

Hydrogen 101

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TEXAS HYDROGEN EDUCATION
HOUSTON ADVANCED RESEARCH CENTER

MARCH 2009

HARC

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- Non-profit research organization founded in 1982 in The Woodlands, Texas
- Sustainable development mission, including technologies and policies in energy, transportation, air quality, and ecosystems.
- **Texas Hydrogen 101 Project** aims to increase basic knowledge and awareness of hydrogen and fuel cell technologies.
- Funded by DOE, HARC is working with the Texas H₂ Coalition and the State Energy Conservation Office (SECO)
- Engaging Clean Cities programs in major Texas cities and other interested organizations

Presentation Outline

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- Hydrogen – basic characteristics
- Production – how it's made
- Use – range of current and future applications
- Safety – basic safety factors
- Fuel cells – primary emerging use
- Texas – hydrogen and our state

What is it?

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- Hydrogen: a gas that is the simplest and lightest element, **lighter than air**
- **Odorless**, non-toxic
- Burns without a visible flame
- Rarely found by itself
- Can be stored in a **gaseous** (compressed) or **liquid** form (cryogenic)
- Found in organic compounds – the “H” in hydrocarbons
- Widely used in the refining, food, and various other industries
- An **energy carrier**, not a primary energy source

Texas and H2 Factoids

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- Texas is the largest hydrogen producer state in the U.S.
 - Used for refining fuels and ammonia production
 - Large U.S. **hydrogen pipeline** network along the Gulf Coast
- Texas produces enough hydrogen annually to fuel 1.7 million light duty vehicles.
- Mostly made from **natural gas**, but also in the refining process itself
- More than 100 hydrogen fuel cells demonstrated in Texas in various applications
- Texas has the largest supply of **renewable resources** for power generation and possible hydrogen production.
- One Texas fueling station to date

Production Methods

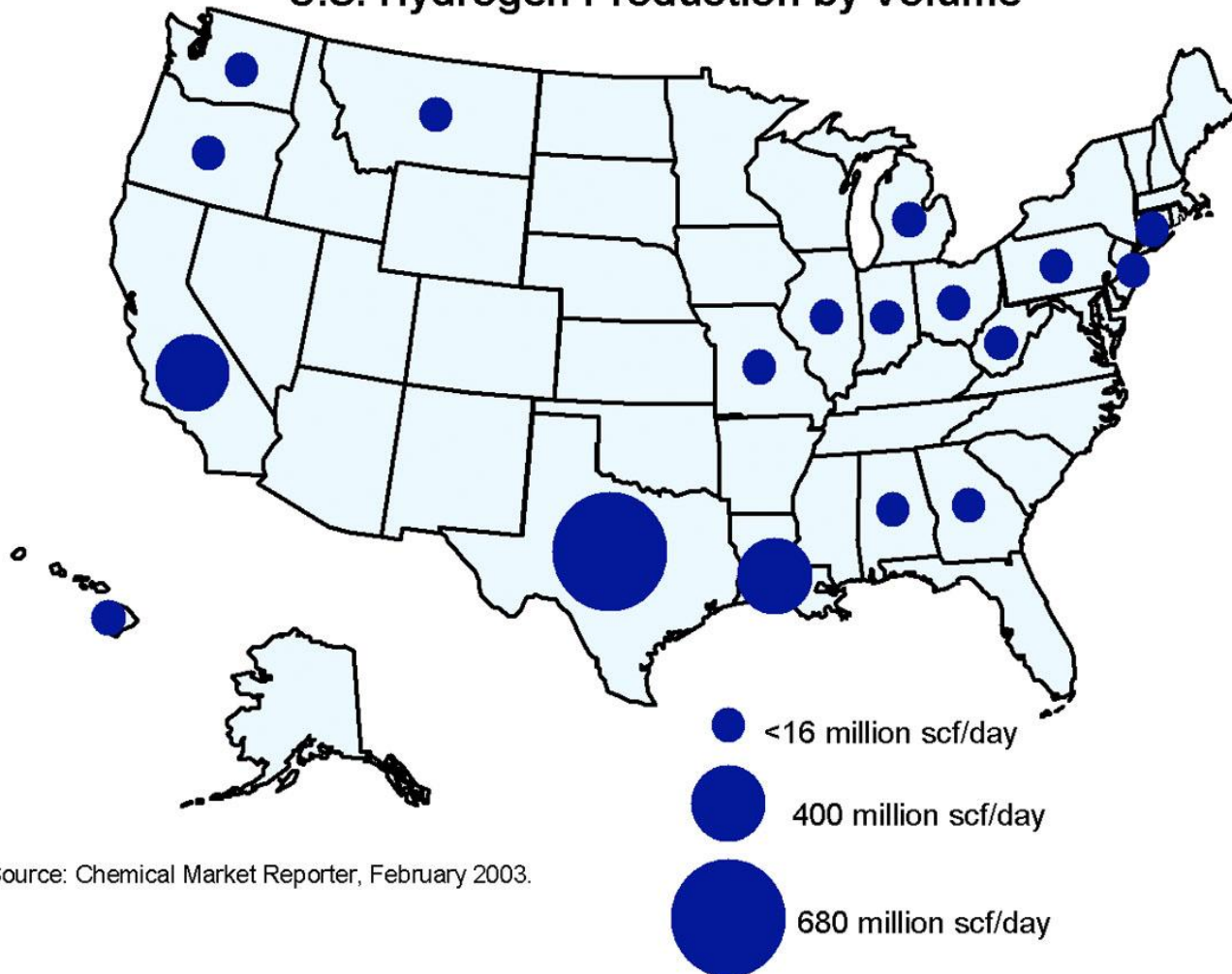
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- Natural gas steam reforming
- **Electrolysis** splits hydrogen and oxygen molecules in water. Electricity sources in Texas can include:
 - Solar
 - Wind
 - Biomass
 - Coal
 - Nuclear
 - Hydro
- Other methods of hydrogen production
 - Coproduction in industrial plant, i.e., petcoke plant
 - Liquid reforming of biomass
 - Photobiological/photoelectrochemical from microbes, such as algae

