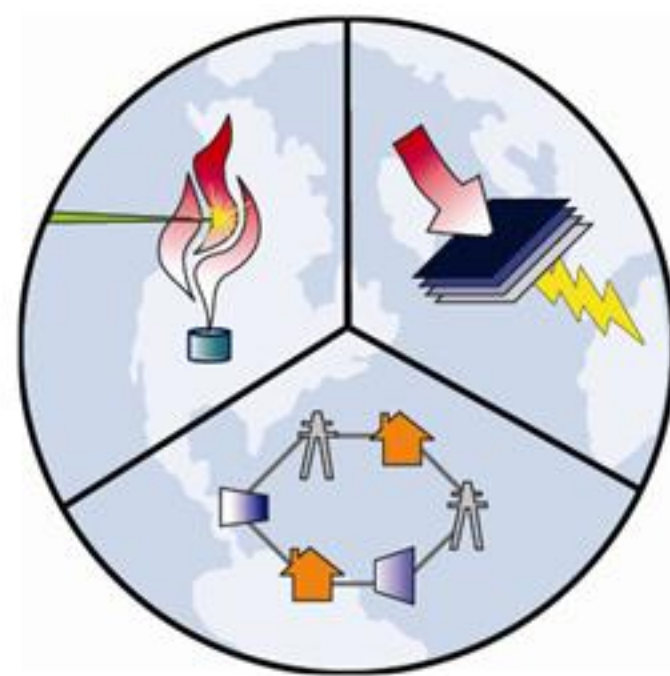


# Renewable Hydrogen and SB 1505



**ADVANCED POWER  
& ENERGY PROGRAM**  
*UNIVERSITY of CALIFORNIA • IRVINE*

Dr. Tim Brown  
Dr. Shane D. Stephens-Romero  
Professor G. Scott Samuelsen  
June 29, 2012



# Motivation for Renewable Hydrogen

California  
Regulation

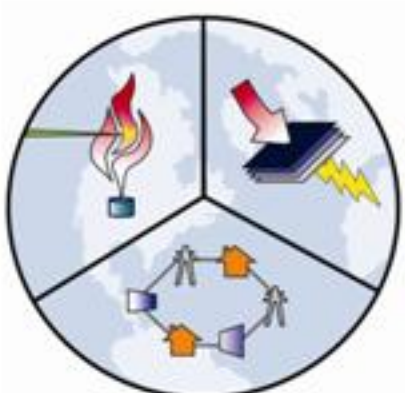
Environmental  
Benefits





# Environmental and Energy Standards for Hydrogen Production (SB 1505)

- Becomes effective when H<sub>2</sub> for vehicle fueling reaches 3.5 million kg annually  
*Will trigger with roughly 10,000 FCVs statewide*
- 50 percent less local emissions of NO<sub>x</sub> 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*





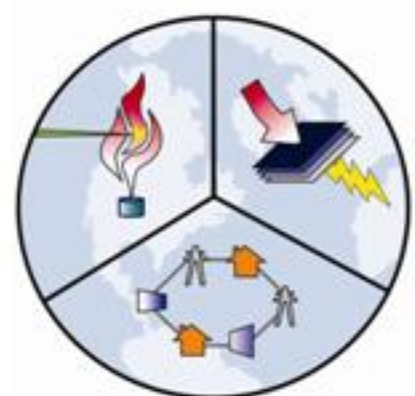
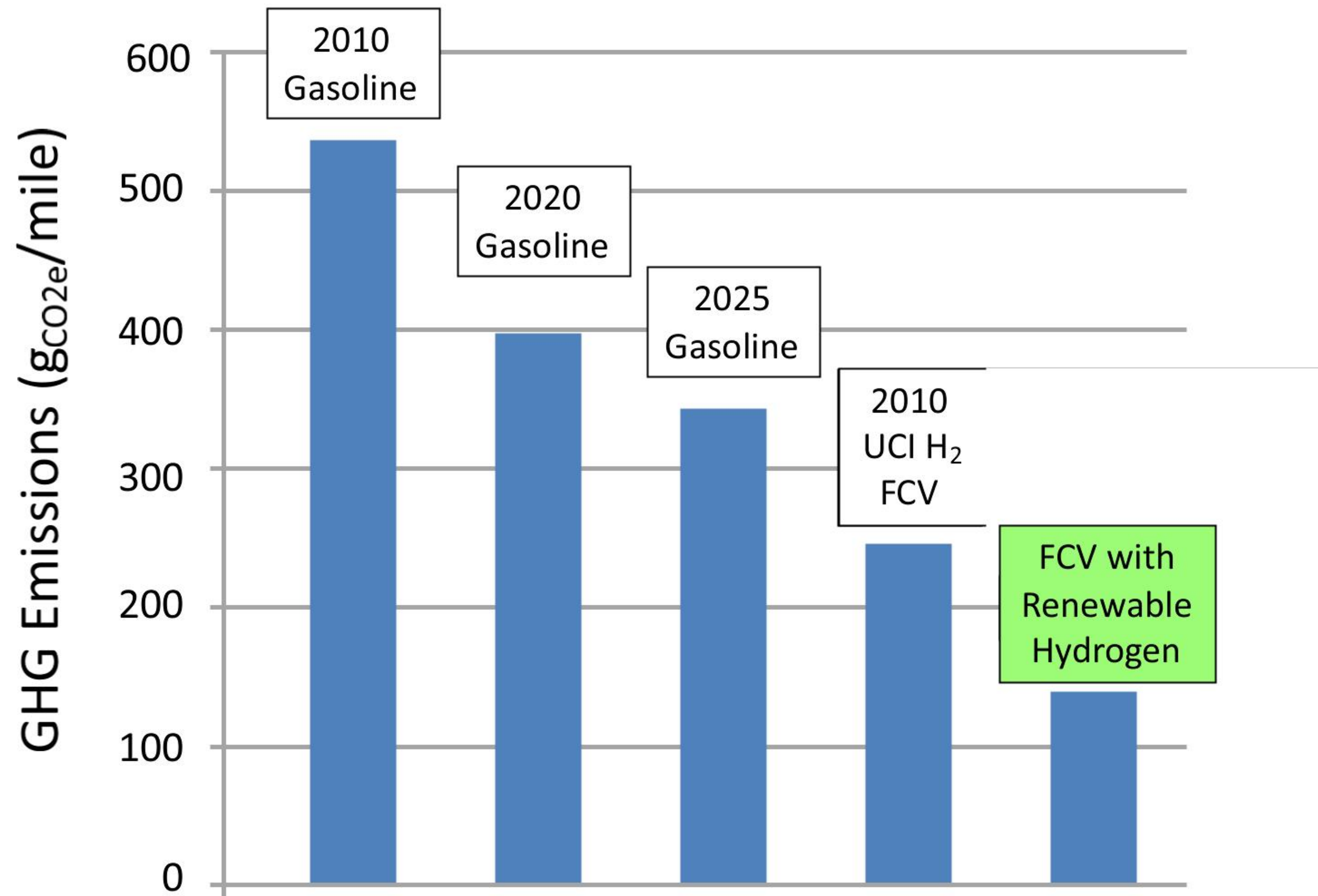
# Motivation for Renewable Hydrogen

