# Hydrogen and Fuel Cells in the Ports and Shipping Workshop

Oct. 9-10, 2018 • Banning's Landing Community Center • Port of LA

California Hydrogen Business Council

*Hydrogen Means Business in California!*

# Workshop Report

## California Hydrogen Business Council

*"Hydrogen Means Business in California"*

www.californiahydrogen.org | 310-455-6095

## Acknowledgements

### Planning Committee

The 2018 Hydrogen and Fuel Cells in Ports and Shipping Workshop was planned and organized by members of the California Hydrogen Business Council's Heavy-Duty Transportation, Goods Movement, and Clean Ports Sector Action Group. We particularly thank co-chairs Gus Block and Andreas Truckenbrodt, as well as Cory Shumaker, CHBC Development Specialist. The workshop attracted over 90 people, an indicator of the strong the interest in this topic.

The CHBC also thanks the Port of Los Angeles for making the Banning's Landing Community Center available for this two-day workshop.

## Workshop Sponsors

The CHBC thanks the following organizations for their financial contributions, without which this workshop would not have been possible.

*Gold Sponsors*

Air Liquide creative oxygen

HYDROGENICS SHIFT POWER | ENERGIZE YOUR WORLD

BALLARD

*Silver Sponsors*

THE LINDE GROUP

PLUG POWER

South Coast AQMD

Report Published: March 11, 2019



For feedback and comments, contact:
Emanuel Wagner | CHBC Deputy Director
ewagner@californiahydrogen.org
This report was prepared by Emanuel Wagner, Peter Thompson, and Cory Shumaker.

## Executive Summary

In their October 2018 report, the United Nations Intergovernmental Panel on Climate Change stated that humanity has 12 years to keep temperature rise between 1.5°C and 2°C[1], above which catastrophic effects are inevitable, particularly along coastlines. This outcome would affect economies heavily reliant on seaports. Governments around the world are taking significant action to set targets on reducing greenhouse gas (GHG) emissions as well as local pollutants such as nitrogen oxides (NOx), sulfur oxides (SOx), and particulate matter. To avoid surpassing the 2°C zone, jurisdictions need to accelerate their emissions reduction programs and begin mass deployment of zero emission technologies across all sectors of the global economy. The amount of GHGs produced from the activities associated with loading a container, transporting it to a port, and loading it onto a ship is generally far greater than the per container GHGs released by ocean transit, even on the longest sea routes.

California has established itself as one of the global leaders in the clean energy transition. The state has significantly increased the share of renewable energy on its electric grid and is developing and deploying zero emission technologies. The ports and maritime sectors represent prime targets for emissions reductions in California, with significant GHG, NOx, SOx, and particulate matter emissions sourced from daily activity that continues to grow as the ports increase their operations. To continue accommodating port expansions while reducing emissions, the Port of Long Beach and the Port of Los Angeles have adopted a joint Clean Air Action Plan to reduce emission and transition equipment to alternative and eventually zero emission technologies.[2]

---

*"Reducing emissions while increasing cargo will not be easy, as those goals seem to run counter to one another, but we have no choice but to reduce emissions in order to grow. We believe, and the past decade has proven, that port growth and emissions reductions are not mutually exclusive ideas. They can, and must, occur together."*

*- Chris Cannon, Director of Environmental Management - POLA*

---

Maritime has become a major focus of the zero emission movement since the International Maritime Organization announced a goal of reducing emissions by at least 50% from the shipping sector by 2050 from 2008 level.[3] In response, shipbuilders and ship owners are seriously considering hydrogen as a way to achieve zero emission propulsion. Fuel cell ferry projects are already underway in Scotland and Norway.

Transitioning from combustion technology will not only accomplish reductions in emissions, it will also improve the air quality for communities in close proximity to ports by lowering local criteria pollutants. Now that zero emission technology is available to ports and maritime sector operations, air quality improvements can be attained, a goal that public health and environmental justice groups have sought for decades.

[1] https://www.un.org/sustainabledevelopment/blog/2018/10/special-climate-report-1-5oc-is-possible-but-requires-unprecedented-and-urgent-action/
[2] http://www.cleanairactionplan.org/
[3] http://www.imo.org/en/mediacentre/hottopics/ghg/pages/default.aspx

As zero emission hydrogen fuel cell equipment is developed, tested and offered for commercial sale, OEMs will need to work with operators to address logistics, operation, maintenance, and safety concerns to ensure a smooth transition away from fossil fuels.

