



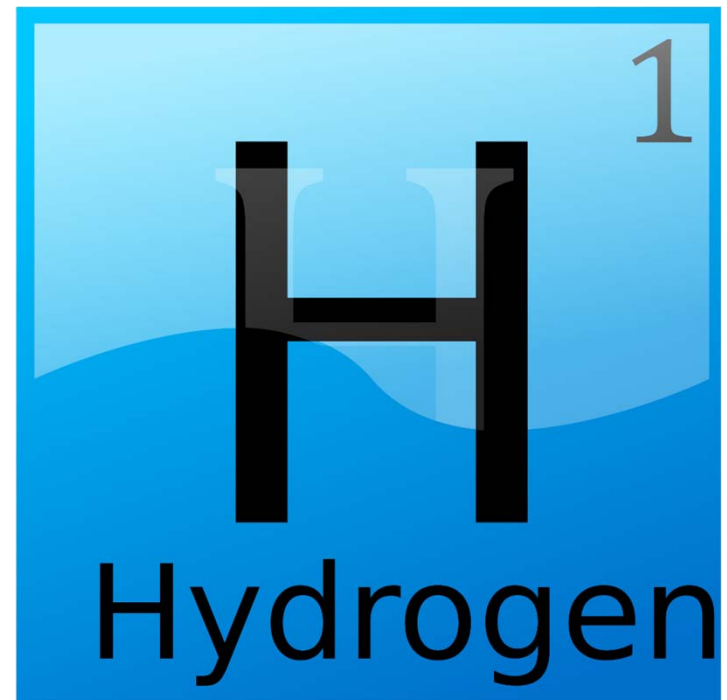
Hydrogen Breakfast #1

February 22, 2022

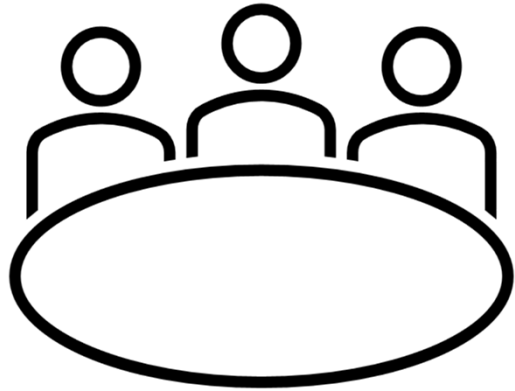


Announcements

1. Thanks to sponsors – Gas Company of NM and ConocoPhillips
2. The 4CED Newsletter – 4cornersed.com
3. The evaluation
4. The next breakfast – March 8 –
Extension of hydrogen discussion with
commercial project developments in San
Juan County
5. Introduction of Panelists



