THE HYDROGEN UTILITY GROUP

Enabling Energy Security & Sustainability

A Means To The Hydrogen Age: *The U.S. Power Industry*

Senate Hydrogen & Fuel Cell Caucus Briefing

February 22, 2006

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Agenda

Introduction / The Hydrogen Utility Group
Frank Novachek, Xcel Energy

Power Industry Demonstrations
Ray Hobbs, Arizona Public Service

Power Industry Key Interests And Next Steps
Norm Stevens, DTE Energy

Automotive Perspective
Keith Cole, General Motors

DOE Perspective
Steve Chalk, DOE Hydrogen Program

Closure And Q&A

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US Power Industry - Natural Players in Hydrogen Age

- Energy independence & sustainability interests
- Existing infrastructure and know-how
  - Physical assets
  - Regulatory structures
- Effective existing mechanisms for integrating public policy and energy needs
- Service territory structure promotes national alliances and systematic learning
- Over a century of success balancing conflicting needs (e.g., society, customers, costs & environment)

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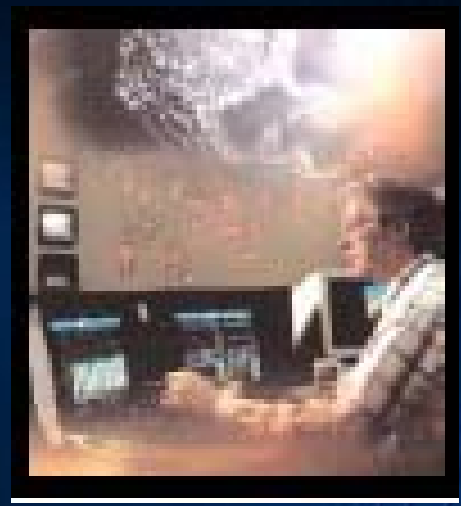
Vested Interests

- Opportunity to levelize electric demand, thus improving asset use and value to customers
- Potential synergies from co-generation of hydrogen and electricity
- New rationale for supporting the advancement of sustainable technology/system investments
- Fuel cells create new opportunities and challenges for utility systems



Both Hydrogen and Electricity are standard carriers that improve energy's utility to society

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The Hydrogen Utility Group

- Founded in October 2005 by:
  - Arizona Public Service
  - DTE Energy
  - Entergy
  - Fort Collins Utilities
  - Nebraska Public Power District
  - New York Power Authority
  - Sacramento Municipal Utility District
  - Southern Company
  - Xcel Energy
- With significant support from:
  - Department of Energy and NREL
  - Electric Power Research Institute
  - National Hydrogen Association
- Membership

  Membership is open to electric and combined electric/gas utilities and others as approved by the Steering Committee

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Reasons We Joined Together

- Power companies are looking for ways to better serve their customers' future energy needs
- Hydrogen system integration efforts can be aided by the sharing of data / lessons learned between companies
- Common questions to the power industry are best considered collectively, rather than individually

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Mission

To accelerate utility integration of promising hydrogen energy related business applications through the coordinated efforts and actions of its members, in collaboration with key stakeholders, including government agencies and utility support organizations

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Objectives

- Create a forum where utilities:
  - Share hydrogen experiences and lessons-learned
  - Build common interest business cases
  - Identify critical R&D needs, opportunities, and priorities
- Provide input to various existing and future roadmaps and R&D programs
- Facilitate utility collaborations
- Develop relationships with other hydrogen-electric stakeholders

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Answers Are Needed

- Synergies from co-generating hydrogen and electricity
- Other utility system (customer) benefits
- New energy conversion options
- Strategic options along the hydrogen value chain
- Electrons over power lines vs. protons through pipelines
- Other societal benefits enabled by hydrogen

