



2017 CALIFORNIA HYDROGEN AND FUEL CELL SUMMIT

Hosted by the California
Hydrogen Business Council

This is the report of the fifth Annual California Hydrogen and Fuel Cell Summit held in Sacramento, California at the California EPA on September 25-26, 2017.

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**CALIFORNIA HYDROGEN
BUSINESS COUNCIL**

Hydrogen Means Business in California!

Abstract

The 2017 California Hydrogen and Fuel Cell Summit, hosted by the California Hydrogen Business Council, attracted more than 225 attendees from California and beyond, to discuss the status, progress, barriers, and next steps in the hydrogen and fuel cell industry.

Keynote speakers included legislative leaders, regulatory agency, and industry leaders, including Senator Nancy Skinner, Air Resources Board Deputy Executive Officer Edie Chang, Environmental Strategist to the Governor's Office of Business and Economic Development Gia Brazil Vacin and American Honda Motor Company's Assistant Vice President, Advanced Powertrain Group Jim Burrell.

The scope of the Summit mirrored the scope of the CHBC with presentations and discussion of the developing hydrogen-fueling infrastructure in California, decarbonizing the energy sector, energy storage, renewable pathways to hydrogen, zero emission transit, heavy-duty trucks and goods movement, and activities outside of California.

Disclaimer

This report is a combination of notable quotations, paraphrasing and notes taken during the Summit by CHBC staff and volunteers. The individual speakers have neither reviewed nor approved this report. Staff does not guarantee an accurate reflection of the presentations and discussions at the Summit.

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Day 1

Welcome, Introduction, Goals of the Summit, CHBC Report

Jeff Serfass, Executive Director, CHBC

The 5th Annual California Hydrogen and Fuel Cell Summit was created for business to government, government to business and business to business conversations about the opportunities, progress and challenges in the growing hydrogen business in California.

Keynote: Industry

Jim Burrell, Assistant Vice President, Advanced Powertrain Group, American Honda Motor Company

Ninety-seven percent of everything sold by Honda in North America is manufactured in North America. Every year, Honda produces 5 million cars around the world; 1.7 million of those vehicles are produced in the United States and 1.3 million in Japan. Honda believes that FCEVs offer the most promising technology to meet environmental concerns, which is why they have committed to the goal of 2/3 of global sales be electrified by 2030.

Honda's current generation of fuel cell technology is 33% smaller than the previous generation with a 60% increase in power density to reach a 366-mile range. The Honda Clarity has more safety equipment than any other Honda vehicle. The Clarity is in high demand, with waitlists between 4 and 12 months. Honda has started a joint venture with General Motors called Fuel Cell Manufacturing LLC.

"No longer is this a science experiment but a vehicle to challenge other alternative vehicles" – Jim Burrell

Honda is participating in the expansion of hydrogen infrastructure, with significant investments made in smart hydrogen stations designed to generate, store and supply hydrogen; the systems do not use a mechanical compressor. Collaborating with H2USA, Honda is developing a roadmap with the goal to bring 250 fueling stations to the northeast corridor by 2027. Plans to build a nationwide hydrogen refueling station network beginning in Atlanta, Dallas, and Seattle are underway. As the hydrogen industry continues to grow, Honda seeks to be a change maker in that development.

Keynote: Government

Senator Nancy Skinner, Representing the 9th Senate District, California

Governor Schwarzenegger had intended a larger vision for the number of hydrogen fueling stations than there are currently today. However, there is now a continuous gathering of momentum and rollout of hydrogen refueling stations. California has the most aggressive policies to decarbonize the transportation sector in the country, creating a model for other countries and states. We were successful in extending the Cap & Trade system, which provides continuing incentives to promote ZEVs. SB 498 will jump start ZEVs in fleets to increase ZEVs to 50% of government purchases. Senate President Pro Tempore Kevin de Leon's SB 100 was designed to require California reach to 100% RPS by mid-century. California's Expenditure Plan for \$800 million to be used to displace diesel in buses, ports equipment, and heavy-duty vehicles. It will be up to advocacy groups to push for their respective technologies.



