

August 14, 2019

# CHBC Comments on to CEC’s Transportation Forecast with Hydrogen FCEVs

## Contents

Introduction.....	1
FCEVs are cost competitive to BEVs and PHEVs.....	2
FCEVs continue to have superior range to BEVs .....	3
Assumptions on attributes for various vehicle classes omit significant cost drivers .....	4
Assumptions on fuel cost/mile.....	4
Lack of T&D cost significantly skews electric charging cost and infrastructure data.....	5
NREL forecasts do not reflect industry expectations on fuel cost decline.....	6
Fuel Cell Electric Buses can play a significant role in California’s Transit Sector .....	7
Medium and Heavy Duty forecasts are lacking fuel cell electric trucks and key limitations of other alternative drive trains.....	8
Hydrogen FCEVs can play a significant role in transportation electrification, but a set of challenges continue to impede progress for FCEVs.....	9
Lack of trade and supply chain disruptions and limitation of resources.....	10
Policy Recommendations .....	11
Conclusion .....	12

## Introduction

The California Hydrogen Business Council<sup>1</sup> (CHBC) appreciates the California Energy Commission’s (CEC) work on the Integrated Policy Energy Report (IEPR) to forecast transportation energy demand, and the opportunity to provide comments on the presentations and issues discussed during the July 22 workshop. We offer the following comments:

---

<sup>1</sup> 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. CHBC Members are listed here: <https://www.californiahydrogen.org/aboutus/chbc-members/>

## **FCEVs are cost competitive to BEVs and PHEVs**

CEC staff indicated during the workshop that FCEVs are cost prohibitive compared to BEV and PHEV options.

Tesla vehicles, which makes up the 90% of all BEV sales and therefore benefit most from economies of scale, are more expensive than FCEVs. The FCEV models available in California (Toyota Mirai, Honda Clarity and Hyundai Nexa) are leased for around \$389 per month including \$13,000 to \$15,000 of fuel. The baseline Tesla Model 3 is leased for minimum of \$422 per month with similar down payments (\$2,499).

The customer service of “fast charge” via hydrogen refueling is already cost competitive with charging. A hydrogen refueling station offers approximately 3,000 kW fueling rate at approximately \$0.70 per kWh while the published price in the Tesla Supercharger network is \$0.52 per kWh when charging above 60 kW. As hydrogen cost in California reaches gasoline parity, it will become competitive with charging below 60 kW while still offering the 3,000 kW fueling rate. This customer service is important for large scale adoption of zero-emission electric vehicles.<sup>2</sup>

McKinsey developed cost projections for BEV and FCEVs by 2030. It expects vehicles under 55 kWh energy capacity to be lower cost for BEVs, while vehicles above 55 kWh energy capacity are forecast to be lower cost for FCEVs. This implies a crossover point for lowest cost from BEV to FCEV at a range of about 185 miles.<sup>3</sup> Vehicle performance with an electrified drivetrain complemented with range, payload, and uptime with fast refueling is important for large scale adoption of zero-emission vehicles.

The use cases for FCEV exist across all vehicle classes where the capability for high-output and high-utilization are either needed (as in the case of commercial fleet operations) or desired (as in the case of customer vehicle purchase decisions moving toward sport utility vehicles). Customer choice is important for large scale adoption of zero-emission vehicles. The universal application of FCEV components across vehicle segments will help achieve economies of scale. The opportunity for hydrogen FCEV is clearly in both light duty and heavy duty vehicles, is complementary rather than competitive with BEV, and will benefit from scale as a universal powertrain.