## Contents

## Day 1 Opening Keynote – Importance of the Role of Hydrogen in Ports & Shipping

*Chris Cannon, Director of Environmental Management – Port of Los Angeles*

> *"We must reduce our reliance on combustion based engine sources, and we must reduce our carbon footprint. Hydrogen is a largely untapped source of power generation and energy storage. For hydrogen, as you know, is the most abundant of all chemical elements on earth."*

The Port of Los Angeles (POLA) is the largest port in North America, spanning 7,500 acres and 43 miles of waterfront. Operations at the bustling port cause high emissions of NOx, SOx, particulate matter, and greenhouse gases (GHG). To improve local air quality, POLA and Port of Long Beach (POLB) adopted the Clean Air Action Plan (CAAP), targeting emissions reductions from ships, on-road trucks, trains, cargo handling equipment, and harbor craft. To accomplish the goals set out in the CAAP, the two ports seek to replace diesel-powered equipment by testing the two available zero emission technology options: batteries and fuel cells.

One of the most publicized heavy duty vehicle pilot projects at the ports has been Toyota's *Project Portal*, a fuel cell powered Class 8 truck. Fuel cell electric trucks (FCETs) are part of Toyota's vision to develop zero emission equipment with the range and operating capabilities to compete with and ultimately replace diesel trucks operating throughout Southern California. To advance the adoption of hydrogen and fuel cell equipment in the ports, a number of issues need to be addressed, including:

- Hydrogen fuel is very expensive in California. In many regions, hydrogen costs in Europe are low as a byproduct of oil refineries. Can that model be brought to California to create a sustainable, cost competitive solution?
- How can affordable hydrogen be produced from renewable energy sources?
- Capital costs for hydrogen fuel cell equipment is 20-40% more expensive than other technologies. How will the manufacturers drive down costs? The path to price reduction must be explained to operators and communities to enable adoption.
- Many operators have expressed concern over the safety of using hydrogen fuel. How can the industry work with the ports to address those concerns and educate operators on the safe use of hydrogen in a port setting?
- POLA is exploring microgrids for warehouses, distribution centers, and manufacturing facilities to operate off-grid and use renewable power generation. What are the steps to include hydrogen and fuel cells in these renewable power generation facilities?

POLA sees a role for both battery and fuel cell zero emission technologies. Battery electric trucks can transport goods between distribution centers close to the ports, while FCETs can handle long haul transport. The port is developing a remote cargo facility in Merced to facilitate the efficient movement of goods throughout the state. Ports around the world are recognizing hydrogen's logistic similarity to other fuels, like diesel and natural gas. Industry must plan 10-20 years ahead to address infrastructure, keeping in mind that much of the existing infrastructure can be used with hydrogen.

## Keynote – Current and Future Hydrogen and Fuel Cell Activities in Shipping

*Laurence Grand-Clément, CEO – PersEE*

When thinking of hydrogen and fuel cell technology deployment for vessels, the question is no longer 'if' – it is now 'where,' 'how,' 'who' and 'when.' The International Maritime Organization (IMO) stated that by 2030 GHG must be reduced by at least 40% from 2008 levels, and by 50% by 2050. To accomplish these goals, industry stakeholders are developing hydrogen and fuel cells for maritime applications, expected to be available by 2020 and beyond. Cost reductions will be critical to the success of fuel cell systems. If 50,000 fuel cells are manufactured each year, overall cost will reduce by an eighth, which could happen as early as 2020 with the developments in China.

Over the next three years, multiple fuel cell maritime projects will be deployed around the globe. The Maranda Project will create a market strategy for fuel cells in maritime applications. The project is developing a 100 kW maritime fuel cell, providing positioning stability to a research vessel operated by VTT in Finland. The project will be operational in 2019. Fuel cell boats are also being developed in France, with two noteworthy project concepts, *Race for Water* and *Energy Observer*. In 2020, the HYSEAS III car ferry and HYBRID ship will begin operations in the United Kingdom. Norway will have multiple deployments beginning in 2021-2022 to reduce emissions from ferries in the fjords. In an effort to reduce their GHG emissions, Viking Cruises is expected to use fuel cells on their cruise ships by 2023.

To accelerate deployment of fuel cells in the sector, a number of barriers need to be addressed. Complications will arise for ship owners seeking to utilize hydrogen due to the lack of rules and regulations at the IMO; therefore working with the IMO over the next four years will be critical for early deployment of these fuel cell maritime projects. The industry will also have to address the need for eventual expansion of hydrogen production capacity to meet the large demand of the marine sector. Liquid hydrogen could meet that demand, as liquefaction technology has made significant progress in recent years.

