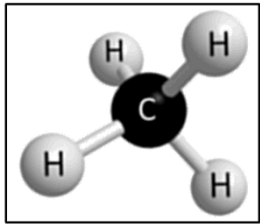


# Hydrogen and Green Shipping: Zero-Emission Fuel in the Maritime Sector

Dr. Joseph Pratt & Dr. Leonard Klebanoff  
Sandia National Laboratories

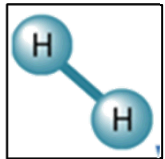


Hydrogen is similar to natural gas, but does not contain carbon. Fuel cells directly convert hydrogen to power with zero emissions.



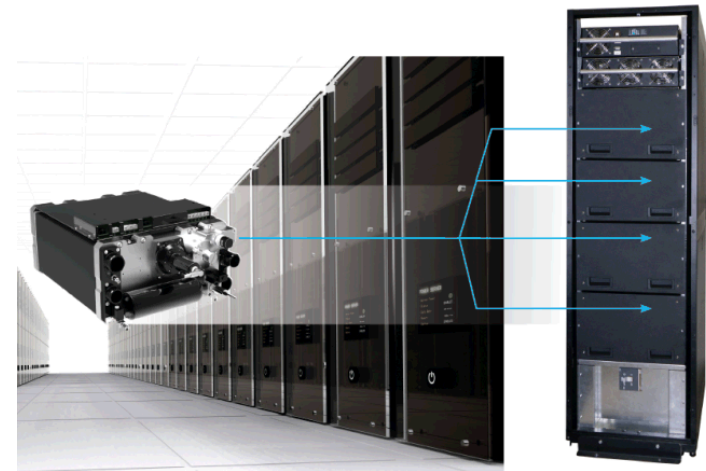
Natural gas

→ energy  
water  
CO  
CO<sub>2</sub>



Hydrogen

→ energy  
water

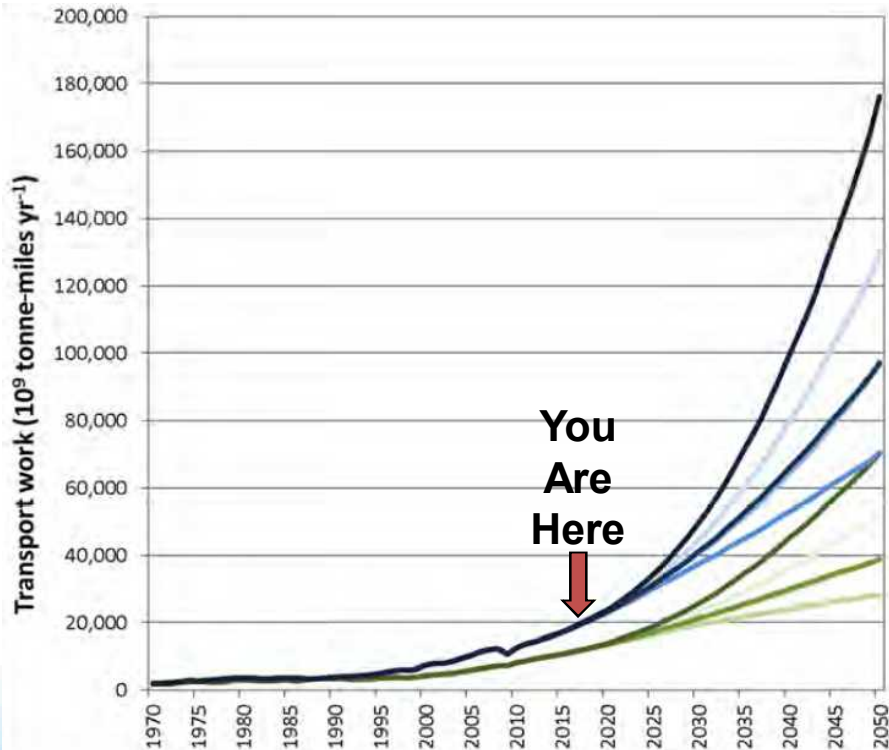


- Non-toxic
- Not a GHG
- No possible water contamination if spilled

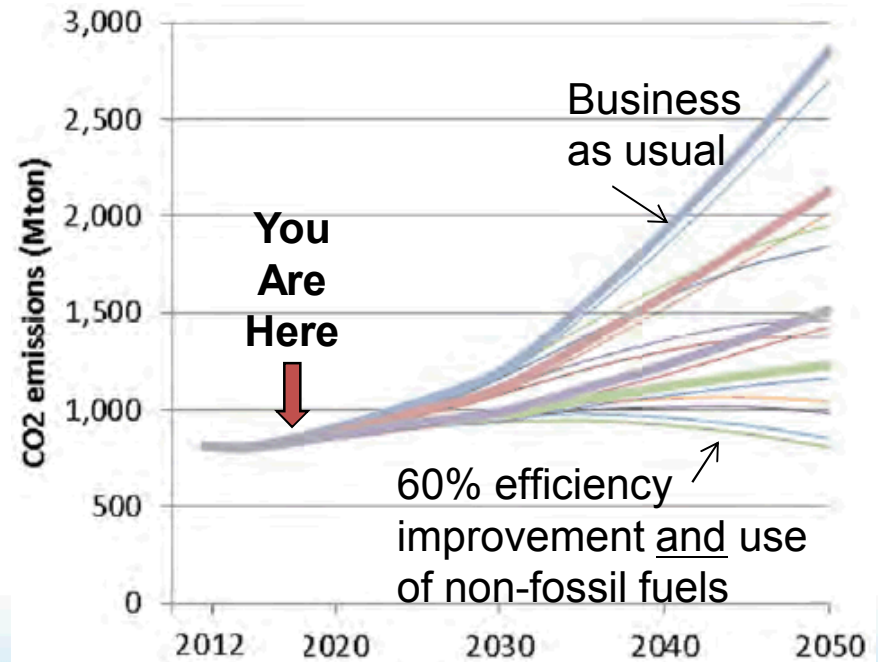


# Worldwide industrialization is supported by increasing shipping capacity, with a corresponding increase in emissions.

## Worldwide shipping trend

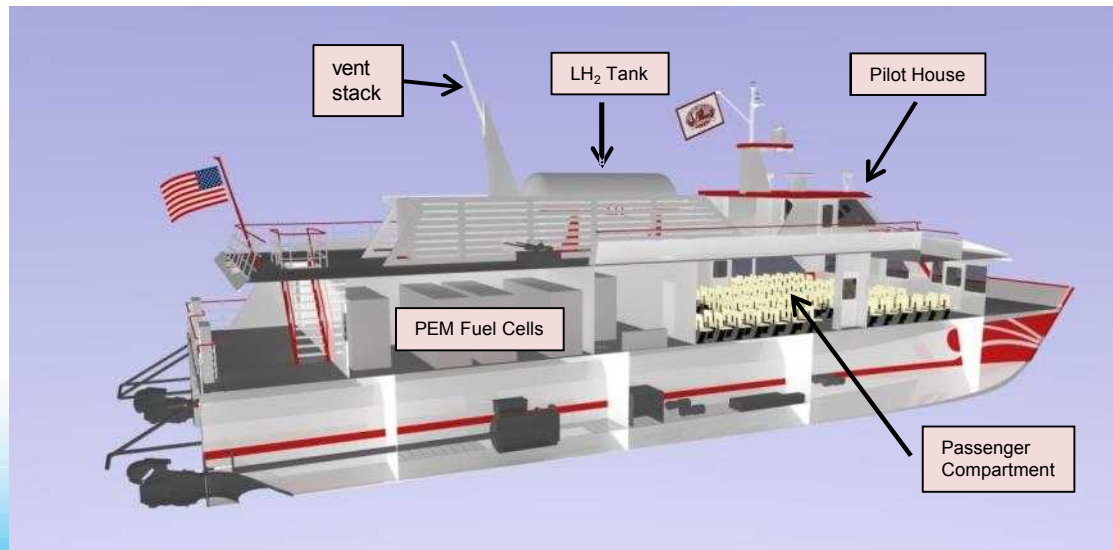


## Maritime GHG emissions





# The SF-BREEZE (San Francisco Bay Area Renewable Energy Electric Vessel with Zero Emissions)



**ZERO Emissions**  
**ZERO Fuel Spills**  
**Low noise, no diesel fumes or odor**  
**Faster response time than diesel**  
Fuel: ~2,000 kg LH<sub>2</sub> per day  