U.S. Hydrogen Production

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U.S. Hydrogen Production by Volume



Source: Chemical Market Reporter, February 2003.

Hydrogen Use

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- **Transportation Power**
 - Fuel cells - FCV
 - Internal combustion engines – HICE
 - Blend with natural gas – HCNG
 - Injected with other fuels
- **Transportation Applications**
 - Light duty – automobiles
 - Buses – transit and school; shuttles and full size
 - Material handling/forklifts
- **Stationary Fuel Cells**
 - Backup/emergency power (cell towers)
 - Supplemental power
 - Prime power sources

Safety

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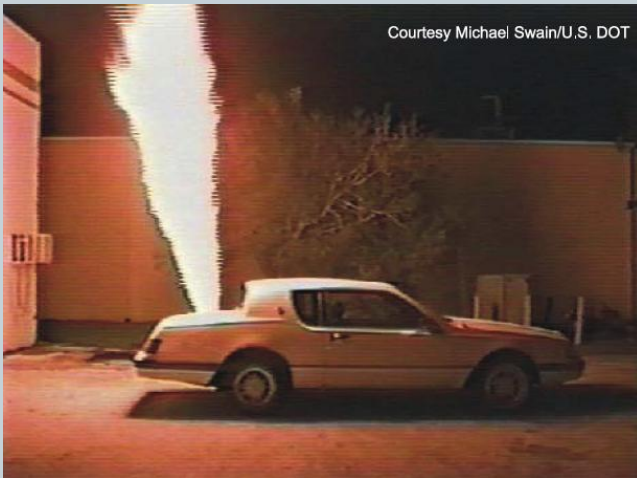
- The critical high priority issue for all fuels
- Some related hydrogen characteristics
 - Non-toxic
 - Light and disperses quickly
 - Burns without flame
 - Wider range of flammability
 - At low concentrations, ignition requirements similar to gasoline and natural gas
 - At higher concentrations, much less energy required for ignition
 - Liquefies at -423°F
- Separate technical session
- To be covered in detail in workshops