## Voice of the Customer: Opportunities and Constraints for Hydrogen and Fuel Cells in Shipping

*Moderator: Cory Shumaker, Development Specialist – California Hydrogen Business Council*

*Bruce Applegate, Associate Director of Ship Operations and Marine Technical Support – Scripps Oceanographic Institute, UC San Diego*

The Scripps Oceanographic Institute (SOI) operates three research oceanographic vessels, one of which will be powered by hydrogen fuel cells. SOI is exploring the replacement of the diesel powered research vessel ROBERT GORDON SPROUL, in operation along the California coast. A feasibility study has been concluded by Glosten and a "Conditional Approval in Principle" was given after regulatory review by maritime safety authority DNV-GL. SOI will utilize zero emission vessels if they can accomplish the SOI's required missions profile. Zero emission vessels are superior to traditional diesel with their quiet operation, ideal for ocean research, and the lack of no noxious fumes on deck improves the health of the scientists onboard, especially since a cause of seasickness on boats today is from diesel fumes. SOI would like to operate the first research vessel powered by fuel cells in the US.

*Klaus Vänskä, Global Business Development Manager, Marine Systems – ABB Marine & Ports*

Replacing an entire shipping fleet with new technology requires a long time scale, up to 45 years. Alternative fuels that fleets adopt will depend heavily on efficiency improvements for each technology. Hydrogen and fuel cells are already capable of meeting the needs of the shipping industry, but integrating a renewable hydrogen supply at affordable cost remains a challenge. To accelerate the deployment of hydrogen fuel cell vessels, the classification, distribution infrastructure, and knowledge to build fuel cell vessels will need to expand. ABB and Ballard have signed an MOU on developing the next generation megawatt level fuel cell power system for sustainable marine e-mobility. The 3 MW unit would fit into a 40-foot shipping container (not including hydrogen storage). ABB is studying with Cruise vessel owners to install MW level fuel cell units to Cruise vessels to supply hotel load.

*Captain Joe Burgard, Executive Vice President – Red & White Fleet*

The Red and White Fleet is a San Francisco-based sightseeing company that operates five vessels in its fleet. They are part of the consortium that won a grant from the California Air Resources Board to build and implement a hydrogen fuel cell ferry. The owner of the Red and White fleet has adopted a vision to be zero emissions by 2025. Apart from the environmental benefits of going to zero emissions, offering a zero emission experience to their customers has attracted attention. A hydrogen fuel cell vessel could reduce operational costs and increase overall fuel efficiency of their fleet. The fleet is addressing two important concerns: 1) safety and the impact of safety concerns 2) availability of public funds for projects as an early adopter.

## Keynote – Safety Regulations, Codes and Standards for Hydrogen in the Shipping Environment

*Gopal Nair, Station Manager – DNV-GL*

DNV-GL is a large, international accredited registrar and classification society headquartered in Høvik, Norway. They create rules and guidelines for installing power systems on vessels, including fuel cells. After looking at different types of fuel cells, DNV-GL sees solid oxide (SOFC) and proton exchange membrane (PEM) fuel cells as the most feasible options for zero emission maritime applications. With noise and vibration being a major issue on ships, fuel cells offer a quieter power system for vessels. Their recent development projects are focusing on a common rule framework for maritime use of fuel cells. Currently for hydrogen and fuel cells there is no prescript IMO code, but there is a part of the IGF code that provides for the possibility for an alternative design process. This is a risk-based approach consisting of a preliminary analysis, quantitative analysis and a report of assessment that requires a large investment and an extended timeline for approval. The final step is a presentation to the flag of authority. There are a number of maritime hydrogen projects that DNV-GL is involved with.

## Hydrogen and Fuel Cell Solutions for Shipping

*Moderator: Thomas Lamberti, Researcher – University of Genoa, Italy & Chief Executive Officer - H2Boat*

Reduction of GHG emissions is a global issue that will need to be addressed by governments and industries across all sectors, including the shipping industry. All stakeholders will need to examine the local sources of emissions in their jurisdictions to bring deep decarbonization.

*Dr. Joseph Pratt, CEO & CTO – Golden Gate Zero Emission Marine*

Emissions from harbor craft have increased over the past several years. Sandia National Laboratory published several studies that show the potential of a ferry vessel converted to hydrogen fuel cell power with three 120 kW fuel cell modules and 250 kg of hydrogen compressed at 250 bar, providing 1-2 days of operation. The electric drive would be outfitted with two 300 kW shaft motors with 100 kWh of batteries to provide the power boost to achieve 22 knots. If this system were retrofitted to a ferry, it could hold 84 passengers.