The February 22 Panelists

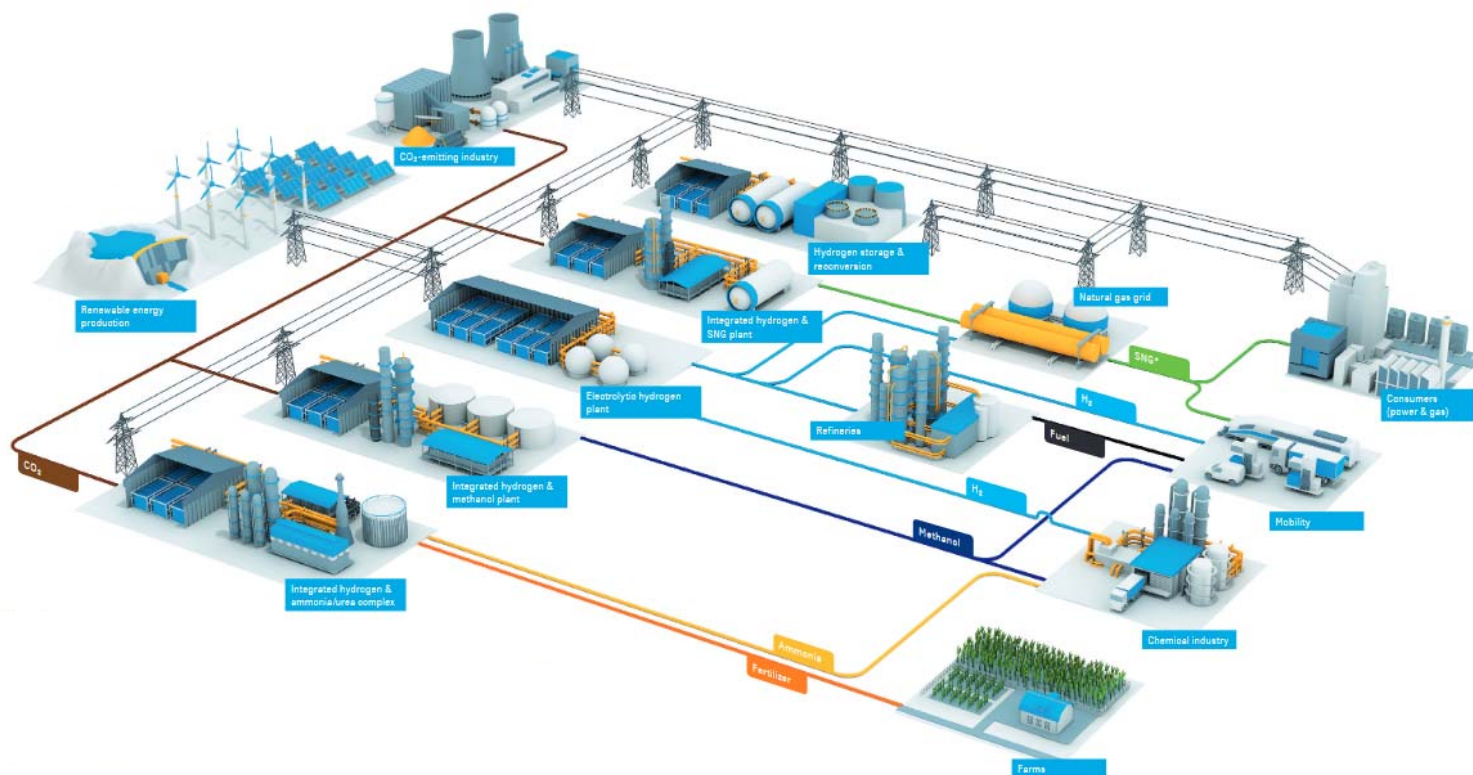


- Eric Miller – San Juan College Professor of Chemistry
- Dory Peters – CEO Big Navajo Energy
- John Byrom – Business Development, PESCO
- Chris Hunter – Cornerstone Business Solutions

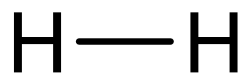
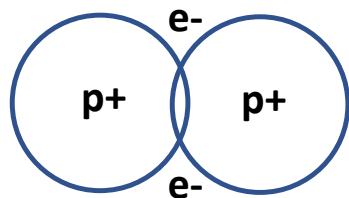
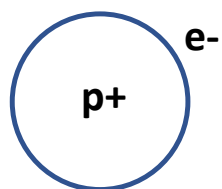
Hydrogen (and Carbon and Oxygen)

Eric Miller, Ph.D.

