California Energy Commission
DOCKETED
12-HYD-1
TN # 66100
JUL 02 2012

Renewable Hydrogen and SB 1505

ADVANCED POWER & ENERGY PROGRAM
UNIVERSITY of CALIFORNIA · IRVINE

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June 29, 2012

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Motivation for Renewable Hydrogen

California Regulation

Environmental Benefits

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Environmental and Energy Standards for Hydrogen Production (SB 1505)

- Becomes effective when H_2 for vehicle fueling reaches 3.5 million kg annually

  Will trigger with roughly 10,000 FCVs statewide

- 50 percent less local emissions of NO_x and ROG than gasoline production

  Easily met with standard SMR hydrogen generation

- 30 percent fewer greenhouse gas emissions than gasoline on a well-to-wheel basis

  Easily met with standard SMR hydrogen generation and FCV efficiency

- Zero increase in toxic air contaminants compared to gasoline

  Easily met with standard SMR hydrogen generation

- 33.3 percent of the hydrogen produced from eligible renewable energy resources

  Achievable, but burdensome to the emerging hydrogen fuel market

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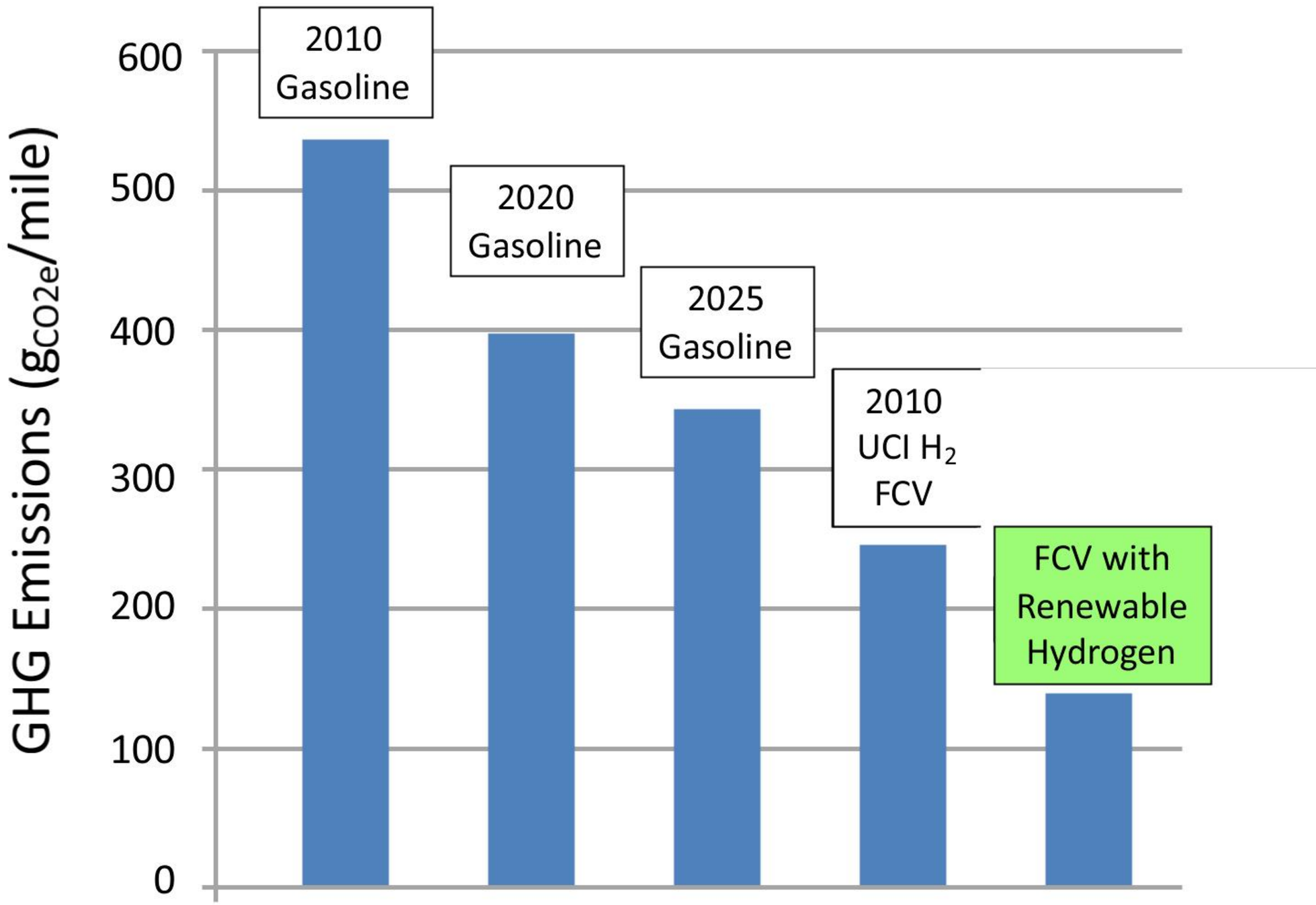
Greenhouse Gas Reduction Using Renewable H_2



