

# **Hydrogen Economy Research from an Academic Perspective**

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# Hydrogen Economy Research

- Hydrogen as an energy vector (primarily for transportation applications)
  - Flexibility of source generation and oil independence
  - Removal of local pollutant generation
  - Potential for global warming reduction
- Current plan to make commercialization decisions regarding transportation fuel cells and large-scale H<sub>2</sub> production by 2015.

# Hydrogen Economy Research Motivation

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# State of the Art in Area

(red are current preferences, others are developed and being improved)

- Hydrogen Production (local vs. centralized)
  - Hydrocarbon (primarily natural gas) reforming
  - Advanced nuclear cycles
  - Coal or biomass gasification (with CO<sub>2</sub> sequestration)
  - Solar-driven water splitting (photoelectrochemical, thermal)
  - Microbial communities
- Hydrogen Transport & Storage (DOE goal for storage 6.5% by weight H<sub>2</sub>)
  - High pressure tanks (composite materials research)
  - Pipeline (material lifetime and safety)
  - Liquefaction (advanced cryogenic storage)
  - Advanced materials
    - Borohydride solutions
    - Complex metal hydrides (e.g., doped NaAlH<sub>4</sub>)
    - Metal organic complexes
    - Hydrocarbons
- Hydrogen-based Energy Conversion (for distributed power and transportation applications)
  - Fuel cells
    - Proton Exchange Membrane Fuel Cells (PEMFC – top choice for automobiles)
    - Solid Oxide Fuel Cells (SOFC – most flexible for distributed stationary power)
  - Hydrogen Combustion Driven Cycles
    - Gas Turbines (for stationary power) and IC Engines (for transportation)

# Research Opportunities

## (focus on University Research Opportunities)

- Materials and nanoscale and microscale engineering optimization
  - Hydrogen storage materials
  - Electrocatalysts
  - Solar-driven water-splitting materials
  - Membrane materials
- Process-level research
  - Coal gasification
  - Fuel cell transport and electrochemical kinetics
- Model development for processes
  - Multi-scale physically driven models (from DFT & MD to CFD)
- Model development for systems
  - Improved physical models for new processes (e.g., hydrogen storage in complex metal hydrides)
  - Optimization of heretofore poorly understood systems
- Collaborations with industrial partners desirous of forward looking research

## Status and Potential of Funding

- Approximate hydrogen research for upcoming year
  - DOE 2007 budget
    - \$289.5 M for Hydrogen Fuel Initiative
      - \$195.8 M for EERE, \$23.6 M for Fossil Energy, \$18.7 M for Nuclear Energy, \$50.0 M for Basic Sciences, and \$1.8 M for DOT
    - \$54.7 M for Future Gen (coal to electricity and H<sub>2</sub>)
    - \$31.4 M for Generation IV Nuclear Plants including H<sub>2</sub> production
    - \$49.8 M for Genomics for microbial communities (significant fraction of which is for fuel generation)
  - Additional synergistic activities through NSF and DoD
  - Fraction that goes to Universities in DOE portfolio 9%, but these programs have a much higher fraction to Universities
  - Currently a \$100 M dollar RFP (without DOE lab participation) for H<sub>2</sub> technology R&D
- These numbers reflect a steady increase in H<sub>2</sub> research funding for the past 4 years.

# Hydrogen-Related Activities at UMD

- Hydrogen Storage Materials
  - E. Williams, Ruett-Robey, Takeuchi
- Solid Oxide Fuel Cell Research
  - Jackson, Eichhorn, R. Walker, Cadou, Zachariah, & Shapiro
- PEM Fuel Cell System Research and Hydrocarbon to H<sub>2</sub> Conversion
  - Jackson, Radermacher & Eichhorn
  - in collaboration with Ballard Power Systems
- Hydrogen Sensors
  - DeVoe, Takeuchi
- Impact of Hydrogen Technology on Climate
  - Joint Global Change Research Institute
- Hydrogen Technology Education Center
  - Jackson & Radermacher in collaboration with Va. Tech