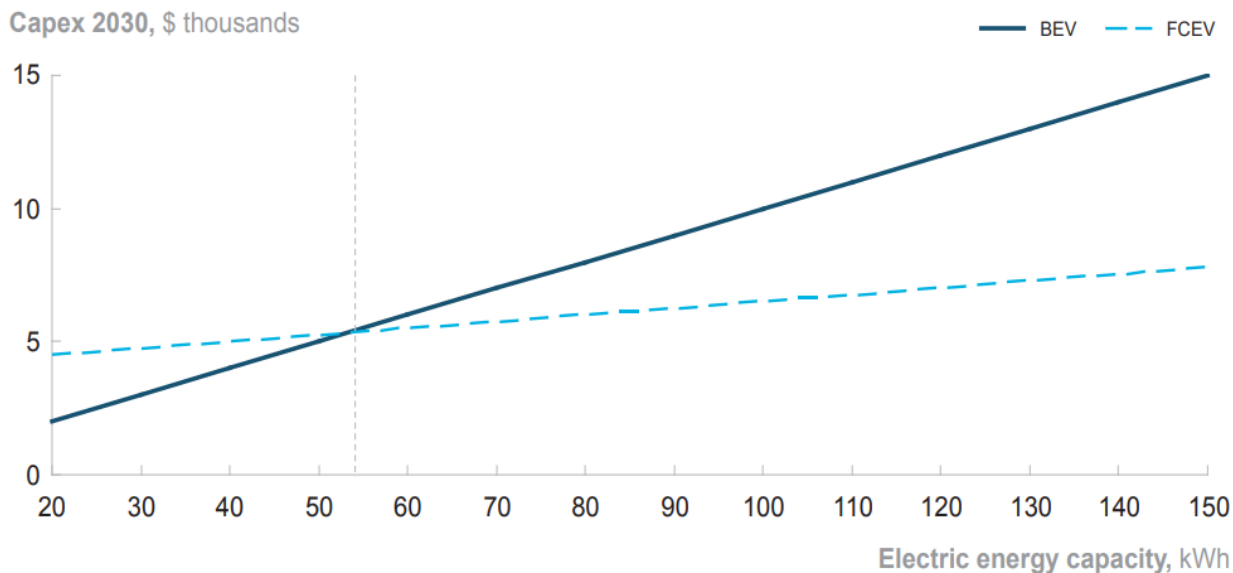
---

<sup>2</sup> Tesla defined Tier 1 charging as at or below 60 kW, for which the published price in the US is \$0.28 per kWh and in California is \$0.26 per kWh. The published price for Tier 2 charging defined as above 60 kW is double the price of Tier 1, or \$0.52 per kWh in California. Sources: [www.tesla.com/support/supercharging](http://www.tesla.com/support/supercharging) and <https://electrek.co/2018/03/11/tesla-increases-cost-supercharger/>.

<sup>3</sup> <http://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-scaling-up-Hydrogen-Council.pdf>, p. 32

## Exhibit 9: FCEVs have lower investment costs for long-range vehicles

Scenario analysis of powertrain costs for FCEVs and BEVs at different capacity levels, 2030



Assumptions: battery \$100/kWh, fuel cell of 100 kW with \$40/kW, hydrogen tank \$24/kWh, FCEV battery with 1% of total capacity, FC to electricity efficiency 55%

SOURCE: Avere-France; DoE fuel cell technology office; McKinsey: Automotive revolution – perspective towards 2030

Toyota has indicated that they expect the cost for their FCEVs to be similar to those of hybrid vehicles by 2025, most likely due to scaling of production and innovation.<sup>4</sup>

### FCEVs continue to have superior range to BEVs

CEC staff also stated that while FCEVs have superior range, BEVs are catching up. While the statement is correct that BEV ranges are increasing, costs are also increasing with added battery capacity. In the case of BEV, either cost reduction at similar range or range improvements at similar cost are to be expected, not both at the same time.

Moreover, FCEV ranges are also increasing from generation to generation, and without cost increase due to efficiency gains in the fuel cell stack and vehicle combined with packaging of larger hydrogen tanks on board the vehicle. For example, Hyundai’s Tucson FCEV had a range of 265 miles. Hyundai’s new FCEV, the Nexo, is rated at 380 miles, an increase of 30%. Further developments in carbon fiber tank technology and increases in fuel cell efficiency will directly translate into higher ranges for FCEVs. Toyota has announced the next generation FCEV will increase its range from the Mirai’s 500 km (312 miles) to 700 km (434 miles), and to reach a range of 1000 km (621 miles) for their FCEVs by 2025.<sup>5</sup> This will be twice of what CEC projects for the range of BEVs by 2030.<sup>6</sup>

<sup>4</sup> <https://www.autonews.com/executives/toyota-sees-fuel-cell-costs-par-hybrids>

<sup>5</sup> <https://www.reuters.com/article/us-toyota-hydrogen/toyota-plans-to-expand-production-shrink-cost-of-hydrogen-fuel-cell-vehicles-idUSKBN1KG0Y0>

<sup>6</sup> Vehicle Attribute Forecast, Slide 10.

We recommend adding FCEV-related data to the attributes of the light duty vehicle demand forecast on slide 8. This would include range of FCEVs, fuel cell stack price, refuel time (0 to full, not 0 to 80%). It should also be noted that FCEVs do not benefit from a federal tax credit, unlike BEVs and PHEVs.

While BEVs are unlikely to ever get fast refueling at large scale compared to FCEVs, FCEVs also offer a fueling advantage for people who cannot charge at home or work.

While Plug-in Hybrid FCEVs are a technology currently demonstrated by Daimler, and offers significant advantages for some owners, there is no consensus among OEMs that this hybridization of both BEV and FCEV technologies will continue. The challenge lies in combining two expensive systems, so cost will likely remain a significant obstacle.

### **Assumptions on attributes for various vehicle classes omit significant cost drivers**

In reference to the “Vehicle Attribute Forecast” presentation<sup>7</sup>, it is important to compare the costs of vehicle types based on the true total cost of ownership, including associated T&D upgrades for BEV infrastructure to develop a realistic comparison of each transportation technology. For example, the slides show that the catenary electric system vehicle costs are lower when compared with fuel cell and battery electric, but the true cost to develop the infrastructure (the costs of equipping two highway lanes with an overhead catenary and building up an energy supply infrastructure (substations, connection to the grid, transformers and rectifiers) is estimated to be in the range of 2–3 million € per km - translates to approx. \$3.5-\$5.3 million \$/mile (calculated) based on Siemens’ estimates.<sup>8</sup> Hence, it is critical to compare the true life cycle cost of each technology on this slide.

### **Assumptions on fuel cost/mile**

CHBC also referenced in its comments to the 2017 draft IEPR<sup>9</sup> that increased efficiencies of fuel cell systems onboard the vehicles and lower costs of hydrogen will significantly reduce the fuel cost per mile.