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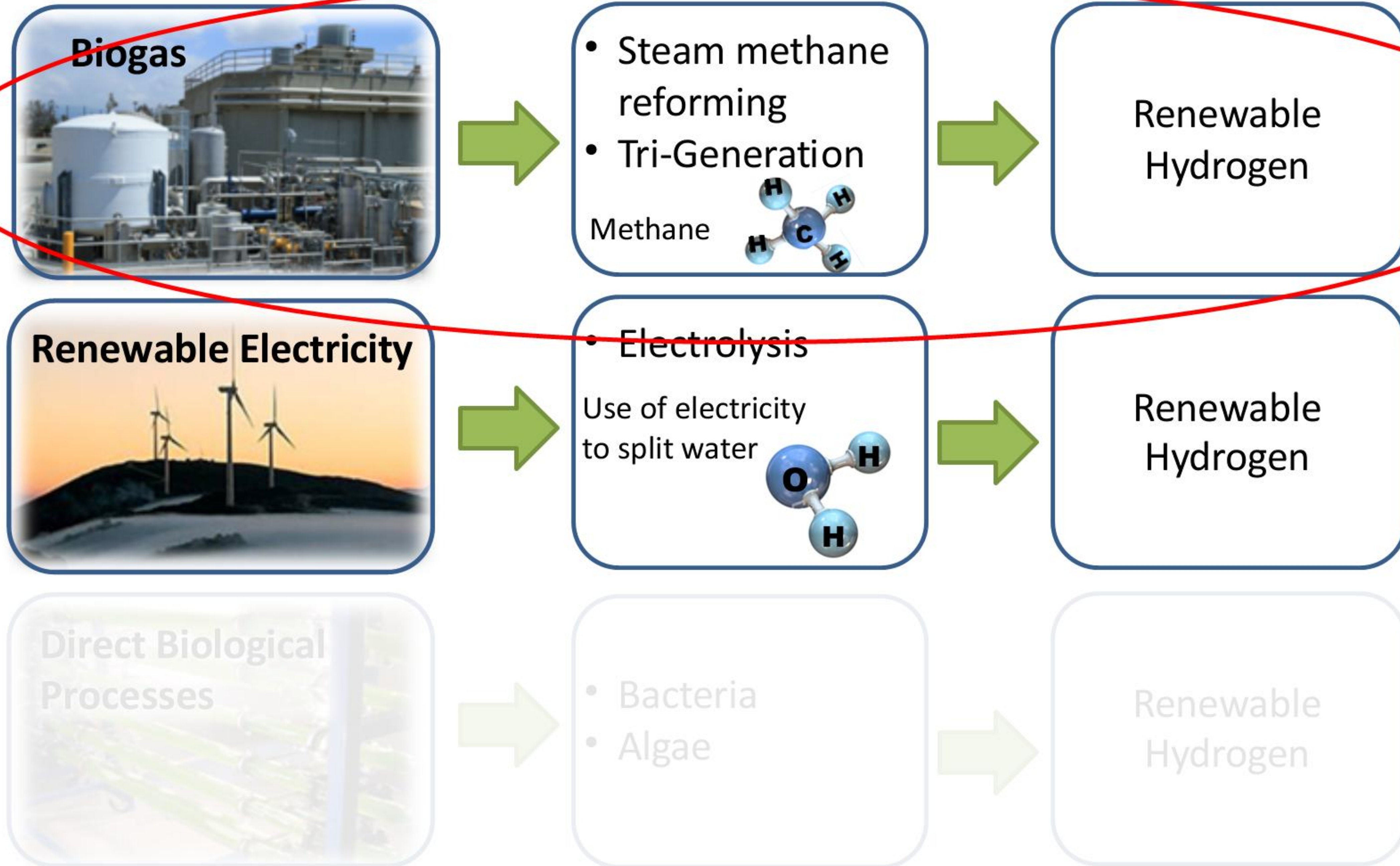