Professor of Chemistry San Juan College



PERIODIC TABLE OF ELEMENTS



1

H

Hydrogen

Nonmetal

3

Li

Lithium

Alkali Metal

4

Be

Beryllium

Alkaline Earth Metal

11

Na

Sodium

Alkali Metal

12

Mg

Magnesium

Alkaline Earth Metal

1

H

Hydrogen

Nonmetal

Atomic Number

Symbol

Name

Chemical Group Block

5

B

Boron

Metalloid

6

C

Carbon

Nonmetal

7

N

Nitrogen

Nonmetal

8

O

Oxygen

Nonmetal

9

F

Fluorine

Halogens

10

Ne

Neon

Noble Gas

13

Al

Aluminum

Post-Transition Metal

14

Si

Silicon

Metalloid

15

P

Phosphorus

Nonmetal

16

S

Sulfur

Nonmetal

17

Cl

Chlorine

Halogens

18

Ar

Argon

Noble Gas

19

K

Potassium

Alkali Metal

20

Ca

Calcium

Alkaline Earth Metal

21

Sc

Scandium

Transition Metal

22

Ti

Titanium

Transition Metal

23

V

Vanadium

Transition Metal

24

Cr

Chromium

Transition Metal

25

Mn

Manganese

Transition Metal

26

Fe

Iron

Transition Metal

27

Co

Cobalt

Transition Metal

28

Ni

Nickel

Transition Metal

29

Cu

Copper

Transition Metal

30

Zn

Zinc

Transition Metal

31

Ga

Gallium

Post-Transition Metal

32

Ge

Germanium

Metalloid

33

As

Arsenic

Metalloid

34

Se

Selenium

Nonmetal

35

Br

Bromine

Halogens

36

Kr

Krypton

Noble Gas

37

Rb

Rubidium

Alkali Metal

38

Sr

Strontium

Alkaline Earth Metal

39

Y

Yttrium

Transition Metal

40

Zr

Zirconium

Transition Metal

41

Nb

Niobium

Transition Metal

42

Mo

Molybdenum

Transition Metal

43

Tc

Technetium

Transition Metal

44

Ru

Ruthenium

Transition Metal

45

Rh

Rhodium

Transition Metal

46

Pd

Palladium

Transition Metal

47

Ag

Silver

Transition Metal

48

Cd

Cadmium

Transition Metal

49

In

Indium

Post-Transition Metal

50

Sn

Tin

Post-Transition Metal

51

Sb

Antimony

Metalloid

52

Te

Tellurium

Metalloid

53

I

Iodine

Halogens

54

Xe

Xenon

Noble Gas

55

Cs

Cesium

Alkali Metal

56

Ba

Barium

Alkaline Earth Metal

57

La

Lanthanum

Lanthanide

58

Ce

Cerium

Lanthanide

59

Pr

Praseodymium

Lanthanide

60

Nd

Neodymium

Lanthanide

61

Pm

Promethium

Lanthanide

62

Sm

Samarium

Lanthanide

63

Eu

Europium

Lanthanide

64

Gd

Gadolinium

Lanthanide

65

Tb

Terbium

Lanthanide

66

Dy

Dysprosium

Lanthanide

67

Ho

Holmium

Lanthanide

68

Er

Erbium

Lanthanide

69

Tm

Thulium

Lanthanide

70

Yb

Ytterbium

Lanthanide

71

Lu

Lutetium

Lanthanide

87

Fr

Francium

Alkali Metal

88

Ra

Radium

Alkaline Earth Metal

89

Ac

Actinium

Actinide

90

Th

Thorium

Actinide

91

Pa

Protactinium

Actinide

92

U

Uranium

Actinide

93

Np

Neptunium

Actinide

94

Pu

Plutonium

Actinide

95

Am

Americium

Actinide

96

Cm

Curium

Actinide

97

Bk

Berkelium

Actinide

98

Cf

Californium

Actinide

99

Es

Einsteinium

Actinide

100

Fm

Fermium

Actinide

101

Md

Mendelevium

Actinide

102

No

Nobelium

Actinide

103

Lr

Lawrencium

Actinide

104

Rf

Rutherfordium

Transition Metal

105

Db

Dubnium

Transition Metal

106

Sg

Seaborgium

Transition Metal

107

Bh

Bohrium

Transition Metal

108

Hs

Hassium

Transition Metal

109

Mt

Meitnerium

Transition Metal

110

Ds

Darmstadtium

Transition Metal

111

Rg

Roentgenium

Transition Metal

112

Cn

Copernicium

Transition Metal

113

Nh

Nihonium

Post-Transition Metal

114

Fl

Flerovium

Post-Transition Metal

115

Mc

Moscovium

Post-Transition Metal

116

Lv

Livermorium

Post-Transition Metal

117

Ts

Tennessine

Halogens

118

Og

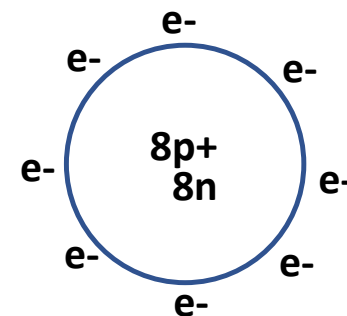
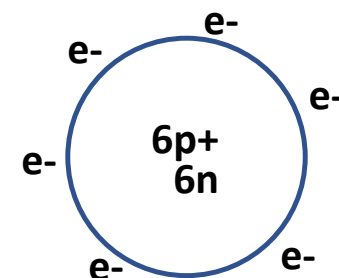
Oganesson

Noble Gas

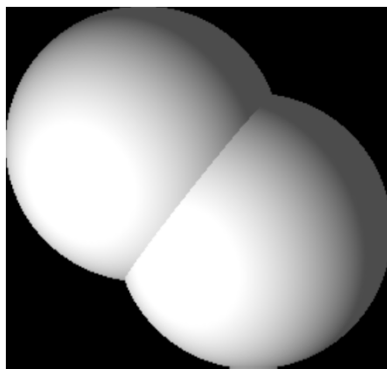
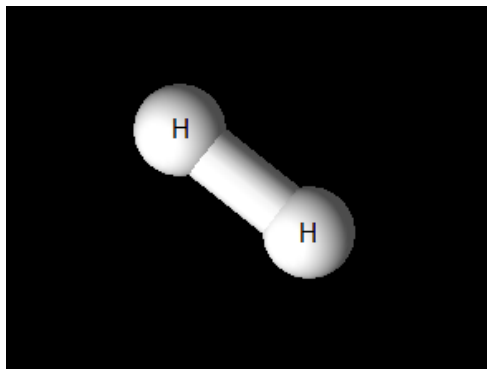
Pub

C

Chem



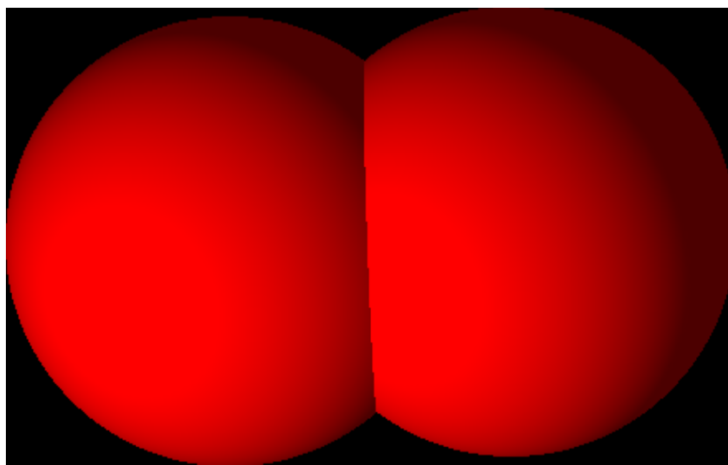
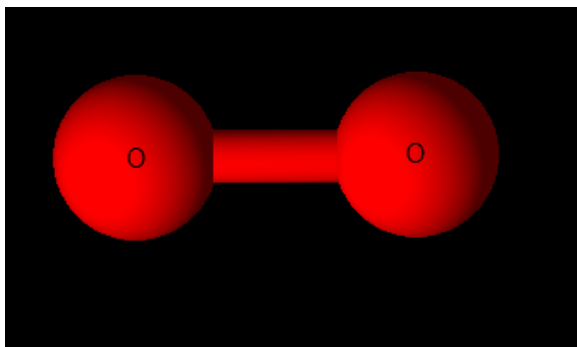
Hydrogen H₂