*“The recently showcased car from Toyota<sup>10</sup> reportedly has an approximate 550 mile range<sup>11</sup> with a 6 kg tank (92 miles/kg), allowing for a cost per mile between \$.11/mile to \$.18/mile with current cost ranges of hydrogen.<sup>12</sup>”*

There are encouraging signs for hydrogen fuel cost reduction in California. For example, the cost of refueling stations has reduced nearly half while capacity doubled from 2014 – 2017 as can be seen in the CEC’s own history of grant funding applications and awards. Industry may now be preparing to deliver another halving of refueling station cost while again doubling capacity in 2019, as has been described by Shell, and is complemented by announcements of new dedicated hydrogen production at cost-efficient scale. This pace of cost reduction and performance improvement approximates Moore’s Law. We recommend the CEC include projections based on these trends in its modeling.

---

<sup>7</sup> Vehicle Attribute Forecast, Slide 17

<sup>8</sup> [https://theicct.org/sites/default/files/publications/CE\\_Delft\\_4841\\_Zero\\_emissions\\_trucks\\_Def.pdf](https://theicct.org/sites/default/files/publications/CE_Delft_4841_Zero_emissions_trucks_Def.pdf), page. 89

<sup>9</sup> <https://efiling.energy.ca.gov/GetDocument.aspx?tn=222507&DocumentContentId=28279>

<sup>10</sup> <https://www.autocar.co.uk/car-news/motor-shows-tokyo-motor-show/toyotas-s-class-rival-showcases-next-gen-hydrogen-technology>

<sup>11</sup> The report cites a 620 mile range under Japanese test cycles. According to the manufacturer, this roughly equals to approximately 550 miles with the LA#4 test cycle.

<sup>12</sup> Current cost of hydrogen at the station ranges between \$10 and \$17 per kg. With a fuel efficiency of 92 miles/kg, that amounts to \$.11/mile to \$.18/mile.

Two important policy innovations created in 2018 may also impact and hasten both carbon intensity and consumer cost for hydrogen fuel in the near-term. The Draft Solicitation Concepts for Light-Duty Hydrogen Refueling Infrastructure (18-HYD-04), originally proposed on 23 January 2019, would enable cost reduction and scale with market certainty through a multi-year structure that would award the remaining funds as per the Clean Transportation Program Investment Plan and authorized under AB 8 legislation. The Hydrogen Refueling Infrastructure Pathway in the Low Carbon Fuel Standard adopted by the California Air Resources Board will augment Clean Transportation Program funds by partially offsetting low initial utilization of hydrogen refueling stations, and increase the immediate incentive to develop renewable and low-carbon hydrogen production. These are important examples of “pivots” in policy that enable industry to deliver significant progress for California emission reduction and economic growth goals with hydrogen FCEV, increasing capacity and coverage of hydrogen refueling to provide customers with stations for convenient refueling, delivering the next halving of cost while doubling of performance, developing new hydrogen production that is renewable and low-carbon from the start, and supporting the increase in availability of vehicle makes and models that is essential for growing customer adoption.

### **Lack of T&D cost significantly skews electric charging cost and infrastructure data**

In reference to the “Preliminary Transportation Energy Demand Forecast presentation (slide 12, see attached), the expected demand for electricity for transportation is a 4 fold increase under high case and 3 fold increase in mid case from the current demand (from 5,000 GWh to between 16,000 GWh and 20,000 GWh). This would again necessitate significant electric transmission and distribution (T&D) upgrades to substation transformers, line positions, and probably adding new distribution circuits to manage the electric load demand. The cost of T&D upgrades needs to be estimated and can be significantly higher than other technologies when addressed at an overall life cycle cost perspective for electric transport.

Impacts on the grid from charging will be significant as it happens on demand, whereas hydrogen serves as an energy storage medium and fueling is not tied to the grid, but actually offers opportunities for grid services. In a high renewable scenario, following the mandates under SB 100, high BEV and PHEV penetration will create significant grid challenges in addition to challenges from high renewable integration. FCEVs therefore put less strain on the grid by decoupling the grid from fueling. This does not even include the risks associated with high wildfire risks and the possible need for de-energizing entire regions. While difficult to quantify, these factors will certainly have impacts on the price of electricity and the need for robust energy storage, which comes at a price for BEVs and PHEVs, yet is already priced in when using hydrogen FCEVs.

Meanwhile, for private individuals, retail rates of electricity will rise with SB100, and so will the cost of charging. It is safe to forecast that power costs are projected to go up, while hydrogen prices will come down, due to scale and technology improvements.

In the 2019-2020 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program (now re-named the Clean Transportation Program), the data on public investments in zero emission vehicle infrastructure based on the number of vehicles it can support shows approximate parity charging (approximately \$6,500 to \$8,500 per vehicle) and hydrogen fueling (approximately \$5,400 per vehicle). This comparison is between the full cost of hydrogen refueling stations and the partial cost of charging infrastructure, leaving out portions of the associated electric grid infrastructure upgrades necessary.