# Greenhouse Gas Reduction Using Renewable H<sub>2</sub>





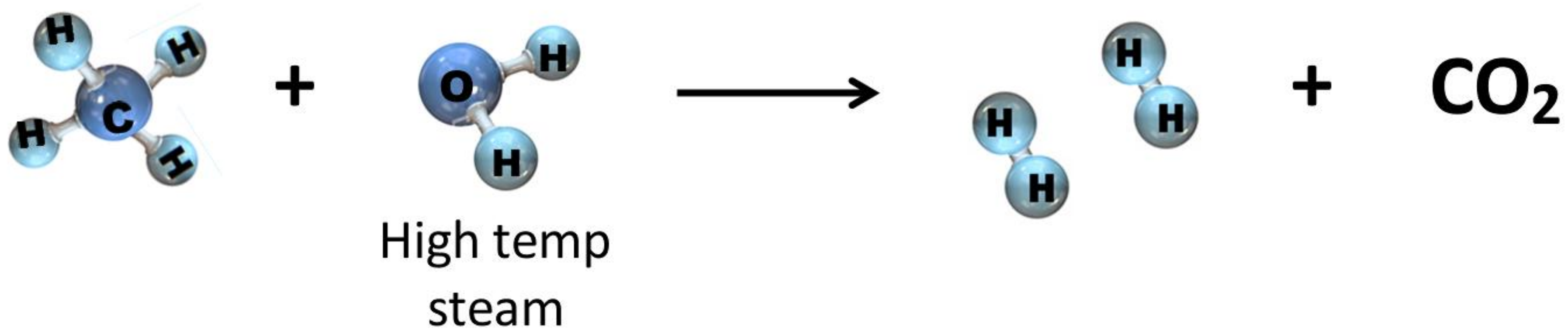
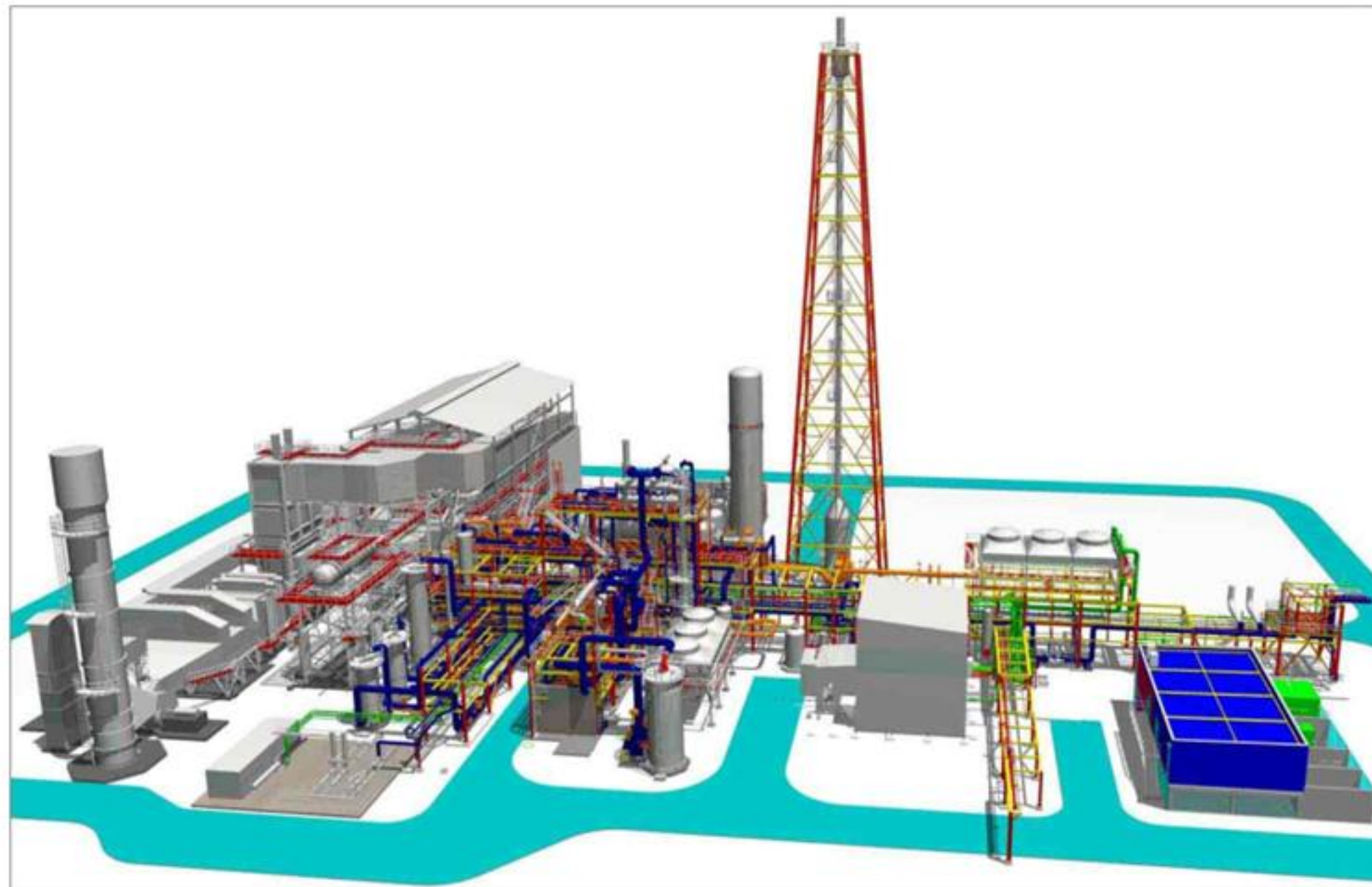
# What are potential sources of Renewable Hydrogen?