H-H bond enthalpy 391 kJ/mol

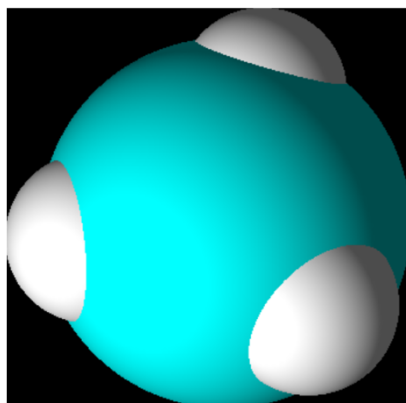
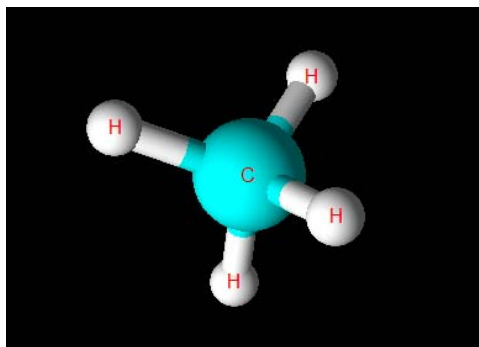
Energy required to break the bond

Oxygen O₂



O=O bond enthalpy 495 kJ/mol

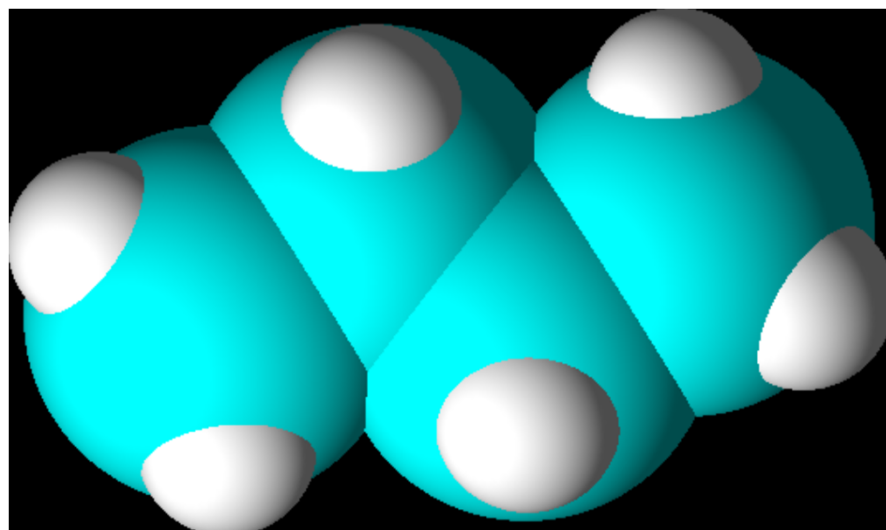
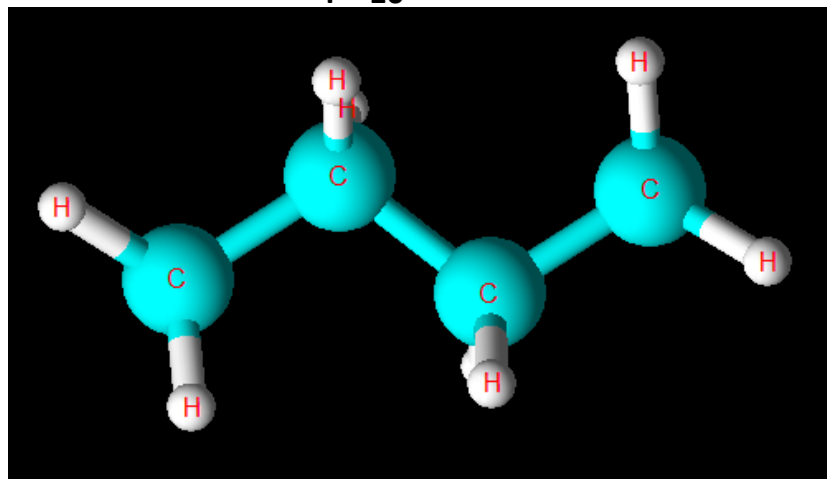
Methane CH₄



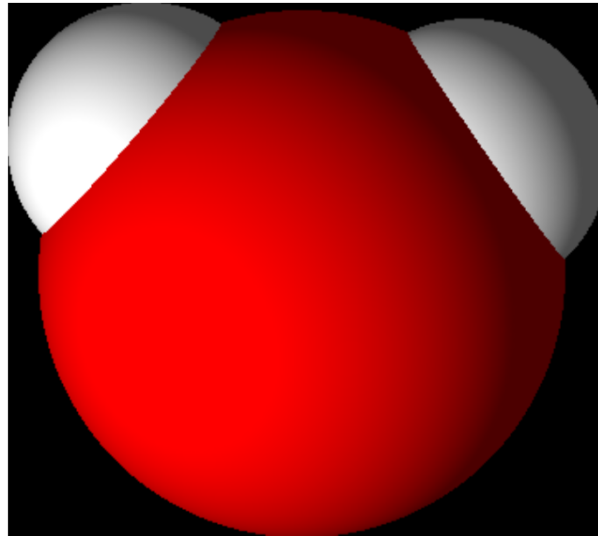
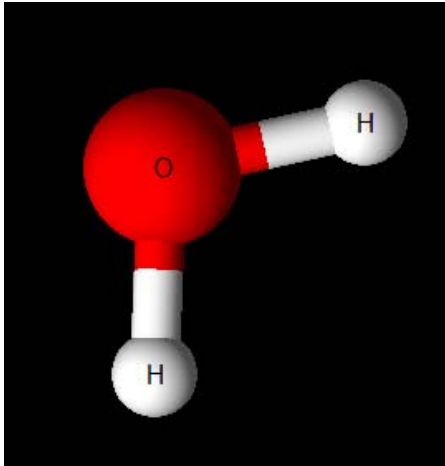
C-H bond enthalpy 413 kJ/mol

