BRIEF # 7

PATHWAYS TO CARBON NEUTRALITY IN CALIFORNIA

The Hydrogen Opportunity

Stanford
Center for Carbon Storage
Carbon Removal Initiative

This brief discusses key findings from the following report: Justin Bracci, Adam Brandt, Sally M. Benson, Gireesh Shrimali and Sarah D. Saltzer, "Pathways to Carbon Neutrality in California: The Hydrogen Opportunity", Stanford Center for Carbon Storage and Stanford Carbon Removal Initiative, February 2022.

Hydrogen is the lightest, simplest, and most abundant element on the periodic table. On a mass basis, pure hydrogen contains more energy than any fossil fuel alternative and has no greenhouse gas emissions when the energy is consumed. Hydrogen can be used for a variety of applications including transportation, space and water heating, cooking, high-temperature combustion applications for heavy industries and electricity generation.

KEY FINDINGS

1. The hydrogen industry is well-established in California with over 1.8 Mt/yr of production capacity. This existing industry experience can be leveraged to spur continued infrastructure development and cost reductions.

2. Hydrogen produced from SMR-CCS and electrolysis using renewables are cleaner than traditional SMR.

3. It would be economically favorable to build SMR-CCS facilities in northern California and electrolysis facilities powered by solar electricity in southern California.

4. Further production and/or end-use incentives are needed to make clean hydrogen competitive in the industrial, residential, commercial, and, to a lesser extent, transportation sectors in California.

5. Hydrogen transport and storage remain major challenges to hydrogen market growth. Development of hydrogen carriers and/or subsurface storage for hydrogen would aid in eliminating these hurdles.

6. Within the electricity sector, if large-scale low-cost underground hydrogen storage can be unlocked, hydrogen can be used for long-duration energy storage and can be used to produce on-demand and easily dispatchable electricity.

7. Within the industrial sector, hydrogen is most likely to be used for high-temperature heating applications, such as in the cement subsector.

8. Within the residential and commercial sub-sectors, electrification technologies are most likely to dominate, but hydrogen technologies may be preferable for some space heating, cooking, and drying applications.

9 Within the transportation sector, hydrogen fuel cell technologies are preferrable for heavy-duty long-haul trucking applications. Consumer choice will play an important role in light-duty fuel cell electric vehicle adoption through 2045.

10. Compared to the other economic sectors, transportation sector hydrogen end-use technologies are the most mature, and transportation sector hydrogen demand is expected to grow the most by 2045.

11. Companies, government, academics, and policymakers each have a role to play in expanding the hydrogen economy in California.

While hydrogen has the potential to play a significant role as California strives to decarbonize, a decision must be made whether it is worth large-scale investment. The costs of hydrogen infrastructure on the production side are potentially reduced with the 45Q tax credit and California's LCFS program, but this is not enough. Without additional financial support or incentive, project developers and equipment manufacturers will continue to hesitate on a clean energy transition with hydrogen. With financial support, there will be lower risk in hydrogen investment. This investment could spur hydrogen infrastructure build-out and maturation that would bring about a hydrogen economy-of-scale no longer dependent on financial aid to prosper. Continued research and development of nascent hydrogen technologies can also aid in reducing investment costs as 2045 approaches. While not a perfect solution, building a hydrogen economy in California would yield significant emissions reductions and contribute to putting the state on a path to reach net-zero by 2045.

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