Overview of State Regulations and Legislation

Moderator: Diane Moss, Owner, dima Communications

Graham Noyes, Managing Attorney, Noyes Law Corporation

The Low Carbon Fuel Standard is currently in the midst of the rulemaking process with the major focus placed on the transportation sector. The LCFS will be judged based on how much GHG emissions go into each unit of energy. It also looks at the feedstock, facility and transportation of the fuel. In terms of the mandate, carbon intensity (CI) must drop by 10% between 2010 and 2020. Each hydrogen pathway has a CI score with the typical gasoline being set at 100. Economically speaking, the best pathway for hydrogen is from 100% dairy biomethane SMR with over a \$6/kg LCFS credit. Kore Technology has demonstrated that organic waste thermally converts into RNG, RH2 and biochar.

Lorraine Paskett, Commissioner, California High-Speed Rail Authority; Owner, Cambridge LCF

For the hydrogen industry, setting the right market signal is tricky. Outside of the transportation sector, the case for hydrogen has depended on the status of regulations, which we have recently lost to the powerful battery lobby. The time is now to participate in the updating of laws relating to electricity in California. The energy storage rules by no means benefit hydrogen and currently no rules exist to regulate or incentivize the production of hydrogen.



“We need your help and leadership in support of CHBC advocacy work. We have a lot of work to do.”
– Lorraine Paskett

David Reichmuth, Senior Engineer – Clean Vehicles Program, Union of Concerned Scientists

We need 4 - 4.5 million ZEVs and PHEVs by 2030 and the reach 100% of sales of ZEVs and PHEVs by 2050. Aggressive standards have been set to make renewable electricity. However, there is not currently a long-term plan to make hydrogen cleaner overtime. If a long-term goal for cleaner hydrogen is created, the FCEV market would improve.

FCEVs and BEVs are complimentary; both are needed for decarbonization. Fuel cells are a more practical solution for larger vehicles used in the heavy duty and freight sector. We must enact policies to accelerate the adoption of fuel cells in heavy duty and freight applications. California has been a leader in transitioning to hydrogen technologies because of the policies it has adopted. California has made significant investments in hydrogen refueling stations and CVRP rebates for vehicles.

Gia Brazil Vacin, Environmental Strategy and Facilitation, California Governor’s Office of Business and Economic Development

The mission now is to accelerate the deployment of hydrogen infrastructure. Our biggest challenge today is climate change and Governor Brown has set aggressive GHG reduction goals. The only way to address climate change is to aggressively adopt zero emission technologies. A commitment must be made to continue the development of the infrastructure network and produce renewable hydrogen. Seventy-eight percent of executives absolutely or partly agree that fuel cell vehicles offer a breakthrough for electric mobility.

“Forty-six percent of light-duty ZEVs in the U.S. are in California: 326,492 vehicles.” – Gia Brazil Vacin

Feature: Renewable Hydrogen Roadmap Publication

Brian Goldstein, Executive Director, Energy Independence Now

In March 2017, 80 GW of renewable energy was curtailed, enough to make 1.3 million kilograms of hydrogen, which could power 100,000 FCEVs for that month. There are currently ~3,000 FCEVs on the road in California, CARB projects that by 2020 there will be a need for over 16,000kg/day. EIN's biggest policy recommendation is to start commissioning more fueling stations dispensing renewable hydrogen today. Stations take years until they're open to the public and it will be more difficult to keep up with demand for renewable hydrogen, which has a 33% renewable hydrogen standard, as FCEV deployment continues. The industry and public need to increase participation in public meetings and respond with comments to policy makers. We must advocate for renewable hydrogen to be added as a utility storage technology and increase education and outreach effort.