C-C bond enthalpy 348 kJ/mol

Butane C₄H₁₀



Water H₂O

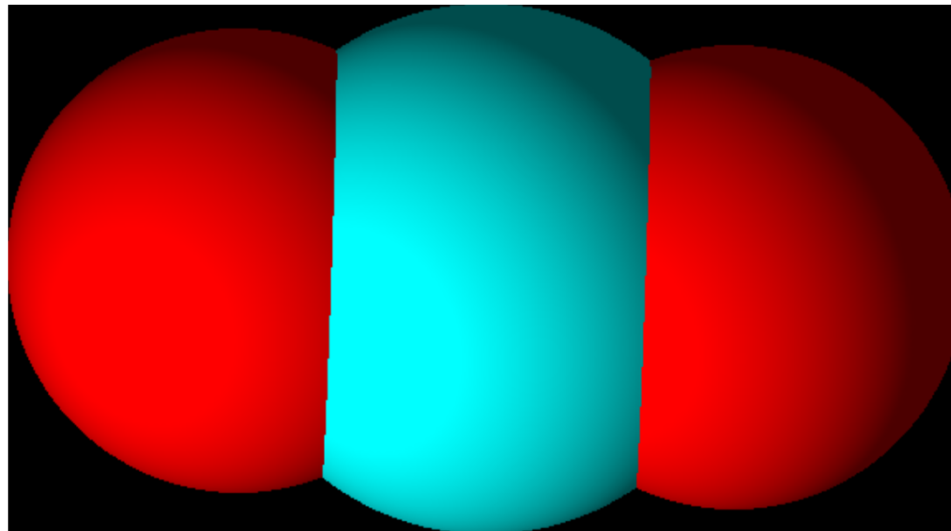
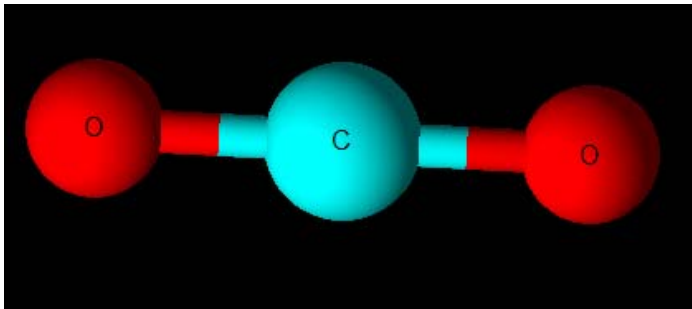


O-H bond enthalpy 463
kJ/mol
2x

C=O bond enthalpy 799
kJ/mol
2x O=C=O

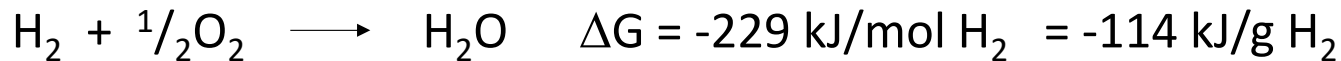
highly polar double bonds
efficient IR absorber
greenhouse gas
Svante Arrhenius 1896

