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CaFCP submission to 2019-2020 ARFVTP Investment Plan

Please find attached the California Fuel Cell Partnership's 2030 vision for a sustainable hydrogen and fuel cell vehicle market - The California Fuel Cell Revolution. This is formally submitted to share our consensus stakeholder vision of what California can and must achieve to reach our environmental, economic and societal goals.

Additional submitted attachment is included below.



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THE CALIFORNIA
Fuel Cell Revolution

*A Vision for Advancing Economic, Social,
and Environmental Priorities*

BY THE California Fuel Cell Partnership

JULY | 2018

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BILL ELRICK
EXECUTIVE DIRECTOR, CAFCP

Twenty years ago, the California Fuel Cell Partnership started with a question: *can we successfully replace gasoline with hydrogen as a transportation fuel?*

No single company or government entity could answer that alone. To move forward, we needed our best scientists, engineers, policy experts, and consumer specialists at the same table.

What transpired over the following two decades was an unprecedented collaboration among leaders in government and industry—even market competitors. This spirit of partnership, driven by a shared mission and hard-earned trust, is the very foundation of the growing fuel cell market we have today.

Thousands of fuel cell cars are on California roads, and drivers can refuel and travel across most of the state. Fuel cell buses have exceeded lifetime and performance expectations, transforming public transit opportunities. The technology for all hydrogen fuel cell vehicle types continues to improve.

So the answer today is a resounding yes—hydrogen can replace gasoline and diesel in California, and fuel cell vehicles can thrive in a retail environment. A new era of clean, carbon-free transportation is underway.

Now is the time to harness this momentum as we take on a new challenge: how to scale the hydrogen and fuel cell vehicle market so that all Californians will benefit?

Ultimately, millions of drivers and riders will have everyday access to affordable, renewable hydrogen and fuel cell vehicles; businesses providing these products and services will create sustainable profits and jobs; and all Californians will breathe cleaner air as a result.

Reaching this vision will again hinge on a common purpose, collective vigor, and shared actions. The California Fuel Cell Partnership is committed to accelerating progress and establishing a better reality for this generation, and the next.

This is our vision and pathway for revolutionary change.

A handwritten signature in blue ink, appearing to read 'Bill Elrick', written over a light blue rectangular background.

Foreword

A maroon Honda car is driving on a winding asphalt road that curves through a lush green valley. The car is in the foreground, moving towards the viewer. The background shows rolling hills and a vast landscape under a blue sky with light clouds. An orange semi-transparent banner is overlaid across the middle of the image, containing white text.

A new era of hydrogen-powered, zero-emission vehicles
is underway in California.



Going the Distance

The global transportation sector is in the midst of a momentous paradigm shift in the pursuit of clean energy. A new era of hydrogen-powered, zero-emission vehicles is underway in California. Fuel cell cars now offer consumers a compelling, viable alternative to cars powered by internal combustion engines.

California currently has the highest number of fuel cell vehicles globally. The state's initial retail hydrogen station network is up and running, and it ranks as one of the largest of its kind in the world. The customer base is poised for substantial growth.

A robust commercial marketplace is on the horizon, and the environmental and economic benefits promise to be transformational. Accelerating the turnover of California's existing vehicle population to zero-emission vehicles is crucial to achieving the state's environmental goals. Developing the hydrogen production and distribution infrastructure will generate significant private and public sector revenues as the vehicle population increases. The market is ready for new and expanded investment.

Since 1999, the California Fuel Cell Partnership, a public-private partnership between government agencies and industry leaders, has been working to establish the world's first self-sustaining retail hydrogen and fuel cell vehicle market. Together, this alliance has positioned California as the fuel cell vehicle launch point for the entire nation. Significant investments have been made, major milestones have been achieved, and momentum toward achieving a free market reality is building.

The time has come to solidify California's status as an innovation hub for the hydrogen-powered fuel cell vehicle industry. This document outlines the vision and strategies to speed up fuel cell vehicle adoption in California and beyond.

Hydrogen-powered fuel cell vehicles can go the distance. More drivers are needed behind the wheel at every phase of development, deployment, and adoption to maintain California's position as a leader in the global green economy—for the greater good of *all* Californians.

Driving Toward a Sustainable Future

Hydrogen and fuel cells are instrumental to successfully electrifying the full transportation spectrum. Fuel cell vehicles provide the same driving experience as conventional vehicles—fast fueling times, long range, and utility. Regardless of vehicle size or function, fuel cells offer better vehicle performance, a long lifespan and produce zero emissions.

A viable market for hydrogen and fuel cell vehicles is emerging in California. As of July 2018, nearly 5,000 fuel cell cars are already on the road. These first adopters currently have access to 35 retail hydrogen stations, with another 29 stations in development.

