Title
Potential Uses of Hydrogen in California's Clean Energy Transition

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POLICY BRIEF

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Potential Uses of Hydrogen in California's Clean Energy Transition

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Issue

Currently, hydrogen is used in California in only a few significant applications, with refining being the most dominant. However, hydrogen has the potential to be a major zero-carbon energy carrier across many applications, including transportation, buildings, and various industries. What would be required for this kind of scale-up? What is the potential for hydrogen in different sectors and in different parts of the state? How can this potential be realized? Scaling up the use of hydrogen will likely require strong policies because currently it is produced on a small scale and is therefore expensive.

This brief covers basic concepts of how hydrogen could be used, and how much end-use demand potential there could be for different applications across transportation, buildings and industry; however, it should be noted that this brief does not consider hydrogen used within the electricity system). It also considers strategy to some degree – such as where the greatest efforts should be placed. It builds on research that is ongoing on UC campuses as well as other sources.

Key Research Findings

There is strong potential for rapid growth in California hydrogen use across light-, medium-, and heavy-duty vehicles. Fuel cell models are now available for many vehicle types, including light-duty vehicles, buses, and some trucks, and the zero-emission vehicle (ZEV) mandates (Advanced Clean Car and Advanced Clean Truck rules) are likely to increase model availability dramatically in coming years. Currently, there are nearly 50 hydrogen refueling stations across the state. Plans call for 150 to 200 stations by 2026. Although supply chains and station reliability have been issues in some locations, these are being resolved. Hydrogen is poised to be an important alternative to electricity as an end-use energy for vehicles and has the advantages of rapid refueling and longer range than most current electric models provide.

Looking further out, the California Fuel Cell Partnership has set a target of 1 million light-duty fuel cell electric vehicles (FCEVs) by 2030, which appears very challenging; although achieving at least half that many appears possible and would require vehicle stock growth of about 40% per year. Medium and heavy fuel cell trucks (M/HDT) could have a similar growth trajectory and may achieve greater hydrogen demand than light duty over the coming decade. Together, there could be a road transportation demand for hydrogen of 350 thousand tons in 2030 (i.e. about 1000 tons/day). In a recent study, the UC Institute of Transportation Studies[1] created a low-carbon scenario that achieves carbon-neutral transportation by 2045. In this scenario about 25% of California's light-duty vehicles and 50% or more of California's trucks are hydrogen fuel cell by 2045, resulting in about 100 times more hydrogen used for transportation than today, and several times more than is currently used in the refining sector. Even lower levels of fuel cell vehicle market penetration would generate a large market for hydrogen, help bring down costs, and cut large quantities of CO_2. Whether this level of demand creates sufficient scale to reach long run cost goals (e.g. around $5/kg delivered to

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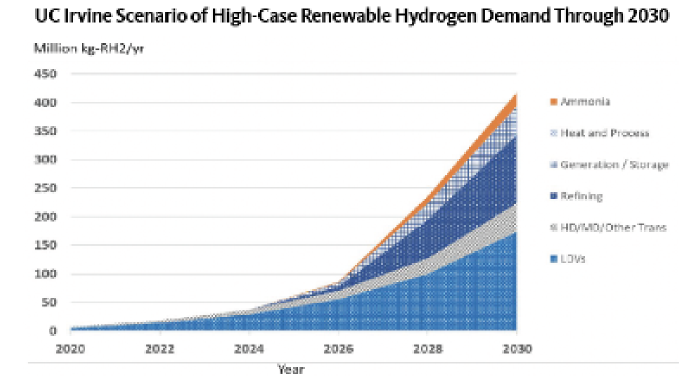

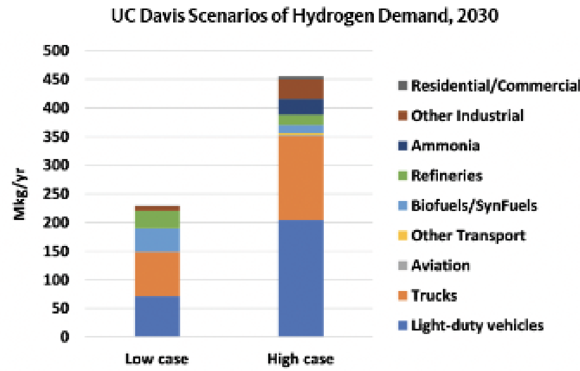

Figure 1. Potential hydrogen demand across sectors in California, to 2030; (left figure) Source: Roadmap for the Deployment and Buildout of Renewable Hydrogen Production Plants in California, California Energy Commission; (right figure) Source: UC Davis California Hydrogen Analysis Project (CHAP).

vehicles) is difficult to predict, but it appears possible since it would support several large production facilities.