Feature: Progress of Stationary Fuel Cell Developments in California

Katrina Fritz, Executive Director, California Stationary Fuel Cell Collaborative



Fuel cells are efficient producers of power and heat; they can ramp in five seconds to 50 kW. California has over 250 MW of stationary fuel cells due to the high efficiency, no noise, no pollution, and they can produce high quality heat. Using a 400 kW fuel cell will offset 1 million gallons of water in a year at a combined cycle power plant. Currently, fuel cells must get permitted and go through safety inspections, especially hospitals, before installation. Companies have been adopting fuel cells due to environmental stewardship, operational goals, and risk mitigation. Large

stationary fuel cell systems are being adopted around the world, including four 20 MW+ installations in South Korea, as well as a 59 MW and 50 MW installations in a parking garage. CSFCC wants to work with CHBC on getting tri-gen systems commercialized. We must also address AB 617, which replaces local primary and backup power combustion generation.

Keynote: California Agency Perspectives

Edie Chang, Deputy Executive Officer, California Air Resources Board

Large corporations, like Toyota and Kenworth, are investing in fuel cell electric vehicles. ARB is looking to build on the activities of the past with a scoping plan providing a blueprint to reach California's GHG goals. Currently, ARB is working on this plan to meet midterm goals for GHG reduction; the revised scoping plan is targeted to be finished by January 1, 2018. Goals include reducing fossil fuel use in the transportation sector by 50%, reach 4.2 million ZEVs by 2030, and making a grid that has greater flexibility on the supply and demand side. The primary mechanism to reduce GHG is the Cap and Trade program, which is one part of California's climate change program. The program places a price on carbon emissions, giving companies allowances depending on the efficiency of their operations.

Ports move tremendous amounts of cargo and are a huge source of emissions, from diesel-powered engines that power all transportation that moves cargo, from ships, to trucks, to rail. ARB is making a big push to work with CalTrans and Go-Biz to improve fuel efficiency and reduce emissions in the ports. Short-lived climate pollutant (SLCP) programs are emerging as a new player in the climate change world. CO₂ will be in the atmosphere for a hundred years but short term pollutants like methane and refrigerants are much shorter lived. ARB has focused on methane capturing which can be used in renewable fuels such as hydrogen. Using fuel cells with renewable fuels offers a triple benefit: reduce criteria pollutants, reduce combustion particulates, and reduce GHGs. ARB is looking to methane on dairy farms to produce hydrogen.

Industry Perspective on Hydrogen's Role in Decarbonization of the Electrical and Gas Grid

Moderator: Stephen Jones, Managing Director, ITM Power

Wolfgang Beez, Chief Executive Officer, Hitachi Zosen Inova
ETOGAS GmbH

Europe, Asia, and North America will lead the way in developing power-to-gas systems. P2G offers versatility in the energy sector and allows energy to carry over between seasons, such as summer to winter. Solar and wind installations will continue to grow and provide a need for long-term energy conversion and energy storage. HZI is optimistic for the future of P2G and its versatile applications.



Steve Szymanski, Director of Business Development, Nel Hydrogen/Proton OnSite

P2G offers long duration storage at a high megawatt capacity. Electrolysis modules are scalable to large, multi-MW size. The nature of energy storage markets requires a rapid response to demand. PEM electrolysis offers high efficiency, dynamic range, durability, and high response time. Nel Hydrogen and Proton OnSite have plans to create a large renewable hydrogen production facility in California. The project will need to be a large, relevant grid scale demonstration of P2G and the multiple benefits associated.

Mallik Angalakudati, Vice President, Corporate Strategy,
Pacific Gas and Electric

When considering the injection of hydrogen into the natural gas pipeline, the major consideration must be safety. Hydrogen can be used as a decarbonizing fuel for the gas sector, and beyond. Moving forward, we must consider the highest value proposition to capture renewable energy, store it, and utilize it.

"P2G with gas pipelines will take 15 years for regulatory change. The electric system is more exciting. We need to focus on business models." – Mallik Angalakudati

Jeff Reed, Director of Business Strategy and Advanced Technology, Southern California Gas Company

Methane and hydrogen, depending on how they are derived, can be renewable. Taking advantage of surplus renewable energy has been discussed for a number of years. Southern California Gas Company will be using purpose-built solar fields to produce renewable fuels through electrolyzers. Southern California has a strong RPS mix with solar which is a good prospect for long-term energy storage. P2G is very attractive due to its modularity and flexibility; however, the feedstock will need to be decarbonized eventually. To address the cost of P2G, factors must be considered; the larger the scale and proximity to the hydrogen system, the more it is possible to spread the fixed costs. In response to a question, electrolyzers can use excess solar sometimes and grid mix other times. There is no data on the hour-by-hour renewable content of grid electricity and this would not be allowable as a certifiable renewable gas.