Furthermore, comparison of the cost effectiveness for emission reduction would take into account the relative carbon intensity of the fuel and the annual mileage of the vehicle. There is opportunity with new, dedicated hydrogen production to decarbonize from the start, and in doing so accelerate emission reduction with FCEVs

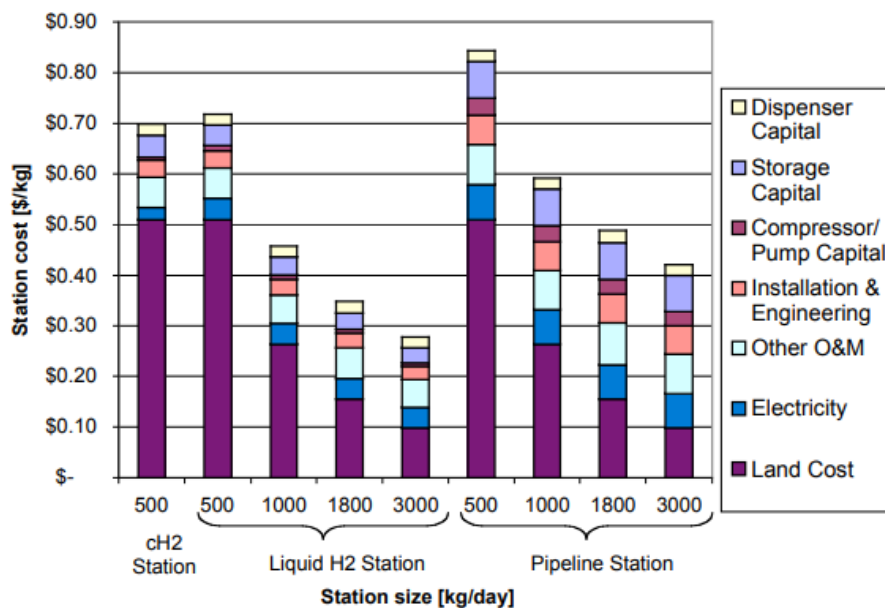
while also supporting further decarbonization of the electric grid for BEV and other sectors. Once again, these are complementary approaches.

### NREL forecasts do not reflect industry expectations on fuel cost decline

The current fuel price forecast generated by NREL for hydrogen projects a cost reduction from the current \$16 per kg to \$7-9 in 2030. We recommend CEC to exercise a reverse modeling with the NREL forecasts to see how accurate they are related to CEC’s modeling.

In 2017, Shell published an internal study, which shows how total hydrogen fuel cost to serve the customer can decrease with higher volumes and full infrastructure utilization, to \$10/kg with 16,000 cars in a major urban area and to \$7/kg with 70,000 cars in a regional market, which would be competitive to gasoline at \$3.50 per gallon, excluding incentives and tax.<sup>13</sup> Since the price of hydrogen at the pump is related to the scaling of hydrogen demand, hydrogen pricing should be projected based on the number of vehicles on the road, not year.

The cost of liquid hydrogen delivery to stations will go down from \$12/kg to \$4/kg at a 1,500 kg/day volume, according to DOE.<sup>14</sup> More than 100 tons/day of hydrogen production capacity are projected by companies like Air Liquide, Praxair, which will drive fuel costs down.<sup>15,16,17,18</sup>



Station costs are also decreasing significantly at scale, according to a UC Davis ITS study.<sup>19</sup>

<sup>13</sup> [https://www.shell.com/energy-and-innovation/new-energies/hydrogen/\\_jcr\\_content/par/textimage.stream/1523053290426/9c3eb9f6ee6f68ecdabb311a9254e621355b52b21/path-toward-competitive-refueling-infrastructure-for-hydrogen-brochure.pdf](https://www.shell.com/energy-and-innovation/new-energies/hydrogen/_jcr_content/par/textimage.stream/1523053290426/9c3eb9f6ee6f68ecdabb311a9254e621355b52b21/path-toward-competitive-refueling-infrastructure-for-hydrogen-brochure.pdf)

<sup>14</sup> [https://www.hydrogen.energy.gov/pdfs/review16/pd014\\_elgowainy\\_2016\\_o.pdf](https://www.hydrogen.energy.gov/pdfs/review16/pd014_elgowainy_2016_o.pdf), slide 15

<sup>15</sup> <https://energies.airliquide.com/air-liquide-build-first-world-scale-liquid-hydrogen-production-plant-dedicated-supply-hydrogen>

<sup>16</sup> <http://www.airproducts.com/Company/news-center/2018/09/0911-air-products-to-build-world-scale-liquid-hydrogen-plant-at-laporte-texas-facility.aspx>

<sup>17</sup> <http://www.airproducts.com/Company/news-center/2019/01/0107-air-products-to-build-second-liquid-hydrogen-productions-facility-in-california.aspx>

<sup>18</sup> <https://www.praxair.com/news/2018/praxair-to-build-new-liquid-hydrogen-plant-in-la-porte-texas>

<sup>19</sup> <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.710.3061&rep=rep1&type=pdf>, p. 10, Figure 2.

## Fuel Cell Electric Buses can play a significant role in California's Transit Sector

The Innovate Clean Transit (ICT) Regulation requires significant investment and conversion a 100% ZEV fleet purchase mandate by 2029 and an entire 100% ZEV fleet for all California transit agencies by 2040.