The Water-Go-Round project will be the first zero emission fuel cell ferry in the world. Construction of the ferry began in November 2018, with operations set to begin in October 2019. It will be tested in multiple configurations – as a commuter ferry, an excursion and tour boat, a research surveyor, a package and freight delivery ship, and a crew boat – during a three-month demonstration. The project will be developed and co-funded between the California Air Resources Board and a consortium of Hydrogenics, BAE Systems, Hexagon Composites, and the Red and White Fleet based in San Francisco. All of the ferry's components are commercially available, allowing it to skip the research and development phase. A FCET will deliver hydrogen fuel to the ferry.

*Alan Mace, Market Manager – Ballard Power Systems*

Fuel cells provide maritime vessels the range and power requirements needed to perform, as well as significantly reduced noise and vibration. This enables the Orkney Island Council to eliminate fossil fuel emissions from watercraft through an initiative called HYSEAS III, a project to demonstrate a hydrogen fuel cell car ferry in 2021. The Orkney Islands produce excess electricity from wind power, which will be used to produce hydrogen electrolytically.

The HYSEAS III project is one of many hydrogen-focused projects on the Orkney Islands, others include BIG HIT, Surf 'n' Turf, and Dual Ports. The pursuit of energy security and independence is a major driver for fuel cell deployments in the islands, with hydrogen produced and utilized at the local level.

*Ryan Sookhoo, Director of New Initiatives – Hydrogenics*

A major advantage of fuel cells is that they can be used across all sectors, for virtually all applications. The maritime sector does not require a fuel cell dedicated specifically for marine use. The only difference is how the fuel cells are packaged for the applications, allowing manufacturers and equipment developers to take advantage of economies of scale. Hydrogenics will use a power rack approach for maritime solutions. As with all new technologies, safety is a concern for the end-users that must be addressed. Fuel cell systems are installed with specific safety mechanisms, including ventilation, sensors, fire detection, and operator training.

Hydrogenics is applying lessons learned from the hydrogen fuel cell commuter train it helped develop with Alstom to the marine sector.

*Steve Jones, Managing Director – ITM Power*

British Columbia is developing a robust, renewable hydrogen production industry, which is planning to export hydrogen to demand centers in California and Japan. The BC strategy will use 300 MW of electrolyzers, producing 50,000 tons of hydrogen per day with power generated from wind, solar, and hydro. The hydrogen will be transported by liquid tankers and allow the importing ports to use hydrogen as it passes through. A feasibility study on this project will be completed by Q2 2019. An intelligent approach to decarbonizing the marine sector will entail the coupling of multiple sectors in order to take advantage of logistical synergies and economies of scale.

## Day 2 Opening Keynote – Green Port of the Future

*Heather Tomley, Director of Environmental Planning – Port of Long Beach, California*

The Port of Long Beach is a major driver of economic activity for California and the United States. To address emissions sourced from the port, POLB adopted a green port policy in 2005 to improve air quality. Since adopting the policy, the port has reduced its emissions while simultaneously experiencing large growth. As the port continues to reduce its GHG emissions, it is beginning to prepare for rising sea levels.

POLB is looking at zero emission technologies to eliminate emissions altogether; the zero emission equipment will play an ever increasing role in the port's operation. The Clean Air Action Plan is the strategy for POLA and POLB to meet 40% reduction of GHG emissions by 2030 and 80% by 2050 from 1990 levels. Specifically, the ports will need to work together to meet the 2030 and 2035 zero emission equipment and truck goals, respectively. As the hydrogen technology becomes more developed, building the supporting infrastructure will be critical. The CAPEX and fuel cost for hydrogen are higher in the early stages of development and deployment compared to battery.

California has made enormous investments to decarbonize light duty transportation throughout the state and is beginning to turn its focus to medium- and heavy duty and off-road transportation. In the past two years, POLB has received over $78 million in grants to demonstrate zero emission technology over the next three years. Most of these demonstration projects are for battery electric equipment, with some for fuel cells. As the demonstrations progress, obtaining feedback from operators will provide developers valuable information on how to improve the zero emission equipment. The Port Authority is looking to establish goals for zero emissions. Ultimately, operators will determine whether or not to adopt them.