"Options to decarbonize are more limited for a gas-only utility." – Jeff Reed

Student Engagement: Power-to-Gas 2017 Hydrogen Student Design Contest

Emanuel Wagner, Vice President, Hydrogen Education Foundation

Public education and outreach are currently a big need for the industry. Competitions with students can play a significant role in getting the technology in front of future entrepreneurs, engineers and decision makers via a relatively small investment by industry. The 2017 Hydrogen Student Design Contest theme is P2G and multi-discipline teams will be developing solutions for P2G in their region.

Special: Hydrogen and Fuel Cells in the Transit Sector

David Warren, Director of Sustainable Transportation, New Flyer Industries

Fuel Cell Electric Buses are now in the commercialization phase. FCEBs are beneficial because they offer quiet, low vibration, no pollution and no jerky gear shifts. Both BEVs and FCEBs will work and have a role in the future of the transit sector. FCEBs offer a more practical solution for public transit because only so many batteries can fit on a bus, they offer a range of 300+ miles compared to the 200 miles for battery, and the refueling rate of 15 minutes for FCEBs, cannot be matched by BEVs. The main challenge for FCEBs is bringing the cost of hydrogen down to a reasonable cost. BEBs encounter demand changes with high power chargers. New Flyer delivered the first FCEB in 2010. They have now built a three axle FCEB in North America, which is currently under commercial validation and will be completed in the January 2018 timeframe. New Flyer has been able to bring the cost of FCEBs down from \$2 million in 2009 to \$1.235 million now, and considerable cost reduction can be achieved with higher volume. The Federal Transit Administration, New York and other states have shown great interest in FCEBs moving forward.

Day 2

Summit Begins: Outlook for Day 2 and CHBC Report

Jeff Serfass, Executive Director, California Hydrogen Business Council

The California Hydrogen Business Council is driven by its member Sector Action Groups. There are three of them: Renewable Hydrogen and Hydrogen Energy Storage/Power-to-Gas; Heavy Duty Freight, Goods Movement and Clean Ports; and Public Transport. This is where advocacy positions are formulated for regulations and investment plans of the Public Utility Commission, the Energy Commission and Air Resources Board, and legislation.



The CHBC conducts a number of educational events, beyond the Summit, including the Freight Workshop at the ACT Expo, the Fuel Cell Bus Workshop taking place the day after this Summit, the Hydrogen and Fuel Cells in the Ports Workshop in Vallejo, October 3, and a Ports Update at the Port of Los Angeles. The CHBC helped create a hydrogen component of the Solar Power International conference with Hydrogen and fuel Cells North America in Las Vegas last month. The Board will consider collocating a major CHBC event with SPI in Anaheim, September 24-27, 2018 in Anaheim.

Keynote: Industry

Rob Campbell, Chief Commercial Officer, Ballard Power Systems

California is fostering significant requirements for change, which is truly important work for the industry and the world. The industry is ready to step up to the challenge to create the next generation of vehicles. Ballard focuses on driving the fuel cell truck market forward and is poised for rapid adoption in the transition to clean energy technology. This foundation of success was laid by years of experience working on fuel cell buses; some of Ballard's FCEBs have passed 25,000 hours of service. The industry has evolved to the point that all major heavy-duty companies have electric drive options. The scale is happening at an unprecedented rate and will ultimately bring down the prices of fuel cells. The fuel cell revolution is now beginning, on the heels of the electric car

"We need to ditch the diesel. We are ready for, and stepping up to, the challenge." - Rob Campbell

revolution. Fuel cell technology is ready for primetime; the industry is ready to step up and meet California's aggressive goals moving forward.

