U.S. DEPARTMENT OF ENERGY

Hydrogen Program

Steven Chalk
Hydrogen Program Manager

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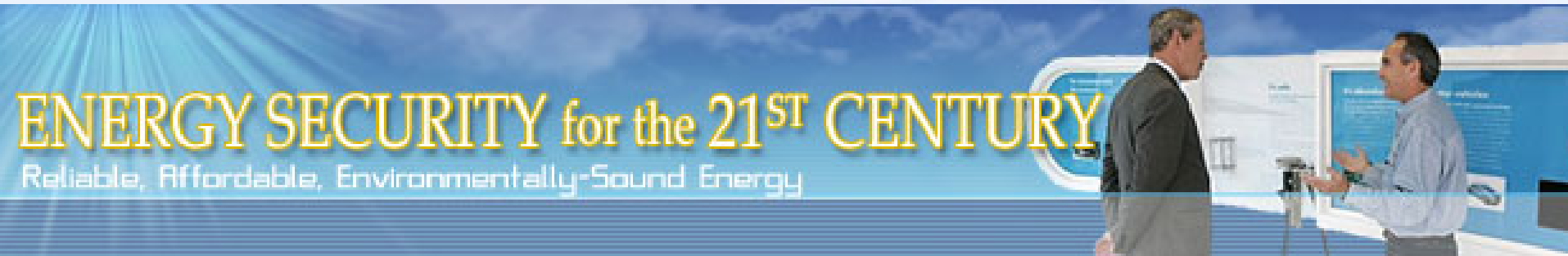
DOE Perspectives on the Hydrogen Utility Group

Senate Caucus on Hydrogen & Fuel Cells

Washington, DC



Hydrogen Production Strategy

Produce hydrogen from renewable, nuclear, and coal with technologies that will all yield virtually zero criteria and greenhouse gas emissions

Coal

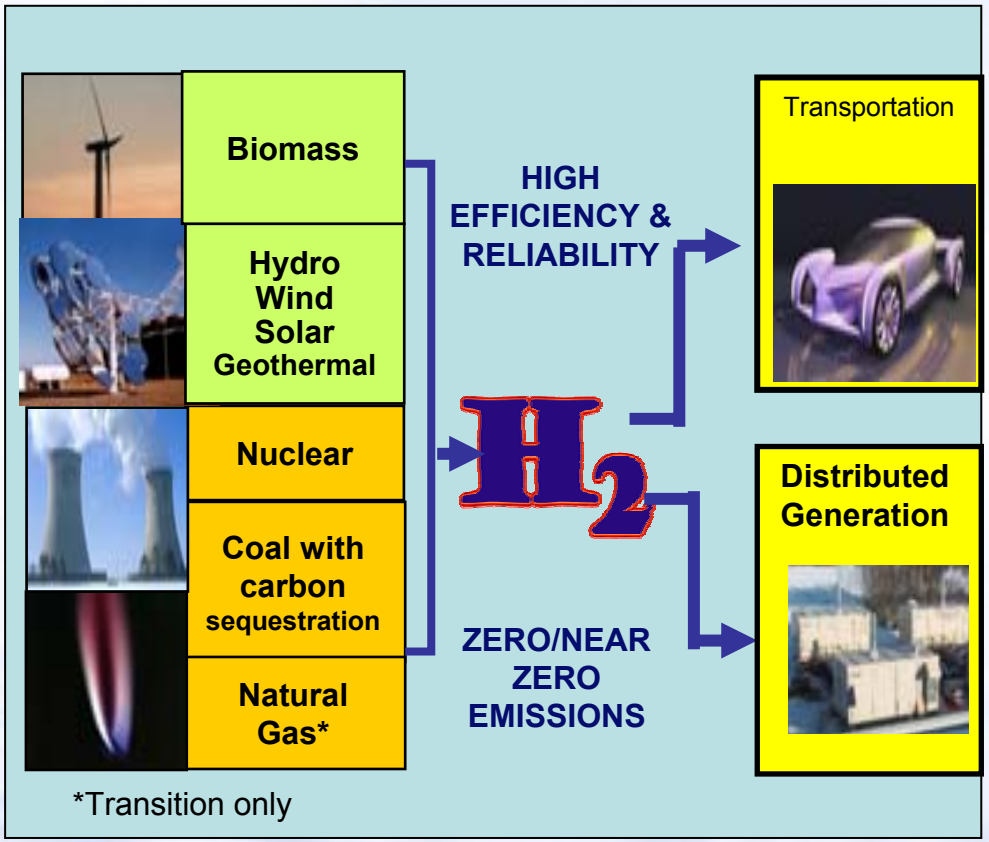
- Only with carbon capture & sequestration
- Gasification process produces hydrogen directly
- Electricity not produced as an intermediary

