FUEL CELL ELECTRIC TRUCKS

A Vision for Freight Movement in California *—and Beyond*

Presented by the California Fuel Cell Partnership | July 2021

PHOTO | PORT OF LOS ANGELES

Contents

The **CALIFORNIA FUEL CELL PARTNERSHIP** *membership represents public entities and private global companies with vested interests in both battery electric and hydrogen fuel cell electric technologies. This document presents our shared vision of the fundamental role of fuel cell electric trucks in the complete transition of California's freight movement sector to zero-emission. While the insights shared are applicable to many vehicle types, this document focuses on the largest and highest-priority, on-road freight vehicle:* ***the Class 8 tractor****. Achieving the vision presented in this document requires the close collaboration of all stakeholders to create the roadmap and take action.*

Achieving California's Zero-Emission Future for Freight Movement

California faces extraordinary challenges to meet its climate, health, and economic goals

Freight movement has a material impact on all of us, extending far beyond the packages arriving on our doorsteps. Nearly all goods that we purchase and consume today were once freight—from the food in our grocery stores to the oxygen at our hospitals. The food and goods shortages in the early days of the COVID-19 pandemic uniquely illuminated exactly how the freight system can affect us on a deeply personal level.

Converting the vital freight movement industry to use clean energy is a significant challenge that will shape California's future. Conventional fuels have enormous environmental impacts on the climate and human health. **While representing only two percent of vehicles on California roads, the hundreds of thousands of trucks that sustain our economy generate more than three percent of its particulate emissions, nine percent of the State's greenhouse gas emissions, and 32 percent of its nitrogen oxides.**[1] Globally, the heavy-duty sector accounts for less than 10 percent of the vehicle population, yet it contributes approximately 40 percent of vehicle-generated carbon emissions.[2]

Heavy-duty truck emissions are a significant source of air pollutants widely recognized to cause detrimental health effects such as heart and respiratory diseases. This is especially true in freight corridors, where the constant flow of truck traffic has led to disproportionate occurrences of these health-threatening conditions among residents living in the surrounding priority communities.

In addition to the negative health impacts of emissions, the effects of climate change have already resulted in longer, hotter summers; more intense forest fires; droughts; sea level rise; and worsening air quality. As an industry, as citizens, and as parents, it is our responsibility to build a healthier, more sustainable future.

These collective realities illustrate the urgency and high stakes that California—and the country—faces as we try to balance the need for a zero-emission freight system with keeping goods moving and ensuring a healthy economy. The effective transition to zero-emission trucks requires that trucking companies convert their existing fleets on a schedule, and that truck manufacturers and fuel providers offer viable products that can seamlessly meet the rigorous demands of the freight industry.

To fast-track the market to a cleaner transportation system, Governor Newsom set targets for a transition to 100 percent zero-emission trucks, specifically calling for all trucks on the road to be zero-emission by 2045. Additionally, the high-emitting drayage truck sector, including 17,000 vehicles registered to the ports of Los Angeles and Long Beach alone, must be transitioned to zero-emission by 2035. Regional air quality districts have also adopted Indirect Source Rules to mitigate truck emissions entering warehouses. In parallel, the California Air Resources Board (**CARB**) is developing several zero-emission truck mandates intended to drive this transition with some requirements going into effect in 2023.

It is time to broaden the portfolio of heavy-duty, zero-emission technology solutions and leverage hydrogen fuel cell electric technologies to meet California's goals. As a complementary and viable alternative to battery electric trucks **(BETs)**, fuel cell electric trucks **(FCETs)** are the optimal one-to-one replacement solution for diesel trucks.

I | Fuel Cell Electric Trucks Are Essential

Fuel cell electric trucks are vital to achieving California's ambitious energy, environmental, and transportation policy goals. No other existing zero-emission vehicles offer diesel truck operators the same one-to-one replacement utility for the most demanding freight movement applications. With the establishment of the necessary market signals and conditions, members of the California Fuel Cell Partnership have confidence in the successful transition of this complex and difficult-to-mitigate emissions sector and see a path to market sustainability.

II | Economic Viability Is Within Reach

The adoption of new technology is traditionally limited by its economic impact. As such, widespread commercial deployment of FCETs requires a cost competitive, sustainable market. In order to create these market conditions by the deadlines set forth in California's existing policies, large-scale public and private investments must start immediately. These time-sensitive investments will not only influence the overall return on investment and total cost of ownership, but will also set the pace for freight operator adoption and air quality improvements.

[1] *https://ww2.arb.ca.gov/criteria-pollutant-emission-inventory-data*
https://ww2.arb.ca.gov/sites/default/files/2021-04/Revised_Draft_2020_Mobile_Source_Strategy.pdf

[2] *https://theicct.org/sites/default/files/publications/Zero-emission-freight-trucks_ICCT-white-paper_26092017_vF.pdf*

PHOTO | TOYOTA MOTOR NORTH AMERICA

III | Policy Is the Chief Accelerator of Market Growth and Scale

Revolutionizing freight movement requires a portfolio of policy solutions that drive scale, vehicle adoption, and private investment. **To meet mandated deadlines, policies must address the needs of operators in conjunction with emissions reduction goals.** If these market signals effectively support the adoption of FCETs, infrastructure buildout, and renewable hydrogen supply chain expansion, they will ultimately trigger market initiation and lead to accelerated and sustained growth.

IV | Reaching the Tipping Point

Achieving a complete and sustainable transition to zero-emission freight movement while meeting the aggressive timelines set by policymakers requires the FCET market to reach a tipping point of sustainability well before the last diesel truck is retired from service. Deliberate and significant action, investment, and coordination are urgently needed by all key stakeholders to realize this vision.