The L.A. Metro Board Report (File #:2019-0458) on the "Metro Bus Fleet Forecast and Zero Emission Bus Program Update" dated July 18, 2019, outlines the estimated costs for a full conversion to BEV fleet as well as other challenges. Those include: low-end estimate capital required for charging infrastructure of \$700 million to \$1 billion, an unknown TCO for buses (utility and operating costs), overhead charging requiring 15MW of power, curb weight limits as an issue for range of the fleet, and CNG buses outperforming ZEBs, possibly requiring more ZEB buses to cover same service level, thus requiring additional BEB purchases to maintain current level of service.

Based on existing projects we offer the following data: the liquid hydrogen delivery approach for the new Orange County Transportation Authority (OCTA) fuel cell electric bus fleet is completely applicable to LA Metro's transit bus fleet.

OCTA's fueling station infrastructure, developed by Trillium, is sized for a 50-bus fleet, with the total station project costs \$4.7 million for 50 buses amounting to **\$94,000 per FCEB**.<sup>20</sup> This includes 3 years of warranty and full maintenance. For better comparison, just CAPEX with a standard 1-year warranty is closer to \$4 million for the above referenced 50 bus station. In addition, liquid hydrogen stations have great scaling characteristics. According to Trillium, with an additional investment of \$2 million at the start of the project at OCTA, the station could have supported 200 buses. Trillium stated that a 200 bus station would cost \$7 million, which would equate to **\$35,000 of capex per fuel cell electric bus** for the infrastructure investment. This compares to LA Metro's low-end infrastructure estimate of \$700 million for 2,300 buses, which would be at least **\$304,000 per battery bus**.

In addition, Shell projects economical delivered cost for hydrogen supply<sup>21</sup> of \$5/kg for fuel contracts of 10 tons/day (= 333 buses) or \$3/kg for 50 tons/day (=1,667 buses), excluding cost of the station. L.A. Metro would create such demand very quickly.

We would also reference the CHBC & California Fuel Cell Partnership Fuel Cell Electric Bus factsheet, which outlines the performance of FCEBs, especially as a 1:1 replacement for current diesel (or CNG) buses while providing the same range, power, refueling time, and duty cycle with zero emissions.<sup>22</sup> An analysis by AC Transit from last year also indicates that today's FCEBs can replace 95% of their routes without compromise.<sup>23</sup> This was validated by AC Transit after conducting an in-service test with their new FCEB. L.A. Metro would not need to look into purchasing additional buses to maintain its current service with FCEBs.

SunLine Transit has also stated that for their FCEBs in operation, "the total cost per mile is comparable to CNG buses we have in service"<sup>24</sup>. AC Transit reported that current fuel cost is at \$7.42 per kg of hydrogen (\$.60 more than diesel equivalent MPG). Their maintenance cost is at \$187,000 per year per fuel station.

---

<sup>20</sup> OCTA is sized for 1,500kg/day = 50 buses at 30kg per day

<sup>21</sup> [https://www.shell.com/energy-and-innovation/new-energies/hydrogen/\\_jcr\\_content/par/textimage.stream/1523053290426/9c3eb9f6ee6f68ecdcb311a9254e621355b52b21/path-toward-competitive-refueling-infrastructure-for-hydrogen-brochure.pdf](https://www.shell.com/energy-and-innovation/new-energies/hydrogen/_jcr_content/par/textimage.stream/1523053290426/9c3eb9f6ee6f68ecdcb311a9254e621355b52b21/path-toward-competitive-refueling-infrastructure-for-hydrogen-brochure.pdf)

<sup>22</sup> <https://www.californiahydrogen.org/wp-content/uploads/2017/10/CHBC-CaFCP-Fuel-Cell-Electric-Bus-Fact-Sheet.pdf>

<sup>23</sup> [http://www.actransit.org/wp-content/uploads/board\\_memos/18-134%20ZEB%20Assessment.pdf](http://www.actransit.org/wp-content/uploads/board_memos/18-134%20ZEB%20Assessment.pdf)

<sup>24</sup> <https://www.sustainable-bus.com/fuel-cell/el-dorado-national-fuel-cell-bus-ballard-completed-successfully-testing/>



## **Medium and Heavy Duty forecasts are lacking fuel cell electric trucks and key limitations of other alternative drive trains**

FCETs are lacking comprehensive forecasting in the presentations, and CHBC disagrees with CEC's assessment that hydrogen prices and vehicle cost will create prohibitive barriers for fuel cell electric truck (FCET) introduction. Fuel cost at scale, especially for high volume fueling with liquid hydrogen, allows for significant cost reduction over current fueling cost for light duty vehicles, see station cost and hydrogen cost comments above. While cost data for FCETs are difficult to ascertain, Nikola Motor<sup>25</sup>, Hyundai<sup>26</sup>, Horizon Fuel Cells<sup>27</sup> and Kenworth/Toyota are all working on large scale deployments of FCETs and thus do not share CEC's skepticism.

