LNG Fundamentals

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What is Liquefied Natural Gas (LNG)?

- Liquefied Natural Gas (LNG) is a clear, colorless, odorless, non-toxic liquid
- LNG is natural gas that is refrigerated and turns to a liquid at -162 degrees Celsius.
- LNG is less than ½ the weight of water.

LNG Properties & First Principles

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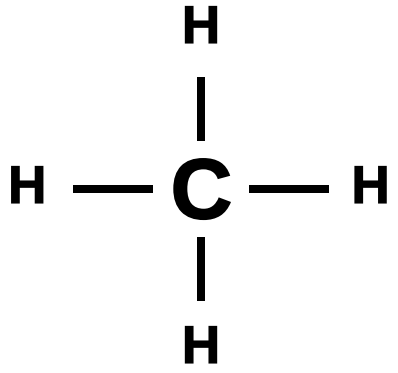
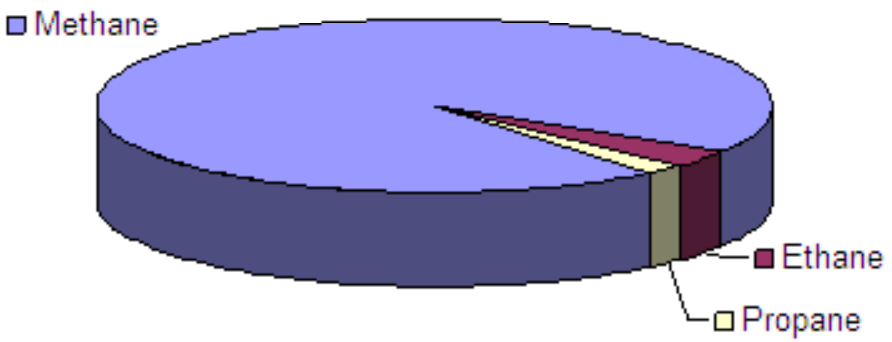
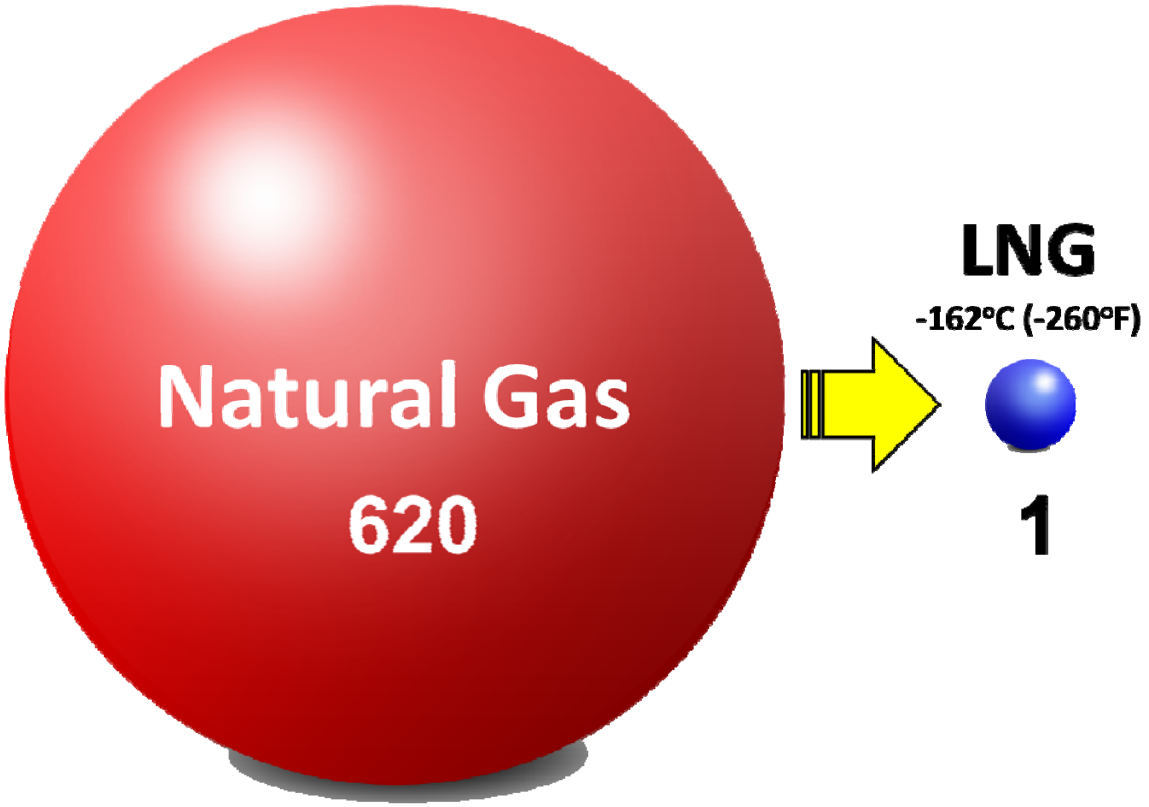
Natural gas and LNG are primarily:

- **Methane** CH_4
- **Ethane** C_2H_6
- **Propane** C_3H_8





Why LNG?



