CALIFORNIA HYDROGEN BUSINESS COUNCIL

Hydrogen Means Business in California!

April 17, 2020

Honorable Chair Mary D. Nichols
Honorable Board Members
California Air Resources Board
1001 I Street
Sacramento, CA 95812

Advanced Clean Truck Rule – Addendum to ACT Coalition Electric Truck Charging Infrastructure Letter

Dear Chair Nichols, dear Board Members,

The California Hydrogen Business Council[1] (CHBC) continues to appreciate and support ARB's work to develop a robust and broad Advanced Clean Truck rule that centers around zero emission technology transportation. We also support the letter you have received from the ACT Coalition on Electric Truck Charging Infrastructure in March, but recognize the lack of information related to fuel cell electric truck technology, which in certain applications can be a good fit for zero emission trucks, as battery electric trucks fit other applications.

This letter is designed to provide you with the same pertinent information provided by the ACT Coalition, but with a focus on hydrogen and fuel cell technology.

FREQUENTLY ASKED QUESTIONS

How do hydrogen trucks refuel?

The majority of trucks are Class 2b-3 (62% or 1,040,000 of all trucks) and can refuel at 350 bar hydrogen refueling stations, or if using 700 bar, use the same infrastructure as light-duty FCEVs. Hydrogen trucks can refuel in 5-15 minutes, reducing operational downtime and be put in service immediately.

Class 4- 8 trucks require infrastructure similar to those of bus transit stations like AC Transit, OCTA or Sunline which can provide fast refueling for dozens or more trucks in short order.

Hydrogen as a fuel requires minimal change to fueling logistics and shift operation compared to diesel and natural gas. Fleets have the same customer experience, driving to a fueling station and refueling vehicles in rapid succession. According to Kenworth[2], a long-haul Class 8 hydrogen truck can achieve an

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[1] The CHBC is comprised of over 100 companies and agencies involved in the business of hydrogen. Our mission is to advance the commercialization of hydrogen in the energy sector, including transportation, goods movement, and stationary power systems to reduce emissions and dependence on oil. The views expressed in these comments are those of the CHBC, and do not necessarily reflect the views of all of the individual CHBC member companies. Members are listed here: www.californiahydrogen.org/aboutus/chbc-members/

[2] ACT News Webinar April 14, 2020: https://www.act-news.com/webinar/webinar-the-facts-on-fuel-cell-electric-trucks-part-1/

approximate 100-400 mile range after 10-15 minutes of refueling, whereas a 250kW DC super-fast charger would require 3.6 hours to charge for a 350 mile range. The future case for hydrogen will be similar to diesel as far as time at the pump.

Where will the money come from for refueling infrastructure?

The California Energy Commission announced $47.5 million available in 2020 for zero emission medium/heavy-duty vehicles and infrastructure. The Volkswagen Mitigation Trust will provide $90 million in funding for Zero-Emission Class 8 Freight and Port Drayage Trucks. The first $27 million installment will be available statewide in Spring 2020 through the South Coast Air Quality Management District on a first-come, first-served basis; up to $200,000 per truck.

Additionally, the California Air Resources Board (CARB) has $20 million of funding for a Zero-Emission Drayage Truck Pilot for large-scale deployments (50 or more within a single fleet) of battery electric or fuel cell electric Class 8 trucks.

Currently Senate Bill 662 (Archuleta) is under discussion in the California legislature which would allow for a more equal treatment of utility (gas and electric) in hydrogen infrastructure, similar to what has been made available for charging under SB 350.

CARB's Low Carbon Fuel Standard (LCFS) can also be considered as a funding source for hydrogen infrastructure.

How many hydrogen stations are needed?

According to Nikola Motor, their target is to build stations that serve 100 – 160 trucks per day, dispensing around 8,000kg per day. If 74,000 zero-emission trucks shall be on the road in California by 2030, and assuming half of those would be fuel cell electric trucks, only 230 to 370 HD stations would be required. This would be even less if the stations were to be scaled appropriately at key infrastructure points.

What state and local efforts exist to support infrastructure deployment?

The South Coast Air Quality Management District has been a strong supporter of FCET deployment. The following are active FCET projects:

Project Name	*OEM*	*# of FCETs*	*Deployment Date*
ZECT II [3]	Multiple	6	2016-2020
Project Portal [4]	Toyota	2	2017-2018
ZANZEFF [5]	Toyota/Kenworth	10	2019-2020

[3] https://www.energy.gov/sites/prod/files/2019/06/f63/elt158_impullitti_2019_o_5.29_1.01pm.pdf
[4] https://pressroom.toyota.com/the-future-of-zero-emission-trucking-takes-another-leap-forward/
[5] https://www.act-news.com/news/ca-zero-emission-freight-projects/

Are there enough trained electricians to build and maintain the infrastructure?