V | The Pathway to 2045 and Beyond

California has embarked upon a challenging and necessary journey towards a zero-emission future, and the State has an opportunity to drive hydrogen fuel cell technology progress around the globe. Our collective actions today and tomorrow will determine if the on-road freight movement sector can transition swiftly enough while successfully balancing business operations and environmental stewardship. The California Fuel Cell Partnership members have set a vision for reaching market sustainability by 2035.

I | Fuel Cell Electric Trucks Are Essential

Operators need FCETs in order to achieve the State's policy goals and mandates

FIGURE 1 *On-road vehicle ecosystem*[3]

The vast logistics supply chain—powered by various forms of transportation—is the backbone of the global economy. All goods take a unique journey from raw material to production and to their ultimate utilization. While all modes of freight movement must be addressed to achieve air quality and climate goals, this vision document focuses on the largest and highest priority on-road freight vehicle: the Class 8 tractor.

Freight Movement Is Complex

Transitioning one particular vehicle segment to zero-emission operation is not a straightforward task. The complex and diverse requirements of drayage and short-, regional-, and long-haul trucking all pose unique challenges for a new powertrain technology. **There is not one specific use case or truly average operational requirement. Most truck**

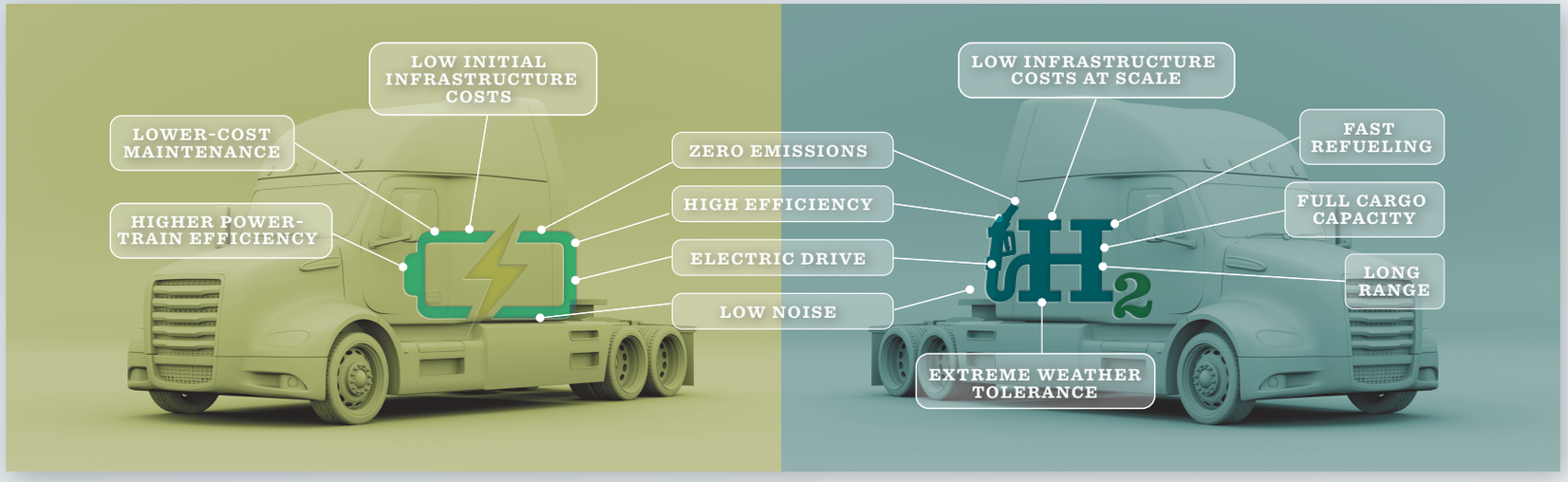

FIGURE 2 | *Zero-emission truck characteristics*

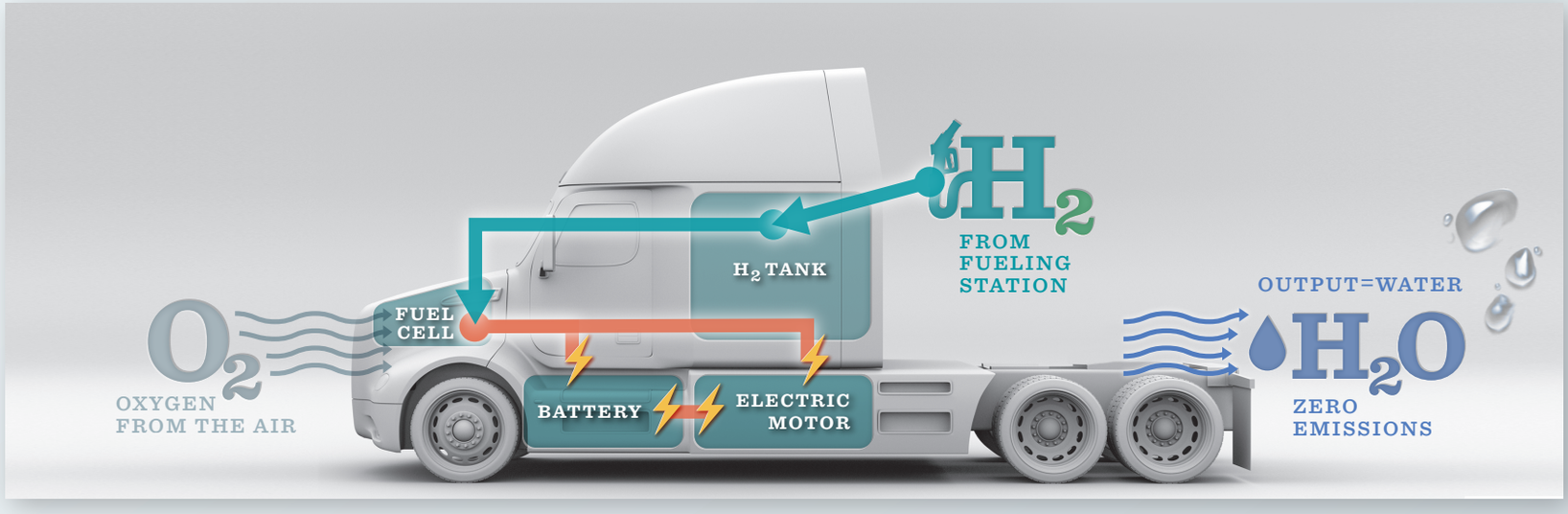

FIGURE 3 | *How a fuel cell electric truck works*

operators demand flexible capabilities to accommodate maximum cargo, multiple shifts, and longer-than-expected delivery distances. These capabilities may not be required every single day, but anything less could hurt the operator's business. Other specialized considerations requiring additional energy storage on board include transportation refrigeration, power take off applications, and overnight idling during long-haul trips.

Diesel trucks offer the full suite of performance and customization, and zero-emission replacements need to as well. FCETs are well-equipped to meet the varied needs of the challenging Class 8 truck sector. While BETs will certainly be part of the freight solution, their operational limitations will impede their adoption in more demanding applications. BETs, FCETs, and the supporting infrastructures will improve over time with appropriate investments, yet to truly realize a successful 100 percent zero-emission transition requires the unique capabilities of FCETs.

Rapid and Complete Transition Requires One-to-One Replacement

The fastest and most efficient transition to zero-emission trucks necessitates utilizing technology that can sustain existing business models with minimal operational disruption. Currently, FCETs and BETs are the only options available. Both are electric technologies that yield zero-emissions; scalable opportunities to increase renewable fuel content; and an improved driving experience. ***The difference?*** FCETs produce electricity onboard using a hydrogen fuel cell, while BETs use the electricity stored in batteries.