- Natural Gas is liquefied to reduce the volume. At atmospheric pressure, the ratio of volumes of gas to the liquid state is about 620:1
- Natural Gas is liquefied in order to transport it from locations with gas supply to locations with no gas pipeline supply.
- Allows for large storage capacity

LNG Handling

- Produce LNG from pipeline natural gas by automated refrigeration process.
- Transport LNG at low pressure in double wall vacuum jacket transport trailers.
- LNG used as truck fuel.
- Store LNG at -162°C, at 1+ atmosphere pressure
- Vaporize LNG to natural gas as needed for power generation or gas distribution.

LNG Safety Record History

- Not new- not unfamiliar
  - 1959- First LNG ship built
  - 1965- First peakshaving plant (there are now over 80 facilities in North America)
  - 1966 – First LNG vehicle
  - 1968- First imports into North America
  - 1969- First exports from North America
  - 1971- First import terminal in North America, Boston (now 9 facilities)
- No release from a storage tank
- No release from a cargo tank

LNG Safety Fundamentals

- As a liquid, LNG is not flammable.
- Ignition and burning requires vaporization and mixture with oxygen (air).
- LNG vapor is flammable. The temperature necessary to ignite natural gas is about 1000°F. Gasoline requires only 450°F.
- Burning is not sustainable outside the flammability limits (5% to 15% air, above 15% there is not enough air. Below 5% there is not enough fuel.)
- LNG produces a “lazy flame” which burns more like a candle and not like gasoline.
- An LNG vapor cloud in the atmosphere will not explode, unlike propane.
- LNG is not shipped or stored under high pressure.
- LNG is stored at -162 ^{0}C at low pressure.

Safety Regulations

LNG is regulated by Canadian Standard CSA Z276 for Liquefied Natural Gas (LNG) Production, Storage and Handling

Environmental Benefits of LNG

Air Emissions for LNG Compared to Diesel*

- **100% Reduction in Sulfur Dioxide (SO_2)**
- **Up to 97 % Reduction in Nitrogen Oxides (NO_X)**
- **50% Reduction in Carbon Dioxide (CO_2)**
- **91% Reduction of Carbon Monoxide (CO)**
- **89% Reduction in Particulate Matter (PM)**
- **50% Reduction In Volatile Organic Hydrocarbon (VOC)**

* US Department of Energy

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LNG Uses: Overview

- **Storage**
  - **Inventory for transportation logistics**
  - **Inventory for short term demand variation**
  - **Inventory for seasonal loads**
  - **Allows for rapid withdrawal**
- **Transportation**
  - **Ship**
  - **Truck**
  - **Rail**
  - **Barge/small ship**
- **Displace Traditional Gasoline, Diesel and Propane**
  - **Power Generation**
  - **Natural Gas Distribution**
  - **Vehicle Fuel**

