

ET Summit 2024

Presented by



CEC Hydrogen R&D Portfolio Overview



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Outline

- Hydrogen Today
- Hydrogen Challenges and Opportunities
- Actions at CEC
- Clean Hydrogen Program
- Hydrogen R&D Overview

Hydrogen Today

- California estimated hydrogen production:
 - 1.05 million metric tons per year (MMT/yr)
 - About 10.5 percent of national capacity
- Hydrogen in California today is strongly linked with fossil fuels
 - Almost exclusively fossil fuel-derived via steam methane reforming
 - Used primarily for oil refining
- Other uses of hydrogen in California (e.g., material handling, transportation) are minimal
 - 7 tons per day dispensed across vehicle refueling network
 - About 0.2 percent of total in-state production

Hydrogen Challenges and Opportunities

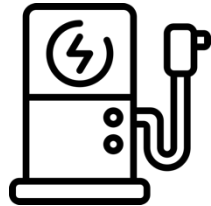
Challenges

- High potential for **leakage**
 - 12.8 – 100-year estimated gwp
- High **cost** relevant to incumbent technologies
- **Availability** concerns
 - 2x current demand in 2045
 - 1,700x increase from current clean hydrogen production

Opportunities

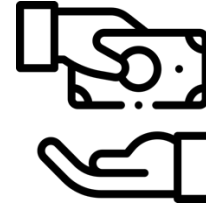
- Decarbonization pathway for hard-to-electrify end uses
 - E.g., grid reliability, heavy-duty and offroad (rail, marine) transportation, ports, industry
- Economic development, workforce, and community benefits (e.g., air quality)

Actions Across CEC Addressing Hydrogen Challenges



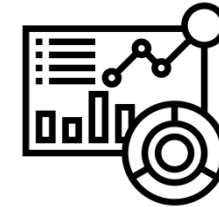
RD&D Funding

- EPIC Program
- Gas R&D Program



Deployment Funding

- Clean Hydrogen Program
- Grants for clean hydrogen production
- Grants for hydrogen refueling infrastructure for FCEVs



Analysis / Reports

- Integrated Energy Policy Report
- SB 1075 hydrogen growth modeling for decarbonizing electricity and transportation
- SB 643 Clean Hydrogen Fuel Production and Refueling Infrastructure to Support MDHD FCEVs and Off-Road

Clean Hydrogen Program

Scope

- Demonstration or scale-up of hydrogen production, processing, delivery, storage, or end use of eligible clean hydrogen

Active Solicitation: GFO-22-903

- Cost Share for Federal Clean Hydrogen Funding
 - Provides cost share funding for eligible federal Funding Opportunity Announcements

Upcoming Solicitations – Estimated Timeline: Q3 or Q4 2025

- Large-scale Centralized Clean Hydrogen Production (H2CENTRAL)
 - Production Capacity: > 5 metric tons per day
- Distributed Clean Hydrogen Production with Onsite End Use (H2ONSITE)
 - Production Capacity: 1-5 metric tons per day



Image Credit: carbonherald.com (top); cngdelivery.com (bottom)

Hydrogen Blends for Large C&I Equipment

Motivation

- Effects of hydrogen blends on large commercial and industrial equipment is not well understood including air quality, performance, and safety impacts at high hydrogen blends up to 100 percent

Scope

- Laboratory testing to evaluate technical limitations and emissions impacts of hydrogen/gas blends in current equipment

Progress

- Priority equipment acquired: large HVAC, boilers, commercial cooking, industrial furnaces
- Completed technical reference report summarizing current understanding of hydrogen usage in various gas appliances
- Testing currently ongoing



Water Heaters

Furnaces



Cooking Equipment

Hydrogen Blends in Gas Pipeline Networks

Motivation

- Additional research needed on high hydrogen/gas blend compatibility, component- and system-level impacts, and costs

Scope

- Accelerated testing on system components
- Target use case studies to perform system-wide tests of blends
- Quantitative risk assessment associated with various levels of blending
- Technoeconomic analysis to estimate costs of risk mitigation