## Keynote – International Hydrogen and Fuel Cell Activities in Ports

*Cory Shumaker, Development Specialist – California Hydrogen Business Council*

Ports around the world are beginning to look at hydrogen and fuel cells as a potential solution to decarbonizing their operations and reducing air pollution. The global port community is well connected, just by the nature of the business. They also share the problem of pollution and emissions. In 2018, the World Port Sustainability Program was launched to contribute to the Sustainable Development Goals of the UN. The program is developed along five themes:

1) Resilient Infrastructure
2) Climate and Energy
3) Community Outreach and Port-city Dialogue

4) Safety and Security
5) Governance and Ethics

The program will report regularly on its progress and in phase two will have a portal of projects and initiatives of port-related partner organizations.

Ports across the globe look at the potential of using hydrogen or are set to demonstrate hydrogen vehicles and equipment. The ports of Los Angeles and Long Beach lead the way in terms of number of demonstrations ongoing and scheduled. The port of Valencia, Spain is now involved in a FCH-JU funded demonstration of a hydrogen fuel cell reach stacker by Hyster-Yale and a hydrogen fuel cell yard tractor. Other ports in Europe such as Rotterdam (Netherlands), Antwerp, (Belgium), Groningen (Netherlands), and Hamburg are seriously considering the use of hydrogen. The Port of Rotterdam produced a study that demonstrates how to reduce emissions by 95% by 2050, with hydrogen being explicitly recognized as a key technology solution to accomplish the emissions reduction goals. The port of Groningen is getting serious with a hydrogen pipeline already developed and plans to use nearby offshore wind to produce renewable hydrogen. In the far corner of the world, Australia is preparing to export large amounts of "CO2 free" hydrogen to Japan on liquid carriers from Hastings. New Zealand announced at the end of 2018 that it will be producing hydrogen from electrolysis and plans to begin incorporating hydrogen fuel cell vehicles and equipment. In 2016, the US EPA created a National Ports Initiative to assess and implement emission reduction strategies across all applications at ports including ocean going vessels.

## Voice of the Customer: Opportunities and Constraints for Hydrogen and Fuel Cells in Port Applications

*Moderator: Tim Sasseen, Business Development Manager – Ballard*

The tougher the job, the better fuel cells are at getting it done.

### José Andrés Giménez Maldonado, Energy in Ports and Safety Director – Port of Valencia, Spain

The Port of Valencia is the fifth largest port in Europe with three large container terminals. Eighty percent of demand for electricity consumption at these terminals comes from refrigerated containers and cranes. Ninety percent of demand for diesel is caused by rubber-tired gantry cranes and yard tractors. The Port of Valencia has successfully completed two demonstration projects for LNG and battery terminal tractor prototypes. However, the LNG prototype was not able to operate for 24 hours (it operated for 16 hours) and was not a zero emission technology. Meanwhile, the battery powered tractor was expensive, required long charging time, and had low autonomy with a six hour duty cycle each day.

Through the H2Ports initiative, Valencia will begin testing a hydrogen fuel cell yard tractor and container handler. Autonomy was a critical factor in the decision to test the hydrogen powered equipment. To increase the deployment of hydrogen powered equipment, manufacturers will need to educate and demonstrate to labor representatives that hydrogen will be the best available solution. Decarbonizing the ports will be a major challenge, expanding port operator's knowledge of hydrogen solutions and addressing safety concerns will accelerate the emissions reduction goals.

*Rosie Mercer, Manager Sustainable Business Improvement – Port of Auckland, New Zealand*

The Port of Auckland (POAL) is positioning itself as a global leader for port sustainability, driving change for the ports sector. POAL created the Climate Leaders Coalition to continue its leadership in the port sector and is a strong advocate for a diverse, multi-technology energy mix for the future. Several years ago, the port was under pressure by the City of Auckland to improve air quality around the port. The city considered repurposing the highly coveted waterfront land. New Zealand's electric grid is currently 85% from renewable sources, with plans to go 100%. By the end of 2019, all straddle carriers in POAL will be autonomous.

POAL is looking to install a renewable hydrogen refueling station, using an electrolyzer to demonstrate that hydrogen can be a fuel of the future. The station will begin by refueling buses and cars, then add cargo handling equipment and trucks. The proposed system would be 1.25 MW and has the support of POAL board and management.