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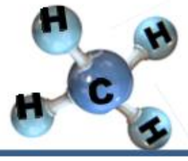
What are potential sources of Renewable Hydrogen?

- Steam methane reforming
- Tri-Generation

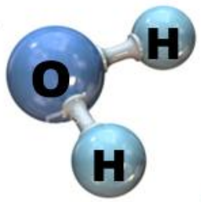
Methane



Renewable Hydrogen

- Electrolysis

Use of electricity to split water



Renewable Hydrogen

- Bacteria
- Algae

Renewable Hydrogen

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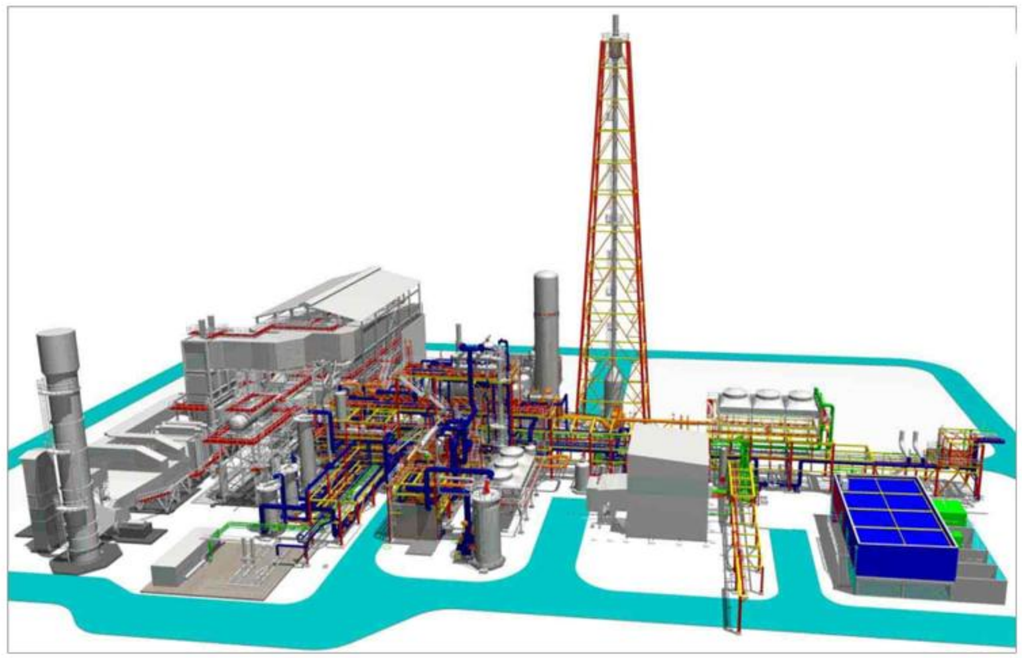
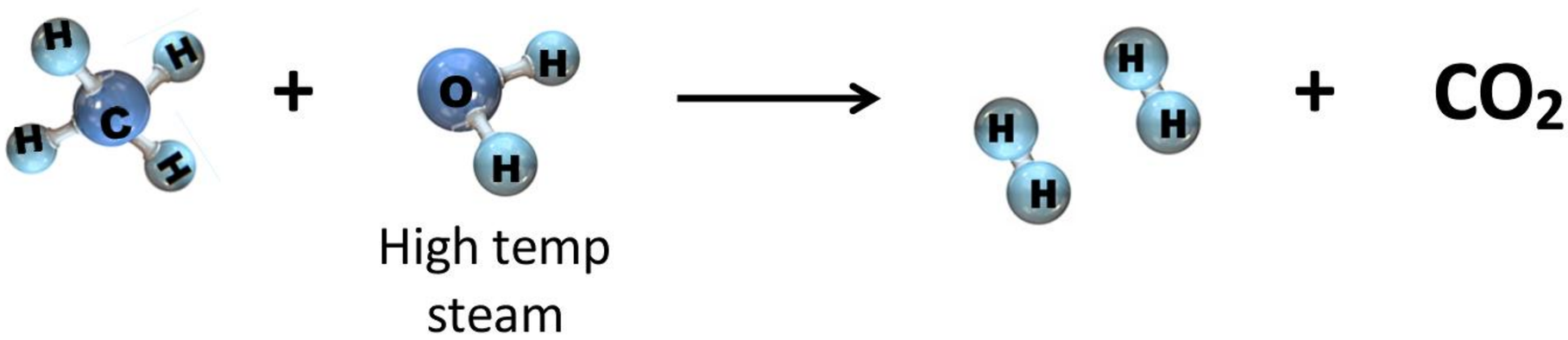
Renewable Hydrogen from Biogas