Distributed Natural Gas

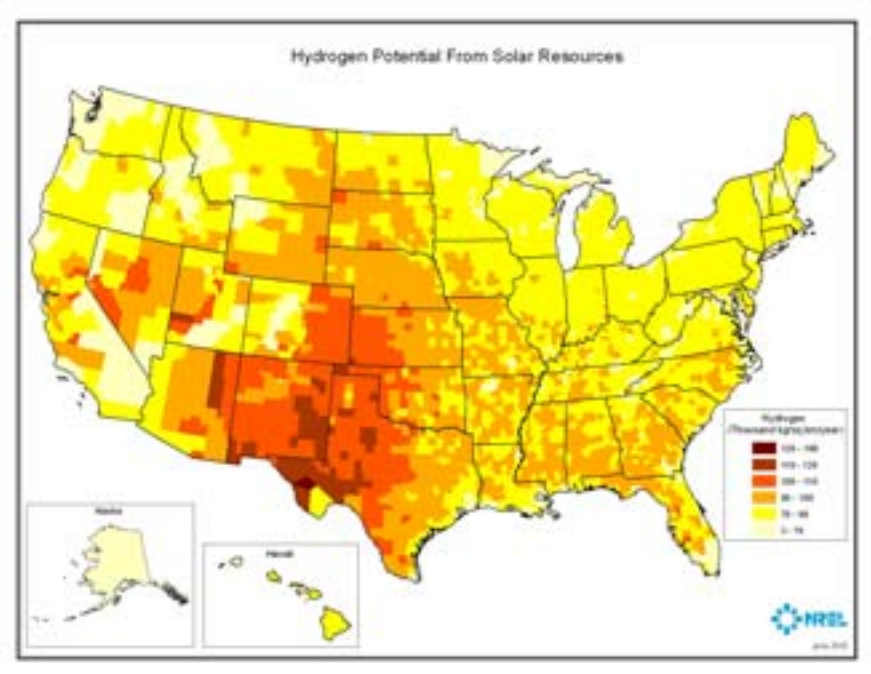
- Transition strategy
- "Well-to-wheels" greenhouse gas emissions substantially less than gasoline hybrid-electric vehicle
- Not a long-term source for hydrogen (imports and demand in other sectors)

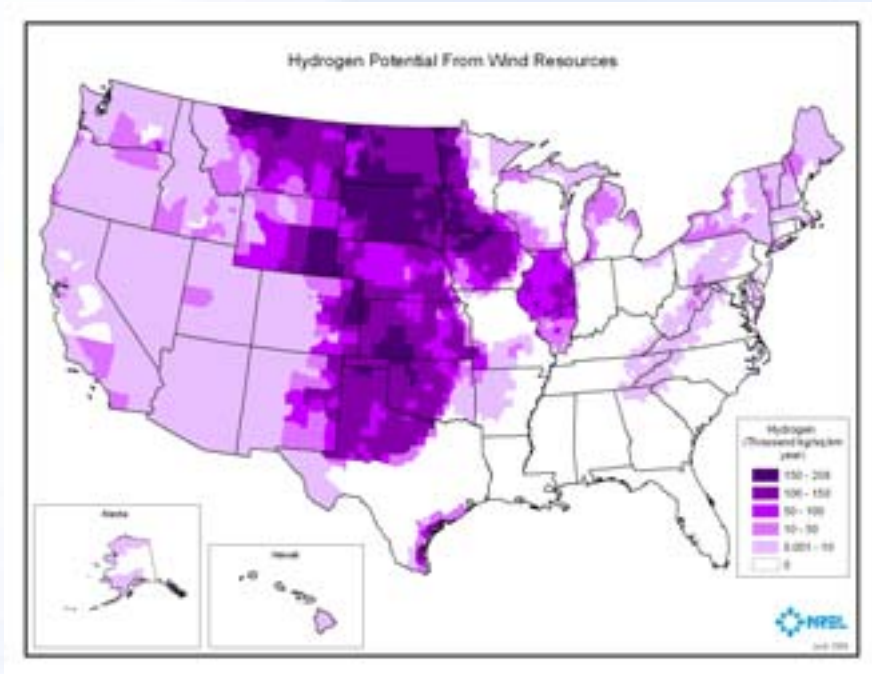
Nuclear/Renewable

- Electrolysis (one option)
- Electricity not necessarily produced as an intermediary, options being pursued include:
  - Gasification of biomass
  - Reforming of renewable liquids
  - Photoelectrochemical
  - Photobiological
  - Thermochemical (solar and nuclear)