Although BETs are farther down the development path, early rollouts of FCETs already excel in terms of payload capacity, range, and fueling time, and thus offer the most compelling one-to-one solution for diesel replacement. Successful deployments of fuel cell electric buses and fuel cell electric forklifts have already proven this capability.

[3] *https://afdc.energy.gov/data/10380*

A hydrogen station mirrors the look, feel, and rapid fueling that is expected of diesel truck stations, and can achieve the equivalent number of vehicles fully filled per day. Given the similarities to diesel fueling logistics, this provides an optimal conversion opportunity and business case for diesel truck stops and private fleet fueling operations.

Conversely, BET charging depots will require new layouts, real estate for parking trucks while charging, and substantial electric grid upgrades—while still falling short on the number of trucks that can be charged each day, even at megawatt level charge rates. Electricity demand charges can also create cost uncertainty for operators. Instead of a one-to-one replacement, fleets running BETs could require additional trucks to achieve the same operational output.

Operational performance is critically important for customer adoption, and FCETs are well-suited to maintain the profitable revenue generation model that fleet operators expect.

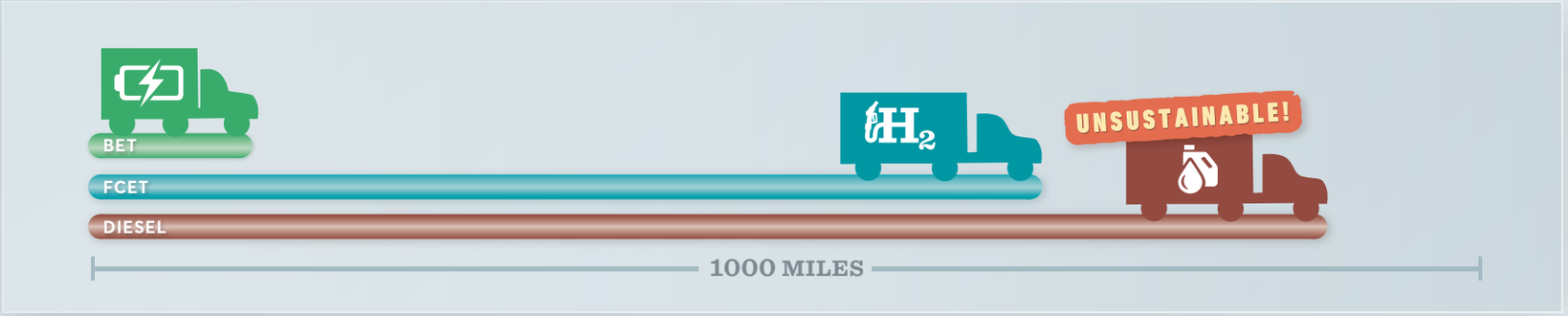

FIGURE 4 | *Truck range comparison for a 10-minute fill* [4]

[4] *Assumes BET charge rate of 1 MW and energy consumption of 2 kWh/mile—**and**—FCET fueling rate of 10 kg/minute and fuel economy of 7.7 miles/kg.*

[5] *https://www.hydrogen.energy.gov/pdfs/review21/sa169_hunter_2021_0.pdf*

[6] *https://www.nrel.gov/docs/fy21osti/75583.pdf*

II | Economic Viability Is Within Reach

Early market economics are the main hurdle for truck operators, truck manufacturers, and infrastructure providers

The cost of FCETs and the hydrogen production, distribution, and fueling infrastructure at small scale present the main challenges to initial FCET adoption. Truck sales volumes are driven by market signals, while unknown or limited expected demand hinders initial hydrogen supply and fueling infrastructure investment. However, achieving larger scale breaks down these economic barriers and enables a business case that is competitive, sustainable, and environmentally sound.

Moving Freight Is a Business

The costs associated with operating trucks and their ability to stay on the road generating revenue are paramount. The total cost of ownership is influenced by the initial truck purchase, fuel, maintenance, and labor costs; the overall return on investment, however, is also directly impacted by the capability of the truck. Freight efficiency and revenue ton-mile are terms used in the freight movement industry to measure this value by combining payload capacity, range, and fuel efficiency.