Progress

- Collected gas system information and performed gap analysis
- Experimental program has commenced, results to follow
- Target use case studies to start Q1 2025



Hydrogen Blends in Distributed Power Generation

Motivation

- Challenges using high hydrogen blends over 30 percent including materials impacts, lowered fuel energy input, and NOx formation
- Inform understanding and demonstrate durability of emissions mitigation measures when using high hydrogen blends

Scope

- Development and testing of generation systems using 30 to 100 percent hydrogen blends while mitigating GHG and NOx emissions:
 - Combustion optimization and cooled high pressure EGR (Enchanted Rock)
 - Split-cycle technology to reduce thermal losses (Tour Engine)
 - Retrofittable Argon Power Cycle to replace nitrogen in air (Noble Thermodynamic Systems)

Progress

- Project testing is currently underway

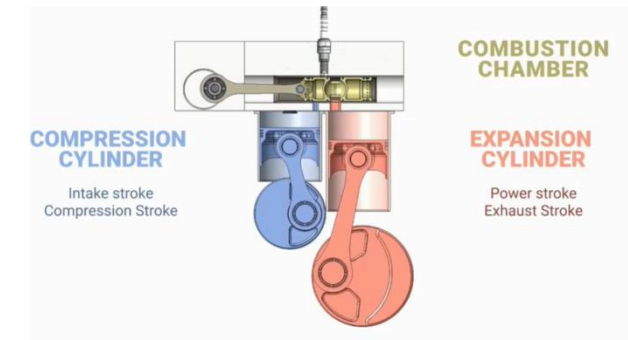
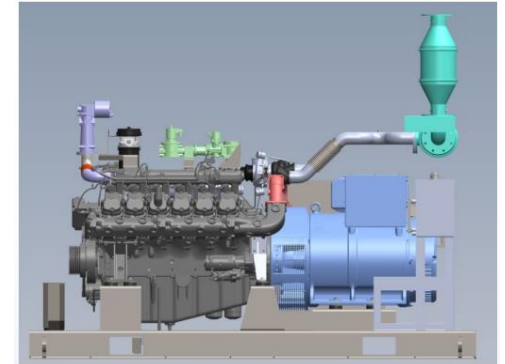


Image Credit: Enchanted Rock (top); Tour Engine (middle); Noble Thermodynamic Systems (bottom)

Emerging Renewable Hydrogen Production

Motivation

- Hydrogen production today almost exclusively fossil fuel-derived via steam methane reforming
- Need to develop cost-competitive clean and renewable hydrogen production technologies

Scope

- Emerging organic waste and biogas to H₂ production pathways including:
 - Microbial electrolysis
 - Direct solar conversion with solid carbon co-production
 - Low temperature plasma reactor
 - Catalytic reformer

Progress

- Lab and pilot testing to validate technology performance underway

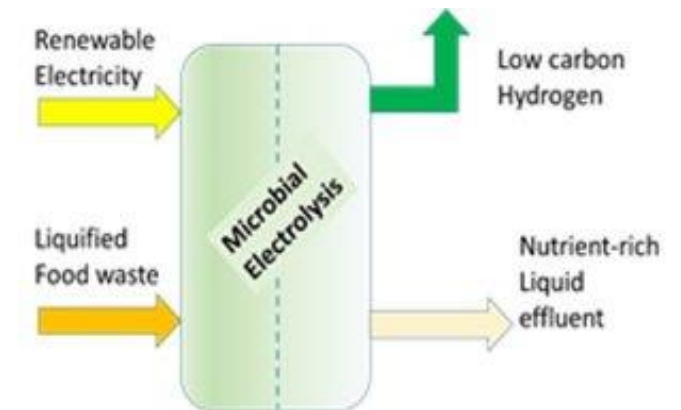


Image Credit: Electro-Active Technologies (top); University of California, Los Angeles (bottom)