The first fuel cell tram is going into service in China; converting trams and trains to fuel cells is a huge opportunity to reduce emissions from diesel engines. Additionally, cruise ships are actively looking into fuel cell technology. These projects and activities demonstrate the versatility of fuel cells and their ability to be used for most applications. Renewable energy is now among the lowest cost of energy sources, which is profound and not predictable a few years ago. California can take on strategic leadership with its tremendous renewable energy options. Industry must show that demand for hydrogen is here and that green hydrogen supply will follow.

China is currently addressing their air pollution causing the government to take massive action with thousands of fuel cells deployed. Ballard opened their first factory to produce fuel cells in China; the growth of the market has been hard to handle and year over year growth rates are rapid. Ballard has shipped 2,500 fuel cell systems this year, indicating the market growth is real and taking off. Ballard believes 30% of commercial vehicles will be hydrogen powered by 2030; the time for demonstration projects is behind us and the time for action is now. Ballard is investing \$60 million in its technology to improve life cycle costs and improve performance. To enter new markets, such as heavy-duty trucks, there needs to be strong support and no barriers. Fleet fueling must be at a realistic cost at \$5/kg or less; California is at a strategic advantage to make this happen with its vast renewable resources. We need to make the conversion to fuel cells easy for transit operators and educate them to increase engagement.

"We have the responsibility and the power to change the world through hydrogen fuel cell technology"- Rob Campbell

Financing will be the most critical part of scaling. Billions of dollars need to be invested in the fuel cell sector in the years to come. The European Union is working on a private/public financing program to advance fuel cells. Legislative support must be established to gain an equal footing with other technologies, as well as continued leadership in regulations to meet California's ambitious climate change reduction goals. Targeted feasibility studies need to start in high pollution areas, comparing battery options to fuel cell systems.

In response to questions, "I see dedicated solar hydrogen factories in the future." With regard to end of life, "We salvage, recycle and refurbish everything we make. The impact on the environment is minimal."

Keynote: Industry

Robert Fourie, Vice President Strategic Partnerships, Hydrogen Energy, Air Liquide

It is truly fascinating to witness the progress of the hydrogen fuel cell industry; the level of commitment to hydrogen from the top of Air Liquide is very encouraging. Air Liquide currently has over 100 projects worldwide in many types of vehicles applications. The new European Hydrogen Council has looked at the role hydrogen plays throughout the energy sector, as an integrated ecosystem. They plan to invest €1.9 million each year, with specific goals each year. They have commissioned McKinsey to study hydrogen's role to reach the 2 degrees Celsius target from the Paris Agreement. By 2030, there should be 10-15 million FCEVs on the road with investment opportunities up to €475 billion, €140 billion in hydrogen production, €100 billion in storage, transport, and distribution, and the rest to end uses. The progress the industry has made to this point is impressive; FCEVs, public transit and forklifts have advanced

the industry forward but much of the work is yet to come. New investments need to be made in hydrogen production in conjunction with wind and solar to drive costs down.

“It is amazing how far this sector has come. It is happening. I don’t see a clear picture of the end game, when it is market-competitive and we don’t need government subsidies. We probably each have a different idea, but we need to develop a common vision and identify where we need government help”- Robert Fourie

In response to questions, “The cost of hydrogen needs to be driven down. Existing hydrogen production capacity in California is nearly sold out so there has to be new hydrogen production.” “The capitalization of the station cost is an important part of hydrogen cost and is nearly \$10/kg today.”

What’s Happening with Vehicles?

Steve Ellis, Manager – Fuel Cell Vehicle Marketing, American Honda Motor Company, Inc.

The Clarity has advanced tremendously, making this a very exciting time. FCEVs are no longer a science project; Honda has committed itself to the technology and needs to go into volume. The powertrain size of the Clarity has been reduced to the size of a V6 powertrain and we have a certified 360 mi range. We still face challenges in the two pathways to zero emissions vehicles: battery with packaging and recharging; and fuel cells with infrastructure. There needs to be more cooperation between the battery and fuel cell industries as both are critical to achieve GHG reduction goals.