Ultimately, return on investment is a more important consideration for operators than total cost of ownership.

Additional considerations for fueling time and vehicle durability also have economic impacts. **Time is money in the freight business; any time spent fueling or charging is time the truck cannot be on the road.** From a servicing perspective, FCETs are electric vehicles with fewer moving parts compared to diesel powertrains, simplifying maintenance and lowering costs. A truck's durability also directly influences the residual value for initial owners and determines the potential usability for second and third owners in the total life cycle.

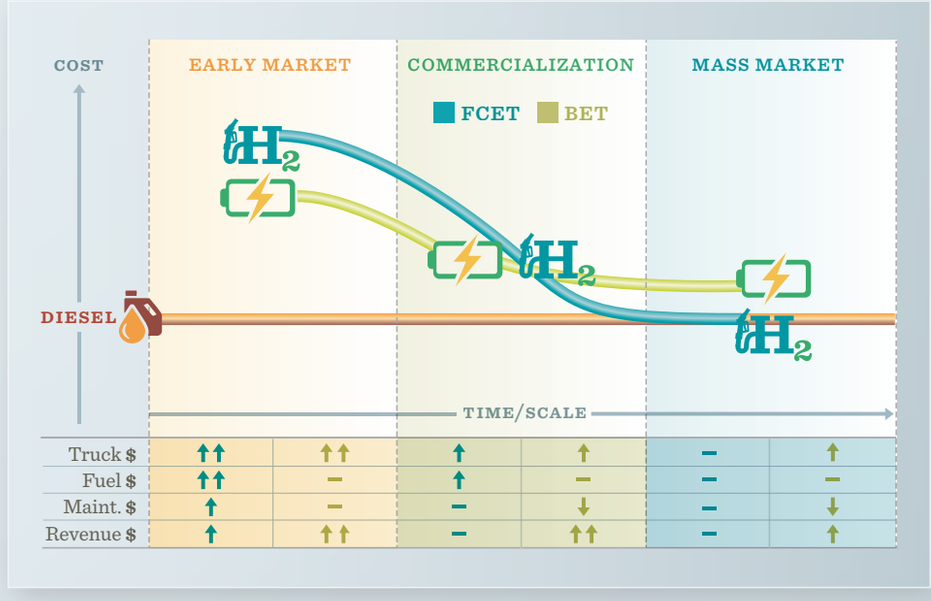

FIGURE 5 | Return-on-investment comparison to Class 8 diesel [5]

Pre-commercial and early-commercial, light-duty fuel cell electric vehicles (**FCEVs**) and fuel cell electric bus demonstrations have already shown great progress toward interim durability targets; some buses have even exceeded ultimate targets.[6] The technology has already progressed multiple generations with considerable improvements. Hydrogen storage tanks can also be certified for 20 years to enable full functionality for the expected life of the vehicle.

The Hydrogen Infrastructure Edge

Hydrogen is a natural universal energy carrier that can be produced, distributed, stored, and utilized in a variety of different ways. Similar to diesel, hydrogen fueling solutions can be configured for public, private, and mobile fueling, making the conversion more seamless for operators. **A robust public fueling network will support second and third owners without requiring additional private infrastructure development.**

The flexibility of hydrogen allows for a diverse supply chain with the potential to become more economically and environmentally sustainable over time as investments in hydrogen production utilizing renewable electricity, biomass and waste, and carbon capture pathways continue to expand. Policy mechanisms such as California's Low Carbon Fuel Standard have pushed the light-duty hydrogen refueling network well beyond the 40 percent requirement to nearly 100 percent renewable hydrogen. A similar signal can push the heavy-duty fueling network towards 100 percent renewable hydrogen to align with the shared life cycle carbon neutrality goal of the Hydrogen Council by 2030.

The pathway for hydrogen fueling infrastructure is understood and predictable given the robust hydrogen industry that exists today. The natural progression towards the necessary larger scale is a clear edge for hydrogen and FCETs, one that will result in cost reductions, market resiliency, and increasing decarbonized content. Small scale is the main hurdle for FCET rollout, with large scale being a key challenge for BET expansion.

Charging a small fleet of BETs today may offer a fairly low barrier to entry, but what would it take to charge a few thousand trucks in the San Pedro Bay ports every night? *What about all 17,000 trucks?*

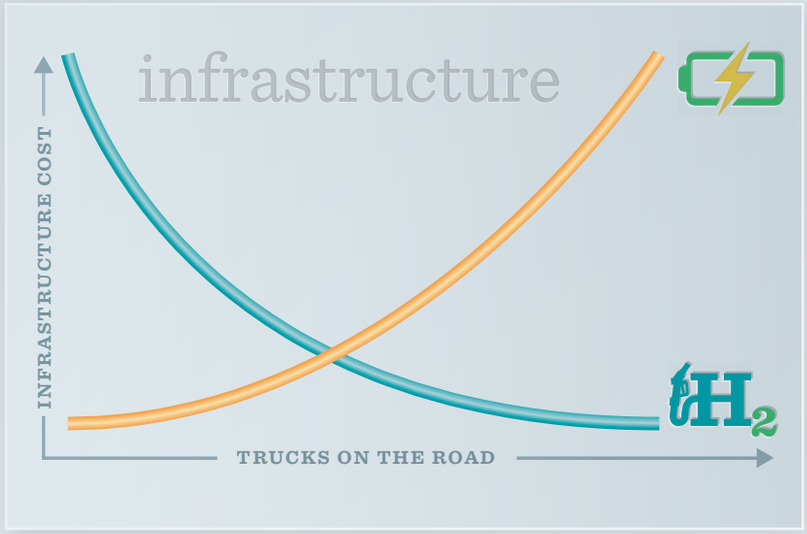

***FIGURE 6** | Infrastructure costs at scale*

The additional electric generation capacity and local distribution to support DC fast charging (at 350 kW) could require an additional six GW for the San Pedro Bay ports alone. To support all Class 8 tractors registered in California today, it could require over 100 GW of additional distribution capacity—more than double the entire California electric grid. That does not even consider electric charging requirements for other segments such as light-duty vehicles, transit buses, medium-duty trucks, rail, and marine applications.