Nikola Motor reports over 14,000 FCETs pre-orders to date, indicating strong demand. Nikola reports that fleet managers specifically look at zero emission solutions that will enable them to move at least 40,000 pounds of payload for at least 600 miles. Battery electric trucks (BETs) are highly unlikely to achieve such benchmarks. Nikola has already built two FCETs for the North American market, and is ramping to build 25 test FCETs by 2021 for testing and 100 FCETs on the road in 2022. Large-scale production of FCETs is scheduled for 2023 in Arizona. Production volume is designed for 2,200 FCETs in 2023 and full capacity of 36,000 FCETs per year is scheduled for 2027. To support this volume of FCETs, Nikola will plan to build one 8,000 kg per day hydrogen production and refueling station to support 200 FCETs. Their plan is to build one 2,000 kg station in Phoenix by 2021, one 8,000 kg station in California by 2021 and at least nine more 8,000 kg stations in California by 2023. To support their full capacity production, Nikola is planning to build 700 more stations around the country by 2027.

With new solar power generation coming from Nikola's business partners and their ability to buy interruptible power by storing excess hydrogen to satisfy their customer's fueling demand, Nikola is planning to purchase power for less than 4 cents per kWh on average. California power costs might be a bit higher than the average but Nikola will supply hydrogen fuel and a FCET and truck maintenance for 95 cents per mile for a 700,000 mile 7-year lease. This cost structure is on par with diesel fuel for fleets and enables fleets to avoid the operational risk and capital cost associated with buying a FCET. BET's cannot compete with this due to the weight of the batteries, which affects the payload capacity and/or the range.

Based on the feedback from freight operators, long charging times required for BETs will not allow operators to meet customer needs. Unlike the light duty sector, the freight sector is time constrained and requires fast turnaround times.

In addition, range will be limited for BETs due to weight issues of the battery pack and catenary systems by the electrified routes. These limitations will significantly impede adoption of this technology, whereas hydrogen does not suffer from either limitation. While not directly related to cost components as outlined in slide 17 of the Preliminary Medium- and Heavy-duty Vehicle Forecast, the heavy weight of batteries in BETs needed to achieve a manageable range will reduce the payload possible to be carried by each truck. This will require additional trucks to be used to carry the same payload of a diesel or CNG truck. This analysis is missing in the presentation. An analysis is recommended to identify these costs for freight transport.

---

<sup>25</sup> In 2018, Nikola reported \$9 billion in pre-order reservations for their FCETs: [https://nikolamotor.com/press\\_releases/anheuser-busch-continues-leadership-in-clean-energy-places-order-for-800-hydrogen-electric-powered-semi-trucks-with-nikola-motor-company-23](https://nikolamotor.com/press_releases/anheuser-busch-continues-leadership-in-clean-energy-places-order-for-800-hydrogen-electric-powered-semi-trucks-with-nikola-motor-company-23)

<sup>26</sup> <https://www.electrive.com/2019/04/15/hyundai-h2e-1600-fuel-cell-trucks-for-european-market/>

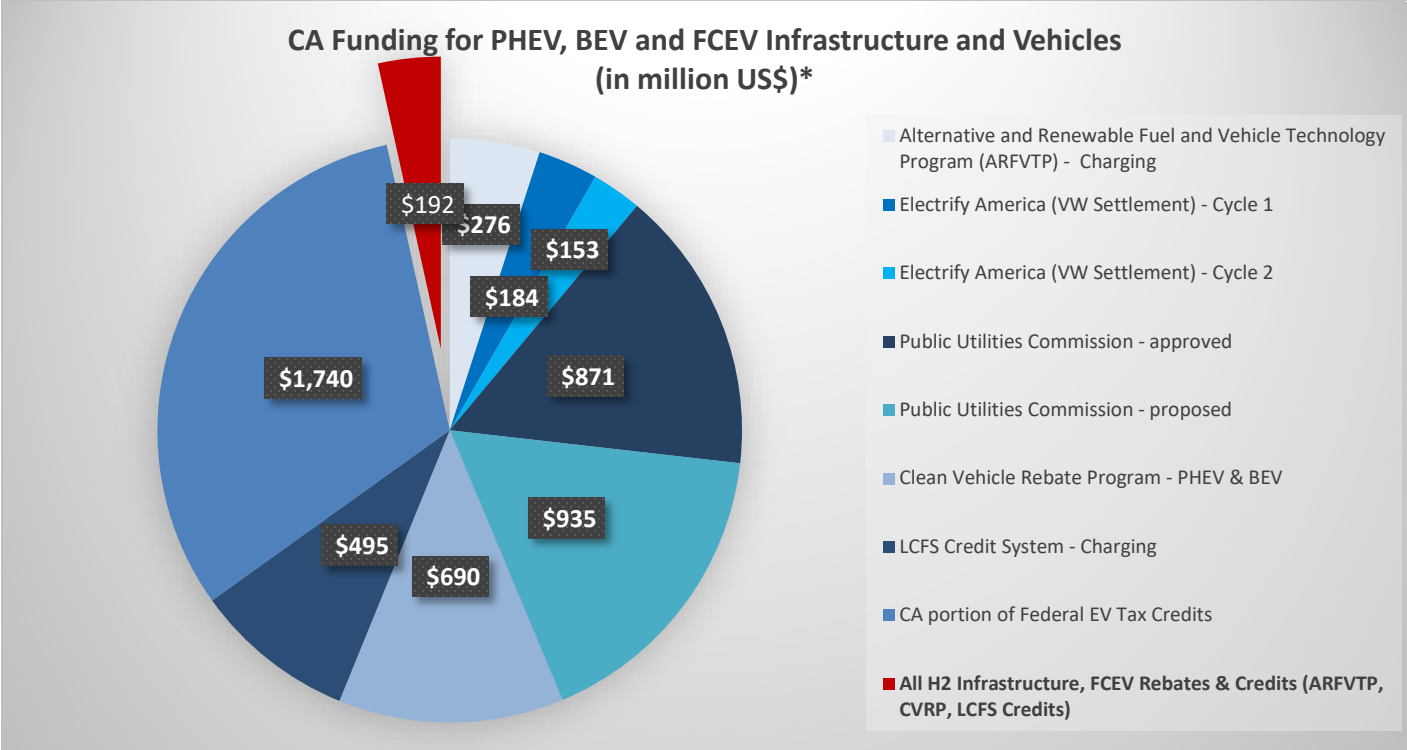
<sup>27</sup> <https://fuelcellworks.com/news/horizon-fuel-cell-technologies-signs-agreement-to-supply-1000-fuel-cell-electric-heavy-vehicles-for-cleaner-port-operations/>



