're used to. Hydrogen is an arrow in the quiver to help maritime industry meet its goals.

Alex Cherin, Intermodal Director, California Trucking Association provided insights to the perspective of trucking companies. Alternative fuel has the epicenter in trucking. Port drayage livelihood depends on the utilization of the asset (the truck). Hydrogen fuel cell trucks need to be cost effective in the long term. His 10 requirements for transitioning trucks to hydrogen technology:

1. Note to vendors – it has to work; high reliability is key.
2. Be able to explain the technology – walk through the science to the customer.
3. COST – must be competitive to existing alternatives.
4. Know the business of the companies that operate in the ports, get to know the people, the technologies, how things operate; know the challenges of waiting in queues.
5. Find someone else to be first; no one wants to be first (this is a problem).
6. Technology / market must be scalable; there has to be capacity to produce multiple units once the technology is accepted.
7. Refueling is everything. Must be easy, available, and sited appropriately. Natural gas has done a great job with the Clean Energy Station. Make sure refueling is EASY from all aspects (procedurally and maneuverability).
8. Vendors must prove that they are in the business to stay, will not be gone a year from now.
9. COST
10. COST!

Jeff Burgin, Senior Vice President, The Pasha Group provided an insight into the perspective of terminal operators. “We are here to help ARB reach its goals.” The legacy he wants “us” to have is like the green Omni terminal across the street in Port of Los Angeles. Energy Island is a great vision for a lot of people. There are epic goals as the freight grows exponentially, it will be a great challenge to reduce emissions. It's about a community

on how we operate as a port. Terminal operator obligations don't stop at the gate or end of rail line. 3-4 years ago there was 1 alternative technology solution, now we have more of those options to support the efforts at the State level to reduce greenhouse gases.

Adrian Martinez, Staff Attorney, Earth Justice provided some insight from community organizations. Earth Justice works with a lot of grassroots and environmental organizations who don't talk a lot about hydrogen. The hydrogen community needs to engage them. A lot of the discussion is promoting zero emissions whenever possible. More discussion needs to happen to update community and environmental groups on the progress hydrogen and fuel cells have made.

Presentations by the panel were followed by an open discussion:

- Demonstrations need to be larger than 1s and 2s, need to be fleets.
- The hydrogen needs to be renewable to make it worth using.
- Fueling needs to be available everywhere. It needs to be adaptable that varies by company.
- There are many physical constraints to the port and getting a fueling solution. Fueling should be a partnership with a local entity that already has a presence.

Key take-away from this panel: Vendors need to understand the business at the port by talking to the operators. Demonstrate that hydrogen and fuel cell products work in the maritime environment, which can be harsh. Products and capacity to produce them must to scalable to full industrial availability.

Summary

- Hydrogen technology providers need to know the business of the ports. Solutions need to be scalable and we need to show the benefits to the operators.
- There is a tremendous amount of waste from drayage trucks being stuck in traffic and waiting in shipping terminal queues, this will not be the case when using hydrogen fuel cells.
- The needs for stationary power can be shore-to-ship power, refrigeration units, and cruise ships.
- We were missing the utility companies that service the ports in today's talks.
- Hydrogen production needs to be emission free, and there are a variety of ways to do that.
- There were a lot of funding opportunities from various state and federal agencies.
- There is a lot of learning that needs to happen on both sides (ports and solution providers) and we all need to get to know each other.

Outcomes and Action Items

Discussion and Next Steps

One strong reaction to comments from the Opportunities and Challenges panel – someone has to be first. The transition cannot succeed if everyone wants to follow. Who will be the leader in moving to clean trucks? Clean forklifts? Fuel cell power plants in the port?

Other wrap-up comments:

- We need projects, not research. There needs to be demos of 5-10, not one off's. There are a lot of funding opportunities, too many to keep track of and it would be nice if the California Hydrogen Business Council could provide an overview. – Andreas Truckenbrodt
- “What we have today is not working from a policy side.” We are all in this together to find a better solution. – Abas Goodarzi
- Need to develop some community based strategies for some of the things that are becoming commercially available. The local FAA has money for zero emission vehicles.
- What the ports need from industry is to talk to the port tenants and figure out what they need. They all operate differently and need different things. The port can help facilitate this. CAAP has technology advancement programs that have a lot of money. – Christine Houston
- An analysis needs to be done for the entire goods movement chain and how we can eliminate silos and work together. – Mark Abramowitz

Recommendations to industry from the workshop

- Get to know the operations at the port so that you really understand the needs of the operators. Convince them that your solutions work in the port environment and are scalable to full industrial availability.
- For transportation companies, the cost must be competitive.
- For stationary power, come test at the port, there are locations available.
- Funding is available. Work with the agencies.