California utilities add demand charges for high-power electric services, which can account for multiple times the base electricity cost when charging battery-electric vehicles. The substantial costs of grid upgrades and delivering high electric loads compound if faster charging is required. Though often ignored, these costs will have to be absorbed by energy ratepayers, truck operators, and ultimately the consumers of the goods.

Bringing Fuel Cell Electric Trucks to Market

FCETs are being developed to meet truck operators' unique needs including durability, functionality, and revenue generation. Reducing the cost of new zero-emission trucks will require a combination of large-scale manufacturing and innovative technology improvements. Many truck manufacturers and fuel cell powertrain providers have formed partnerships to bring compelling FCET products to market. Like any new vehicle technology or platform, the ramp-up to mass market scale production will take time. To help accelerate this pathway to scale, existing fuel cell automakers are leveraging decades of development and multiple generations of commercial light-duty FCEV rollouts.

In addition to the value of economies of scale, continued innovation and collaboration among industry, government, and academia will also drive improved performance and cost reduction through their collective efforts in the push towards the techno-economic targets set by the Department of Energy.[7]

Major investment from private industry is required to achieve a pathway toward a self-sustaining market for FCETs. Fortunately, the journey is already underway. Commitments have been made and expressed through investments, developments, and public announcements. Creating the right market signals to further encourage FCET adoption is the next necessary step to fully engage the private industry and freight operators.

[7] *https://www.hydrogen.energy.gov/pdfs/19006_hydrogen_class8_long_haul_truck_targets.pdf*

III | Policy Is the Chief Accelerator of Market Growth and Scale

Supportive policies will amplify market signals and help industry overcome barriers to scale

Policy support for game-changing new technologies can mitigate both technology and market risks. In the case of FCETs and the hydrogen production, distribution, and fueling infrastructure, the technology risk for market success is already fairly low and industry will continue to invest and improve the technology. Public funding is needed to help initiate the early market by addressing market risk—reducing economic barriers to customer adoption.

Fuel Cell Technology Is Ready for Market Initiation

Policy will play a major role in sending the right mix of market signals that are imperative for a smooth transition to this new zero-emission technology. Aggressive directives in the form of targets, goals, and mandates have continued to expand in California, sending a strong market signal that the transition to zero-emission trucks must happen as swiftly as possible to achieve the State's environmental and public health goals. However, mandates alone will not spur the necessary customer adoption or private investment required to actually achieve these goals.

To truly push zero-emission truck adoption in a customer segment that is defined by return on investment and total cost of ownership, equally **strong and supportive policy levers must be put in place to drive customer demand. This will unlock the investment and commitment from industry and private investors to develop the necessary products and supply chain at mass market scale.**

Market Certainty and Vision Enable Investment

The suite of supportive policies must be predictable, long term, and zero-emission technology focused to create a meaningful impact. They must also address return-on-investment needs and help close the economic gap to diesel parity in order for truck operators to adopt new zero-emission technology. Supportive policies could combine known programs including, but not limited to, truck sales tax exemptions; vehicle purchase and infrastructure incentives; state-backed financing; grant funding programs; government fleet purchases; the low carbon fuel standard; and station capacity credits—complemented by new, innovative policy levers that can further reduce the cost-of-ownership gap. Any indication of uncertainty or changes year-over-year will only delay timelines.

Given California's leadership position in seeking to eliminate on-road vehicle emissions on such a short timeline, critical policy support must be initiated and championed by California agencies and policymakers. However, California can not transform the national freight movement industry alone. Collaboration with other states and federal agencies could further support the transition of incumbent trucks to zero-emission. We can also look to advancements made across the globe that are directly tied to policies and investments initiated by leaders in China, Europe, Japan, and South Korea.

IV | Reaching the Tipping Point

Market sustainability is the target milestone on the pathway to 100 percent zero-emission freight movement

FIGURE 7 | Foundational elements of a sustainable market

The California Fuel Cell Partnership membership envisions a future when operators purchase FCETs because they run profitably while generating zero emissions. **This tipping point will occur when a self-sustaining market for zero-emission trucks exists without the need for government financial incentives**, which is feasible before 100 percent market penetration of zero-emission trucks is achieved. Sales and purchase mandates and other non-financial policy levers can continue on until 100 percent of trucks are zero-emission. Yet direct financial levers, such as customer incentives and grant funding programs, do not need to be sustained throughout the entire transition process. The costs to the public are too high to support full-scale turnover and there is no viable offramp from financial subsidies if market sustainability is not prioritized.

The Time for Action and Investment Is *Now*

The sooner the tipping point is reached, the sooner environmental and public health goals can be met. Accelerated actions and investments are urgently needed from all key stakeholders now.

The fuel cell and hydrogen industries are ready, actively engaged, and making progress, and all major truck manufacturers in the U.S. are actively developing FCETs. However, uncertainty among future customers prevails. Truck operators remain skeptical that the high initial costs of zero-emission trucks will actually be subsidized to diesel parity and that the necessary fueling infrastructure will be in place. There is also a misguided belief that BETs will be able to meet all operational needs. Each day these clouds of uncertainty remain further prolongs the pathway to 100 percent zero-emission trucks.