This progress was facilitated by the California Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program. Known as AB-8, the 2013 legislation established long-term authority to co-fund the first 100 retail hydrogen stations. This signaled to private industry that it had the state's support to jumpstart the market and ramp up vehicle sales.

Additionally, a ramp up of public and private sector engagement is needed to further accelerate consumer adoption. Widespread stakeholder involvement and new investors are needed to realize the market's full potential and ensure its long-term sustainability.

Hydrogen—previously referred to as the fuel of the future—is being produced from clean, renewable energy sources *today*. It is enabling the capture and near-indefinite storage of renewable energy resources, instead of curtailing excess electricity production. Hydrogen can be used to expand renewable electricity production and improve grid stability and efficiencies across the entire energy system.

The market is wide open for those looking to capitalize on the sizable business development opportunities. Now is the time to act to create a fully self-sustaining commercial market that eliminates greenhouse gas emissions and criteria air pollutants from the transportation sector.

The California Fuel Cell Revolution

The California Fuel Cell Partnership (CaFCP) envisions a new era of zero-emission fuel cell vehicles and domestically produced, renewable hydrogen that will transform the state's transportation and energy systems for the benefit of all Californians.

CaFCP members are committed to defining, enabling, and creating the necessary market conditions to drive the California fuel cell market from its early success to a fully self-sustaining market with widespread adoption.

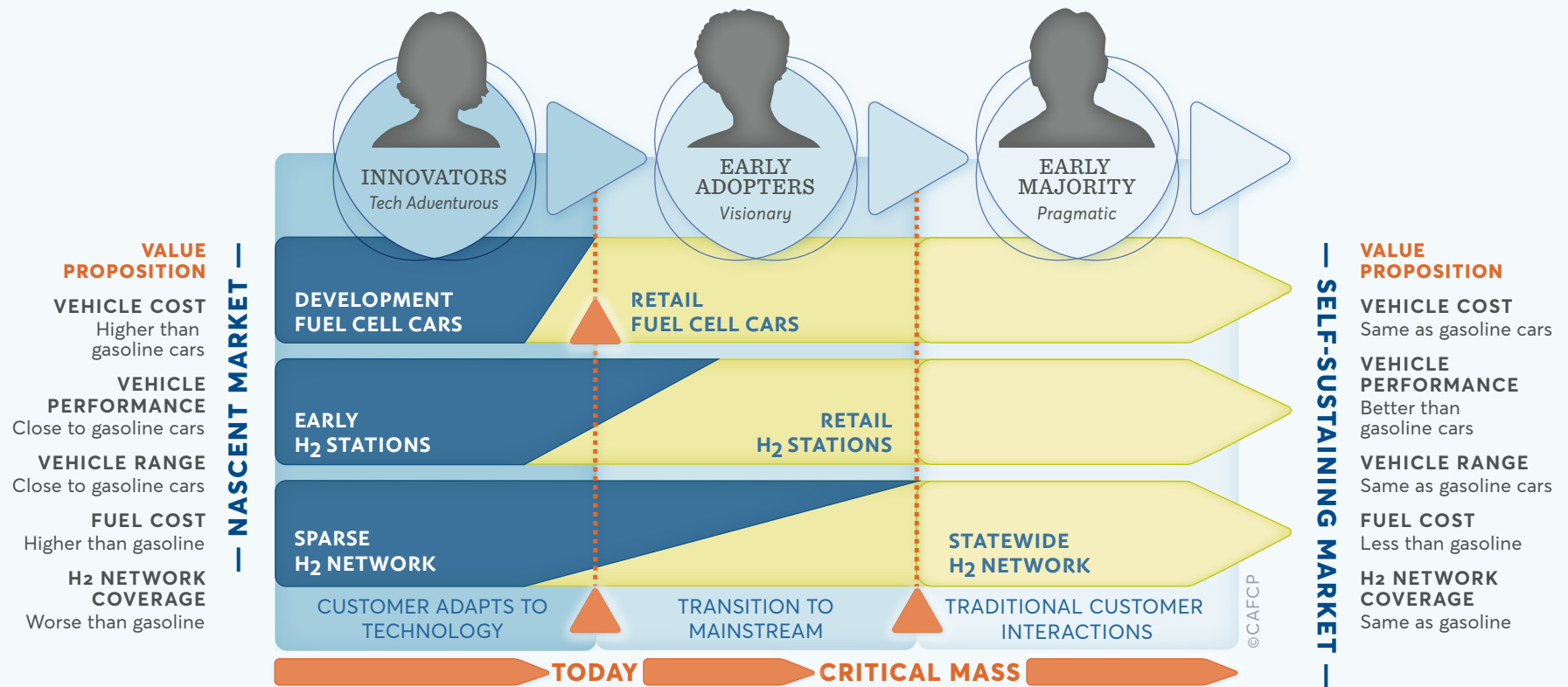
The California Fuel Cell Partnership is pursuing a network of 1,000 hydrogen stations and a fuel cell vehicle population of up to 1,000,000 vehicles by 2030.