Recommendations to CHBC

- Keep members informed of all funding / demonstration opportunities.
- Facilitate discussion with port operators and vehicle companies. A list of contacts would be particularly useful.
- Next time, make sure the relevant utility companies are represented.
- Provide an analysis that shows synergies between technologies and matches needs at the ports.
- Work with experienced staff at DOE to develop strategies for community-based development.

Next activities – CHBC Planning

- Follow-up action items to communicate with all participants: survey, report, access to presentation materials.
- Plan for follow-up webinar to present findings and a subsequent workshop, possibly at the California Maritime Academy - Vallejo, where an invitation has been extended.

Appendix A – Workshop Agenda

Hydrogen and Fuel Cells in the Ports Workshop – November 10th at Banning's Landing Community Center – Port of Los Angeles	
<p>PURPOSE: Develop an understanding for the needs and challenges of California Ports to reduce their emission footprint and meet California State air quality requirements as well as provide current hydrogen solutions.</p>	
8:00 AM	Check-In
8:30 - 8:50	<p>Welcome, Introductory Remarks and Overview</p> <ul style="list-style-type: none"> • Mike DiBernardo, Deputy Executive Director of Marketing and Customer Relations, Port of Los Angeles • Jeff Serfass, Executive Director, California Hydrogen Business Council
8:50 – 9:10	<p>Keynote - Deploying Advanced Technologies at Ports</p> <ul style="list-style-type: none"> • Rick Cameron, Managing Director of Planning and Environmental Affairs, Port of Long Beach
9:10 – 9:30	<p>California’s Freight Landscape: Agencies Working Together</p> <p>Agencies within California coming together to implement the California Sustainable Freight Action Plan, including critical deployment of advanced technology.</p> <ul style="list-style-type: none"> • Heather Arias, Goods Movement and Freight Transportation Branch Chief, California Air Resources Board <p>Followed by Open Discussion</p>
9:30 – 10:15	<p>Current Opportunities and Challenges for Hydrogen Projects</p> <p>Ports, trucking companies, terminal operators, and environmental groups can identify their concerns and needs so that technology providers can be informed.</p> <p style="padding-left: 40px;"><i>Moderator:</i> Rick Cameron, Managing Director of Planning and Environmental Affairs, Port of Long Beach</p> <ul style="list-style-type: none"> • Thomas Jelenic, Vice President, Pacific Merchant Shipping Association • Alex Cherin, Intermodal Director, California Trucking Association • Jeff Burgin, Senior Vice President, The Pasha Group • Adrian Martinez, Staff Attorney, Earth Justice <p>Followed by Open Discussion</p>

<p>10:15 - 10:30</p>	<p>Networking Break</p>
<p>10:30 - 11:15</p>	<p>Hydrogen Mobile Application Solutions</p> <p>Mobile hydrogen technology solutions are presented for trucking and goods movement in Ports.</p> <p><i>Moderator: Alan Mace, Product Manager, Ballard Power Systems</i></p> <ul style="list-style-type: none"> • Heavy Duty Trucks – Abas Goodarzi, President and CEO, US Hybrid • Material Handling – John Cococcia, Vice President, Strategic Marketing and Investor Relations, Plug Power <p>Followed by Open Discussion</p>
<p>11:15 - 12:30</p>	<p>Hydrogen Stationary Application Solutions – Panel</p> <p>Stationary hydrogen technology providers in onsite power generation showcase their technologies and experience for Ports.</p> <p><i>Moderator: Cory Shumaker, Project Coordinator, CHBC</i></p> <ul style="list-style-type: none"> • Port Power demand, strategies and security planning – Ben Chavdarian, Senior Electrical Engineer, Port of Long Beach • Scott Baird, Associate Engineer, Port of Los Angeles • Primary Power – Robert Nielsen, FuelCell Energy • Backup Power - Ryan Sookhoo, Director, Business Development, Hydrogenics <p>Followed by Open Discussion</p>
<p>12:30 - 1:45</p>	<p>Lunch & Tabletop Exhibits – Lunch Provided</p> <p>Hydrogen technology providers will be stationed at tables to meet with potential customers, terminal operators and port personnel, to discuss their solutions and hear from the end user.</p>
<p>1:45 - 2:45</p>	<p>Hydrogen Supply Solutions for Ports - Panel</p> <p>Hydrogen can be provided to the ports in a variety of ways, this panel will hear from different solution providers for refueling and storage.</p> <p><i>Moderator: Jeff Reed – Director of Emerging Technology, Southern California Gas Company</i></p> <ul style="list-style-type: none"> • Hydrogen Delivery – Dwight Zuck, Hydrogen Energy, Advanced Business and Technologies US, Air Liquide • Onsite Electrolysis – Steve Szymanski - Director, Business Development, Proton Onsite • Onsite Tri-generation – Jennifer Hunt - FuelCell Energy <p>Followed by Open Discussion</p>