Hydrogen and Gasoline Intentional Fuel Tank Releases

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- Hydrogen can rise and diffuse quickly in unconstrained environment
- Liquid fuels can pool, spread horizontally, and vaporize

Hydrogen (l) and gasoline (r) fuel tank releases



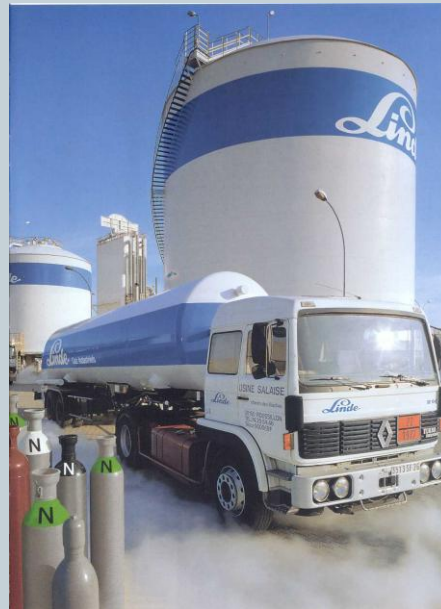
Hydrogen fuel tank release



Distribution and Fueling

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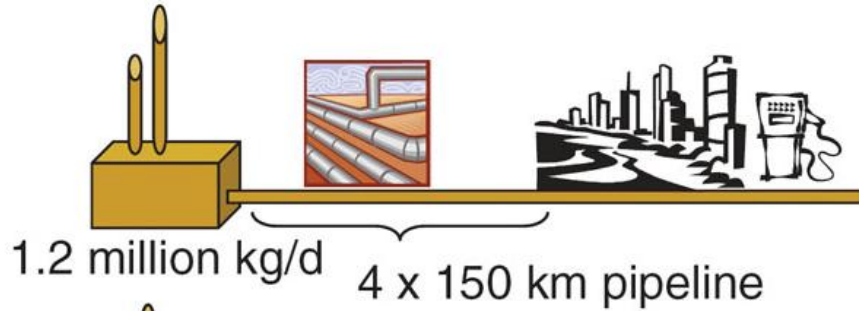
- Current Distribution
 - Cylinders
 - Tank truck/liquefied
 - Tubes/compressed
 - Pipeline