This vision reflects the input and consensus of more than 40 partners—auto manufacturers, energy companies, fuel cell technology companies, government agencies, non-governmental organizations, and universities.

The strategic focus and commitment of all stakeholders will enable CaFCP to realize this shared vision and help California meet its environmental sustainability, economic development, and renewable energy goals.



Evolution of Customer Adoption



At scale, fuel cell cars will be a no-compromise solution for mainstream California drivers. The familiar fueling experience and freedom of long distance travel will fit comfortably into their everyday lives. Critical mass will occur when a statewide hydrogen infrastructure network allows fuel cell vehicles to deliver proven value to all customers.

*Accelerating the pace
of market growth
requires broader
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Accelerating Growth

The deployment trajectory for hydrogen infrastructure and fuel cell vehicles requires a considerable push to accomplish CaFCP's vision for 2030. Accelerating the pace of market growth requires broader involvement and new stakeholders entering the market.

To build upon the current momentum and capitalize on the gains already achieved, it is critical that a network of strategically located hydrogen stations is established to enable scaled production and sales of fuel cell cars to consumers. Broadening the network will foster consumer adoption of fuel cell vehicles and result in more zero-emission vehicles on California's roadways.

The State of California has demonstrated a steadfast commitment to supporting this vision. In January 2018, Governor Brown called for a dramatic increase in the number of zero-emission vehicles to reduce greenhouse gas emissions and criteria air pollutants from transportation to help meet the state's air quality goals and reduce California's dependence on fossil fuels.

Executive Order B-48-18 directs all state entities to work with the private sector and all appropriate levels of government to put at least five million zero-emission vehicles on California roads by 2030 and support the construction and installation of 200 hydrogen stations by 2025.

The environment for hydrogen-powered fuel cell cars has never been more conducive to growth. **The time to act is now.**



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Our Strategic Priorities

Building a robust commercial fuel cell market requires continued, coordinated planning and implementation among stakeholders. Moving forward, CaFCP members are focusing on three strategic priorities to enable, establish, and expand the market.

1 | **ENABLE THE MARKET**

Foster large-scale infrastructure development for hydrogen with a market-driven policy framework that will attract capital investment, increase the availability of hydrogen, and reduce costs. Focus on risk management and capital cost offsets to advance economies of scale in manufacturing, production, and dispensing, and lead the transition to a self-sustaining commercial market.

2 | **ESTABLISH THE MARKET**

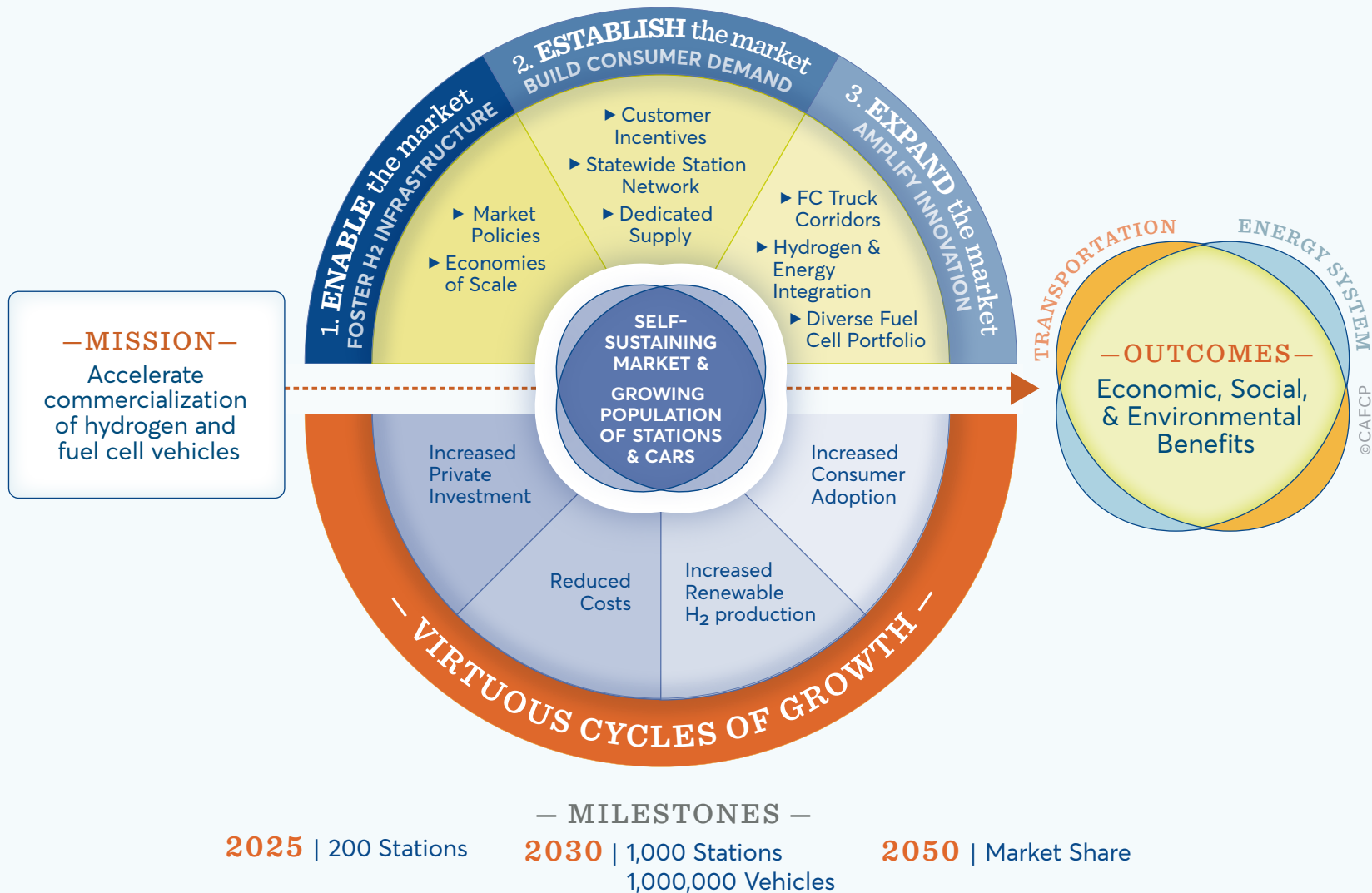
Build consumer demand for fuel cell cars by offering a compelling value proposition to attract new buyers and broaden the customer base from first adopters to mainstream users. Aim for widespread consumer activity that will in turn prompt continued private investments and cost reductions in infrastructure and vehicles.