*Heather Tomley, Director of Environmental Planning – Port of Long Beach, California*

The POLB has signed onto the World Ports Climate Declaration, which seeks to increase collaboration between ports on how to reduce GHG emissions. The Port of Rotterdam led the development of this declaration. Thirteen percent of equipment in POLB is zero emission, all of which are operated in the middle harbor project, a fully electrified, automated terminal. POLB is targeting RTGs, top picks, and forklifts to be transitioned to zero emission first. By 2020, 16% of equipment in the port will be zero emission.

POLB sees hydrogen as an appealing technology solution because of its zero emission, high performance, and long range characteristics. The majority of truck operations (62%) goes to the downtown railyard, but 33% of trucks go to San Bernardino. POLB is developing a scope of work for a pilot demonstration for 50 to 100 zero emission trucks that will operate there and in POLA. The two ports will need to find the necessary funding support before the RFP is issued.

POLB is performing a variety of tests, including a hydrogen yard tractor, microgrid to provide power to pilot vessels during outages, and a project with NREL to produce hydrogen at their maintenance facility and use stationary fuel cells to provide power to the maintenance and controls facility.

## Hydrogen and Fuel Cell Solutions for Ports

*Moderator: Al Cioffi, Business Development – Plug Power*

Plug Power was the first company to commercialize fuel cell forklifts. Today there are 20,000+ fuel cell forklifts in the market, requiring 16,000 fills per day at 70 fueling stations across the country.

*Ben Nyland, President & CEO – Loop Energy*

To transition to a new technology, the business case for the new technology must be better than the incumbent technology. Loop Energy has developed a technology that allows for 30-40% less materials in their fuel cell stacks. Their fuel cell yard tractor to begin testing at POLB will be manufactured by Hova; it includes a 50 kW fuel cell and a 50 kWh battery to allow it to perform two shifts at the port. Loop Energy is working with Walmart and terminal operators to educate them on Loop's business and address their

concerns. Assuming end users can secure a low cost source of hydrogen, the total cost of ownership for a fuel cell yard tractor will be cheaper than the diesel equivalent.

*Laurence Dunn, Chief Engineer – Hyster-Yale Group*

Hyster-Yale is working to provide fuel cells for all sizes of their forklifts. One size of fuel cell does not fit all the different varieties of container handling equipment. The reliability of the fuel cells will need to improve before customers are comfortable purchasing the equipment. The return on investment for battery electric Big Trucks and the supporting infrastructure is 1.5 years. The benefits of the battery technology are reduced maintenance and lower energy costs. Comparatively, the projected return on investment for the fuel cell equipment and supporting infrastructure is 2.5 years.

## Keynote - Commercializing Hydrogen Technology in the Ports

*Andreas Truckenbrodt, Chair – Loop Energy*

To commercialize hydrogen and fuel cell technology, the market must see value in using the technology. Furthermore, there must be societal value, the product needs to outperform the direct and indirect competitors, and the supporting infrastructure needs to be in place. If manufacturers address those factors and the technology is cost competitive, it will be adopted. The individual value of using hydrogen and fuel cells is low, with a less than optimal business case. However, the public value for this technology is high because it is zero emission and can help mitigate climate change.

Today, hydrogen fuel cells feature great performance but still need to improve mean time between failures and lifetime. When done correctly, safety for hydrogen is not an issue. Improving the ease of operation for the end user is critical. Operation needs to be as similar to current practices as possible.

Policy requests need to go beyond asking for financial support and include comprehensive regulations. Expanding the infrastructure network remains a critical hurdle for the hydrogen industry but it will become financially attractive as more vehicles are deployed. Cost reductions and sustainable business cases are still critical topics.

## Port Community Impact Panel

*Moderator: Dr. Joe Lyou, President & CEO – Coalition for Clean Air*

*Jesse Marquez, Executive Director – Coalition for a Safe Environment*

The community of Wilmington, California has had major health problems from the operations at the ports and surrounding trucks. The top reasons the Coalition for a Safe Environment (CSE) is an advocate for hydrogen are to improve public health and reduce greenhouse gases. CSE is compiling a list of all the zero emission options for trucks and equipment that is continuously being updated. The general public, end users and policymakers must be educated with the same set of facts. CSE can advocate for additional hydrogen projects.

The primary sources of pollution in the San Pedro ports area are Class 8 on- and off-road drayage trucks. California Assembly Bill 32 (AB32) and the Cap & Trade Program provide billions of dollars each year for clean projects. It's the people that drive change, not ports or regulatory agencies. AB617 is about the community bordering the ports and will require reductions in greenhouse gases. The industry must share problems and roadblocks at public hearings.