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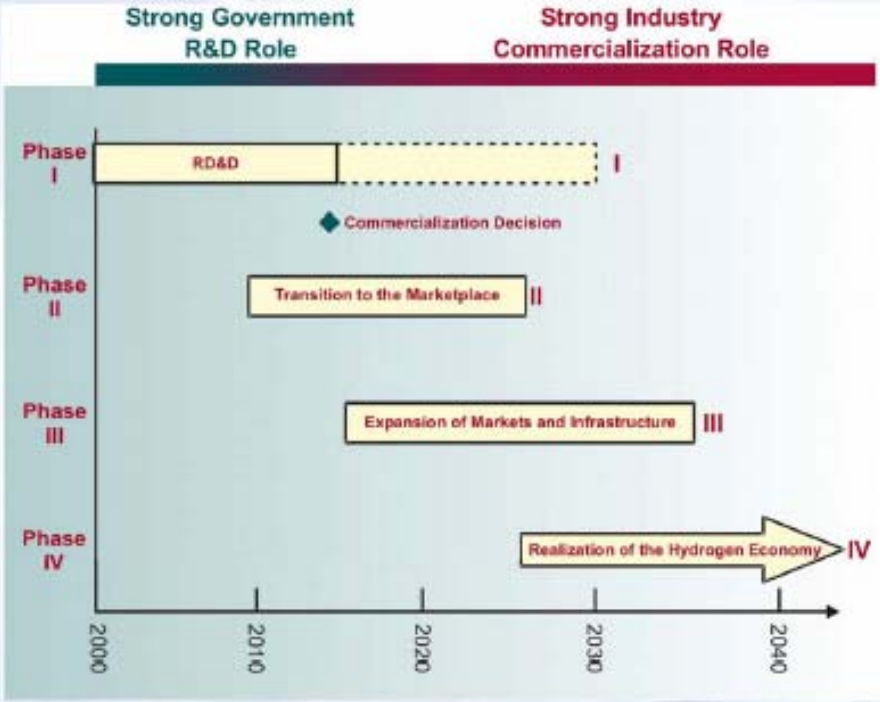
The National Hydrogen Timeline

Timeline for Hydrogen Economy



Transitional Phases

I. Technology Development Phase
Research to meet customer requirements and establish business case lead to a commercialization decision

II. Initial Market Penetration Phase
Portable power and stationary/ transport systems begin commercialization; infrastructure investment begins with governmental policies

III. Infrastructure Investment Phase
H_2 power and transport systems commercially available; infrastructure business case realized

IV. Fully Developed Market and Infrastructure Phase
H_2 power and transport systems commercially available in all regions; national infrastructure

Positive commercialization decision in 2015 leads to beginning of mass-produced hydrogen fuel cell cars by 2020

Summary

- The power industry is inherently aligned with the nation's objectives for energy security and sustainability
- The more power industry involvement now, the more likely the hydrogen infrastructure will be ready when needed
- Collaboration to address common issues makes sense
  - Diverse perspectives will improve the quality of the resultant hydrogen infrastructure

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POWER COMPANIES

Create and integrate energy systems to support society and communities

Teaming with:

- Equipment manufacturers to create specification and performance requirements
- Community planners, developers, and businesses
- Community safety officials (e.g., fire officials, police, building inspectors)
- Elected officials in matters of energy

From the nuclear plant …to helping light the family Christmas tree…power companies are there every day, safely bringing energy to each person in our communities.

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POWER COMPANIES

TODAY

- Hydrogen - Fuel Cell pilot programs underway
- Effectively use no imported petroleum to produce electricity
- Renewable energy
  - Wind
  - Solar
  - Hydro
  - Biomass
- Renewable Portfolio Standards
  - 24 States now have RPS requirements for electric supply
- Producing hydrogen from renewable energy

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ARIZONA PUBLIC SERVICE HYDROGEN PILOT IN DOWNTOWN PHOENIX

- 8,100 Kg of H2 produced from distributed water electrolysis
- 324 H2 fueling events
- 1,648 H2 – NG blend fueling events
- 7,000 total public fueling events (H2, CHyNG, CNG)
- 47,000 kwh of electricity produced
- 0, zip, nada - accidents or near misses

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BRITISH COLUMBIA HYDRO HYDROGEN & FUEL CELL PROGRAM

- H2 Distributed Electrolysis Vehicle Fueling Station: 5,000 and 10,000 psi
- Developed 10,000 psi on-board fueling system; partnering with Ford, Toyota, Nissan, DaimlerChrysler, Hyundai, PSA Peugeot
- Vancouver 2010 Winter Olympics coordinating use hydrogen/fuel cells in venues
- Fuel cell Telecom UPS system; increased backup time from 8 hours to 8 days
- Developed the “Hydrogen Highway” concept and trademarked the term in the U.S. and Canada
- HARP (H2 Assisted Renewable Power) for remote communities; working with GE
- Vehicles:
  - APS/BC Hydro H_2 ICE Program
    - Roush GMC trucks
  - H2 Hybrid Line Truck with grid interconnect
  - Ford Focus FC demonstration program

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BASIN ELECTRIC
HYDROGEN FROM WIND ENERGY

- Use electricity from local wind generators at a regional hydrogen production site
  - transportation fuel,
  - a fuel to provide firm schedulable (non-intermittent) power
- Phase 1 analyzed the economics and environmental impacts
- Phase 2 places the electrolyzer
- Stuart Energy system for the hydrogen refueling station
  - 2.7 kg/h
  - 100 kg of storage capacity