3 | **EXPAND THE MARKET**

Leverage fuel cell products to amplify technology innovations and accelerate the electrification of the entire spectrum of transportation. Capitalize on increasing demand for hydrogen to drive further investments in renewable hydrogen production, distribution, and dispensing. Couple renewable electricity and hydrogen production to increase grid resiliency and enable greater emissions reductions.

Theory of Change

Transforming California's Transportation and Energy Systems





Pathways to Scale

A variety of tools and programs have been implemented over the years to foster early hydrogen infrastructure build-out in California. Stakeholders can expand upon this solid foundation and pursue additional creative approaches to scale up the market.

1 | **ENABLE THE MARKET**

Once it becomes mainstream, the business of hydrogen in the transportation sector will be as attractive as the business of petroleum fuel is today. Until then, while market demand is still nascent, it is essential to establish a policy environment that helps nurture the market and enables commercial ramp up.

Leverage Market-Based Policy to Attract Private Capital

Early government grant funding programs have proven essential to successfully stimulating the initial build-out of hydrogen stations in California. Infrastructure programs supported financing of capital investments for hydrogen stations, as well as the initial operating costs for the first few years of retail hydrogen sales.

These state funding mechanisms helped companies manage investment risk and build market confidence at a time when vehicle volumes were low and the pathway to a viable business case seemed distant. Between June 2010, when the California Energy Commission's first grant solicitation was released, and July 2018, 35 retail hydrogen stations have opened. Another 29 stations are funded and in development.

The next critical milestone is to build 200 hydrogen stations by 2025, leading to 1,000 stations thereafter. To achieve this, the transition away from public funds toward private capital investment will require increasing stakeholder confidence and decreasing costs.

Activate Economies of Scale for Large-Scale Infrastructure Development

Stable, long-term policies will attract private capital and provide infrastructure companies the certainty needed to establish multi-year, large-scale construction projects for station network development. Private industry will be able to optimize production and minimize costs across the entire value chain, leading to essential economies of scale.

According to Shell's report, *Hydrogen's Role in the Future of Transport*,¹ capital costs for hydrogen infrastructure could be reduced by 50 percent through economies of scale by as early as 2020, if developers were to build between 30 and 50 hydrogen stations per year globally.

Upstream, economies of scale will allow suppliers to dedicate sales and manufacturing to focus on meeting a steady demand for their station components. This will also enable companies across the value chain to scale their labor force to support the construction, operation, and maintenance of these stations.

Economies of scale are crucial to establishing viable business cases and opening the door for private financing to overtake government funding as the primary market driver. Moreover, this will attract additional market participants and usher in large-scale hydrogen station deployment at a pace needed to stay ahead of fuel cell vehicle demand.