Meeting the Needs of Hydrogen Infrastructure

Moderator: Elan Bond, Project Manager North America, Nel Hydrogen

Dr. Andrew Martinez, Air Resources Engineer, California Air Resources Board

California will have 37 hydrogen refueling stations by the end of the year with 62 expected to be open by 2020. Due to challenges, the 50 station goal by the end of 2017 will not be accomplished. Every year, OEMs provide their FCEVs sales projections by county for the next 3 years; the latest projections expect California to have 13,400 FCEVs on the road by 2020.

The California infrastructure tool helps the CEC identify and target high priority areas for new refueling stations; Los Angeles being the highest currently. The Bay Area, Orange County, and San Diego are also high target areas for stations. The biggest barrier to opening more stations remains to be funding. With FCEVs transitioning from the pre-commercial phase to early commercial phase, opening more stations and increasing the production of hydrogen are the issues facing the industry today and is a bottleneck to expansion.

Dr. Tim Brown, Chief Operations Officer and Principal, First Element Fuel

Hydrogen has had zero safety incidents in 70,000 refueling sessions with 98.5% availability for the last 90 days and nearly 800kg/day dispensed. The hydrogen refueling station network is progressing nicely, but larger scale hydrogen production remains a need.

Jean Baronas, Hydrogen Unit Supervisor, California Energy Commission

Assembly Bill 8 mandates that the ARFVTP funding go through January 1, 2024 with \$20 million/year for HRS. The CEC is currently writing the 2017 assessment of time and cost needed to reach the 100 stations goal to ensure it has the



right coverage and capacity. The plan is designed to front load station construction before the vehicles hit the road. Capacity of the network is expected to reach 13,400 kg/year. CEC began keeping track of hydrogen dispensing by county. The time to permit and construct a new station has dropped dramatically, ~1400 day to ~600 days. The total cost for delivered gaseous hydrogen station is between \$2 million and \$2.4 million; \$2.8 million for liquid delivered; and \$3.2 million for onsite electrolysis.

Bill Elrick, Executive Director, California Fuel Cell Partnership

The time for demonstrations has passed and the industry is in the commercialization phase. To stay ahead of future demands, development of larger stations must be considered. To continue funding the hydrogen refueling network, we must look at credit programs and think bigger.

Dr. Marc Melaina, Senior Engineer, National Renewable Energy Laboratory (NREL)

To replicate the existing gasoline network, there needs to be 70,000 hydrogen stations built across the U.S. Gas stations are businesses, the markets will push the technology; it will be up to businesses to decide if and when they want to transition to alternative fuels.

During the Q&A, it was asked why HySTEP for station start-up testing is only reserved for state supported systems. Andrew said that HySTEP certification is required by OEMs to fill at a station. CEC is working on building a commercial market for testing stations. Furthermore, it was asked why is there more funding for PHEV than FCEVs? It was answered that funding is a factor based on how many vehicles can be support with the available funding.

Lightning Round – What’s happening outside of California?

Moderator: Cory Shumaker, Project Coordinator, California Hydrogen Business Council

Global demand for hydrogen will ultimately reduce prices. In Norway, fuel cells have a focus in maritime and heavy-duty applications. Germany is focusing on curtailed energy. In France, Kangoo service vehicles with Renault and the Toulouse Port and other parts of the country are showing a high interest in hydrogen technology. In the Netherlands, Rotterdam is interested in using wind power in conjunction with hydrogen.

Pat Valente, Executive Director, Ohio Fuel Cell Coalition

The Ohio Fuel Cell Coalition is works in the supply chain and Ohio is a top five state for hydrogen in the USA. Ohio has invested \$150 million in fuel cell development and has made \$100 million in component purchases. Their Integrated Regional Technical Exchange Center is focused on:

- Supply chain development
- Components standardization efforts
- Identify where gaps in supply chain exists and how they can be addressed
- Compiling a national database (500 entries), with 200 suppliers in Ohio
- Honda and GM collaborate on fuel cell drive trains and created 100 new jobs
- SARTA to get 13 FCEBs in 2018 - LG Fuel Cell Systems in Canton, MW Fuel cell system development
- Plug Power has 35 stations and 137 dispensers for forklifts