Steam methane reforming
(*Hydrogen from methane*)





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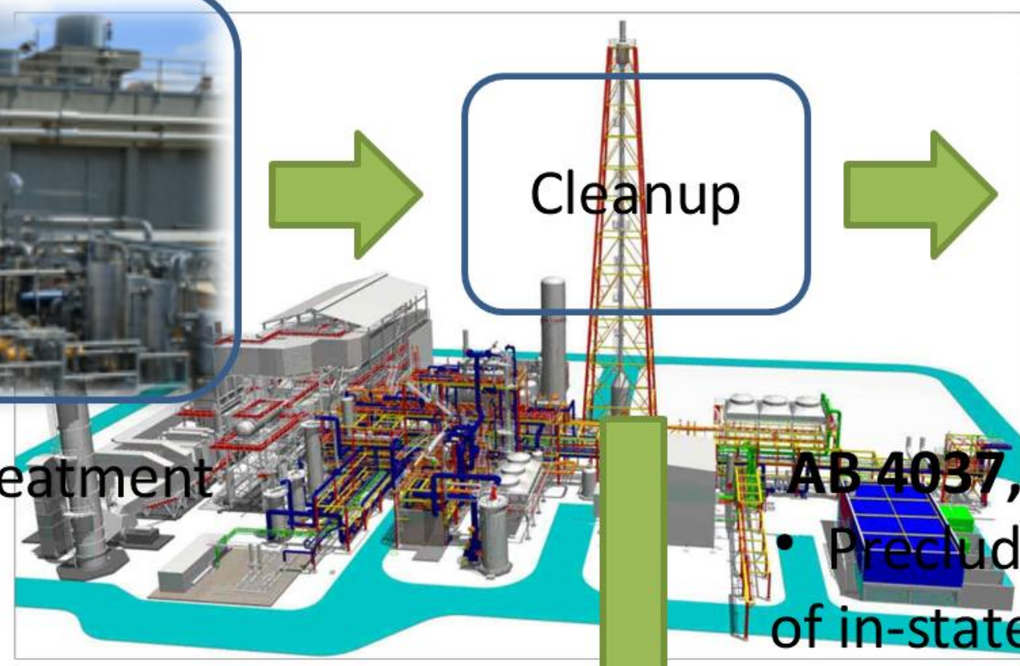
Renewable Hydrogen from Biogas

Steam methane reforming
(*Hydrogen from methane*)



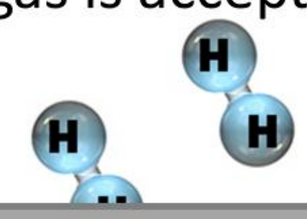
Wastewater treatment
Landfill gas
Dairy farms
Gasified biomass

AB 4037, Hayden Law

- Precludes injection of in-state landfill gas
- Out-of-state landfill gas is acceptable