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DTE ENERGY
HYDROGEN TECHNOLOGY PARK

- 250kW demonstration quality
- Off-peak hydrogen generation, on-peak electric generation
- Fueled by 100% renewable generated electricity
  - 26.4kW on-site solar array
  - Balance provided by biomass-produced grid power
- 250kW electrolyzer
- 135kg on-site hydrogen storage
- Ten 5kW PlugPower fuel cells
- 3 cars/day hydrogen fueling station
- Partnered with DaimlerChrysler and BP

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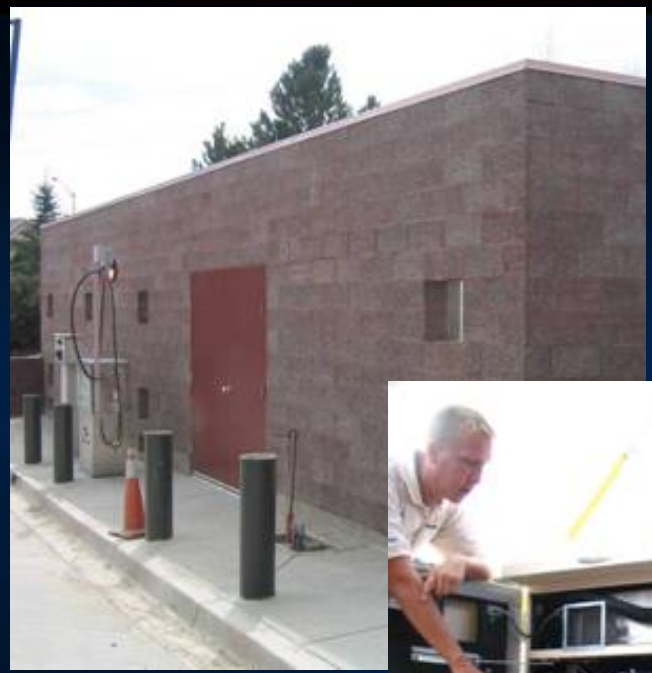
FORT COLLINS UTILITIES – COLORADO
H_2 & HYTHANE FUELING STATION AND BUSES

- Hythane® city minibus – runs on mixture of natural gas and hydrogen – low emissions
- High-Pressure electrolyzer to produce hydrogen (Avalence) using wind-purchase electricity.
- 5 kW hydrogen fuel cell for demonstrations (PlugPower)



City of Fort Collins

olorado
Governor's Office of Energy Management and Conservation

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SACRAMENTO MUNICIPAL UTILITY DISTRICT

SOLAR H_2 FUELING STATION

Home of the California Fuel Cell Partnership – Fuel Cell Vehicle Demonstration Program

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SOUTHERN CALIFORNIA EDISON PILOT HYDROGEN

Fuel Cell Testing Facility

Designed specifically to test stationary and transportation fuel cells up to 10kW in an environmentally controlled space.

Hydrogen Maintenance Bay

Designed with hydrogen detectors, ventilation, and fire-safety devices. Shown is a DiamlerChrysler F-Cell FCEV.

Hyundai•KIA FCEV Testing

Up to ten Hyundai•KIA FCEVs will be tested in the SCE fleet as part of DOE demonstration project.

Rosemead H2 Energy Station

- U.S. Department of Energy demonstration project
- Chevron (lead), Hyundai•KIA Motors, UTC Fuel Cells and SCE (site-owner)
- On-site alkaline electrolyzer
- Dispensing Ability (40 kg/day)
- Storage capacity (60 kg)
- One dispenser to fuel up to 10 FCEVs at 5,000 psi

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XCEL ENERGY WIND 2 H_2 PROJECT

Xcel Energy®

XCEL ENERGY: OUR NEXT GENERATION...

GETTING MORE OUT OF WIND

Using wind power to produce electricity
Generating the fuel of the future (hydrogen)

Wind Turbine

Making Hydrogen off-peak using electrolysis

Storing Hydrogen

Using Hydrogen for:
- *On-peak grid power*
- *Vehicles of the future*

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SOUTHERN COMPANY FUTUREGEN PROJECT

- Collaborative government-industry funded project to design, build, and operate a nominal 275 MW prototype plan to produce electricity and hydrogen from coal
  - Sequester 90% of CO_2 emissions
  - Generate electricity with less than 10% cost increase compared to nonsequestered systems
  - Make hydrogen at a cost competitive to alternatives
- FutureGen Industrial Alliance members: AEP, BHP Billiton (Australia), CONSOL Energy Inc., Foundation Coal, China Huaneng Group (China), Kennecott Energy, Peabody Energy, and Southern Company
  - Issue a site selection solicitation in early 2006, and make a final site selection in mid to late 2007
  - Initiate operations around 2012