Dr. Andreas Truckenbrodt, President and CEO, Canadian Hydrogen and Fuel Cell Association

Canada has been a leader in the hydrogen industry since the 1970s with Ballard. The Canadian export market for fuel cell systems is very strong with very little happening in domestic adoption or vehicle rollout. Canada is developing policies with many areas lacking. A pan-Canadian ZEV framework is in the early stages of development; without a framework, there has been little interest from vehicle manufacturers. Canada has one open refueling station and nine FCEVs with four stations expected to be open in 2018 and seven by 2019 in British Columbia. The British Columbia market size is 1/10 compared to California, comparable to 70 stations in California. Ontario was awarded two refueling stations. Canada's 2030 goal for GHG reductions is 30% below 2005 levels.

Morry Markowitz, President, Fuel Cell and Hydrogen Energy Association

California has brought the "if" to "when" in product deployment and has pushed the market forward. The Northeast represents a bigger challenge, fragmented into more state governments, creating high regulatory obstacles. Public officials' awareness of hydrogen and fuel cell technologies is in the single digits and political support is lacking. There is a lack of dedicated funding to grow the market in the Northeast and the population density makes station development much trickier. To advance the industry in the Northeast, awareness and education will lead to support and action. FCEHA conducted a roadshow in June 2017 and created strong interest in follow-up meetings. Some areas have unique challenges that must be overcome, such as New York's tunnels, bridges, and footprint constraints of stations. The key message is sharing; government on government with industry support. FCTO budget is between \$45 million with \$92 million in the White House and Senate budgets. The lack of regulatory pressure remains a massive problem.

Discussion Roundtable – Environmental Benefits of Hydrogen – Meeting California's Climate Goals

Moderator: Bud Beebe, Senior Advisor, California Hydrogen Business Council

Dr. Jack Brouwer, Associate Professor of Mechanical and Aerospace Engineering and Associate Director of the National Fuel Cell Research Center (NFCRC) at the University of California, Irvine



Today, installation of renewable energy continues but we are not significantly changing the balance of the generation mix. Stationary fuel cells must play a larger role in California's air quality stability moving forward.

Damian Breen, Deputy Air Pollution Control Officer, Bay Area Air Quality Control Management District

There are large streams of waste that can be utilized as renewable energy, especially for the large, heavy-duty vehicles. Future challenges for hydrogen will be competition from other technologies, the high cost of infrastructure, and the scalability of the technology needs to move forward. Hydrogen is a very good option for BAAQMD, the future looks bright and the industry will continue to solve issues and advance hydrogen forward.

Bill Magavern, Policy Director, Coalition for Clean Air

The first bill Mr. Magavern worked on was for climate policy and included a hydrogen component. California has a lot of work to do on air quality issues; most of the work is to rescue the emissions from transportation because that is a major source of pollution. Over 80% of NOx and particulate matter come from vehicles. Legislation supporting the adoption of hydrogen vehicles would be a major step forward to solve this issue. The sooner we can get to producing renewable hydrogen, the closer we will be to public acceptance and ultimately a cleaner environment. We must

continue our education and outreach to the legislature to explain the virtues and positive attributes of hydrogen and fuel cells.

V. John White, Owner, V. John White Associates

Hydrogen can fundamentally change the energy sector; the deeper the penetration of solar and wind, the more it matters how the pieces fit with the complimentary strategies and policies. The amount of solar energy in California is now causing major challenges for grid operators. Hydrogen is capable of playing a complimentary role in managing excess renewable energy. The price of hydrogen will drop to conventional fuel prices if we use cheap hydrogen production facilities that utilize surplus electricity.

California's future is tied to SB100. We need to do a better job defining the difference between what we think is going to happen versus what actually happens during a heat storm. This will be a significant debating point and renewable hydrogen should be a part of that debate.

"Hydrogen can be used in so many energy applications. This is its strength, and this is its weakness because it is hard to explain." – V. John White

Special: What opportunities do Ports offer to Hydrogen and Fuel Cells?