Directed Biogas

High temp steam



Natural Gas Pipeline

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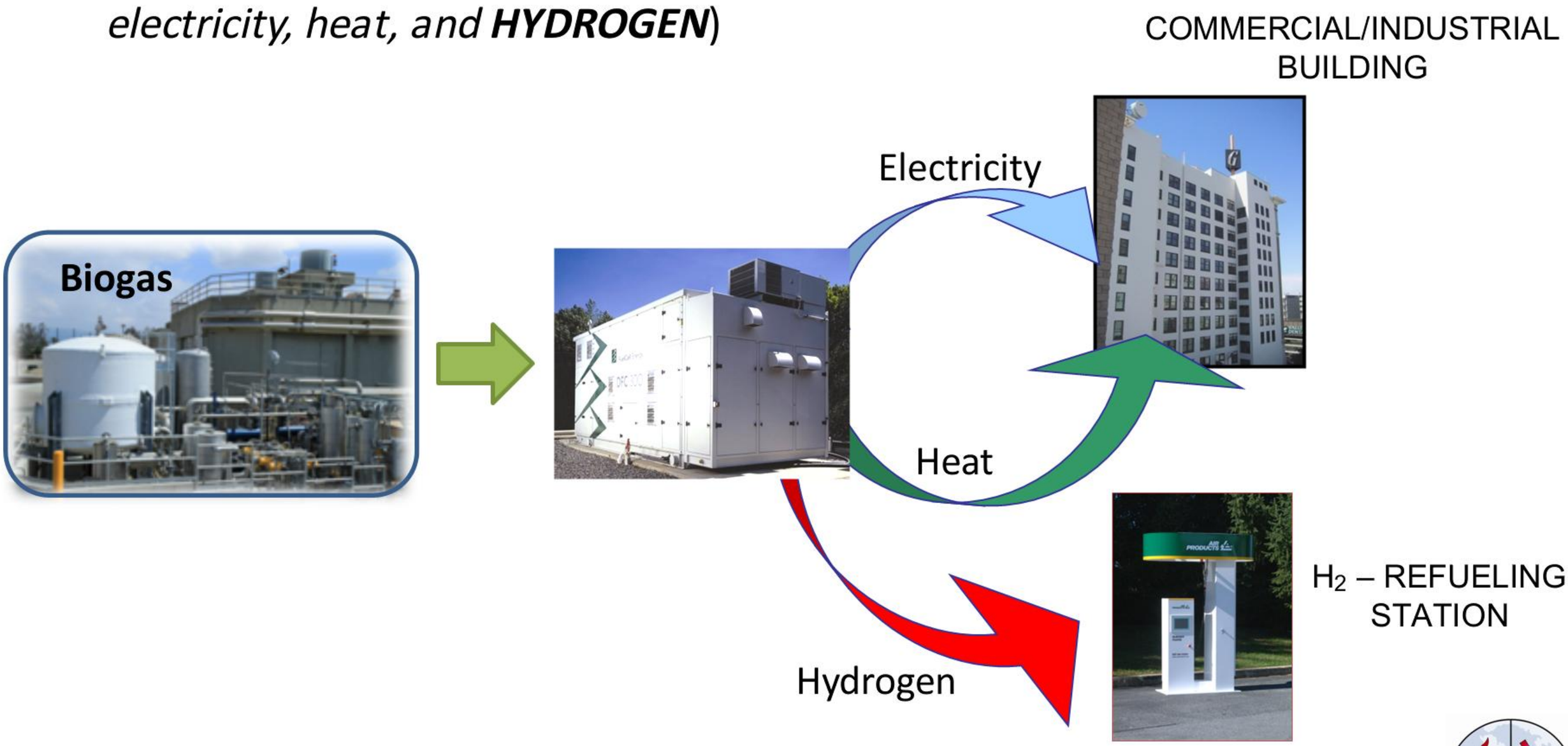
Renewable Hydrogen from Biogas (Tri-Generation)

Tri-Generation

(*Using a large, stationary fuel cell to produce electricity, heat, and* ***HYDROGEN***)



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Orange County Sanitation District H_2 Station

Sponsors/Participants:

AIR PRODUCTS

FuelCell Energy

NFCRC NATIONAL FUEL CELL RESEARCH CENTER UNIVERSITY of CALIFORNIA · IRVINE

ORANGE COUNTY SANITATION DISTRICT · PROTECTING THE ENVIRONMENT

U.S. DEPARTMENT OF ENERGY

CALIFORNIA AIR RESOURCES BOARD

AQMD

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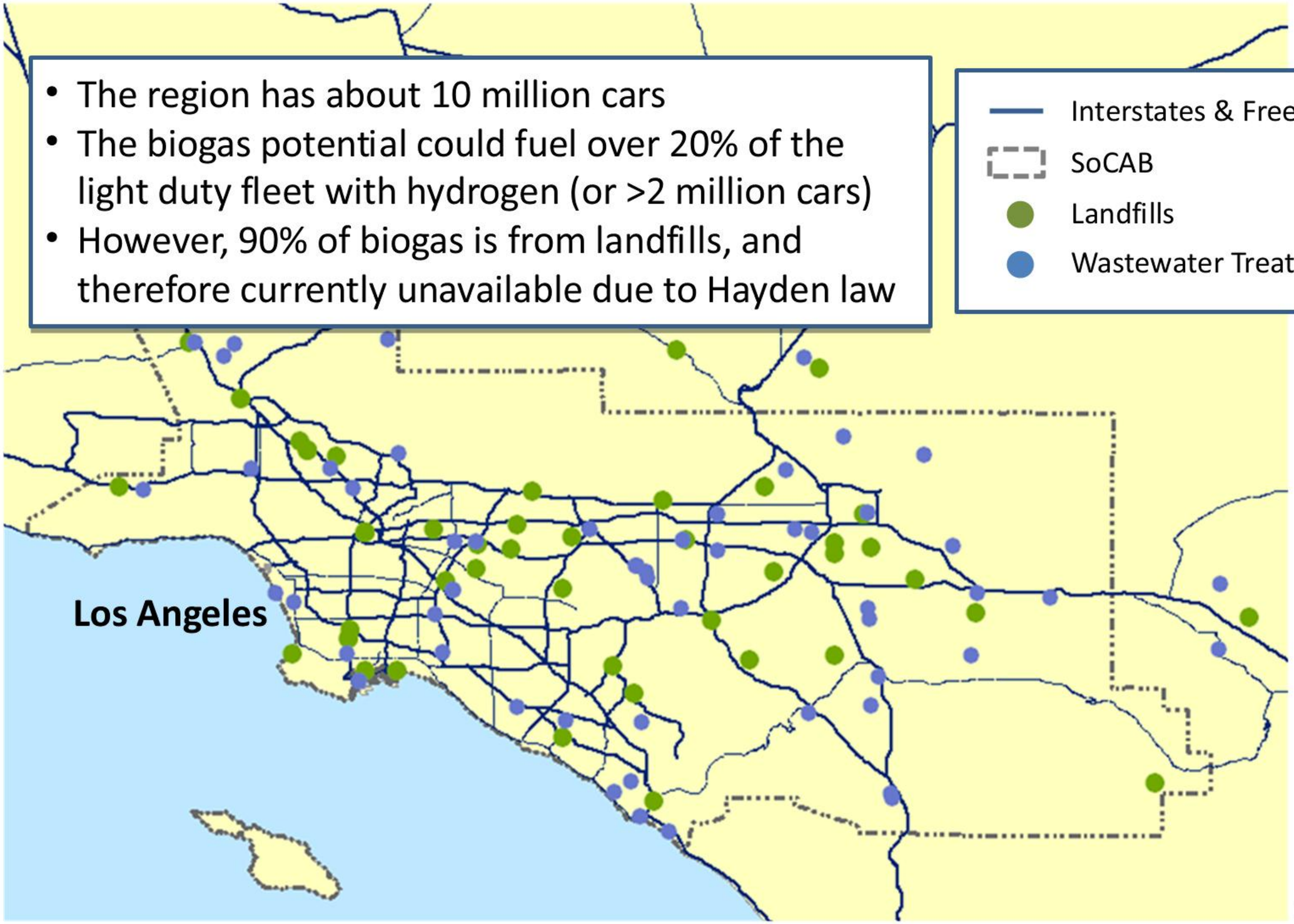
Renewable Hydrogen from Biogas

- The region has about 10 million cars
- The biogas potential could fuel over 20% of the light duty fleet with hydrogen (or >2 million cars)
- However, 90% of biogas is from landfills, and therefore currently unavailable due to Hayden law



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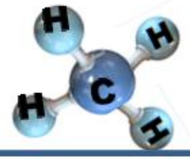
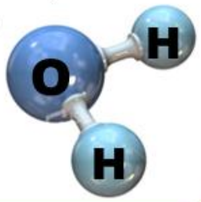
Methane



