

Why Hydrogen?

“I believe that water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable.”

([Jules Verne](#) 1874)

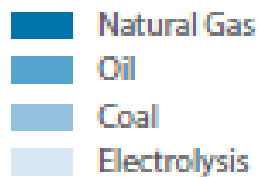
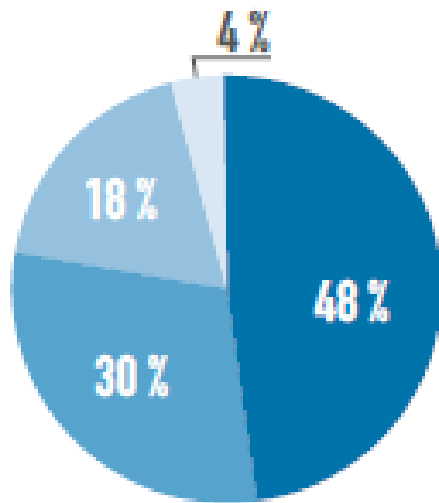
June 6, 2019

Hydrogen is a unique element

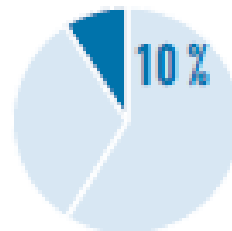
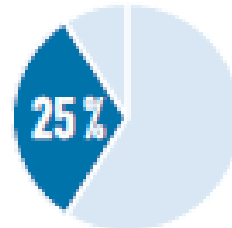
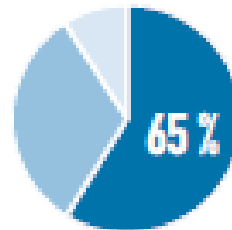
- Hydrogen is the most abundant, smallest and lightest element in the earth's biosphere
- It is not found “free” in nature but contained in water and chemical compounds (mainly hydrocarbons)
- Hydrogen combustion produces only heat and water
- Its high specific energy content (3X gasoline by wt.) makes it potentially valuable as a energy carrier (in parallel to electricity) and storage medium
- Hydrogen can be produced by electrical energy (electrolysis) and visa versa (fuel cell)
- Low carbon hydrogen can also be produced from existing hydrogen production methods with carbon capture added

Global Production is about 70 million tons/year

HYDROGEN SOURCES



PERCENTAGE OF GLOBAL H₂ DEMAND



INDUSTRY SECTOR

CHEMICAL

REFINING

IRON & STEEL

GENERAL INDUSTRY

Potential Roles of Hydrogen in a Low Carbon World - 1

Role	Need	Hydrogen Advantages
<i>Electricity and Heat Source</i>	<ul style="list-style-type: none">• Offset intermittency and seasonality of wind and solar electricity production	<ul style="list-style-type: none">• Hydrogen can be a source of continuous low carbon electricity and heat for buildings and industries
<i>Long Distance Energy Transportation</i>	<ul style="list-style-type: none">• Top ten energy importing countries import nearly 20% of global energy production• Most international energy trade is in fossil fuels	<ul style="list-style-type: none">• Hydrogen and derived compounds can be long distance clean energy carriers
<i>Large Scale Energy Storage</i>	<ul style="list-style-type: none">• 25% of annual global energy demand is held in storage to cover in-transit, buffer, and seasonal storage needs• Most storage is in fossil fuels	<ul style="list-style-type: none">• Hydrogen, via physical and material-based storage mechanisms, could be a significant clean energy storage medium

Potential Roles of Hydrogen in a Low Carbon World - 2

Role	Need	Hydrogen Advantages
<i>Transportation Fuel</i>	<ul style="list-style-type: none">• Transport large payloads over long distances or fast centralized refueling	<ul style="list-style-type: none">• High energy density fuel for heavy vehicle transportation with a favorable trade-off of power and stored energy weight versus range
<i>Industrial Fuel and Feedstock</i>	<ul style="list-style-type: none">• Steel, cement, ammonia, petrochemicals and refining are large GHG emitters	<ul style="list-style-type: none">• Clean energy replacement of fossil fuels in many industrial applications including steel production via direct iron reduction and high temperature process heat
<i>Contributor to Captured CO2 Utilization</i>	<ul style="list-style-type: none">• Carbon capture from fossil fuel fired plants will create opportunities to use CO2	<ul style="list-style-type: none">• Hydrogen can be combined with captured CO2 to produce chemicals (like formic acid, methane, methanol, and dimethyl ether) and clean liquid syn-fuels (i.e., aviation fuel)

The Houston area should be at the forefront of expanding hydrogen's role

Today's Advantage

- Large industrial base, existing infrastructure of hydrogen production and network of hydrogen pipelines and storage and large nearby natural gas production

Future Opportunities

- “Blue Hydrogen” production from existing steam reforming plants with carbon capture added
- “Green Hydrogen” production from new electrolysis plants
- Hydrogen blended into the existing natural/fuel gas systems or used in existing natural gas power plants
- Clean high temperature process heat for refining, petrochemicals, ammonia, steel and cement plants
- New production and export facilities for ammonia and liquid organic hydrocarbon carriers
- Fast fueling facilities for return-to-base LDV and HDV fleets