DOE's Artist Concept of the FutureGen

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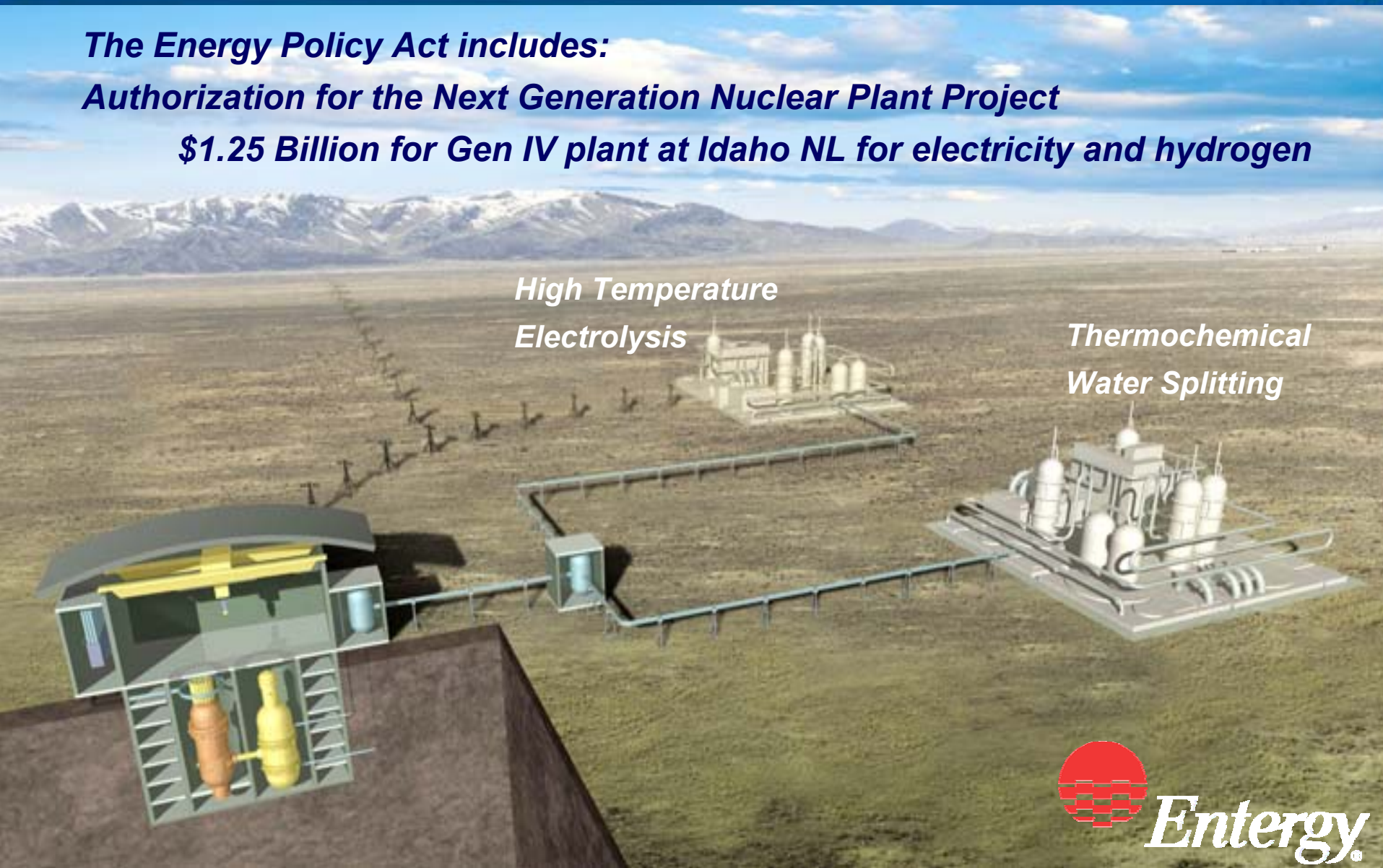
ENTERGY
NEXT GENERATION NUCLEAR PLANT

The Energy Policy Act includes:

Authorization for the Next Generation Nuclear Plant Project

$1.25 Billion for Gen IV plant at Idaho NL for electricity and hydrogen



Entergy

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LESSONS LEARNED FOR THE NEXT STEP