Propulsion power: 4.4 MW  
Passengers: 150  
Service Speed: 35 knots

# Zero Emission Research Oceangoing Vessel (ZERO/V)



Glosten

2,400 nm and  
15 day range

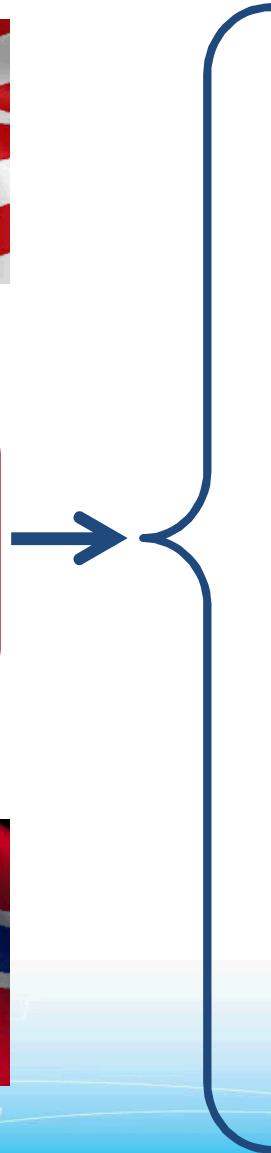
Increased scientific value:

- **Very low noise:** higher resolution underwater imaging
- **No airborne emissions:** keeps air and marine samples clean
- **No possibility of fuel spills:** operation in sensitive ecologies

# Collaboration enables achieving common goals



**Shared  
Resources &  
Information**



**Clean Maritime Transport**



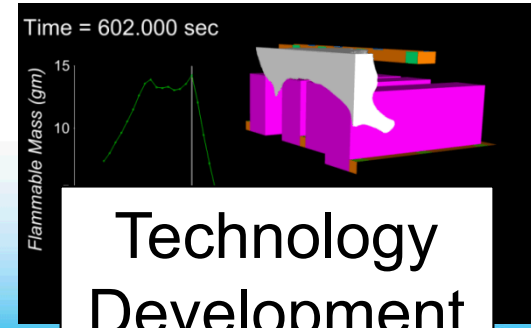
**Jobs**



**Industry**



**Training**



# Thank You!

For more information visit:  
**[maritime.sandia.gov](http://maritime.sandia.gov)**

- Past and current maritime projects
- Download reports
- Connect with our *Zero Emission Hydrogen Vessel Working Group*

## Sandia Maritime Program

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