*Bahram Fazeli, Director of Research & Policy – Communities for a Better Environment*

Communities for a Better Environment has been around for 40 years in the environmental community with multiple departments. The 2030 and 2050 targets cannot be accomplished unless aggressive moves are made toward zero emissions. Hydrogen can fill some of the gaps to get to the 2050 zero emission transportation goals. The hydrogen and fuel cell industry needs to take an interest in the community of Wilmington, which has one of the highest cancer rates in the country. The industry should identify all avenues to reduce emissions in the community. By establishing a successful pilot program in Wilmington, such as a clean hydrogen project, it will gain the trust of community partners and legislators. The hydrogen industry should focus on goods movement, especially in Southern California. Public policy and regulation are years behind the need to improve public health.

## Opportunities and Barriers to Hydrogen Infrastructure in Ports

*Moderator: Dwight Zuck, Hydrogen Energy Business Development – Air Liquide*

*Paul Fukumoto, Director Business Development – FuelCell Energy*

FuelCell Energy developed a large, multi-megawatt fuel cell in South Korea. To decarbonize the decentralized transportation and thermal energy sectors, significant investment in infrastructure will be needed to advance hydrogen as a solution.

*Jonathan Palacios-Avila, CEO – StratosFuel*

Development of the hydrogen infrastructure represents a great investment opportunity. StratosFuel sees three barriers to the adoption of hydrogen:

1) Market entry: the incumbent technology has a strong foothold on port operations.
2) Lack of subsidies: More funds and incentives need to be offered in order to increase hydrogen refueling at the ports. There are currently many incentives for light-duty vehicles and refueling, but not enough for heavy-duty.
3) Equal technology treatment: Equal funding opportunities need to be offered to both fuel cell and battery electric options.

*Rob Del Core, Director, Fuel Cell Power Systems Group – Hydrogenics USA*

In the early phases of the industry, matching the growth of demand with supply is important. A distinct advantage for hydrogen is the scalability of infrastructure. Five megawatts of electrolyzers can produce 2,000 kg of hydrogen per day, enough to support one train, one ferry boat, five RTGs, and 100 fuel cell trucks. Two containerized electrolyzers combined is a 5 MW system, and Hydrogenics has the ability to combine containers to create a 20 MW system, producing 8,000 kg of hydrogen per day. That is enough hydrogen to support 250-300 fuel cell buses. This equipment can be stationed close to the point of end use for onsite production and refueling, as well as support mobile refueling.

## Government Programs and Funding Opportunities for Hydrogen Projects in Ports and Maritime

*Moderator: Emanuel Wagner, Deputy Director – California Hydrogen Business Council*

The CHBC has grown its advocacy efforts in Sacramento significantly over the past several years. The hydrogen and fuel cell industry has a long way to go to match the advocacy efforts of the other energy industries. For every hydrogen advocate there are 10 battery advocates, and for every one of them there are 10 natural gas advocates. The CHBC will continue to build momentum and stay vocal.

*Chris Jenks, Air Pollution Specialist – California Energy Commission*

The California Energy Commission created the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) to develop and deploy innovative technologies that transform California's fuel and vehicle types to help implement the state's climate change policies. The goals of ARFVTP are to improve air quality, increase alternative fuel use, reduce petroleum dependence and promote economic development. Currently, through the program there are $20 million available each year for hydrogen fueling infrastructure.

$8.5 million in the program is designated for manufacturing and workforce development that could go towards getting tomorrow's technicians ready to service fuel cell vehicles. Other categories in the program that hydrogen could apply for are Advanced Freight and Fleet Technologies ($17.5 million for 2018-2019) and Low-Carbon Fuel Production and Supply ($25 million for 2018-2019).

In April 2018, Shell was awarded $8 million for a 1,000 kg/day renewable hydrogen refueling station at Port of Long Beach for 10 fuel cell trucks. Nikola applied for the same grant for production of 1,000 kg/day of hydrogen from rooftop solar to demonstrate operation of 5 Nikola Class 8 hydrogen fuel cell trucks, later to be expanded to a fleet of 35, at a manufacturing facility. Their project was not awarded.

*Leslie Goodbody, Air Resources Engineer – California Air Resources Board*

The Zero and Near-Zero Emission Freight Facilities Project preliminarily awarded funds to 11 projects, including "Shore-to-Store," which will involve 10 Class 8 fuel cell trucks with two large capacity Shell hydrogen stations in Wilmington and Ontario along with two fuel cell yard tractors in POLA, and 19 fuel cell UPS delivery vans. Before mass adoption of the available zero emission technologies can happen, stakeholders must show the feasibility of the technology, the amount of equipment to transition to zero emission, and the infrastructure needed to support the operation of the equipment.

