BAKKEN ENERGY

Hydrogen Introduction

What is Hydrogen?

- **Hydrogen** is the lightest and most abundant element in the universe
- **Hydrogen** in isolated form does not occur in nature and is combined most often with Oxygen to form water (H_2O) or Carbon to form a range of hydrocarbons (oil and gases)
- **Hydrogen** is measured in kilograms (kg) and has an energy value of 33.6 kWh per kilogram
- **Hydrogen** produces zero carbon when used as a fuel source

How is Hydrogen produced?

- **Hydrogen** is produced from hydrocarbons such as natural gas (primarily methane C_1H_4) or water (H_2O)
- **Hydrogen** is most commonly produced from hydrocarbons using heat to separate Hydrogen from Carbon. These production methods can be done with or without carbon capture and storage.
- **Hydrogen** is produced from water (H_2O) using a process named electrolysis that uses electric current to separate the Hydrogen from the Oxygen. Electrolysis requires large amounts of electricity
- **Hydrogen** itself is a zero-carbon fuel source however the vast majority of Hydrogen currently produced uses production methods that generate high levels of CO_2

What are the colors of Hydrogen?

- **Hydrogen** production requires water or hydrocarbon feedstock, power and carbon capture and storage if hydrocarbon are the feedstock for production

- **Hydrogen** colors are an attempt to describe how hydrogen is produced, the feedstock, energy sources and whether carbon capture is used. Colors lack detail on the actual CO2 created through the production process. The DOE uses the term Clean Hydrogen to better define lifecycle CO2 emissions from the various hydrogen production methods.

GRAY hydrogen is produced from natural gas or coal without capturing CO2 from the process. This is how the vast majority of the world's hydrogen is currently produced.

BLUE hydrogen production follows the same production process as gray hydrogen however, blue hydrogen adds a carbon capture and storage to the process

TURQUOISE hydrogen is produced through a process named methane pyrolysis, which requires inputs of natural gas and low- to zero-emissions electricity

GREEN hydrogen is produced through the process of electrolysis, where zero-carbon electricity from renewable energy sources is used

PINK hydrogen is produced through the process of electrolysis, where zero-carbon electricity from a nuclear power plant is used

How is Hydrogen used currently?

- **Refining** accounts for about 57 percent of U.S. hydrogen demand, making it the largest hydrogen-consuming industrial subsector.

- **Ammonia** production accounts for roughly 20 percent of U.S. hydrogen demand. Ammonia is primarily used for fertilizer production, supporting farming and other agricultural industries.

- **Methanol** production accounts for around 10 percent of U.S. hydrogen demand. Methanol is used as a feedstock to produce chemicals and products, such as plastics and fuels.

How will Hydrogen be used in the future?

Clean Hydrogen will replace Gray Hydrogen produced with high CO2 emissions in existing applications and Clean Hydrogen will be used to replace hydrocarbon fuels in the following sectors:

- Heavy Duty Trucking
- Industrial and Manufacturing
- Aviation
- Power Generation

What are the challenges in developing a Clean Hydrogen Economy?

- **Clean Hydrogen** production costs are currently high and lower cost production methods are required to reach parity with existing fuel and feedstock options.
- **Hydrogen** as a source of energy requires a great deal of physical space for the amount of energy it contains resulting in higher transportation and distribution costs. Hydrogen gas must be highly compressed or liquefied to facilitate transporation.
- **Hydrogen** gas must be liquified to maximize the amount of Hydrogen that can be transported requiring large amounts energy to reach the -423 F temperature required. -423 F is colder than the average temperature on Pluto.
- **New Clean Hydrogen** applications need to be developed to replace existing applications to fully leverage the potential of this zero-carbon fuel.
- **Clean Hydrogen** production, transportation and distribution infrastructure must coincide with Clean Hydrogen market development to establish and expand the Clean Hydrogen economy

Thank You