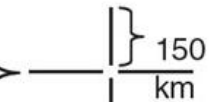
Production/Distribution/Fueling Options

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Central Station

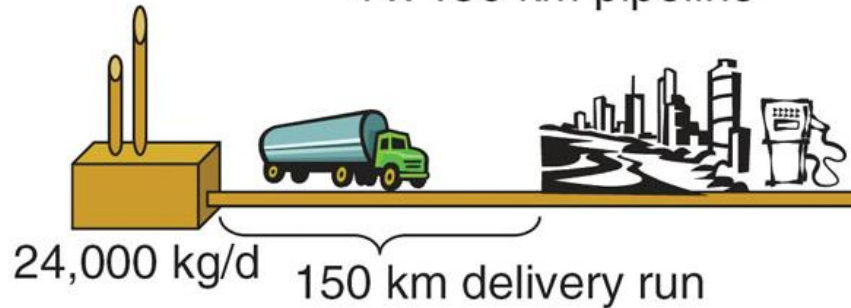


One plant for 438 filling stations

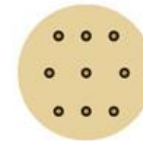


2.1 million cars

Midsized

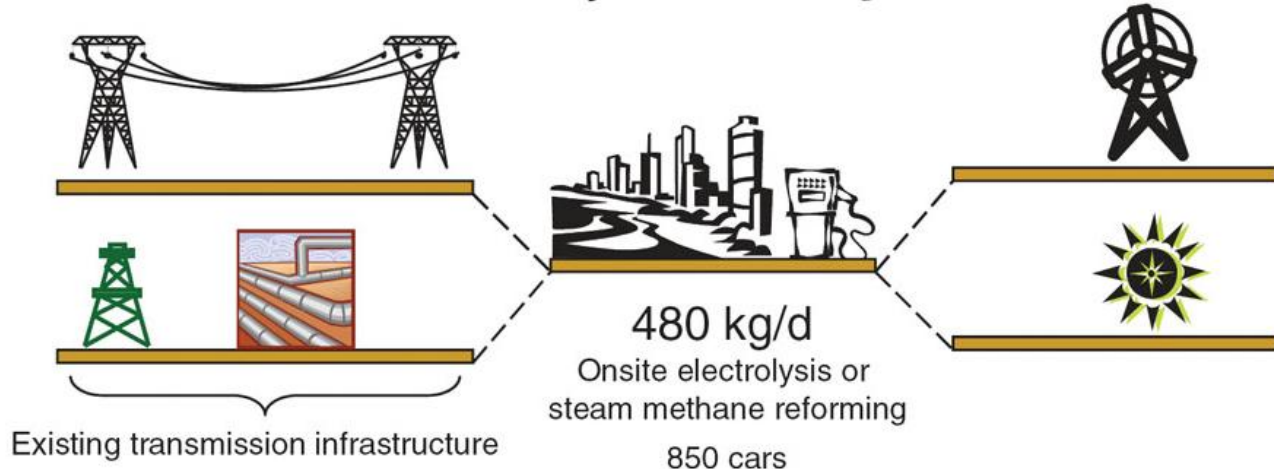


One plant for 9 filling stations



43,000 cars

Distributed



Distribution and Fueling Plans

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- Natural gas distribution to small reformers
- Electric power distribution to electrolysis
- Home refueling
- Trailer delivery to small distributed fueling stations
- Centralized production and distribution

Fuel Cells

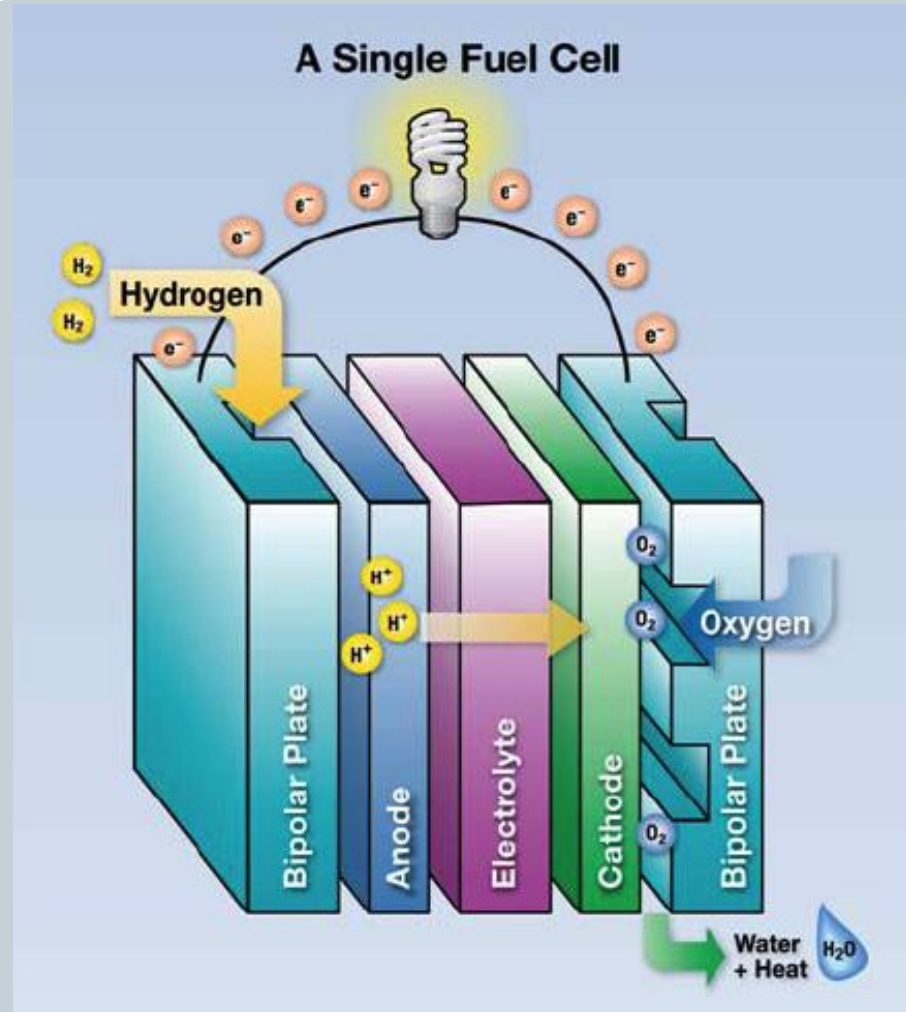
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- **Components**