Carbon Dioxide CO₂



Energy Comparisons

Combustion of hydrogen



60% efficient

Reversible

Combustion of methane



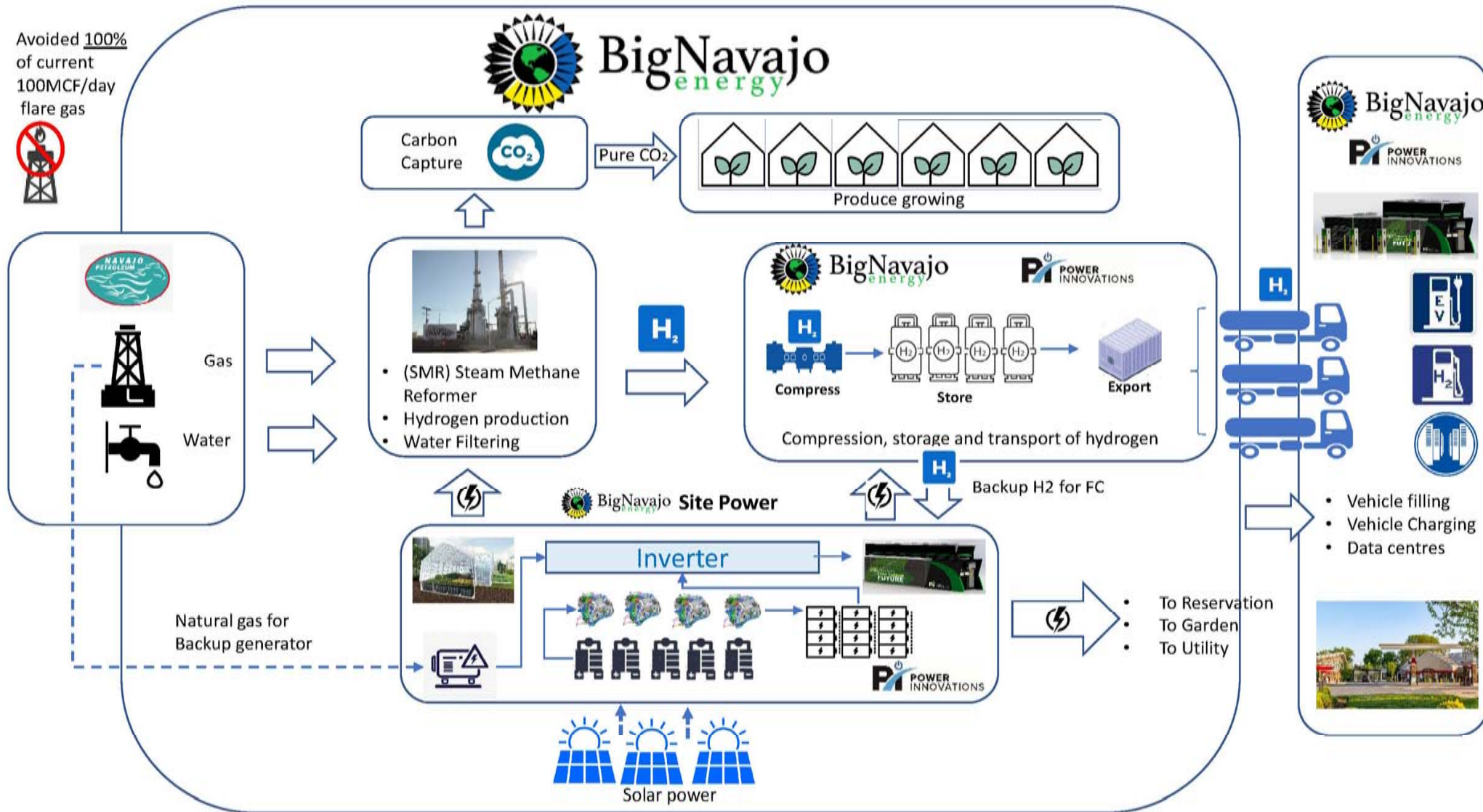
Combustion of butane



30% efficient

Not very reversible, & Other pollutants

Avoided 100%
of current
100MCF/day
flare gas



Dory Peters CEO 801-920-2376 dory@bignavajoenergy.com

Hydrogen Transportation - Present

- Tanker Truck
 - Compressed Hydrogen



<https://wha-international.com/>

- Liquid Hydrogen



Flicker

- Pipeline: short distance, plant to plant

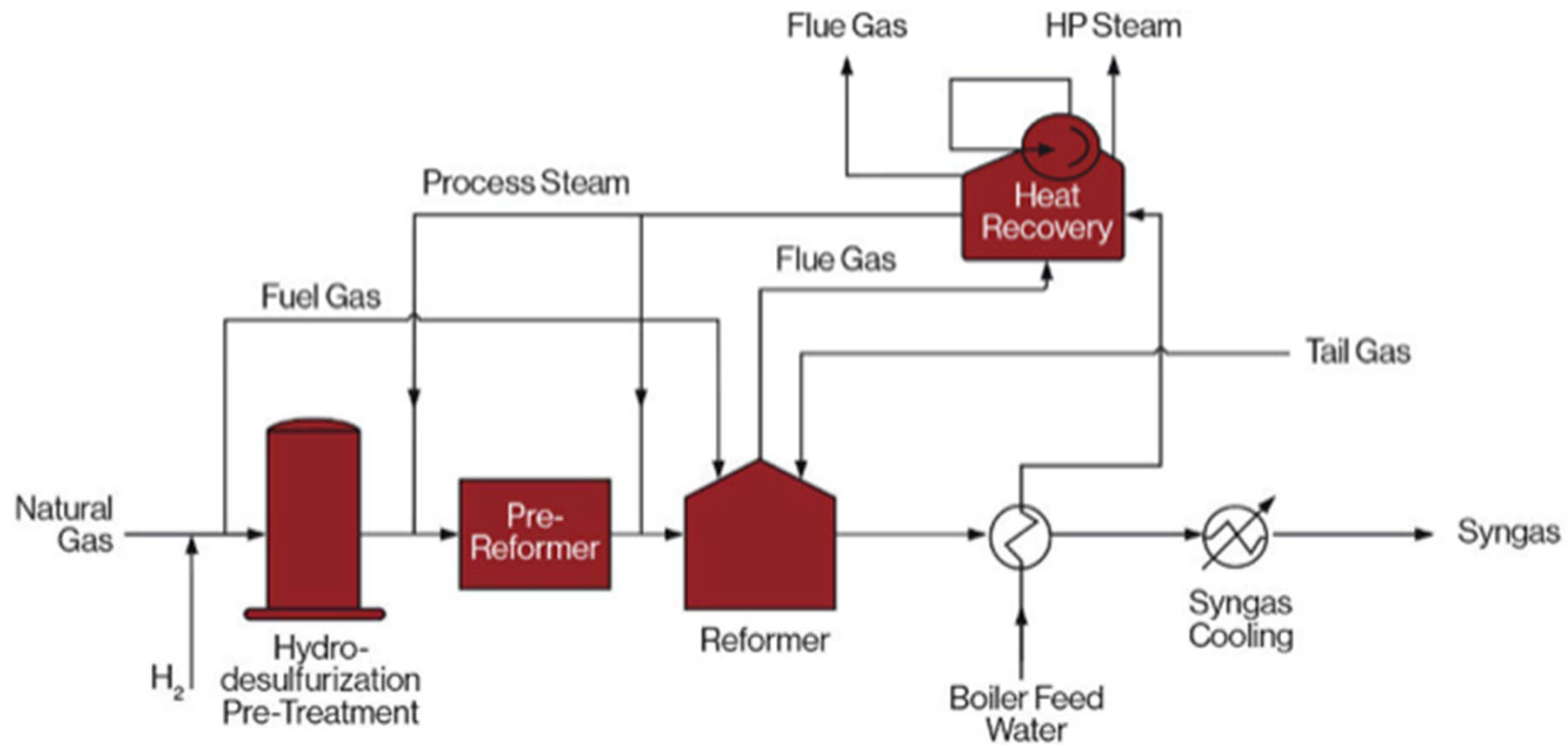


Hydrogen Transportation - Developing

- Shipping
 - Compressed Hydrogen
 - Liquid Hydrogen
- Pipeline
 - Blend in Existing Natural Gas Pipelines
 - Research regarding max concentrations and hydrogen embrittlement