As mentioned in the comments on buses, volume production can significantly reduce the price of the fuel cell electric vehicles, including trucks. Buses see a 40% price reduction by quadrupling the production volume from 25 to 100. There is no reason to not assume a similar price reduction for FCETs. However, since ZETs are not commercial yet, any price forecasts are marketing, not data driven. We urge CEC not to rely on marketing data from individual companies, especially if their record on announcing vehicles at certain prices has been spotty, at best. Extensive modeling data, which member companies are willing to share confidentially, has shown FCETs being more affordable than for BETs from a total cost of ownership perspective, and that much earlier than 2030. Shell New Energies recently released an assessment that sees cost parity of hydrogen fueling with diesel in the heavy duty market at 10,000 vehicles.<sup>28</sup> Additionally, repeated use of fast charging also has the potential to deteriorate the large battery packs, and fast charging of large battery packs itself will create more strain on the grid than overnight charging or workplace charging.

**Hydrogen FCEVs can play a significant role in transportation electrification, but a set of challenges continue to impede progress for FCEVs**

California has adopted asymmetric policies that favor BEVs in its zero emission transportation policies that enable BEVs to begin scaling toward Early Majority adoption. Harmonization of policies – with multi-year funding programs, investment tax credits, and other market-based mechanisms – can now enable similar and complementary results with FCEVs. For example, approximately 97% of all funding for electrified vehicles and infrastructure to date have been invested or are being allocated towards BEVs and PHEVs, with 3% dedicated towards FCEVs, fueling stations and hydrogen production. This balance should be adjusted toward increasing support for hydrogen and FCEVs to accelerate toward self-sufficiency, as support for BEVs begin to reach self-sufficiency and an off-ramp from direct public support.



<sup>28</sup> [https://www.hydrogen.energy.gov/pdfs/htac\\_dec18\\_06\\_munster.pdf](https://www.hydrogen.energy.gov/pdfs/htac_dec18_06_munster.pdf)

California policy goals for emission reduction will require acceleration and scale in the adoption of both BEV and FCEV. Although new vehicle market share for zero emission vehicles is approaching 10%, neither a tipping point in customer adoption nor an off-ramp in direct public funding has been achieved. It is now nearly 30 years since the California Zero Emission Vehicle (ZEV) regulation was created, leaving approximately 30 years remaining to achieve California policy objectives for 2050. Although the ability to act has been established – with technologies that have become products and industries ready to invest, policies that have become investable markets – essentially no reduction in emissions from the transportation sector from levels in the 1990s have been made. The question for California policy makers may then be aptly framed as how to accelerate and scale for emission reduction and economic development, without economic harm from stranded assets.

Fortunately, the approaches to electrifying transportation with BEV and FCEV are complementary. Each may serve somewhat different customer and vehicle segments. Each may enable the other to de-carbonize more quickly and at lower cost.

It is therefore important for California to continue state programs with certainty and without delay – to harness the momentum begun over the past decade into material results in scale and acceleration – while also continuing to implement enabling innovative pivots in policy for electric mobility. The goal should be supporting all technologies that assure GHG and pollution reduction.

CHBC urges the CEC to include FCEV technology in all forecasts to avoid a continuation of a one-sided focus on PHEV/BEV technology. CHBC and its members offer to provide data to help make the necessary projections.

To achieve broad and rapid FCEV adoption, infrastructure is the key core enabler. CEC and CARB must work with stakeholders to complete the AB 8 mandate of at least 100 stations, and fulfill the Governor’s Executive Order to reach 200 stations by 2025<sup>29</sup>. At the same time, they must work with industry to plan for the 2030 vision of 1 million FCEVs and 1,000 stations, and a self-sufficient market in California that does not require further subsidies.<sup>30</sup> CEC should include the CaFCP’s *California Fuel Cell Revolution* as a bookend scenario in its analysis, rather than the 300,000 vehicle scenario shown on slide 12.