# Renewable Hydrogen from Biogas

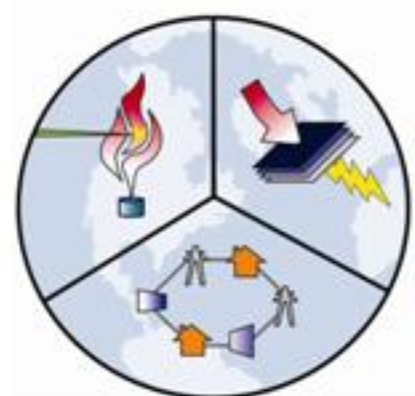
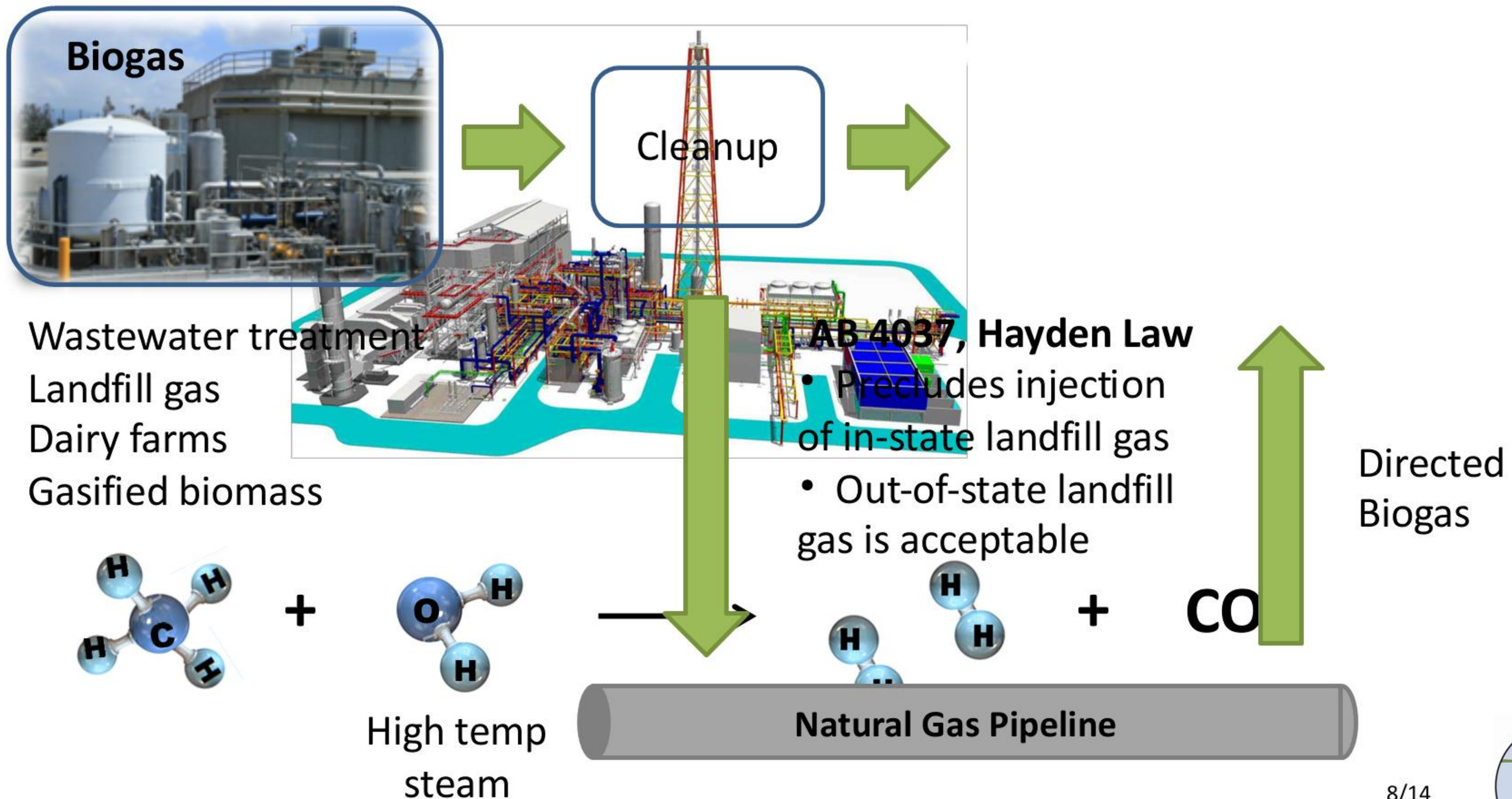
Steam methane reforming  
(*Hydrogen from methane*)





# Renewable Hydrogen from Biogas

Steam methane reforming  
(*Hydrogen from methane*)