With multiple zero-emission truck mandates and targets already set and well underway, the major outstanding trigger is a significant expansion of supportive policies. Providing enough financial support for truck operators to offset the initial higher cost of zero-emission technologies will stimulate customer demand. If this customer demand is predictable up to the tipping point, private investment in truck manufacturing and the hydrogen supply chain will scale up dramatically to meet that demand.

Parallel to large public-private investment, close collaboration will enable a more optimal transition. This involves public-private partnerships, roadmapping, advocacy, education, and coordination with other states and federal agencies. Furthermore, increased scale and investment around the world will directly benefit the technology and cost effectiveness in California and vice versa. While larger scale alone unlocks significant cost reductions, ongoing technology improvements through both government and academic research and development initiatives will further drive innovation and lower costs.

The Importance of the Hydrogen Supply Chain

Progress towards zero-emission truck adoption will only go as far as the supporting infrastructure. Operators need to see a robust, reliable, and cost-friendly fueling network in the ground before considering a major purchase of FCETs. Yet infrastructure providers need to know future demand to justify their investments in production, distribution, and fueling station assets. This necessitates close collaboration between truck manufacturers, truck operators, infrastructure providers, and policymakers to ensure the required fueling infrastructure is planned and built out ahead of expected demand. Policy levers, such as streamlined site permitting and incentivizing station capacity for future growth, can help accelerate infrastructure deployment fast enough to support targeted truck volumes.

The industry has already taken action to develop global interoperability standards for hydrogen fueling stations and FCETs, ensuring that all fueling network expansion can be utilized by all FCET users. This is a key step in streamlining coordinated hydrogen infrastructure investments, and will provide freight operators the fueling location flexibility they expect.

The operational similarities of hydrogen and diesel fueling present a compelling opportunity for existing diesel fueling depots and truck stops to add hydrogen in the near term, and fully convert to hydrogen in the long term.

Freight Corridors Initiate the Roadmap

Hydrogen infrastructure development is already underway in key California freight hubs and further buildout is needed. **Focusing initial efforts on major California freight hubs—including seaports, airports, and other large warehousing districts—will maximize the potential of zero-emission truck purchases within a compact and localized regional infrastructure network.** The larger share of captive fleets with return-to-base operations in freight hubs will help optimize the utilization of hydrogen infrastructure, lowering fuel costs. These hubs can then be connected by expanding the fueling network along major freight corridors and eventually linking to more remote in-state freight destinations.

California's existing network of approximately 500 public access truck stop stations is the perfect proxy for creating a heavy-duty hydrogen roadmap. Prioritizing which sites to target first and how many fueling positions to convert to hydrogen over time will be an important step to ensure strong station utilization by initial FCET fleets. This mirrors the natural transition of existing gasoline stations to hydrogen in support of light-duty FCEV fueling. The buildout of hydrogen fueling at truck stops also provides the opportunity to add co-located light-duty fueling from separate dispensers to further support a robust fueling network and unlock new markets for FCEVs.

Of course, freight movement does not stop at the border, so coordination with neighboring states is essential to reach high levels of zero-emission truck penetration in California and beyond. Given the broad reach of freight movement, achieving 100 percent zero-emission truck penetration will require a full national rollout.