<p>2:45 – 4:15</p>	<p>Government Programs and Funding Opportunities Overview On Hydrogen Applications in Ports and in Freight</p> <p>Summary of funding landscape for the next 1 – 5 years from various government funding agencies, such as the DOE, ARB, CEC, and SCAQMD so technology participants will be informed of various opportunities. Discuss opportunities for centralized fueling station for ports:</p> <p><i>Moderator:</i> Fred Minassian, Assistant Deputy Executive Officer, Technology Advancement Office, South Coast Air Management Quality District</p> <ul style="list-style-type: none"> • Heather Arias, Freight Transport Branch Chief, California Air Resources Board • Andre Freeman, Supervisor – Medium- and Heavy-Duty Vehicle Technology Unit, California Energy Commission • Pete Devlin, Market Transformation and Intergovernmental Manager, Hydrogen and Fuel Cells Technologies Program, U.S. Department of Energy • Francisco Donez, Air Quality, Environmental Protection Agency • Mark Glaze, Air Quality Specialist, Federal Highway Administration <p>Followed by Open Discussion</p>
<p>4:15 – 4:30</p>	<p>Final Remarks – Purpose for Zero Emission Technologies: Community/Environmental Perspective</p> <ul style="list-style-type: none"> • Nidia Erceg, Deputy Policy Director, Coalition for Clean Air
<p>4:30 - 5:00</p>	<p>Open Discussion, Outcomes and Action Items</p> <p>Moderator: Jeff Serfass, Executive Director, California Hydrogen Business Council</p>
<p>5:30 – 7:30</p>	<p>Happy Hour Networking</p>

Appendix B – List of Participants

Organization	First Name	Last Name
Advanced Power and Energy Program, UC Irvine	Michael	MacKinnon
Air Liquide Advanced Technologies	Dwight	Zuck
Air Products	Christine	Kretz
Ballard Power Systems	Alan	Mace
BASF - Venture Capital America, Inc.	Adam	Lack
Bay Area Air Quality Management District	Joseph	Steinberger
Burns & McDonnell	Dwayne	Bradley
Cal Maritime	Keir	Moorhead
Cal Maritime	Ryan	Storz
California Air Resources Board	Heather	Arias
California Air Resources Board	Alberto	Ayala
California Air Resources Board	Ajay	Mangat
California Energy Commission	Andre	Freeman
California Fuel Cell Partnership	Keith	Malone
California Hydrogen Business Council	Mark	Abramowitz
California Hydrogen Business Council	Vera	Medici
California Hydrogen Business Council	Jeff	Serfass
California Hydrogen Business Council	Cory	Shumaker
California Trucking Association	Alex	Cherin
CALSTART	Michael	Ippoliti
Clean Energy	Greg	Roche
Coalition for Clean Air	Nidia	Erceg
Deloitte	Kohei	Masaki
Doosan Fuel Cell America	Derek	Hildreth
DW Thornburg, Inc.	David	Thornburg
E2 Manage Tech	Yair	Crane
Earth Justice	Adrian	Martinez
Environmental Defense Fund	Christina	Wolfe
Environmental Protection Agency	Francisco	Donez
ETA Power Systems, Inc.	Gene	Mendez
Federal Highway Administration	Mark	Glaze
Fuel Cell Lincoln	Louis	Wolf
FuelCell Energy Inc.	Pere	Margalef
FuelCell Energy Inc.	Pinakin	Patel
Gas Technology Institute	Brian	Weeks
Gladstein, Neandross & Associates	Cliff	Gladstein
Gladstein, Neandross & Associates	Jon	Leonard
Governor's Office of Business and Economic Development	Gia	Brazil Vacin
H2 Tek	Paul	Petach
H2B2 LLC	Jose	Gallego
Harbor Association of Industry and Commerce	Jesse	Urquidi
Hornblower	Gordon	Loebl
Hornblower	Julian	Rose
Hydrogenics Corporation	Michel	Archambault