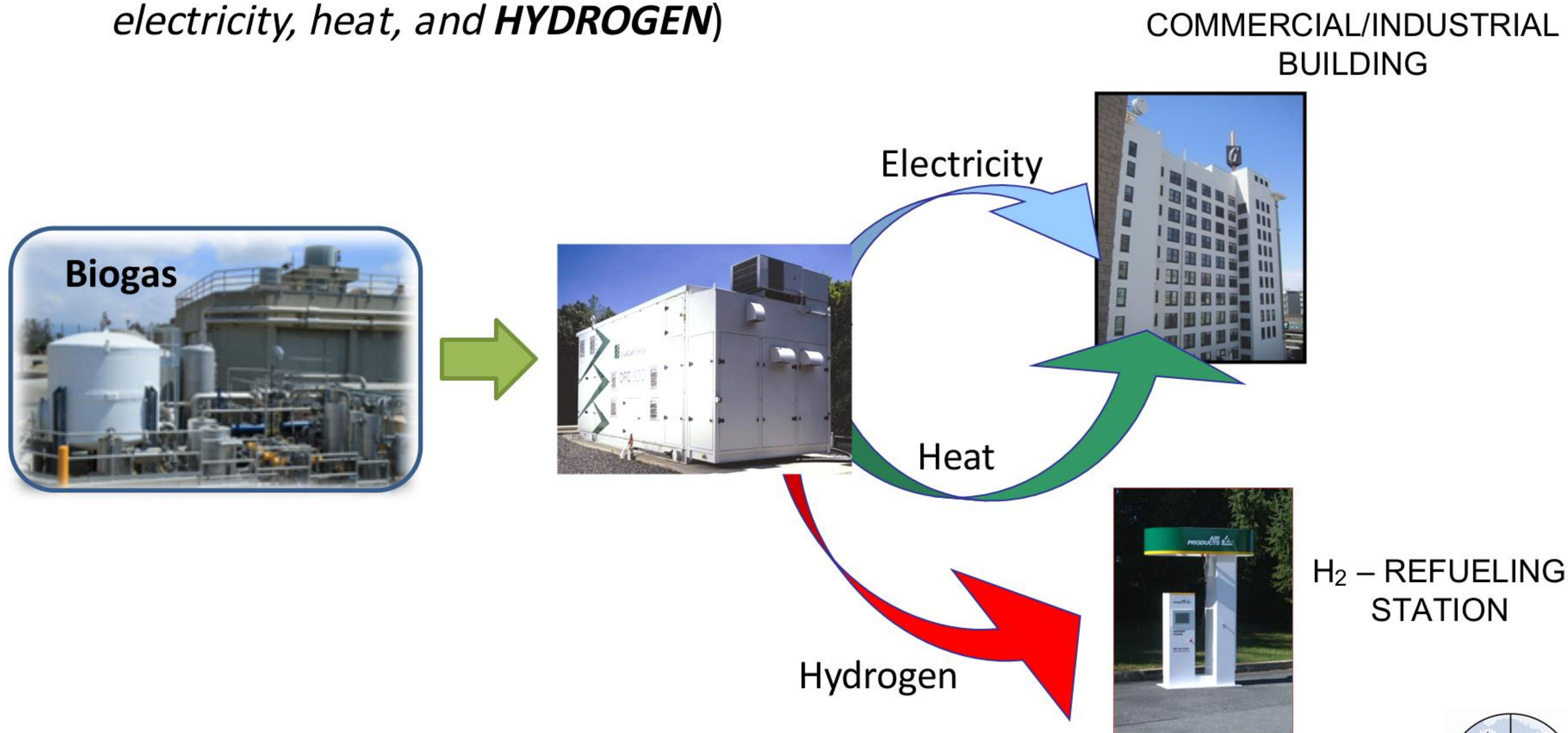




# Renewable Hydrogen from Biogas (Tri-Generation)

## Tri-Generation

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





# Orange County Sanitation District H<sub>2</sub> Station



## Sponsors/Participants:



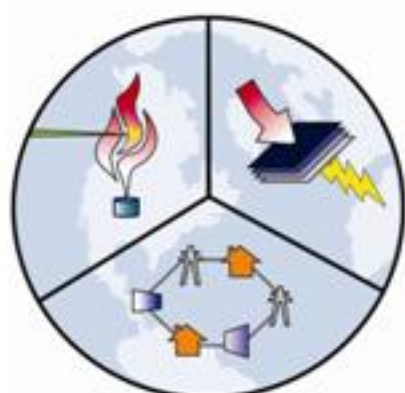
FuelCell Energy



NATIONAL FUEL CELL  
RESEARCH CENTER  
UNIVERSITY of CALIFORNIA • IRVINE



U.S. DEPARTMENT OF  
**ENERGY**





# 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

- Interstates & Freeways
- - - SoCAB
- Landfills
- Wastewater Treatment Plants