There is a similarly large potential market for hydrogen use in buildings and industry. Recent and ongoing work at UC Irvine[2] and UC Davis[3] estimate significant hydrogen demand potential for a variety of industries and building types, but with a lot of uncertainty on timing and ultimately achieved usage levels. A conservative estimate is that by 2030 demand from specific industries (e.g., refining, biorefining, ports and chemicals, along with some large institutional buildings) could together rival demand from cars and trucks in California. Further, individual users (e.g., refineries, ports, buildings) would generally be much larger than vehicle refueling stations, providing opportunities for rapid scaling of the system with concentration of activity.

Overall, (and apart from existing refinery use), annual hydrogen demand in California could be upwards of 500,000 tonnes by 2030, supporting many large-scale production plants and ensuring scaling benefits. Recent studies from UC Irvine and UC Davis show similar pictures for hydrogen demand by 2030 (Figure 1). Both studies show that, in an ambitious scenario, hydrogen demand could reach 500 million kg (500,000 tonnes, 1,500 tons/day) by 2030. Both studies estimate the highest potential demand for hydrogen comes from light-duty vehicles, but this assumption is also one of the most uncertain and depends on whether fuel cell vehicles catch on with the general public. UC Davis estimates a similarly large market potential for trucks, particularly medium- and long-haul trucks. Figure 1 also depicts a "low case" or lower demand scenario, which can be considered a "fallback" option; however, the more ambitious scenario seems achievable with sufficient policy support.

A scale-up to several hundred thousand tons of annual hydrogen demand by 2030 will require strong policy support and cost reduction. Hydrogen costs and prices are currently high, usually over $10 per kg retail (i.e., delivered to vehicles). A target of half that price ($5/kg) is generally considered what is needed to achieve commercialization and natural demand increases across sectors. Achieving a combined multi-sectoral level of demand toward 500,000 tonnes by 2030 would support large scale development of infrastructure and many supply facilities at a large enough scale that hydrogen prices should drop substantially. The only way to reach scale and drive down costs is through policies that incentivize or in some cases directly invest in hydrogen end uses and infrastructure. Researchers estimate that realizing a system size of 500,000 tonnes per year should be sufficient to help bring down costs and make the market sustainable, which appears possible with large-scale investments in either stationary or transportation systems, or both. Scale-up in turn depends on policies that incentivize adoption of fuel cell vehicles, build stations, encourage adoption by industries, spur investments in low-carbon hydrogen supply, and construct the infrastructure needed to move and store hydrogen. Because these steps must be taken concurrently, policies that encourage co-development and coordination are also needed.

Supply side investments must be carefully coordinated with demand side investments. Some may ask if supply side investments are made with the target of creating a large scale hydrogen system, then what happens if demand doesn't develop? This is a significant concern; however, it can be addressed by careful planning, and coordinating supply and demand investments. Ideally, for every hydrogen supply facility built, a set of "offtaker" demands (e.g., types, locations) are already identified several years out that will be ready to receive the supply. This type of coordinated approach will be needed at least through 2030 and maybe longer.

More Information

This brief is one in a series highlighting the latest research findings and insights related to the role, production, and use of hydrogen in achieving a zero-emission energy future for California. To learn more about this series, visit www.ucits.org/research-project/rimi-3n. For more information about findings presented in this brief, contact Lew Fulton at lmfulton@ucdavis.edu.

[1]Brown, A. L; Sperling, D.; Austin, B.; DeShazo, JR; Fulton, L.; Lipman, T., et al. (2021). Driving California's Transportation Emissions to Zero. UC Office of the President: University of California Institute of Transportation Studies. http://dx.doi.org/10.7922/G2MC8X9X Retrieved from https://escholarship.org/uc/item/3np3p2t0

[2]Reed, J. G., & University of California, Irvine. Advanced Power and Energy Program. (2020). Roadmap for the Deployment and Buildout of Renewable Hydrogen Production Plants in California: Final Project Report. California Energy Commission.

[3]Fulton, L. et al, The Future Role of Hydrogen in a Carbon-neutral California, Synthesis Modeling Report, California Hydrogen Analysis Project Working Paper, Spring 2022. Report prepared by the UC Davis Institute of Transportation Studies, Retrieved from: https://its.ucdavis.edu/research/uc-davis-hydrogen-fuel-cell-projects/

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