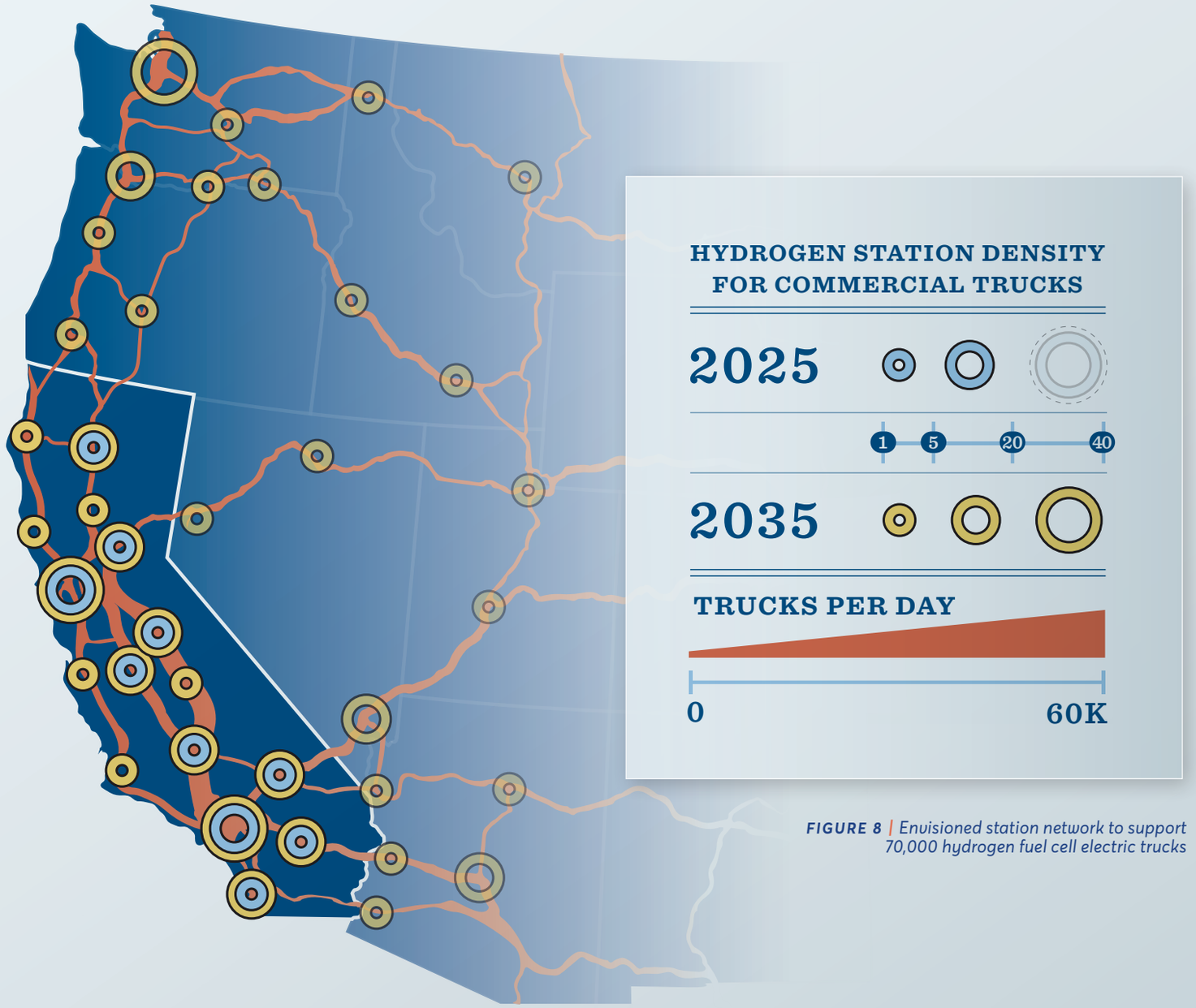

FIGURE 8 | *Envisioned station network to support 70,000 hydrogen fuel cell electric trucks*

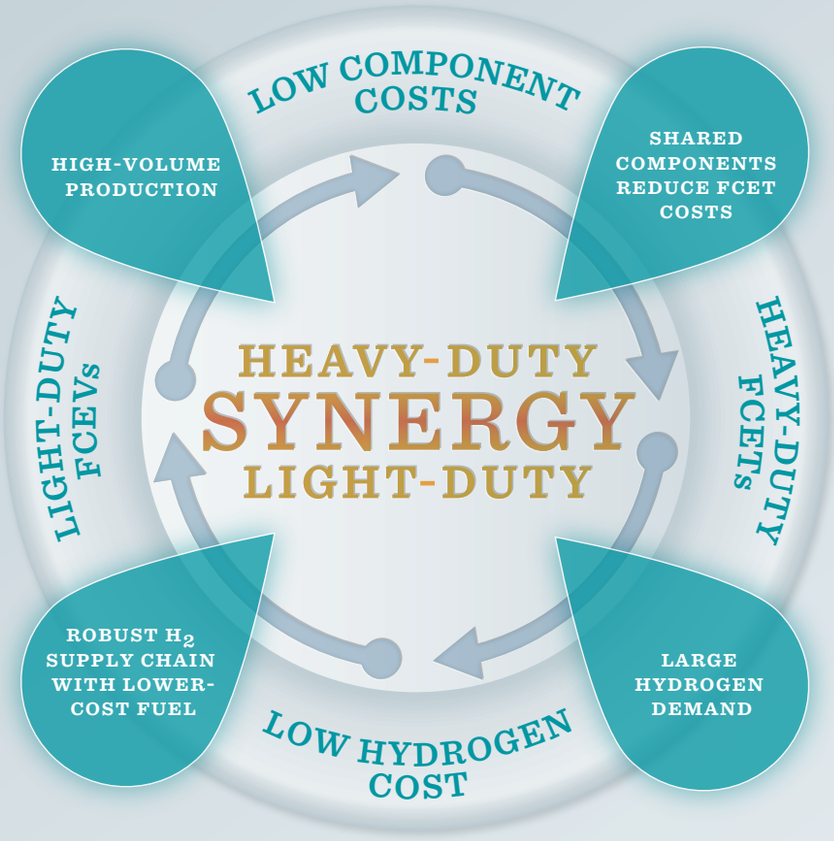

***FIGURE 9** | Economies of scale reduce cost*

The Synergy of Expansion

The expansion of FCETs also offers noteworthy synergies with other market sectors. As a universal energy carrier, scale up and improvements in the hydrogen supply chain to support heavy-duty truck fueling can directly benefit other applications for hydrogen. The modularity and scalability of fuel cell technology has a similar trait. Put simply, the scale of hydrogen demand from FCETs can yield a more robust and reliable hydrogen supply chain with lower prices at the pump. These benefits transfer directly to light-duty FCEVs and other end uses of hydrogen. Simultaneously, the scale of light-duty FCEV production enables component reliability, modularity, and cost reduction for FCETs and other end uses.

The synergies associated with expanding both the FCET and FCEV market can further reduce the barrier to entry for other mobility, stationary, and industrial applications of hydrogen and fuel cells in sectors that need to reduce emissions and decarbonize. This is especially true in port ecosystems that require zero-emission solutions for off-road equipment, rail, and marine applications.

Hydrogen will also benefit the electric grid. Using hydrogen for long-term energy storage and electrolyzers to offtake excess electricity production can help increase the penetration of renewables; improve grid reliability; and support higher penetration of battery electric vehicles.

[8] *https://ww2.arb.ca.gov/sites/default/files/2020-11/ab_8_self_sufficiency_report_draft_ac.pdf*

v | The Pathway to 2045 and Beyond

The California Fuel Cell Partnership members envision that nearly all of the Class 8 tractors on the road could be replaced by FCETs given their full spectrum of capabilities and one-to-one operational performance. With adequate policy support for zero-emission trucks, by 2035, an interim milestone of 70,000 Class 8 FCETs on the road supported by 200 heavy-duty hydrogen stations could be achieved. This represents the market sustainability tipping point, and from there, the market will carry out its natural evolution on a pathway to 2045.

Based on analysis, this scale aligns with the success case of current truck manufacturer sales requirements, fleet purchase requirements, and Governor Executive Orders in California, and enables a public heavy-duty fueling network across California and neighboring states to support drayage and short-, regional-, and long-haul Class 8 trucking.