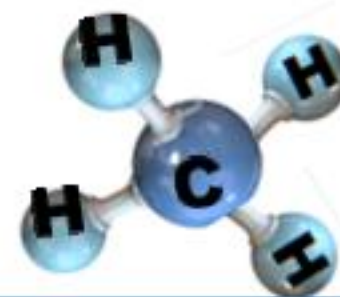


# What are potential sources of Renewable Hydrogen?

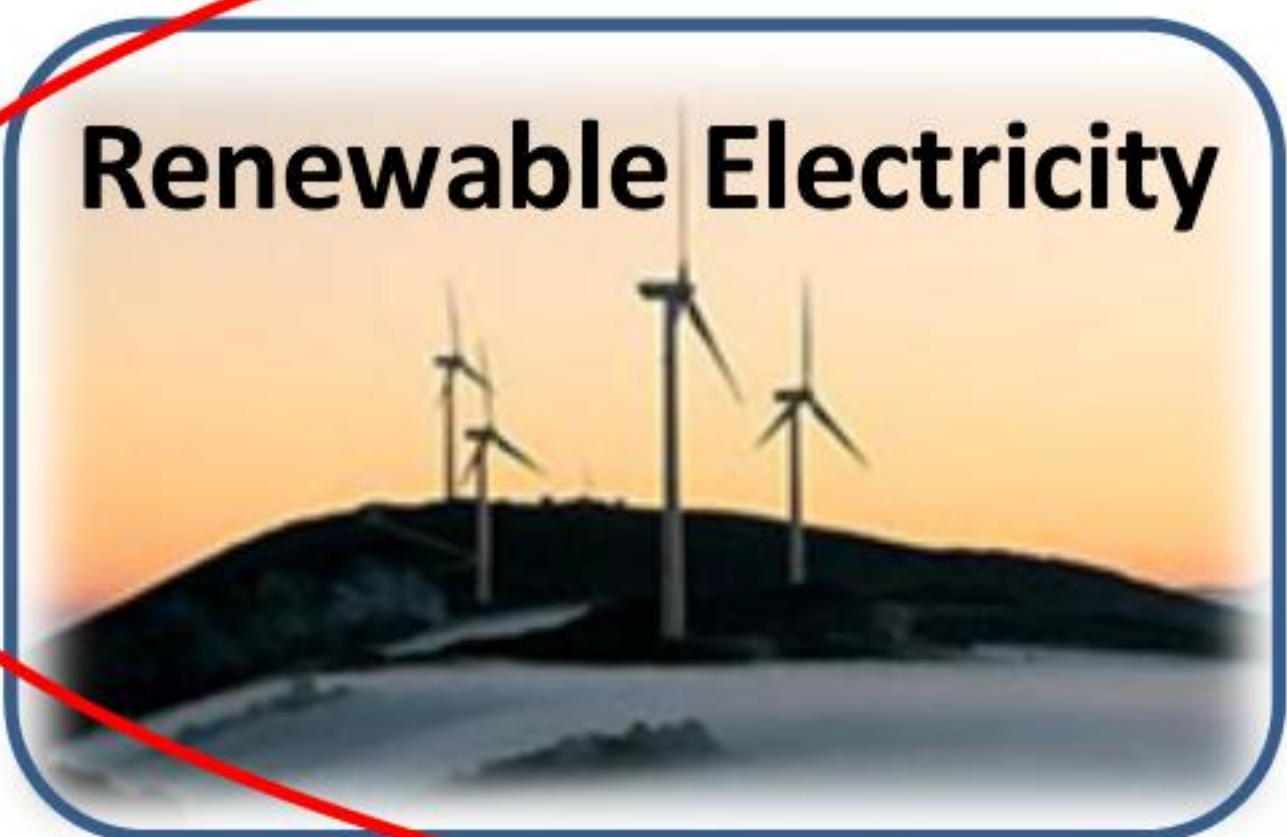


- Steam methane reforming
- Tri-Generation

Methane

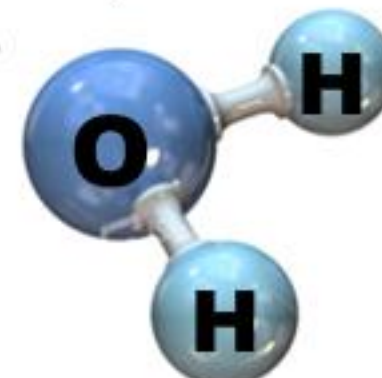


Renewable  
Hydrogen



- Electrolysis

Use of electricity  
to split water



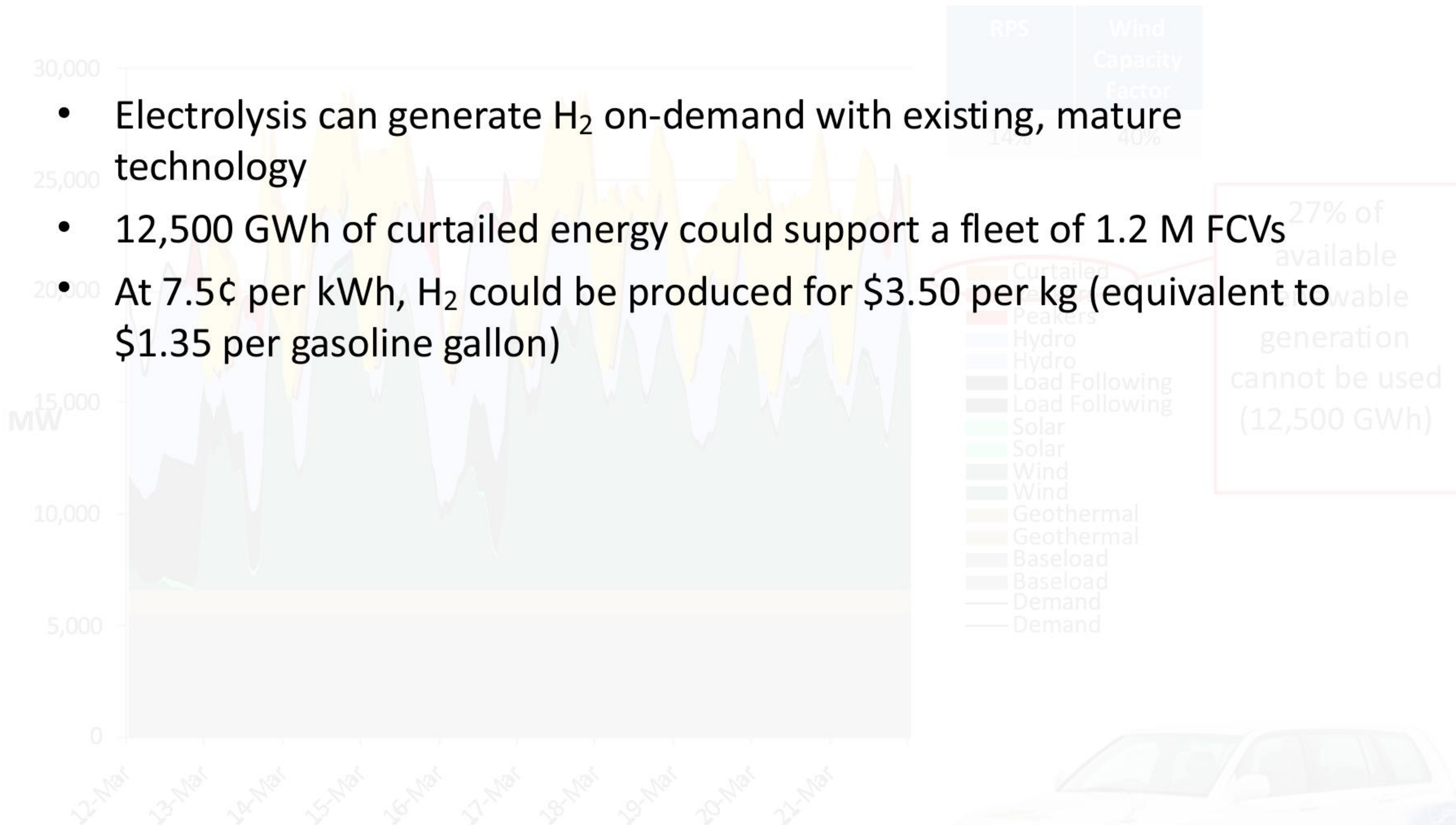
Renewable  
Hydrogen





# Renewable Hydrogen from Renewable Electricity

- Electrolysis can generate H<sub>2</sub> 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<sub>2</sub> 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