Fernando Corral, Vice President Sales, Retail and Distribution, Plug Power

There is a large amount of activity at the ports. Plug Power is looking at yard tractors, large forklifts, top handlers, and rubber tired gantry cranes. There are a number of value propositions and market drivers for using fuel cells in port equipment that is similar to the forklift market. By the end of this year, there will be 27,000 fuel cell forklifts in use. Plug Power is now looking to move into Class 8 trucks but remains focused on goods movement and delivery trucks. Plug Power has identified three phases:

1. Captive Fleet
2. Tethered Local Fleet
3. Tethered Regional Fleet

Ports represent the next target market that the hydrogen economy should look at.

Novel Approaches for Hydrogen Applications in Commercial Environments

Dr. Madhav Acharya, Technology-to-Market Advisor, ARPA-E, US Department of Energy

There is a program in ARPA-E called REFUEL, in which they seek technology breakthroughs that will be orders of magnitude better not just an improvement. US DOE looks to fund technologies that are too risky for the private sector. The see renewable energy curtailment is an issue and have developed the REFUEL program with 16 teams working with about \$33M for the Advanced Research Projects Agency - Energy. He's looking for active feedback to help these teams really achieve success.

Dr. Anca Faur, Development Program Manager, Johnson Matthey Fuel Cells

The hydrogen economy is gaining traction. The industry is beginning to see increasing demands, specifically for heavy-duty transportation driven by legislation and continuous power generation. Johnson Matthey's manufacturing is designed to meet requirements and expand that manufacturing to where the demand is. Further investments in technology and manufacturing are required for the next generation of larger volume manufacturing. Johnson Matthey would like to see the development of the fuel cell market help drive future technological and manufacturing investments.

Good Movement and Freight: Hydrogen Fuel Cells Medium and Heavy Duty Trucks

Moderator: Naveen Berry, Technology Demonstration Manager, Science and Technology Advancement, South Coast Air Quality Management District

Brian Lindgren, Manager – Research and Development, Kenworth Truck Company

Kenworth produced its first fuel cell vehicle with development continuing. As drivetrain agnostic, Kenworth is also looking at developing a renewable natural gas, near-zero Class 8 with an electric powertrain. Kenworth does not know which technology will “win” but so far, hydrogen has offered the best option and capability. The truck uses a Ballard fuel cell and will go into service in the first quarter of 2018. The truck will begin research and development testing soon followed by PTC testing, and then a field test. Kenworth is in the early stages of entering the market.



Ben Nyland, President and Chief Executive Officer, Loop Energy

Canadian government programs have worked to Loop Energy’s benefit. The fuel cell industry has developed into fuel cell industry 2.0 with a more mature supply chain. Loop Energy has developed a highly efficient fuel cell through increased airflow. Now, Loop is working on a fuel cell module for range extenders for trucks and ports equipment. Loop is developing new vehicle platforms; Loop is collaborating with SinoTruck, who manufactured 200,000 trucks last year in China. Loop believes it has an economic solution for zero emission trucks and ports.

“Infrastructure support and operation subsidies will speed market adoption.” – Ben Nyland

Dr. Abas Goodarzi, President and Chief Executive Officer, US Hybrid

Fifty percent of transportation energy is consumed by energy wasted due to traffic. Electric drive trains could help solve that with higher efficiency. The fuel cell is a combustion-less engine with all the same controls and better performance. Material and production processes have continued to improve and are reducing cost. Overall operational costs will not be less but we bring added value.

Craig Scott, National Manager, Advanced Technologies Group, Toyota Motor Company

Working with Ricardo in Michigan, Toyota developed a fuel cell truck in 10 months and completed the build in December of 2016. The purpose of that project was to demonstrate the capability of hydrogen and fuel cell technology; the concept has proven to be feasible and testing will begin in the ports soon. A major need to support larger vehicles is infrastructure. Toyota is working to develop a faster refueling process for larger fuel cell vehicles. Japan has no Class 8 truck, which has led to misconceptions on how important the sector is. Japan is currently developing Class 5 and 6 refrigerated fuel cell trucks. Toyota has committed itself to the development and adoption of fuel cell technology.