

THE FUTURE OF GASES IN A DECARBONIZED CALIFORNIA



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SCIENCE & TECHNOLOGY

About the CCST Disaster Resilience Initiative:

Ongoing, complex, and intersecting disasters—including climate change, extreme heat, power outages, and the COVID-19 pandemic—are radically disrupting the ways in which Californians live and work. CCST is committed to delivering science and technology advice to improve our resilience to disasters, reduce harm, and improve the lives of all Californians.

SUMMARY

- Increasing California's use of carbon neutral gases such as hydrogen and biomethane can help meet California's climate goals to procure 100% of electricity from carbon-neutral sources and achieve net-zero CO₂ emissions by 2024.
- Carbon neutral gases can help decarbonize energy end uses that traditionally rely on fossil fuels including electricity production, transportation, heating, and industrial processes and can also help reduce emissions of air pollutants.

SCALING UP CARBON NEUTRAL GASES IN CALIFORNIA

To address the threat of climate change, California has set goals that mandate 100% of electricity in California must be served from carbon-neutral resources by 2045 and to achieve net-zero CO₂ emissions by 2045 and negative emissions thereafter.

Natural gas and other nonrenewable fossil fuels used for electricity production, transportation fuels, heating, and industrial processes are a significant source of CO₂ emissions in California.

Some gases can be produced and used in ways that release no additional CO₂ to the atmosphere. These carbon-neutral gases can also result in fewer emissions of other greenhouse gases (such as methane) that also contribute to climate change, and fewer air pollutants (such as PM_{2.5}) that are hazardous to public health.

Scaling up the use of carbon-neutral gases can help California achieve its goal of a reliable, carbon-neutral electric grid and net

EXAMPLES OF CARBON NEUTRAL GASES

HYDROGEN: Produced from the electrolysis of water, the pyrolysis of woody biomass, or fossil sources paired with 100% carbon capture and storage (CCS). Can replace many fossil end uses following modifications to the process. Expected to emit little to no criteria air pollutants when used.

BIOMETHANE: Methane produced from the anaerobic digestion of organic materials such as manure and landfill waste. Can directly substitute fossil natural gas in end uses. Expected to emit similar levels of criteria air pollutants as fossil natural gas.

NATURAL GAS: Fossil sources of methane (natural gas) can be carbon neutral if paired with 100% CCS so that none of the CO₂ produced is emitted to the atmosphere.

zero CO₂ emissions. Doing so would reduce anthropogenic carbon emissions—a leading cause of climate change—at a scale that is globally significant.

SELECT EXPERTS

The following experts can advise on ways to produce and use carbon neutral gases:

JACK BROUWER, PHD (Moderator)
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WHAT MAKES A GAS CARBON NEUTRAL

Gases are considered to be carbon neutral if:

- 1) No CO₂ is emitted (e.g. hydrogen-powered fuel cells emit only water as a byproduct).
- 2) The carbon in the emitted CO₂ derives from plants or microbes that recently pulled CO₂ from the atmosphere (e.g. CO₂ emitted from biomethane).
- 3) The carbon in the CO₂ derives from a geologic reservoir but is 100% captured before reaching the atmosphere (e.g. fossil natural gas with CCS).

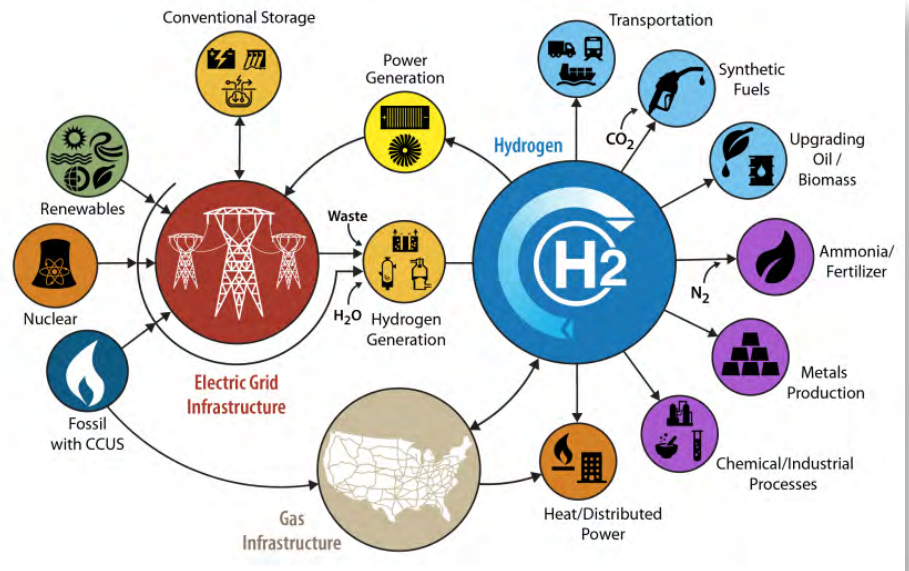


Figure: Production and use pathways for carbon neutral hydrogen.

REPURPOSING INFRASTRUCTURE

California has extensive infrastructure across the state to transport, store, and use natural gas. However, contaminants in biomethane can foul end use equipment and hydrogen can cause increased degradation of steel pipelines. The extent to which existing gas infrastructure could be repurposed for use with carbon neutral gases such as biomethane or hydrogen is an active area of research.

UTILIZING WASTE BIOMASS

Organic waste streams that would otherwise decompose and emit greenhouse gases can be diverted to produce carbon neutral gases such as biomethane and hydrogen. When the process is paired with carbon capture and sequestration (CCS) the gases become carbon negative—removing more CO₂ from the atmosphere than was added, resulting in a net decrease in atmospheric CO₂ levels.

REDUCING THE CARBON FOOTPRINT

Increased use of carbon neutral gases can help decarbonize many energy end uses, including:

Transportation: Replacing gas or diesel internal combustion engines with hydrogen fuel cells.

Electricity: Using hydrogen to produce grid electricity in place of natural gas plants.

Industry: Replacing carbon coke with hydrogen in steel production to reduce CO₂ emitted in the process.



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