Hydrogen infrastructure is technically and functionally analogous to CNG infrastructure, which is widely distributed across California. Multiple major fueling providers offer O&M support for hydrogen infrastructure, including Trillium, Clean Energy, Air Liquide, Linde, Air Products, and others. Plug Power, for example, has been adding 6-8 technicians per year and has a total of 36 hydrogen dedicated O&M personnel at multiple customer locations throught California. This provides a broad workforce already trained for the technical needs of hydrogen fueling infrastructure installation, service and maintenance.

Do hydrogen fueling standards and protocols exist?

Hydrogen fuel cell trucks can utilize fueling protocols developed for light duty FCEVs and fueling protocols for heavy duty fueling is currently under development (SAE J2601/2 TIR).

What are key features and performance metrics?

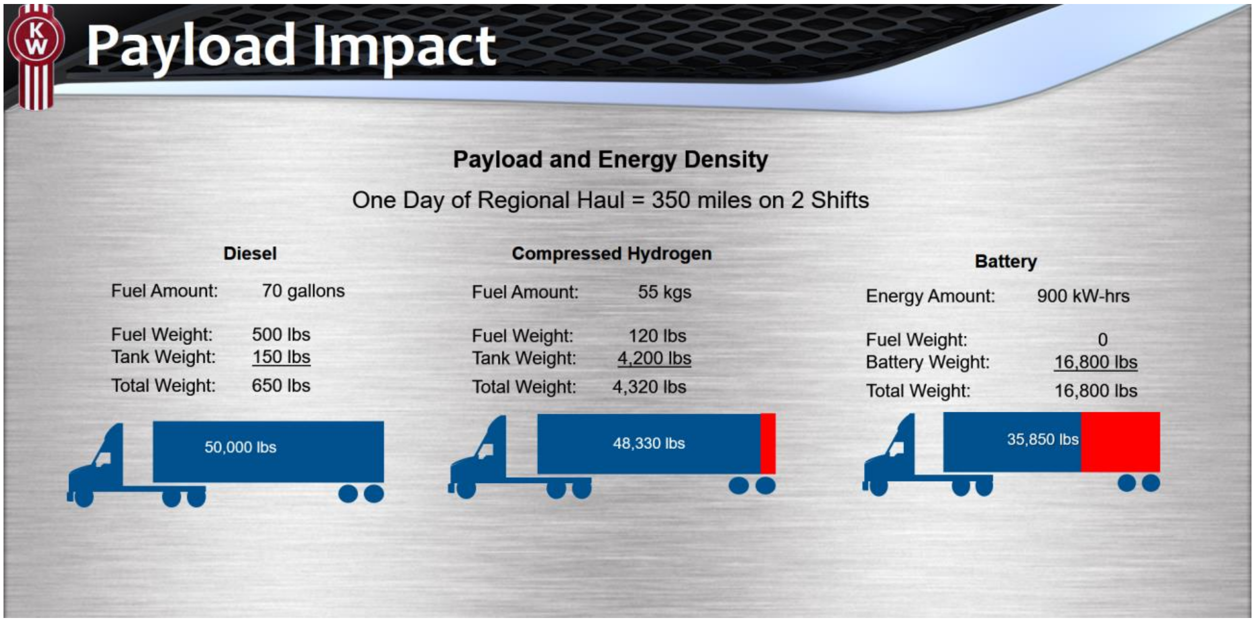
FCETs are performing very well in pre-commercial testing in real world port and freight applications. Multiple OEMs are validating that FCETs are a 1-to-1 zero emission replacement for Class 8 diesel trucks both in terms of vehicle performance and operations.

Fuel cell powertrains offer distinct advantages over incumbent powertrains, including zero well-to-wheel emissions (when using renewable hydrogen), zero local tailpipe emissions, higher energy efficiency, and reduced noise. For goods movement, FCETs have advantages over battery electric trucks (BETs): longer driving range and duty cycles, quick refueling, conventional payload capacity, and unaffected performance in extreme temperatures. The latest generation of fuel cells are capable of starting and operating at temperatures of -25C (-13F)[6], with continued development towards even lower temperatures.

Prolonged fuel cell durability in demanding environments has been proven in transit bus fleets where fuel cells surpassed 30,000 hours of operation over the course of 8 years at TFL in London, UK[6] and AC Transit[7] in the San Francisco East Bay in Northern California. FCETs provide a comparable freight capacity to diesel, whereas BETs will have a significantly reduced payload, see in the figure below.

[6] Ballard, 2019 https://www.ballard.com/about-ballard/newsroom/news-releases/2019/05/13/ballard-announces-order-from-wrightbus-for-20-fuel-cell-modules-to-power-london-buses

[7] US DOE 2019 AMR, NREL



Source: Kenworth – ACT News/CHBC Webinar April 14, 2020[8]

What are the economics?