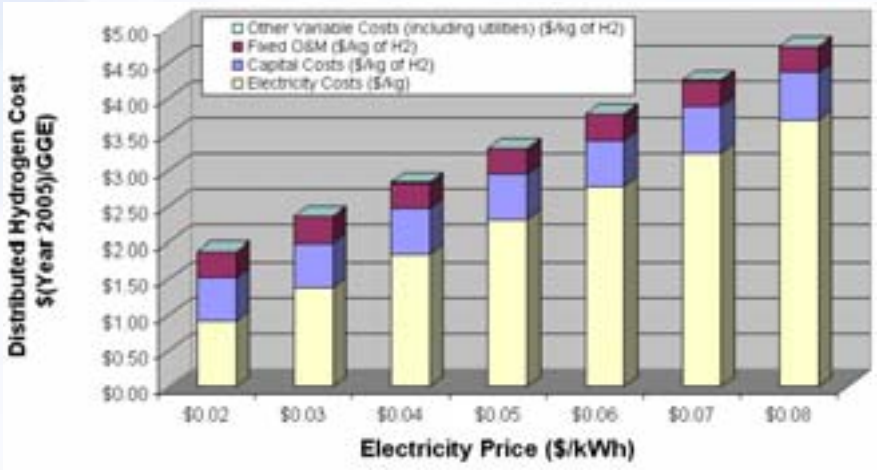
Wind and Solar Energy Potential

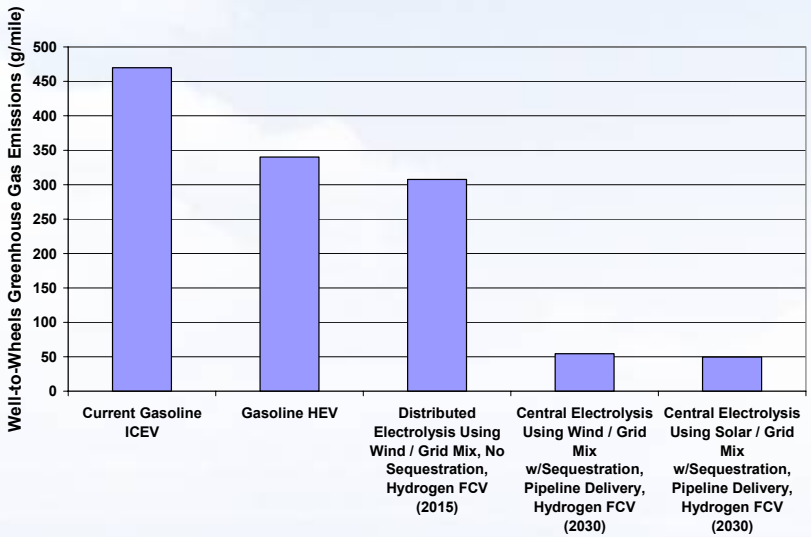




- The “Solar and Wind Technologies for Hydrogen Production” report was submitted to Congress as required by Section 812 of the 2005 Energy Policy Act
- The report shows that wind and solar energy sources for producing hydrogen are present in many parts of the country
- The report is available at www.hydrogen.energy.gov/congress_reports

Effect of Electricity Price on the Cost of Hydrogen and Greenhouse Gas Emissions





- The Report to Congress shows that the cost of electricity is the dominant component in the cost of hydrogen via electrolysis
- Using renewable electricity sources for producing hydrogen has a profound effect on green house gas emissions
- Hydrogen Utility Group members can be key to using this capability

Electrolysis R & D Status and Goals of the Hydrogen Program.