# What are potential sources of Renewable Hydrogen?

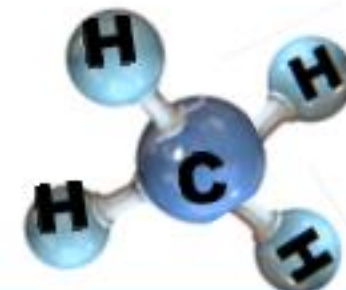


**Biogas**



- Steam methane reforming
- Tri-Generation

Methane



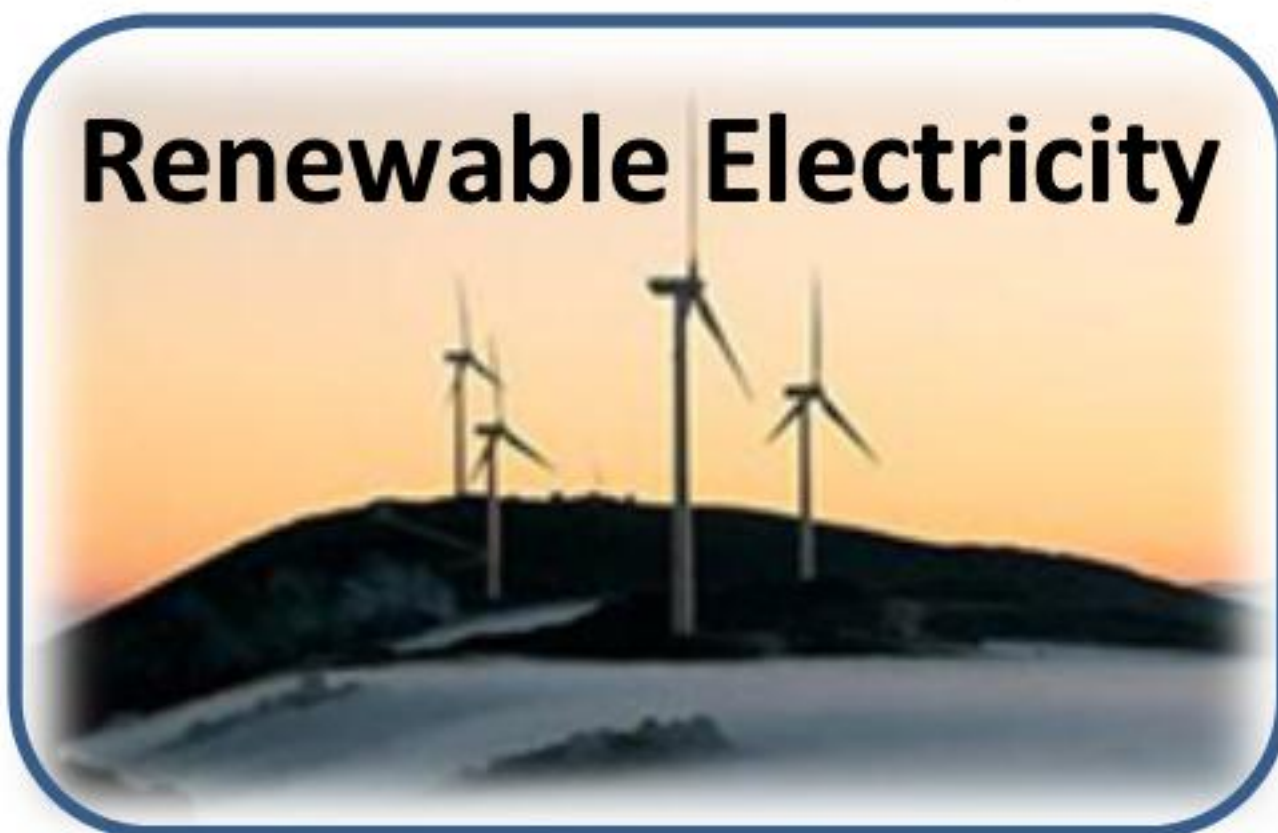
Renewable  
Hydrogen

## Drivers:

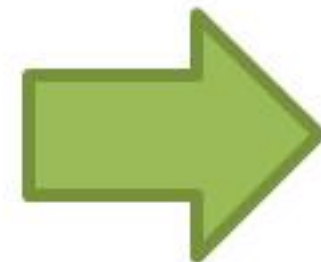
- Policy (SB 1505)
- Incentive (AB 118)?

## Outlook:

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

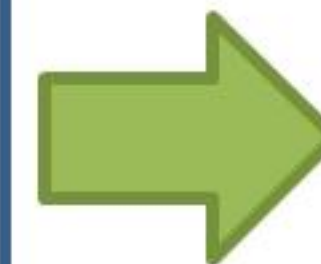