Reaching the tipping point—when the market chooses zero-emission trucks naturally without mandates or financial incentives—any later than 2035 makes the 2045 target extremely challenging. In turn, actually reaching this tipping point by 2035 is highly dependent on accelerated policy support in the early 2020s. Greater investment upfront can both shorten timelines and require less overall public investment to reach market sustainability. This message parallels the key conclusions from the *CARB Self Sufficiency Study*[8] on the light-duty hydrogen station network.

Both FCETs and BETs are needed to achieve targets, and the zero-emission technology split will be driven by customer choice. The more operational changes required to adopt a new technology, the less likely a truck purchase will be. Operational sacrifices are minimal with FCETs because of the technology's inherent characteristics. BETs have less range, less payload capacity, and longer fueling times, thereby potentially jeopardizing an operator's business model. While this gap is the largest for Class 8 trucks, the operational challenges of BETs persist for other transportation applications where range, payload, and fast fueling are needed.

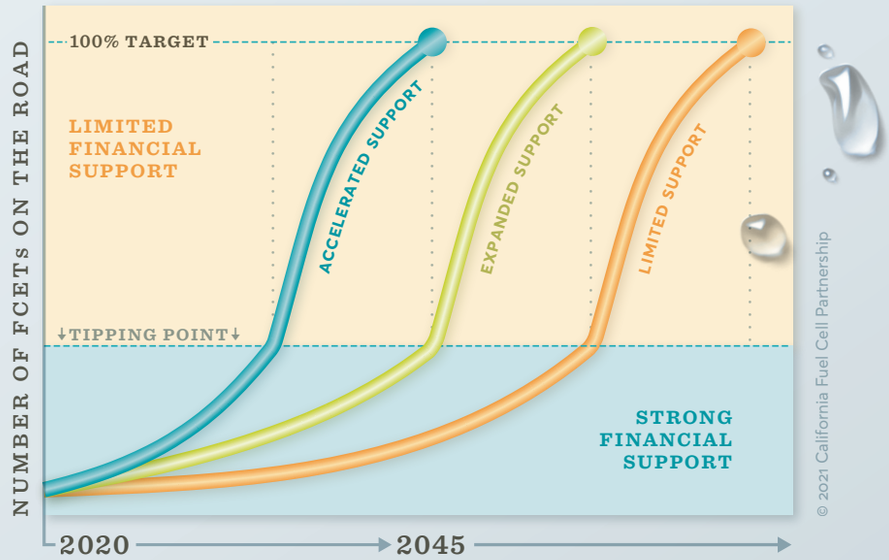

***FIGURE 10** | Policy scenarios*

In addition to the trucks meeting operator needs, the supporting infrastructure must also offer a plug-and-play solution that performs well at large scale. Once again, FCETs demonstrate their value, starting with the fact that the fueling experience mirrors that of a diesel truck stop. Plus, as scale increases, the hydrogen supply chain will become more robust, cost effective, and renewable. Conversely, BETs may require a new operational model for truck charging while grid upgrades, electricity costs, and unpredictable rates all increase with scale. The use of hydrogen will actually improve resilience of the electric grid and support the optimal rollout of BETs.

Achieving FCET market sustainability in California is just the start to spur other fuel cell mobility markets across the U.S. and around the world. It will also help California meet its climate, health, and economic goals. **Now is the time to leverage hydrogen fuel cell electric technology for freight movement to create a healthier, more sustainable future for all.**

PHOTO | DAIMLER TRUCKS NORTH AMERICA


GenH2
TRUCK
MERCEDES-BENZ
GenH2 TRUCK
H2

PHOTO | HYUNDAI MOTOR GROUP

Benefits by the Numbers

BY 2035

70,000 CLASS 8 TRUCKS

+ 200 HEAVY-DUTY STATIONS **=**

541.8 million gallons
per year of diesel displaced

6.7 million metric tons
per year GHG avoided*

18,100 metric tons
per year NOx avoided

SOURCE | CARB AND GREET

* assuming 100-percent renewable hydrogen

PHOTO | NIKOLA

PHOTO | CUMMINS

PHOTO | AIR LIQUIDE

Acknowledgments

The California Fuel Cell Partnership acknowledges the following individuals for their tremendous contribution to the development of this document, and for their unwavering support in helping make hydrogen and fuel cell trucks a commercial success.

TASK FORCE CHAIR

James Kast
Toyota Motor North America

KEY CONTRIBUTORS

David Edwards
Jordan Truitt
Air Liquide

Nico Bouwkamp
Keith Malone
California Fuel Cell Partnership

Gia Brazil Vacin
Michael Kashuba
Governor's Office of Business and Economic Development

Matthew Forrest
Mercedes-Benz

Arnab Chatterjee
Tom Mourmouras
Shell Renewables & Energy Solutions

Lisa Mirisola
South Coast Air Quality Management District

EDITORIAL & CREATIVE SUPPORT

Shannon Brooks
FORWØRD

Shelby Putnam Tupper
Shelby Designs

THE CALIFORNIA FUEL CELL PARTNERSHIP recognizes the contributions of the members, staff, and key non-member stakeholders who participated in the workshops, discussions, and reviews that led to the development of this document.

The California Fuel Cell Partnership is a unique collaboration of organizations, including vehicle manufacturers, energy providers, government agencies, fuel cell technology companies, and others that work together to promote the commercialization of hydrogen and fuel cell vehicles. Together, we help ensure that vehicles, stations, regulations, and people are in step with each other as the technology reaches its full market potential.

Published in July 2021 by the California Fuel Cell Partnership

Copies of this document are available upon request or can be downloaded from our website, ***www.cafcp.org***

IMAGE CREDITS

Figure 6 concept courtesy of
Center for Transportation and the Environment


Together, we'll make this vision a reality!
California
FUEL CELL
PARTNERSHIP
DRIVING FOR THE FUTURE
Connect with us—info@cafcp.org
cafcp.org