1. *Hydrogen's Role in the Future of Transport*, Shell. <https://www.shell.com/energy-and-innovation/the-energy-future/future-transport/hydrogen.html>

2 | ESTABLISH THE MARKET

Building a strong customer base for fuel cell cars is vital to increasing the total population of zero-emission vehicles in California. Fuel cell cars must provide competitive value and be as convenient and reliable to the customer as conventional cars. This applies to the entire ownership experience, from purchase and performance to fueling and maintenance.

Motivate Consumers to Buy Fuel Cell Cars

California's early commercial market for fuel cell cars launched in 2015, with three vehicle models available for sale or lease through a small number of dealerships. Developing a robust marketplace will require increasing the number of available vehicle makes and models through 2030.

As the vehicle selection expands and purchase volumes increase over time, a virtuous cycle of vehicle supply and customer demand will ensure that more buyers have an easier time finding a fuel cell car that suits their needs, with the equipment and features that they desire.

Raising consumer awareness of fuel cell cars depends on clearly communicating the overall value proposition of the vehicles and enabling the customer to make an informed purchase decision. Buyer decisions will be based on perceptions of key selling points such as safety, performance, dependability, affordability, driving range, and fueling network coverage—attributes expected of any modern vehicle.

To transition the consumer fuel cell market from first adopters to mainstream buyers, market-based and customer-focused purchase incentives should be in place to encourage more people to purchase a less familiar technology.

To complement incentives that auto manufacturers are using, California contributes customer-facing incentives to improve the value proposition of fuel cell cars and motivate prospective car buyers to purchase them. Existing programs include the California Air Resources Board's (CARB) Clean Vehicle Rebate Project and High-Occupancy Vehicle (HOV) lane access.

These types of clean vehicle incentives give consumers a cost and convenience similar to gasoline cars, while enjoying the benefits of zero emissions. They also raise the public's awareness and familiarity with the new technology and motivate future customers.

Broadening the customer base for fuel cell cars will require continued expansion of the value proposition for all buyers. Equitable, customer-focused incentives will benefit Californians across the full economic spectrum.

Market-based incentives that influence consumer purchasing decisions and increase total fuel cell car sales are important to developing the market and tipping the scale in favor of zero-emission vehicles.

*Equitable,
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Establish a Statewide Fueling Network

As of July 2018, an initial network of hydrogen stations has been serving the major cluster areas identified in CaFCP's 2012 *A California Roadmap*. These include Los Angeles County, Orange County, and the San Francisco Bay Area, as well as emerging markets in Sacramento and San Diego. Several destination and connector stations are also serving customers, enabling long-distance travel across California.

To build consumer confidence and increase the number of fuel cell vehicle on the road, the hydrogen station network needs to empower drivers to travel across California and beyond. For the light-duty sector, network coverage over a larger geographic area will convince more car buyers that purchasing a fuel cell car is a pragmatic decision.

CARB modeled a year-by-year scenario for a hydrogen station network build-out that demonstrates how a population of up to one million fuel cell cars could be served by the strategic placement of only