Hydrogenics Corporation	Ryan	Sookhoo
Hyster-Yale	Barry	Larrain
i-2-m	Stuart	Miller
International Transportation Service, Inc.	Eric	Bayani
ITM Power	Steve	Jones
James Dumont Consulting	James	Dumont
Longitude 122 West, Inc.	Susan	Schoenung
Loop Energy	David	Leger
Nel Hydrogen	Arndt	Lutz
National Renewable Energy Laboratory	Jennifer	Kurtz
Nuvera Fuel Cells	Gus	Block
Office of Naval Research	Leo	Grassilli
Pacific Gas & Electric	Easar	Forghany
Pacific Gas & Electric	Ron	Goodman
Pacific Merchant Shipping Association	Thomas	Jelenic
Plug Power	John	Cococcia
Plug Power	James	Petrecky
Port of Hueneme	Christina	Birdsey
Port of Long Beach	Matt	Arms
Port of Long Beach	Hayden	Beckman
Port of Long Beach	Rick	Cameron
Port of Long Beach	Morgan	Caswell
Port of Long Beach	Ben	Chavdarian
Port of Long Beach	Rafael	Delgado
Port of Long Beach	Christine	Houston
Port of Long Beach	Renee	Moilanen
Port of Long Beach	Allyson	Teramoto
Port of Long Beach	Heather	Tomley
Port of Los Angeles	Scott	Baird
Port of Los Angeles	Amber	Coluso
Port of Los Angeles	Tim	DeMoss
Port of Los Angeles	Michael	DiBernardo
Port of Los Angeles	Jacob	Goldberg
Port of Los Angeles	Teresa	Pisano
Port of Los Angeles	Lisa	Wunder
PowerHouse Energy Americas	David	Moard
Proton OnSite	Stephen	Szymanski
Ramboll Environ	Varalakshmi	Jayaram
Sandia National Laboratories	Joe	Pratt
Sheldon Research and Consulting	Mark	Sheldon
Shell	Wayne	Leighty
Sierra Energy	Paul	Gruber
Southern California Gas Company	Jeffrey	Reed
Solar Hydrogen Inc.	Sigrid	Cottrell
Solar Hydrogen Inc.	Andrew	Heath
South Coast Air Quality Management District	Naveen	Berry
South Coast Air Quality Management District	Brian	Choe

South Coast Air Quality Management District
South Coast Air Quality Management District
The Pasha Group
TRIZ Engineering Solutions
Truckenbrodt Clean Energy Consulting
U.S. Department of Energy
US Hybrid & US Fuel Cells
Vopak Terminal Los Angeles Inc.
Yusen Terminals Inc.

Joseph	Impullitti
Fred	Minassian
Jeff	Burgin
Gregory	Malenich
Andreas	Truckenbrodt
Pete	Devlin
Abas	Goodarzi
Mike	LaCavera
Linda	Frame

Appendix C – Links to presentations and additional materials

Heather Arias, Freight Transport Branch, California Air Resources Board	 California's Freight Landscape: Agencies Working Together
Heather Arias, Chief Freight Transport Branch, California Air Resources Board	 ARB Freight Incentives Overview
Scott G. Baird, Electrical Engineer Associate, POLA Engineering Division	 Hydrogen Stationary Application Solutions - Port of Los Angeles
Rick Cameron, Managing Director of Planning and Environmental Affairs	 Road to Zero Emissions
P. (Ben) Chavdarian, Senior Electrical Engineer, Port of Long Beach	 Port Power Demand, Strategies and Security Planning
John Cococcia, Vice President, Strategic Marketing & Investor Relations, Plug Power	 Material Handling
Pete Devlin, Market Transformation and Intergovernmental Manager, Hydrogen and Fuel Cells Technologies Program, U.S. Department of Energy	 DOE Overview of Motive Fuel Cell Technologies
Francisco Donez, Air Quality, Environmental Protection Agency	 Environmental Protection Agency Programs
Nidia Erceg, Deputy Policy Director, Coalition for Clean Air	 Purpose for Zero Emissions Technology
Andre Freeman, Supervisor MD-HD Vehicle Technology Unit Fuels and Transportation Division California Energy Commission	 CEC Alternative and Renewable Fuel and Vehicle Technology Program
Mark Glaze, Air Quality Specialist, Federal Highway Administration	 Alternative Fuel and Port Related Uses of Congestion Mitigation and Air Quality Improvement (CMAQ) Program Funds
Abas Goodarzi, President and CEO, US Hybrid	 Integrated Electric, Fuel Cell and Hybrid Powertrain Components Powering Clean Mobility
Jennifer Hunt, Manager -Applications Engineering, FuelCell Energy	 Tri-Generation Technology for Port Applications
Alan Mace, Product Manager, Ballard Power Systems	 Mobile Application Solutions

Fred Minassian , Assistant Deputy Executive Officer, Technology Advancement Office, South Coast Air Management Quality District	 Funding and Program Landscape at SCAQMD
Robert Nielsen, Director, Business Development, Fuel Cell Energy	 Fuel Cells for Primary Power at the Ports
Jeffrey G. Reed, Director Business Strategy and Advanced Technology, Southern California Gas Company	 Hydrogen Supply Solutions
Ryan Sookhoo, Director New Initiatives, Hydrogenics	 Multi-Functional Fuel Cell Power System (Ports)
Stephen Szymanski, Director -Business Development, Proton OnSite	 Renewable Electrolysis for Fuel and Energy Storage: Introduction and Application Considerations
Dwight Zuck, H2 Energy, Air Liquide Advanced Business & Technologies	 Hydrogen Delivery: Considerations & Options