The potential for economic development in California through private investment in new energies and new fuels infrastructure is significant. The recent 2019 Annual Evaluation of Fuel Cell Electric Vehicle Deployment & Hydrogen Fuel Station Network Development (California Air Resources Board, July 2019) shows 94% of investment in hydrogen infrastructure coming from private sector from 2020 - 2039, leveraging public funds along with renewable power toward the infrastructure and in-state energy industry for which California policy calls.

### **Lack of trade and supply chain disruptions and limitation of resources**

California must be careful not to become overly dependent on energy choices that are prone to supply constraints and disruption. Li-ion battery technology, which currently dominates the BEV industry, requires cobalt, lithium and graphite, which are prone to resource constraints or trade and market upheavals.<sup>31</sup> Furthermore, lithium cannot be recycled, and graphite is difficult and costly to recycle, creating constant demand for further resource extraction.

---

<sup>29</sup> [https://cafcp.org/sites/default/files/hydrogen-stations\\_100-200-1000.pdf](https://cafcp.org/sites/default/files/hydrogen-stations_100-200-1000.pdf)

<sup>30</sup> <https://cafcp.org/sites/default/files/CAFCR.pdf>

<sup>31</sup> <https://www.theguardian.com/environment/2017/jul/29/electric-cars-battery-manufacturing-cobalt-mining>

Fuel cells only require platinum in an amount equivalent to what is currently used in regular catalytic converters of regular combustion vehicles. Furthermore, more than 95% of the platinum in fuel cells, when reaching their end of life, is recycled and can be used indefinitely in new fuel cells, reducing the need for new resource extraction. No other rare or precious metals are required, creating a robust supply chain independent of international trade disputes or shortages in raw materials and allowing for full homegrown domestic production.

This is reflected in Chairman of Audi Board of Management, Bram Schot's recent announcement to intensify fuel cell development: *"at the end of the day, batteries are not sustainable enough — it is sustainable, but if you want to go all the way, you need fuel cells."*<sup>32</sup>

According to UK scientists, *"currently projected estimate of two billion cars worldwide, based on 2018 figures, annual production would have to increase for neodymium and dysprosium by 70%, copper output would need to more than double and cobalt output would need to increase at least three and a half times for the entire period from now until 2050 to satisfy the demand."* For just UK *"electric car targets for 2050, we would need to produce just under two times the current total annual world cobalt production, nearly the entire world production of neodymium, three quarters the world's lithium production and at least half of the world's copper production."*<sup>33</sup>

## Policy Recommendations

1. Continue state programs with certainty and without delay to harness the momentum begun over the past decade by approving the 2019 – 2020 Investment Plan Update for the Clean Transportation Program and releasing the grant funding opportunity for light-duty hydrogen refueling stations aligned with the innovative Draft Solicitation Concepts for Light-Duty Hydrogen Refueling Infrastructure (18-HYD-04).
2. Infrastructure is by far the biggest obstacle to FCEV scale-up. Therefore, CHBC recommends the CEC to support the goal of 200 stations by 2025 to initiate the development of a self-sufficient market. CEC should also commit to working with stakeholders to plan for the 2030 goal of 1,000 station enabling upwards of 1,000,000 FCEVs.
3. Continued innovation and pivot in policy and state programs can enable continued expansion of the hydrogen fueling network, cost reduction in hydrogen fueling stations and supply, and decarbonization of hydrogen production. Examples may include scalable market-facing mechanisms like investment tax credits and support for FCEV adoption into fleets. From a consumer point of view, if the fuel price gets down to \$8, and California has several hundred stations, a self-sufficient market with scale and private investment may begin, creating an off-ramp to direct public funding. Minimizing the total "buydown cost" of public support and accelerating to achieve California emission reduction goals are both achieved by supporting a more rapid market launch to these tipping points.
4. California decision makers and the CEC along with CPUC can develop policies and rate structures to enable synergies in decarbonizing both hydrogen and electricity via low cost electricity for hydrogen production, processing and distribution across vehicle classes.
5. CEC should identify mechanisms to capture the value of hydrogen energy storage for grid management, per the direct requirement of SB 1369, the indirect requirement of SB 100. Scaling up hydrogen production and demand will have game-changing effects on lowering prices and increasing volume.

---

<sup>32</sup> <https://fuelcellsworks.com/news/audi-increasing-investment-into-hydrogen-fuel-cells/>

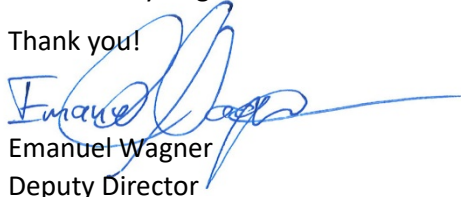
<sup>33</sup> <https://www.nhm.ac.uk/press-office/press-releases/leading-scientists-set-out-resource-challenge-of-meeting-net-zero.html>

6. Relatedly, CEC should help establish natural gas pipeline access for hydrogen to help scale up hydrogen production and supply.

## **Conclusion**

We appreciate the opportunity to offer these comments and stand available to connect CEC with our members and industry to get direct feedback on industry data and analysis.

Thank you!



Emanuel Wagner

Deputy Director

California Hydrogen Business Council