The VW Beneficiary Mitigation Plan will focus on funding the following:

- Zero-Emission Transit, School and Shuttle Buses ($130 million)
- Zero-Emission Class 8 Freight and Port Drayage Trucks ($90 million)
- Zero-Emission Freight / Marine Projects includes forklifts, port cargo handling equipment, airport ground support equipment, shorepower, zero-emission ferry, tugboat, and towboat repowers ($70 million).

*Nichola Kinsinger, General Engineer – Department of Energy*

There is more than $40 billion available in the US DOE loan and loan guarantees authority. Title 17 Clean Energy Projects need to have an innovative technology, greenhouse gas benefits, located in the US and has a reasonable prospect of repayment.

The loan terms are asset financing up to 30 years at interest rates set based on equivalent Treasury rate plus credit-based spread (~0.5-1.5%). LPO can only guarantee up to 80% of the total project cost;, most projects have at least 35% equity. Co-lending with commercial lenders is encouraged but not required.

The application process includes a $50,000 application fee and a $100,000+ application fee.

## Final Remarks – The Case for Hydrogen in Ports and Maritime

*Pete Devlin, Program Manager – Department of Energy*

Fuel cells are seeing tremendous uptake globally. The US Department of Energy is looking at cryo-compressed hydrogen for heavy duty fuel cell trucks. The DOE 2020 target price for fuel cell systems is $40/kW. H2@Scale is a look at the big picture of hydrogen and the growing future of demand. The current US market for hydrogen is 13 MMT/year; technical potential of demand is 87 MMT/year.

DOE is conducting an evaluation of Port of Tacoma/Seattle hydrogen use for cargo handling, port transit and port marine, such as container ships at berth by a barge mounted hydrogen fueled PEM fuel cell, using renewable hydrogen generated onsite. DOE wants to start an international collaborative for maritime and rail. DOE is the Chair of the International Partnership for Hydrogen and Fuel Cells in the Economy.

See the table below for shore power required for different vessels and equipment:

| Vessel Type | Power Required | | | Run Time (hr) | | |
|---|---|---|---|---|---|---|
| | Typical | Low | High | Typical | Low | High |
| **Harbor Tug** | 100 kW | 7.5 kW | 410 kW | 4 | 1 | 6 |
| **Tug-Barge** | 115 kW | - | - | N/A | - | - |
| **Fishing Trawler** | 200 kW | 75 kW | 670 kW | continuous | 48 | months |
| **Bulk** | 200 kW | 150 kW | 300 kW | 48 | - | - |
| **Tanker (steam pumps)** | 700 kW | 550 kW | 800 kW | 48 | 24 | 72 |
| **Auto/RoRo** | 800 kW | 700 kW | 890 kW | 24 | 24 | 36 |
| **Container** | 1.4 MW | 500 kW | 8.4 MW | 48 | 24 | 72 |
| **Reefer** | 3 MW | 900 kW | 5.6 MW | 60 | 48 | 72 |
| **Cruise** | 6 MW | 3.5 MW | 11 MW | 10 | 10 | 12 |
| **Tanker (elec. pumps)** | 7.8 MW | - | - | 48 | 24 | 72 |

## Open Discussion, Outcomes and 2019 Action Items

*Moderator: Cory Shumaker, Development Specialist – California Hydrogen Business Council*

The industry needs to conduct community workshops to better explain the technology. Increasing the number of advocates from the general public will bring more attention and support to hydrogen and fuel cells to accomplish emission reduction and air quality improvement goals. CHBC could work with Rio Hondo College to create an education program with one of the Centers of Excellence.

The City of Los Angeles has developed a plan to electrify the transportation sector. Thus far, there has been little engagement and representation from the hydrogen and fuel cell industry.

Industry advocates, like the CHBC, must press policymakers to create additional opportunities to improve hydrogen infrastructure and expand to all applications.

The Ports of LA and Long Beach should work with the CHBC to establish a better mutual understanding of the ports and hydrogen fuel cell industries.

The Coalition for a Safe Environment is forming a group to propose replacing diesel engines for specific applications in ports, hydrogen should play a role. Additionally, encouraging the IMO to take action will accelerate effort. The Coalition for a Safe Environment has a network of organizations that could sign on to letters pressuring the IMO to act.