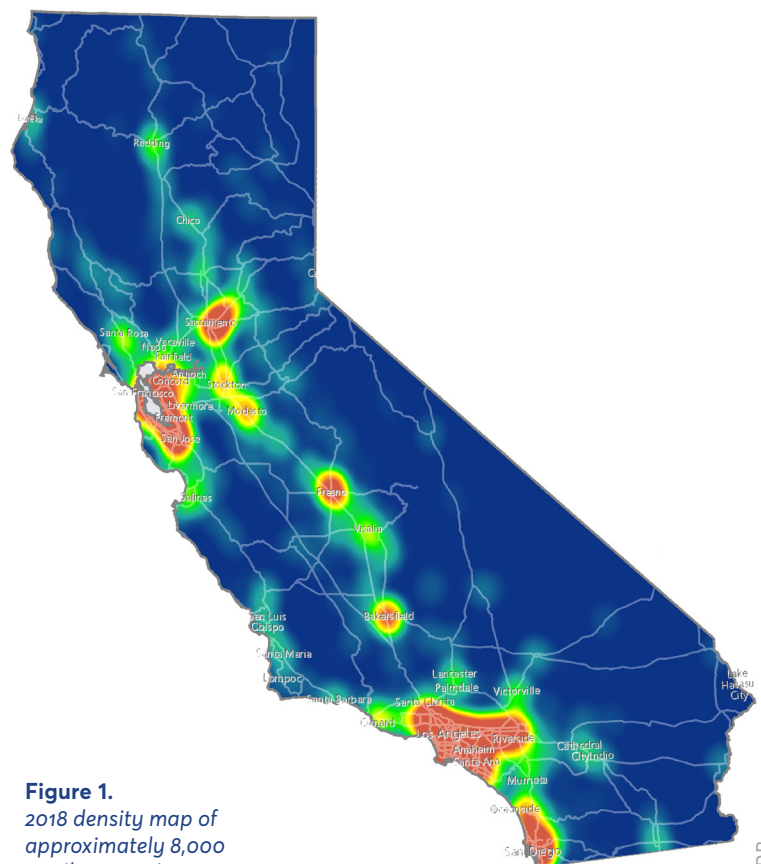


Figure 1.
2018 density map of
approximately 8,000
retail gas stations

© CARB

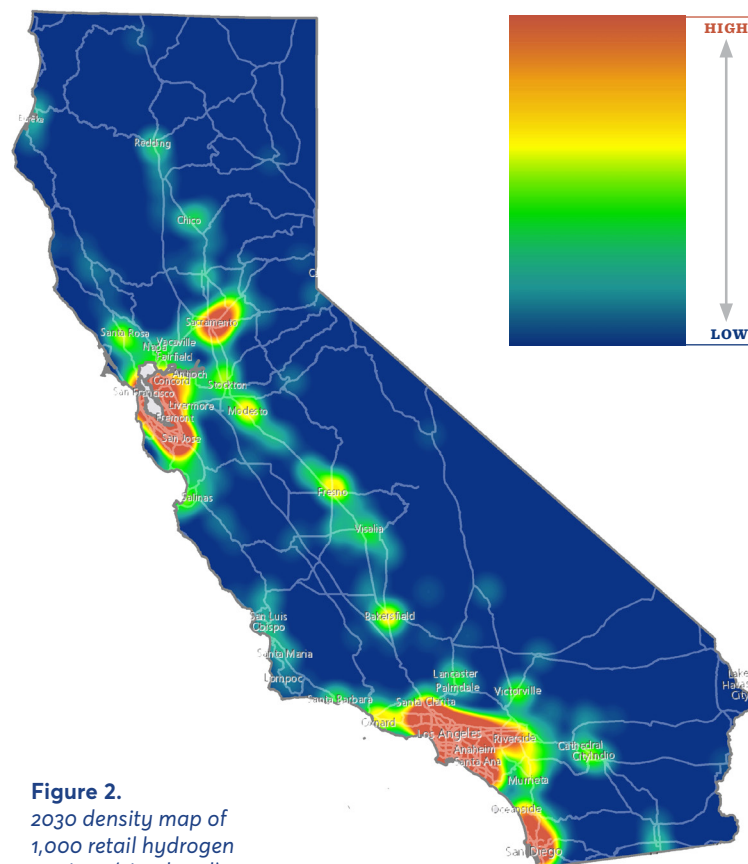


Figure 2.
2030 density map of
1,000 retail hydrogen
stations (simulated)

© CARB

1,000 appropriately-sized hydrogen stations (Figure 1). This network will provide fuel cell vehicle customers with similar ready-access to fuel as is provided by California's gasoline station network, which currently consists of over 8,000 stations (Figure 2).

The model forecasts the timing and capacity of future station deployments, using the gasoline station network as a template for potential hydrogen station locations. It also aims to provide guidance to stakeholders on the balance between building station density in the metropolitan areas and expanding the overall network into emerging markets, travel corridors, and popular destinations.

Coordinating the statewide station rollout with anticipated vehicle deployment will ensure the right balance over time between expanding overall network coverage and providing sufficient fuel supply in established areas where customer demand continues to increase.

In practice, regional expansion beyond existing clusters will begin with popular destinations where drivers go for vacations, excursions, or business. This effort has begun with early stations developed in Santa Barbara and Lake Tahoe. These destination markets will be among the next fuel cell vehicle communities to emerge and expand.

Community-level planning and implementation will be increasingly important to ensure individual stations and regional networks meet customer demand on the local level. The first communities to develop their own municipal or regional plans for public and private usage—including economic development, supportive policies, education, and outreach—will become important models for other communities and will foster greater statewide adoption.

Long-term success depends upon having enough hydrogen stations a half-step in front of the vehicles to provide certainty to prospective customers, and a substantial population of fuel cell cars on the road to support station operation and establish the pathway to profitability. The continued commitment to collaboration among the state and industry partners will bring about long-term market growth.

Develop a Dedicated Hydrogen Supply

In addition to a statewide hydrogen station network, the advertised retail price of hydrogen is particularly important to creating a compelling value proposition for mainstream buyers. Hydrogen prices are influenced by the cost of production, distribution, and sales, among other factors. As of July 2018, the average price of retail hydrogen was around \$15 per kilogram. With fuel cell vehicles being twice as efficient as conventional vehicles, hydrogen around \$7 per kilogram will be cost competitive with gasoline at \$3.50 per gallon on a dollar per mile basis.² At scale, the cost of hydrogen could approach the U.S. Department of Energy's cost target of \$4 per kilogram. That would make a zero-emission fuel roughly half to two-thirds the cost of gasoline.³

The way to achieve the Department of Energy's lower fuel cost target is to simultaneously increase the fuel cell vehicle population while developing a robust complementary hydrogen infrastructure network.