Electrolysis Barriers

- Low cost materials and high efficiency system designs
- Integrated compression
- Integrated wind power/electrolysis systems

Recent Electrolysis Achievements

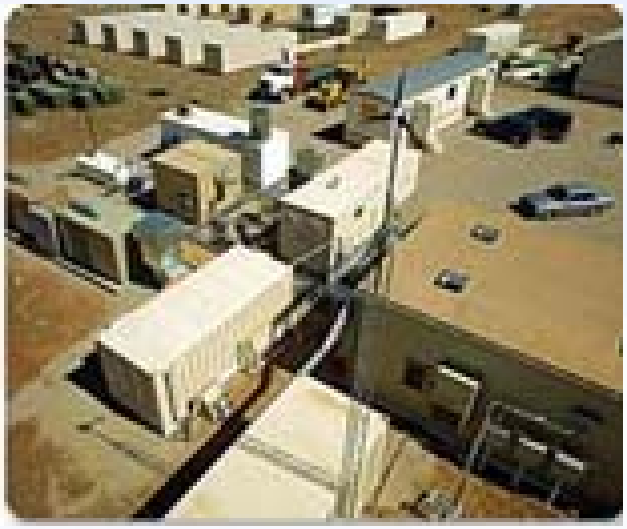
- 2000 psi H2 production in planar electrolysis stack
- Developed new system designs with 40-50% part count reduction
- Novel stack design for alkaline system on track for achieving a hydrogen production cost of $2.85/gge by 2010.

Teledyne Electrolyzer

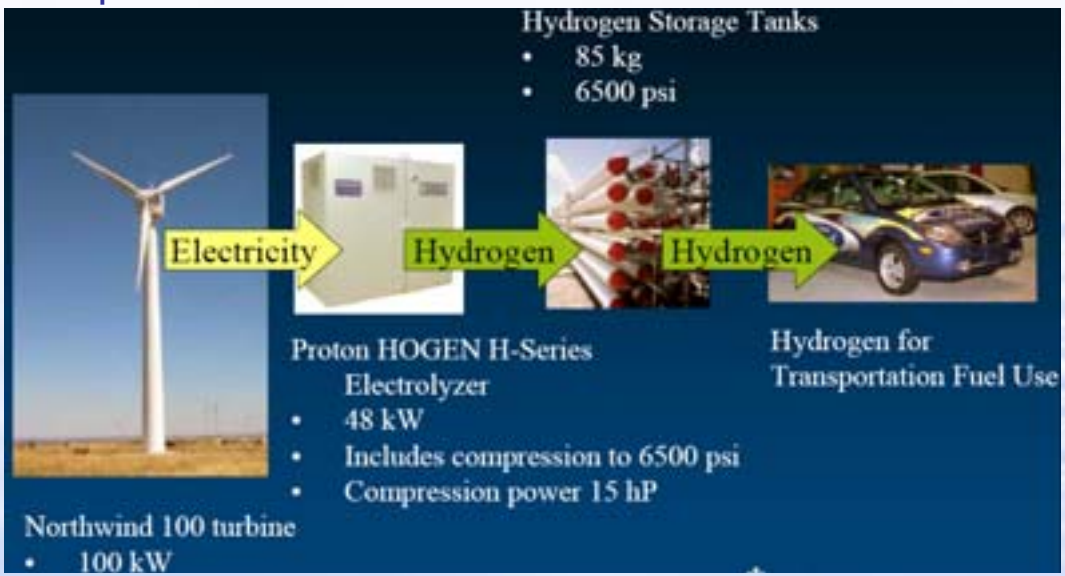
Electric Power to Hydrogen from Renewable Power

Renewable Electrolysis Integrated Systems Development and Testing

- Examines the issues with using renewable energy to produce hydrogen by electrolyzing water
- Characterizes electrolyzer performance under variable input power conditions
- Designs and develops shared power electronics packages and controllers to reduce cost and optimize system performance, and identify opportunities for system cost reduction through breakthroughs in component integration.
- Tests, evaluates, and optimizes the renewable electrolysis system performance



The NREL Wind Hybrid Test Facility at the National Wind Technology Center in Colorado