- Safe practices to use hydrogen as fuel in our cars, and backup electricity
- Developing distributed hydrogen integrated systems and techniques relying on efficient and economical use of existing infrastructure
- Defining future role of power companies in the developing hydrogen economy
  - Determine demand for hydrogen
  - Co-production of hydrogen and electricity
  - Efficiency goals for integrated systems and consumer products
  - Regulatory bodies
  - Issues of liability and responsibility
  - Insurance and mitigation steps
- Creating a future vision

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Historical Perspective

- The U.S. Power Industry has over 100 years of experience in creating integrated conduits in all of America's communities
  - "Core" business – Electricity/Steam
  - National infrastructure
  - A diverse portfolio of "sustainable" U.S. energy resources
- Power companies are major hydrogen players today and have advanced Fuel Cell Development and the Hydrogen Economy for over 10 years
- Power companies have been reliable team players with local, state and federal governments
- The U.S. Power Industry is second to none in meeting our customers' energy needs *with native resources*

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Our Experience Tells Us …

- The U.S. Hydrogen Program will require the support and involvement of the U.S. Power Industry
  - Nuclear Hydrogen Initiative
  - Hydrogen from Clean Coal
  - Hydrogen from renewables
  - Distributed hydrogen from electrolysis
  - Hydrogen distribution from central stations
- Our expertise in systems integration makes us an effective partner in enabling the nation to:
  - Move away from petroleum dependence, and
  - Create a Hydrogen Economy with energy security and sustainability

DOE Hydrogen Program

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Business Interests

- Understanding of potential business environments
- Value opportunities created by hydrogen-electric synergies
- Demonstration and development of technologies and systems
  - Electrolysis (small and large distributed systems)
  - Co-production of electricity and hydrogen
  - Hydrogen Delivery (transmission and distribution)
  - New energy conversion technologies
- Early identification of commercialization issues

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Potential Electric Demand

When 20% of all light duty vehicles are running on hydrogen …

Additional electricity to supply via electrolysis:

490 terawatt-hours (*NREL*)

Existing unused off-peak electricity available (emissions aside):

368 terawatt-hours *(Accenture)*

Existing electric assets can accommodate the transition

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Key Issues

- Hydrogen Production Technologies
  - Cost
  - Performance
- Markets
  - Transportation
  - Stationary
- Timing
- Asset impacts & potential synergies
- Hydrogen delivery infrastructure
- Business models

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Next Steps:

- Position Power Industry to best support DOE Hydrogen Roadmap initiatives and Auto Industry commercialization
- Advance development of key technologies
  - Continue current and planned demonstrations
  - Collaborate on future demonstrations to maximize industry learning
- Develop business relationships
- Develop business models

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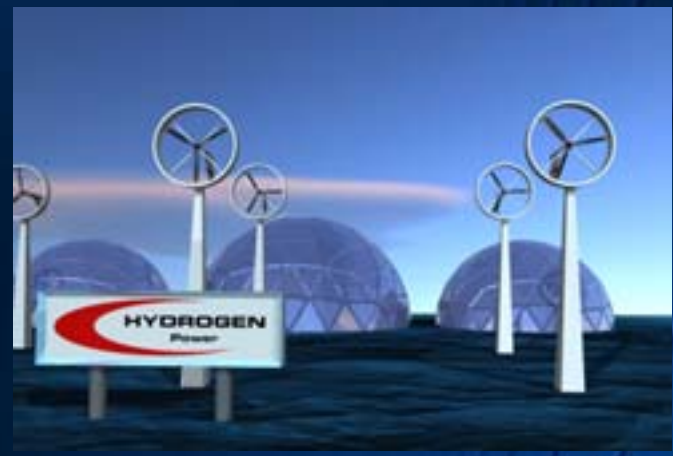
Vision For The "Hydrogen Age"- *Sustainability*

- Nation that has achieved energy security from foreign sources of fuel – *Power Industry already there*
- "Clean" centralized electric/hydrogen co-production
  - Renewables
  - Clean Coal technologies
  - Advanced Nuclear technologies
- "Clean" distributed hydrogen via electrolysis
  - Point of use production
- Hydrogen-fueled distributed energy applications
- Hydrogen transmission and distribution
  - Industrial processes
  - Electric & transportation corridors
- Hydrogen for emergencies/natural disasters
  - FC vehicles power homes & emergency centers



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Q & A

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Appendix

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Energy Content of Hydrogen

Energy Content for 1 kg (2.2 lb) of Hydrogen = 424 Standard Cubic Feet

(Reacting with oxygen to form water)

Higher Heating Value	Lower Heating Value
134,200 Btu	113,400 Btu
39.3 kWh	33.2 kWh
141,600 kJ	119,600 kJ
33,800 kCal	28,560 kCal