- Carrier Molecule – ship as a liquid
 - Ammonia (NH_3)
 - DME (Dimethyl ether – $\text{C}_2\text{H}_6\text{O}$)



Steam Methane Reforming process



Air Liquide

Typical Hydrogen Chemical Plant



Steam Methane Reforming Plant, Germany

Air Liquide Engineering & Construction builds industry-leading plants for its customers world-wide



Hydrogen Production Systems

Ready to become a hydrogen producer? Hydrogen generation systems manufactured by BayoTech are a reliable source of locally produced low-carbon, low-cost hydrogen.

BayoTech

- Modular Hydrogen Plan
 - At the point of need
 - Minimize transportation

ZE<5/-8\$

V1>9 5- : \$

S A8@5)C 188\$

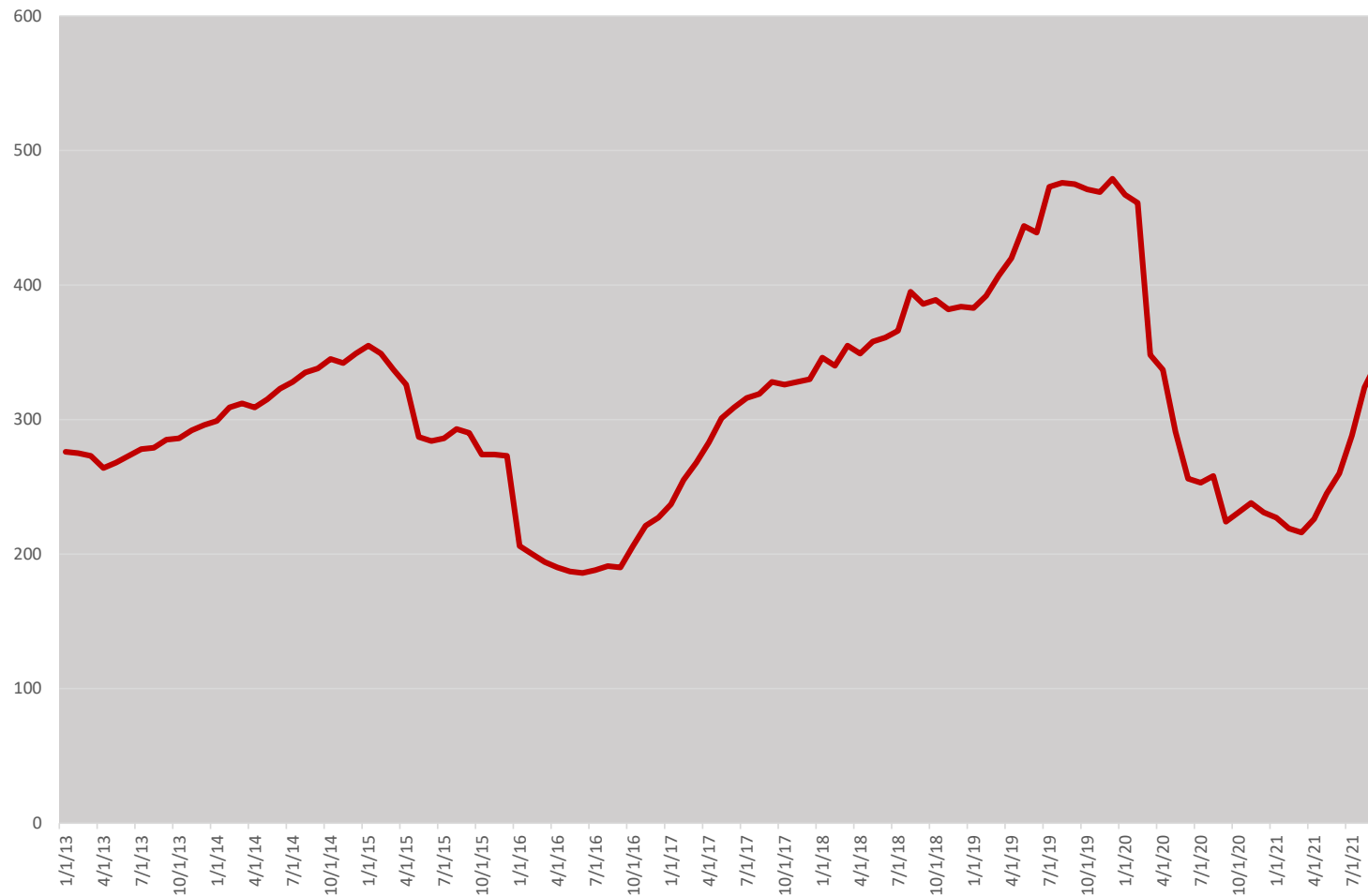
V-0



“Flatten the Curve”