- ✦ Two electrodes; cathode and anode
- ✦ Catalyst/electrolyte – causes protons and electrons to separate
- ✦ Membrane – allows only protons to pass through
- ✦ Bipolar plates – distribute gas and collect current

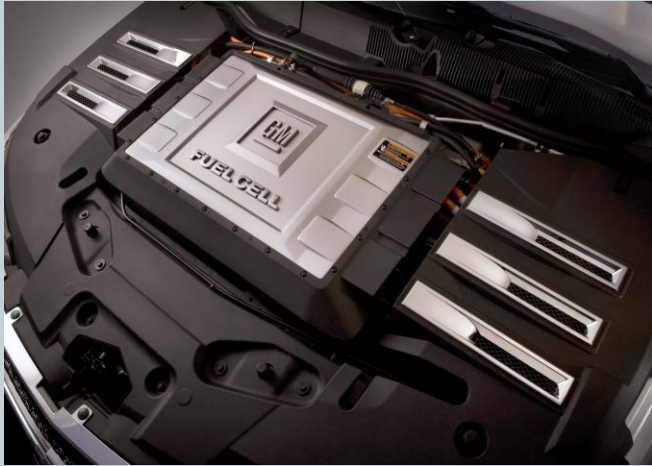
- **Process**

- Pure hydrogen flows into anode
- Electrons and protons separate
- Proton passes through membrane (proton exchange membrane or **PEM**)
- Electrons flow through external circuit
- Oxygen combines with protons to form **water**
- Process also produces **heat**
- **Electron flow is electricity** which powers lights, electric motors or other devices
- In a vehicle, fuel cells directly or indirectly power (hybrid) the electric motor or motors.



Hydrogen Fuel Cell and Fuel Tank

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Fuel cell



Fuel tanks in car trunk



Fuel tank – Honda FCX Clarity

Austin Fuel Cell Bus & Fueling

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GTI's Fuel Cell Bus In Austin, operated by the University of Texas

Fuel Cell Bus

- Ebus Fuel cell electric battery hybrid bus
- 22 feet, with 22 passenger capacity
- ADA Compliant
- Air Conditioning
- Regenerative braking
- Ballard fuel cell



Hydrogen Fueling Dispenser

- Public Style Dispenser
- Simple and Reliable Operation (GTI HydroFill™)
- Fast-fill Capability
- Card access for security or transaction management



Fuel Cell Applications

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- **Current Commercial Applications**
 - Fork lifts/material handling
 - Backup power/cell phone towers
 - Stationary applications
 - Small portable energy devices/ "battery"
- **Demonstration and Near Market**
 - Transit
 - Autos

Fuel Cell Vehicles

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- AC Transit
- 12 new buses
- Chevy Equinox
- Honda FCX
- BMW H7
- Nissan Zerotruck

Clockwise from right top



Example Fuel Cell Applications

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- Fork lift*
 - Residential
 - Commercial
 - Cell tower*
 - Small battery fuel cells
- Clockwise from left



Costs and Funding

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- Hydrogen cost
- Distribution cost
- Vehicles
- Incentives
 - Tax credits
 - Loans
 - Demonstration funds
 - Market transformation funds

Ideas for Texas Projects

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- Fleet demonstrations
- Materials handling/forklifts
- Military bases
- Backup/emergency power
- Economic development – related industries
- R&D
- Training

Contact Information

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