The current cost for a heavy-duty fuel cell module is estimated at $500/kW in low volume, approximately $150,000 for a 300kW truck module. However, this cost is projected to decrease to about $120/kW by 2025 in high volume[9], or about $36,000 for the same 300kW truck module, and ultimately to $90/kW ($27,000 for 300kW).[10]

The cost of fuel is estimated at more than 40% of the total cost of operating a commercial truck[11]. It is vitally important that the cost of hydrogen fuel decreases to a level that will support the commercialization of FCETs. U.S. DOE estimates this hydrogen cost at $4.00/kg.[12] In their most recent report, NREL found the average cost of hydrogen incurred by the Stark Area Regional Transit Authority (SARTA) was $5.27 per kilogram (kg). Bloomberg recently estimated the cost of producing renewable hydrogen could decrease to $1.40/kg as soon as 2030, which would support a pump price approaching $4.00/kg[13] for renewable hydrogen. The result is a lower overall cost than BEVs and comparable cost to CNG/LNG/Diesel trucks for urban and port operation.

In addition, the McKinsey report developed for the Hydrogen Council report projects that *"hydrogen can meet a large share of the mobility energy demand by 2030. Even with hydrogen costs at the pump of USD 6 per kg – including production, distribution, and retail – the fuel can meet about 15 per cent of*

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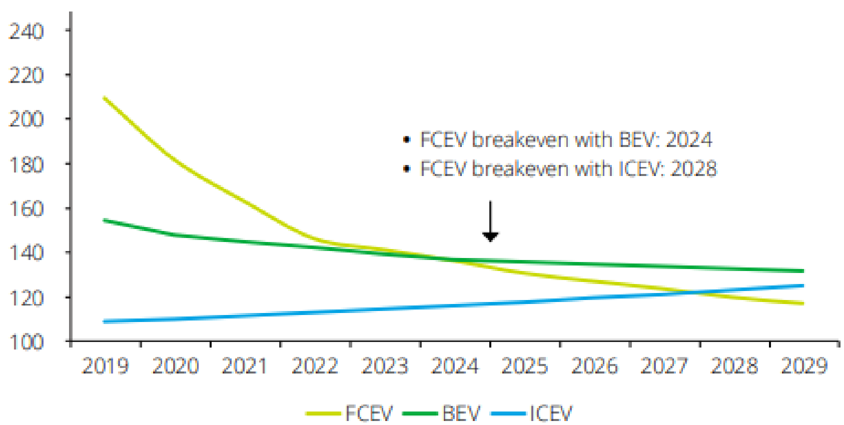
[8] https://www.act-news.com/webinar/webinar-the-facts-on-fuel-cell-electric-trucks-part-1/
[9] https://www.hydrogen.energy.gov/pdfs/review19/fc163_james_2019_o.pdf; assuming price is 1.5x markup over cost
[10] https://www.energy.gov/sites/prod/files/2018/08/f54/fcto-truck-workshop-2018-10-james.pdf; assuming price is 1.5x markup over cost
[11] https://truckingresearch.org/wp-content/uploads/2019/11/ATRI-Operational-Costs-of-Trucking-2019-1.pdfATRI, 2019 *not including driver costs
[12] https://www.hydrogen.energy.gov/pdfs/review17/pd000_miller_2017_o.pdf
[13] https://www.bloomberg.com/news/articles/2019-08-21/cost-of-hydrogen-from-renewables-to-plummet-next-decade-bnef

transport energy demand cost competitively by 2030. If costs were USD 4 per kg at the nozzle, hydrogen could even meet more than 50 per cent of the mobility sector's energy demand. Trucks, long-distance buses and large passenger vehicles are particularly competitive, as the cost of batteries required to secure the necessary range is very high for the battery alternatives."[14]

Furthermore, Deloitte projects a total cost of ownership for fuel cell drayage trucks to be breakeven with BEVs in 2024 and with ICEs in 2028.[15]

Figure 60. Total cost of ownership/ USD per 100km



In conclusion, the CHBC is very supportive of a strong Advanced Clean Truck rule that takes into consideration both battery and fuel cell technology that can support California in meeting its air quality and climate goals, to provide healthy air and reduce adverse health effects for all residents of this State.

Best regards,

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[14] https://hydrogencouncil.com/wp-content/uploads/2020/01/Path-to-Hydrogen-Competitiveness_Full-Study-1.pdf, p. 17
[15] https://www2.deloitte.com/content/dam/Deloitte/cn/Documents/finance/deloitte-cn-fueling-the-future-of-mobility-en-200101.pdf