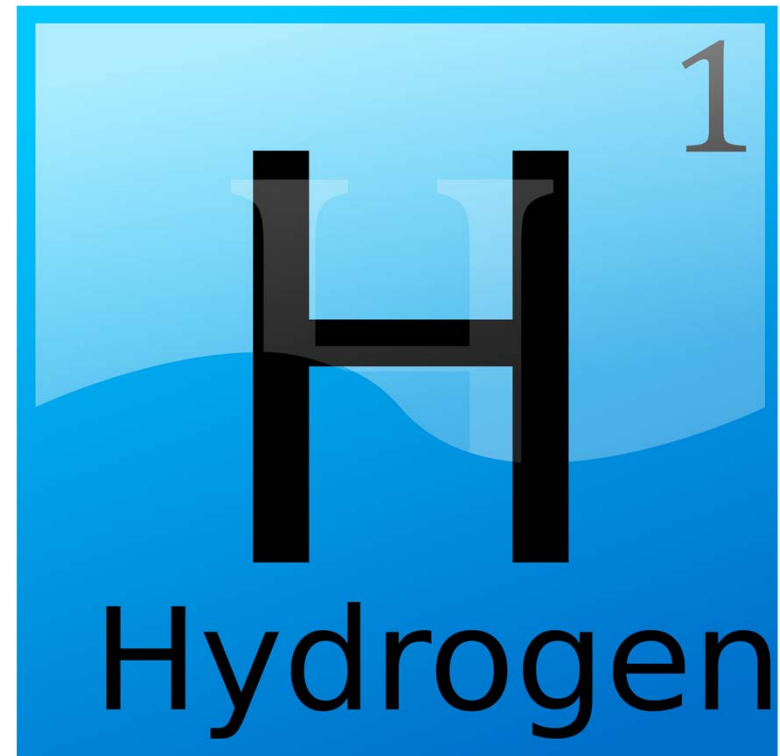


PESCO Headcount



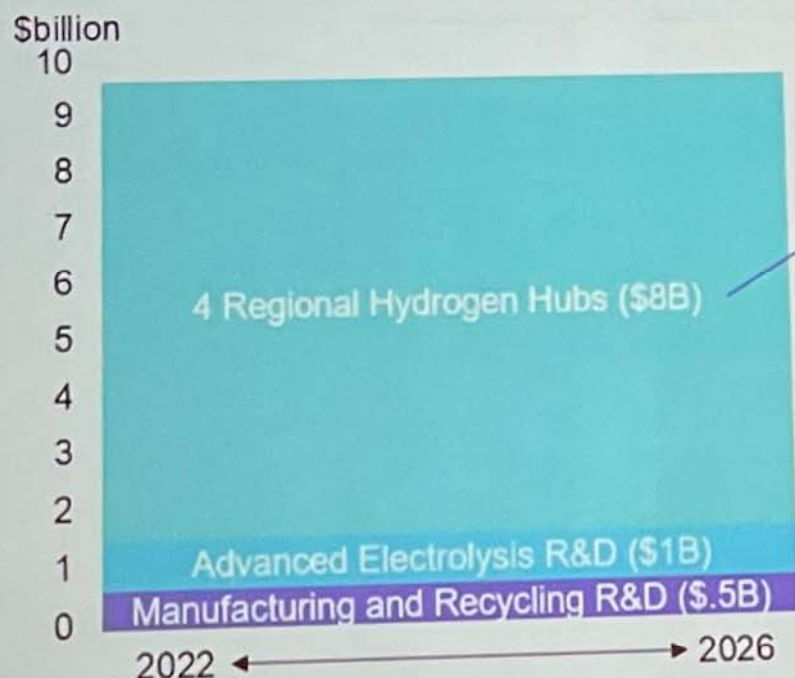
What exactly is a Hydrogen Hub?

- New term. Is being defined by the U.S. Department of Energy
- Term being used to define criteria for allocation of U.S. DOE grant money to spur infrastructure development of hydrogen
- U.S. DOE issued a “Request for Information” from parties interested in being in the hunt for hydrogen hub designation



Senate bill would invest \$9.5b, most notably in regional hubs

Overview of spending plan



Stipulations:

- 1) Two of the four hubs must be located within fossil fuel regions.
- 2) The four hubs must demonstrate the following production and consumption methods:

Supply:

- a. Renewable power
- b. Nuclear power
- c. Fossil fuels

Demand:

- a. Transport
- b. Power generation
- c. Industry
- d. Heating

Source: U.S. Government, BloombergNEF

BloombergNEF

Key U.S. Developments

- DOE Establishes Bipartisan Infrastructure Law's \$9.5 Billion Clean Hydrogen Initiatives -
- <https://bit.ly/3I7FHdM>
- Fact Sheet: Biden-Harris Administration Advances Cleaner Industrial Sector to Reduce Emissions and Reinvigorate American Manufacturing --
<https://bit.ly/3LIHpVr>
- Manchin, Capito, Mckinley, Justice Announce Launch Of West Virginia Hydrogen Hub Working Group -- <https://bit.ly/3sWLzjl>



Audience Questions and Answers



1. Two roving microphones. We're recording. Wait for the microphone.
2. Feel free to use an index card
3. Remember to sign up for Breakfast #2 on March 8 - EventBrite



Hydrogen Breakfast #2

March 8, 2022