Hydrogen is a common industrial gas used to make a wide variety of products, ranging from gasoline to computer chips. As of July 2018, most of the hydrogen sold at hydrogen stations was excess production left over after supplying these industries. As the customer base grows and the fuel cell vehicle population increases over time, hydrogen demand

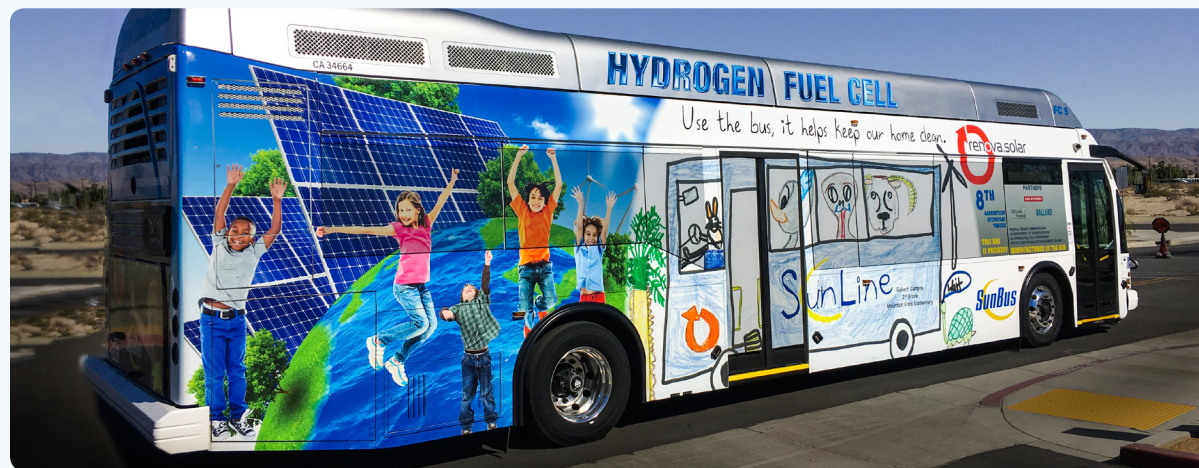


2. A kilogram of hydrogen has essentially the same energy content as a gallon of gasoline
3. <https://www.eia.gov/>

*Fuel cell vehicles
provide the same
driving experience as
conventional vehicles—
fast fueling times,
long range, and utility—
while offering better
vehicle performance
and zero emissions.*



By 2030, California transit agencies will only purchase zero-emission buses to replace existing conventional bus fleets. Only fuel cell buses provide one-to-one replacement characteristics, with superb power and acceleration performance in cold and hot climates, combined with smooth, quiet and fuel-efficient operation. Since 2000, SunLine Transit and AC Transit have demonstrated the country's largest fueling infrastructure and revenue operations for fuel cell buses.



will exceed current production capacity. New, large-scale, dedicated hydrogen production facilities will be needed to ensure that the hydrogen supply stays ahead of demand. This dedicated infrastructure can be developed for lower cost production and distribution through a combination of new technologies, feedstocks, and distribution efficiencies. Growing demand also presents an opportunity for California to ensure that the resulting scale-up of the hydrogen supply emphasizes renewable hydrogen. Under SB-1505, adopted in 2006, the state requires that one-third of the hydrogen sold at hydrogen stations comes from renewable sources. Many hydrogen infrastructure developers have indicated that

they intend to exceed the state's renewable hydrogen content requirement in order to make hydrogen the best-in-class alternative fuel. With this level of commitment from industry, the ultimate goal of producing hydrogen entirely from renewable resources is realistic.

Strong policies coupled with industry commitment will translate to lower retail hydrogen prices at stations and incentivize the transition to 100 percent renewable hydrogen. Air quality will improve as more consumers, businesses, and municipalities adopt fuel cell vehicles in response to the value proposition. All of this will provide a strong return on the state's investments in hydrogen infrastructure.

3 | EXPAND THE MARKET

Hydrogen and fuel cells offer value beyond passenger cars. Broadening the use of fuel cells and leveraging synergies and advancements across the range of technology applications will drive innovation, capitalize on economies of scope, and accelerate market growth.

Diversify the Portfolio of Fuel Cell Products

Fuel cells are extremely flexible and can be combined and scaled across different applications—from transit buses and heavy-duty trucks to cars and stationary fuel cell power systems. Given the commonality and modularity of components, a manufacturer can integrate the same fuel cell stack

across several car models or integrate two stacks into a heavy-duty truck. The underlying technologies are the same across various applications.