Renewable Hydrogen

- Electrolysis

Use of electricity to split water



Renewable Hydrogen

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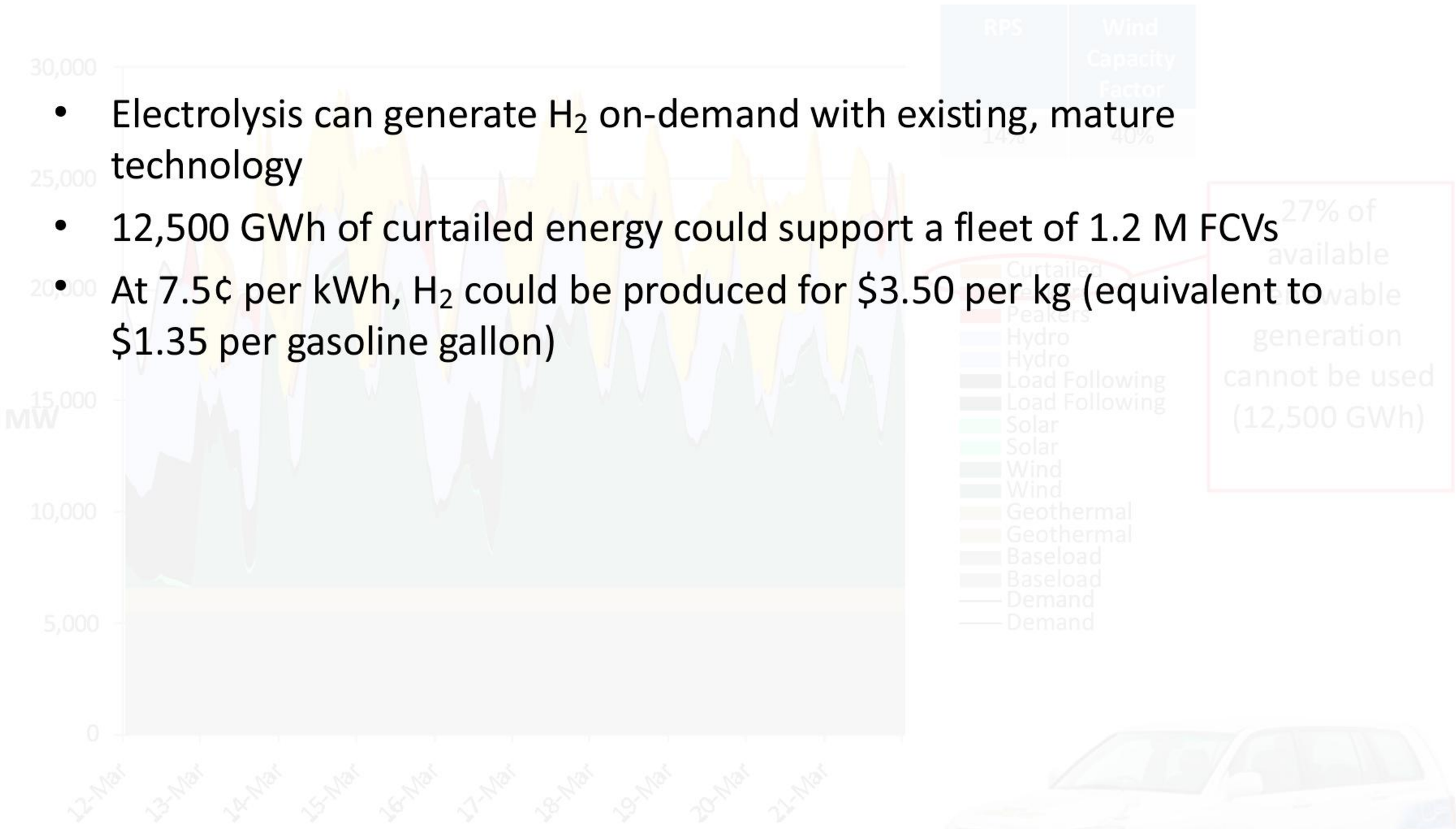
Renewable Hydrogen from Renewable Electricity

- Electrolysis can generate H_2 on-demand with existing, mature technology
- 12,500 GWh of curtailed energy could support a fleet of 1.2 M FCVs
- At 7.5¢ per kWh, H_2 could be produced for $3.50 per kg (equivalent to $1.35 per gasoline gallon)



J. Eichman, et al., "Analyzing Renewable Power in CA," in draft

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What are potential sources of Renewable Hydrogen?

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Methane

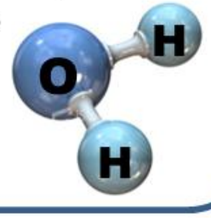
Renewable Hydrogen

Drivers:
- Policy (SB 1505)
- Incentive (AB 118)?

Outlook:
- Most likely near-term option
- Cost will be a premium over natural gas

- Electrolysis

Use of electricity to split water



Renewable Hydrogen

Drivers:
- Policy (RPS standards)
- Policy (SB 1505)
- Incentive (AB 118)?

Outlook:
- Mid-term to long term
- Will require larger infrastructure build-out

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