Hydrogen for Heavy-Duty Transportation

Motivation

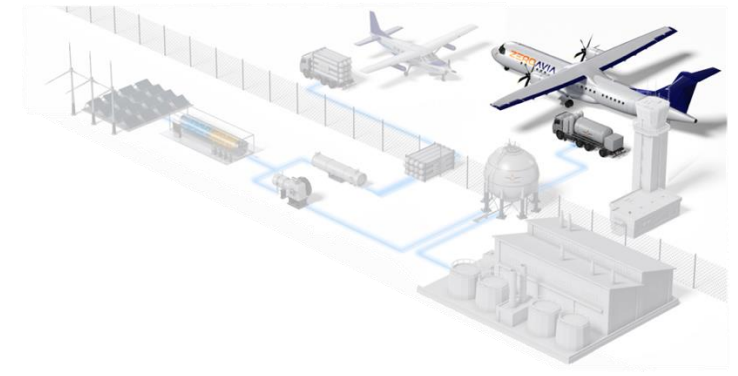
- Hydrogen fuel cells are a promising zero-emission technology for difficult-to-electrify transportation end-uses
- Additional RD&D can drive down costs, improve performance, and enable hydrogen to be used for heavy-duty transportation

Scope

- Developing high-power fuel cell systems for integration with HD vehicles that address operational and safety requirements
- Developing high-flow mobile refueling solutions that mimic current liquid refueling operations

Progress

- Demonstrations to validate technology performance planned in HD truck, rail, aviation, and marine applications

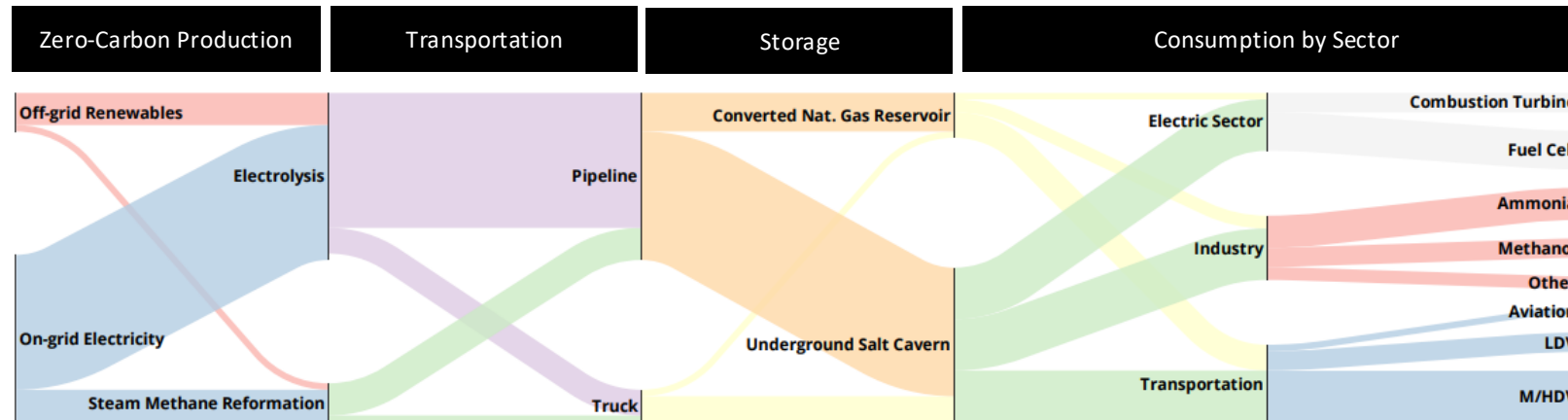


Source: ZeroAvia Federal, Inc.



Image Credit: ZeroAvia Federal (top); Sierra Northern Railway (bottom)

Economy-wide Hydrogen Fuels Optimization Modeling



Motivation

- Gap in clear understanding of mid-stream transportation, storage, and distribution infrastructure and electric system implications of a future clean and renewable hydrogen network

Scope

- Determine conditions/metrics where hydrogen provides cost-effective emissions abatement in CA
- Develop new models to evaluate least-cost configurations of hydrogen infrastructure
- Assess underground storage in CA for balancing time-varying supply and demand across sectors

Progress

- Model underway, will be leveraged in economy-wide hydrogen analyses, including SB 1075 Report

Image Credit: Energy and Environmental Economics

Thank you!

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