This adaptability allows manufacturers to leverage research and development for product innovations across diverse applications. New design specifications or improvements developed for one type of fuel cell application, such as a forklift, can be transferred to another application, such as a passenger car, or lead to the development of an entirely new product.



By offering a variety of products that share common technology and components, companies can also take advantage of these economies of scope by distributing the costs of product development and manufacturing across multiple product lines. Maximizing production efficiencies is especially important in the developing years when markets and initial production volumes are smaller.

Incentivizing businesses and transit agencies to foster zero-emission fleets and technologies will hasten the turnover of legacy fleets. This will accelerate the air quality gains from electrifying these heavier vehicle types—which produce more emissions per mile than lighter vehicles—speed up the building of dedicated hydrogen stations for these vehicle classes, and increase the overall demand for renewable hydrogen.

Deploy Heavy-Duty Hydrogen Infrastructure Along California's Freight Corridors

Long-haul trucks transport most cargo between the major metropolitan areas of California and neighboring states, and short-haul trucks move that cargo within every town and city in the state. As a result, the majority of conventional heavy-duty fueling demand is along the state's freight corridors in regions such as the Central Valley. Heavy-duty

trucks are also concentrated in commercial ports, deep-water seaports, airport cargo terminals, and shipping and warehouse facilities.

Medium- and heavy-duty trucks consume more fuel per mile and their fuel usage is more consistent and predictable than the light-duty sector. Deploying dedicated hydrogen stations for fuel cell trucks near ports and along California's highways offers the potential for large, rapid growth in hydrogen demand. Predictable fuel throughput expectations and attractive station economics will foster faster and greater hydrogen production investments to further stimulate market expansion.

In addition to dedicated hydrogen stations for fuel cell trucks, the market can benefit from multi-use hydrogen stations in areas that already service both light- and heavy-duty vehicles, such as the travel plazas throughout California. These facilities can support fuel cell truck fleets, local fuel cell car adoption, and interregional travel of light- and heavy-duty fuel cell vehicles.

Figure 3 identifies the freight corridors with high diesel fuel throughput, overlaid with the light-duty hydrogen station buildout scenario from Figure 2. These freight corridors represent opportunities for new hydrogen stations to serve both light- and heavy-duty fuel cell vehicle traffic, complementing the station network already in place as of July 2018.

Progress for All Californians

A thriving, self-sustaining fuel cell vehicle market will benefit all Californians, not just the active market players and fuel cell vehicle adopters.

The environmental bottom line is just as powerful as the promising economic possibilities. More zero-emission vehicles on California's roads means cleaner air and improved public health. The expanding market will also grow the Golden State's green economy and create new jobs.

California has an opportunity to lead the nation in this transition to hydrogen-powered fuel cell vehicles. The robust California fuel cell vehicle market envisioned by CaFCP will further stimulate fuel cell growth nationally through increased consumer demand.

California's policy-led incentive programs provide successful models that other jurisdictions can adopt. A fully mature fuel cell vehicle market will be capable of sustaining the nation's mobility while delivering economic, environmental, and energy system benefits.

A self-sustaining hydrogen-powered fuel cell vehicle market is indeed within reach. Collectively, we have the vision and resources to create changes, in the near- and long-term, that will improve the quality of life in California for generations to come.

A self-sustaining commercial fuel cell vehicle market will mean:

- Increasing consumer adoption and demand for fuel cell cars, trucks, buses, and other vehicle types.
- Market sustained by increasing private sector investment leading to a phase out of government funding.
- Substantial cost reductions and improved availability for hydrogen infrastructure and fuel cell-related components and vehicles.
- Renewable hydrogen fuel available at prices that can compete with gasoline and diesel on a per-mile basis.

*Now is the time to
work together toward
transformative change
that will ensure a
brighter, healthier
future for all.*







Benefits by the Numbers

SOURCE | CARB & SCAQMD, 2018

BY 2030

$$1,000 \text{ STATIONS} + 1,000,000 \text{ CARS} =$$

693.5 million gallons
per year of gasoline displaced

2.7 million metric tons
per year GHG avoided*

3,900 metric tons
per year NO_x avoided

97% of disadvantaged communities
within the station network coverage

**with today's energy mix of 33 percent renewable hydrogen*

Acknowledgements

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 vehicles a commercial success.

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The California Fuel Cell Partnership is a unique collaboration of organizations, including auto 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.

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*Copies of this document are available
upon request or can be downloaded
from our website at www.ca-fcp.org*

IMAGE CREDITS

Figure 1: CARB Analysis of California
Energy Commission PIIRA Form
CEC-A15 Results, 2018

Figure 2: CARB, 2018

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Now is the time
to work together toward
transformative change
that will ensure a
brighter, healthier future
for all.



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