Existing Power Parks Projects

DTE Energy Hydrogen Technology Park in Southfield, MI

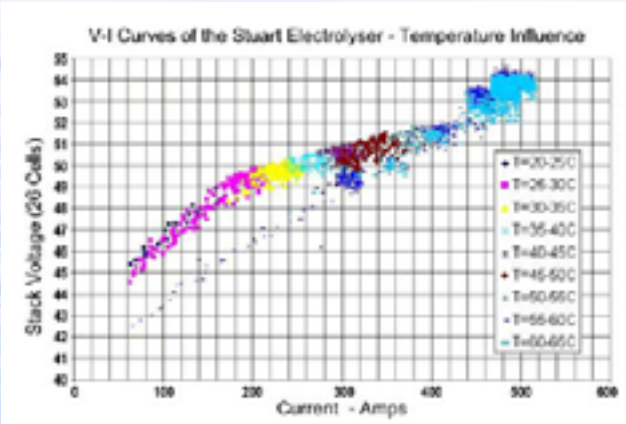
- Hydrogen produced by electrolysis using electricity from PV panels and grid-sourced biomass
- Hydrogen used for both fuel cell vehicle refueling and for operating stationary fuel cells

Arizona Public Service Power Park

- The system has been in operation for 4 years
- Over 8,100 kg of hydrogen produced from an Electrolyzer and 7,000 vehicle fueling events
- Over 14,000 kWhrs of electricity produced by PEM fuel cells

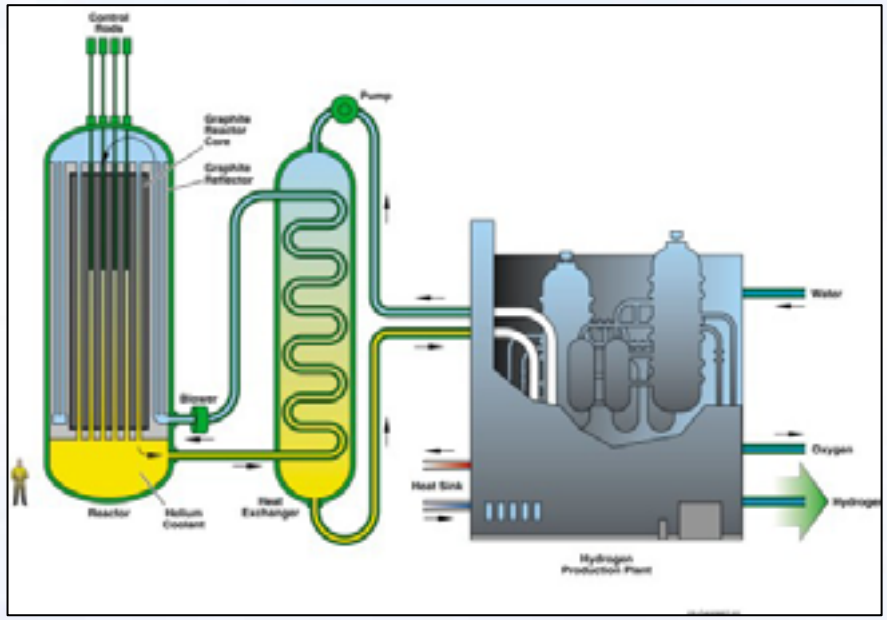
Hawaiian Electric Power Park

- Will be collecting data for fuel cell and electrolyzer components in real world settings.
- The voltage-current curve shown is for a Stuart electrolyzer being tested in Hawaii.



DOE Nuclear Hydrogen Initiative

- Focused research on production technologies compatible with advanced nuclear energy systems
  - Thermochemical
  - High Temperature Electrolysis
- In the near term, the Energy Policy Act of 2005 requires DOE to analyze and demonstrate commercial production of hydrogen at existing nuclear power plants. A solicitation to address the EPAct economic analysis requirements is being prepared.



Update on FutureGen

December 6, 2005- Secretary of Energy announces that DOE and the FutureGen Industrial Alliance signed agreement to build FutureGen

- Alliance formed & has initial capital
- 8 charter members
- Open membership policy with an active recruiting effort
- Will produce both electricity and H_2 with near zero emissions (including CO_2)
- Output of 275 MWe, 1 million metric tonnes of CO_2/year
- Cost: $950 million [private sector $250 M and gov't $700 M]
- To begin operating in 2012

DOE's Work with HUG Members

HUG members as partners in experimentation and testing wind and solar power electrolysis systems

- NREL and Xcel Energy have started this at the NREL Wind Test Site
- DOE intends to pursue more projects addressing renewably powered electrolyzer systems such as:
  - Scale up to 1MW electrolyzers
  - Evaluate power conversion options
  - Analyze test data for optimum systems with lowest cost
  - Next opportunity is the recently released Fuel Cell Solicitation – especially the stationary area