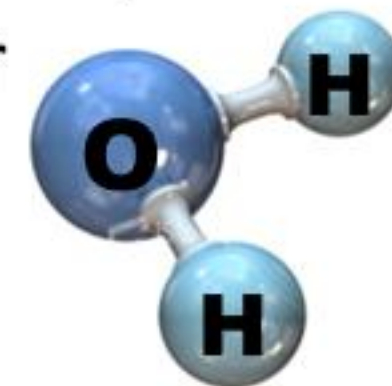


**Renewable Electricity**



- Electrolysis

Use of electricity  
to split water



Renewable  
Hydrogen

## Drivers:

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

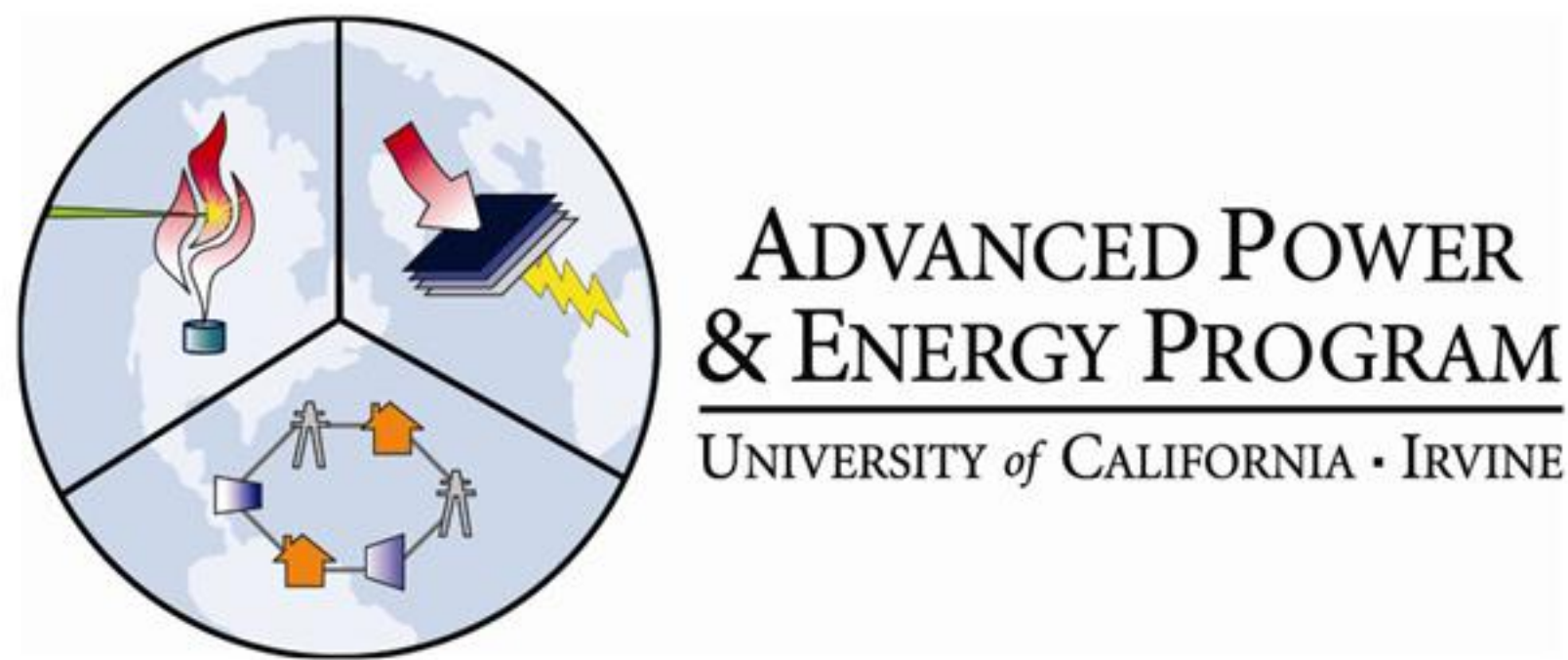
## Outlook:

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





# Renewable Hydrogen and SB 1505



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