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Natural Gas Supply Chain

Natural Gas Production & Treatment

Natural Gas Transmission Pipeline

Components to be Developed

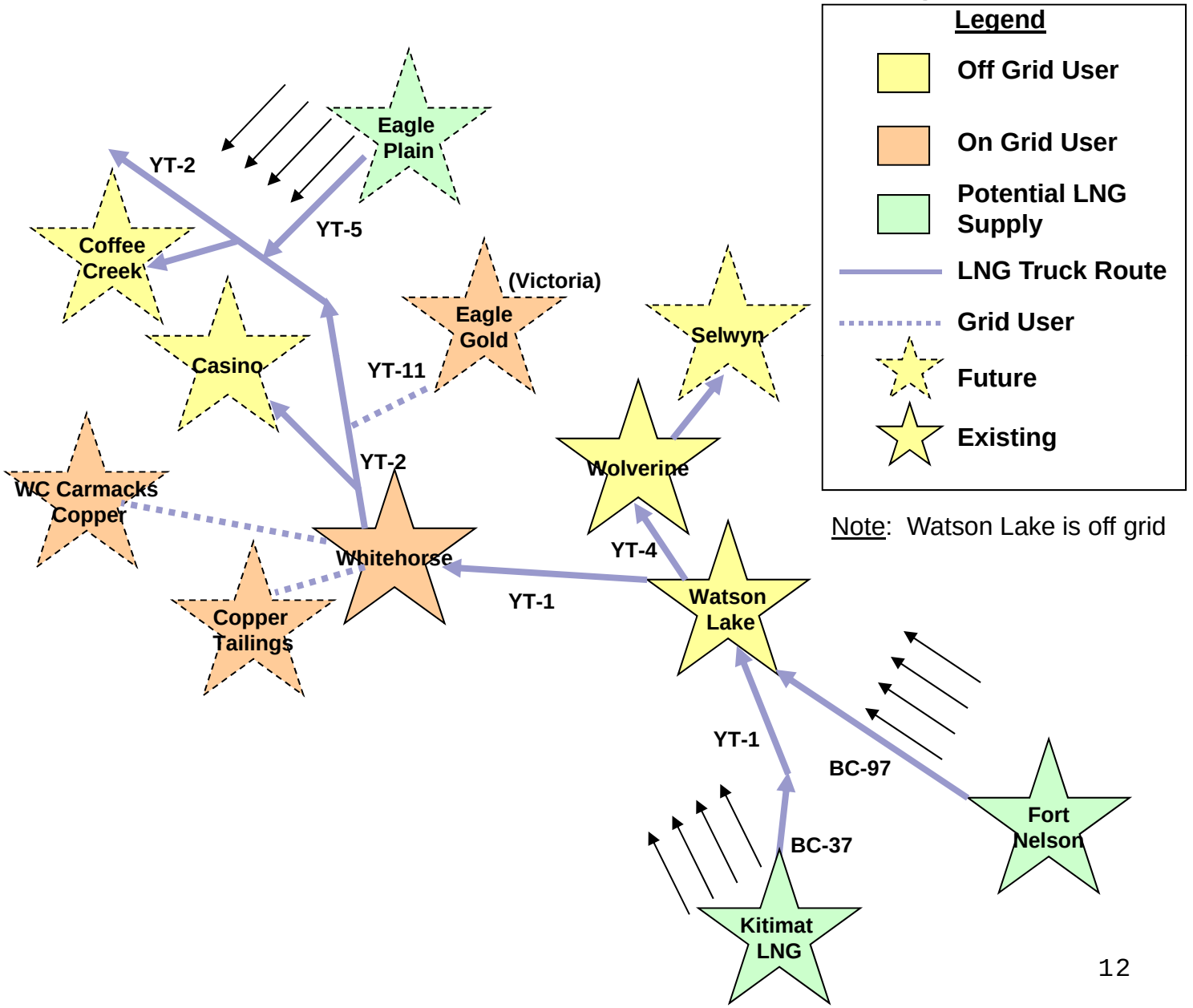
Natural Gas Liquefaction

LNG Road Transportation

LNG Receiving, Storage and Vaporization

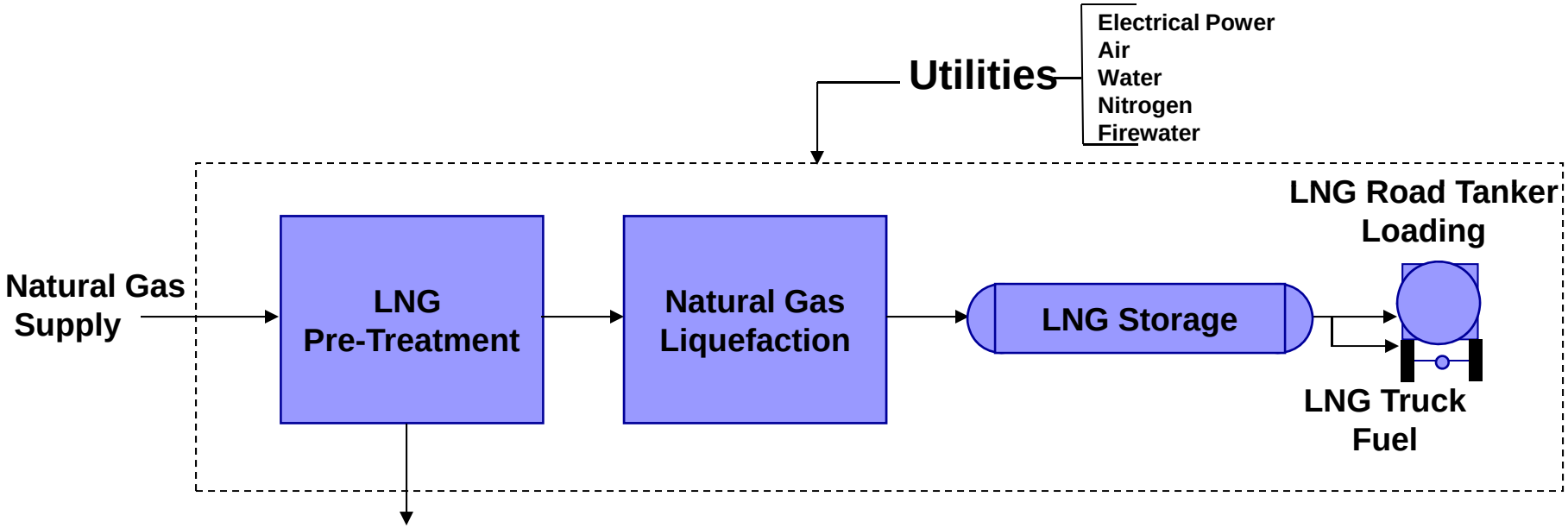
Natural Gas Power Generation

Yukon Potential Natural Gas/LNG Supply Chains & Driving Distances



Note: Watson Lake is off grid

Small Packaged LNG Liquefaction



1. Scalable – Off the Shelf Technology
2. No Venting or Flaring of Natural Gas During Normal Operations.
3. No Air Emissions for Electric Motor Driven Refrigeration Process.

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China Case Study

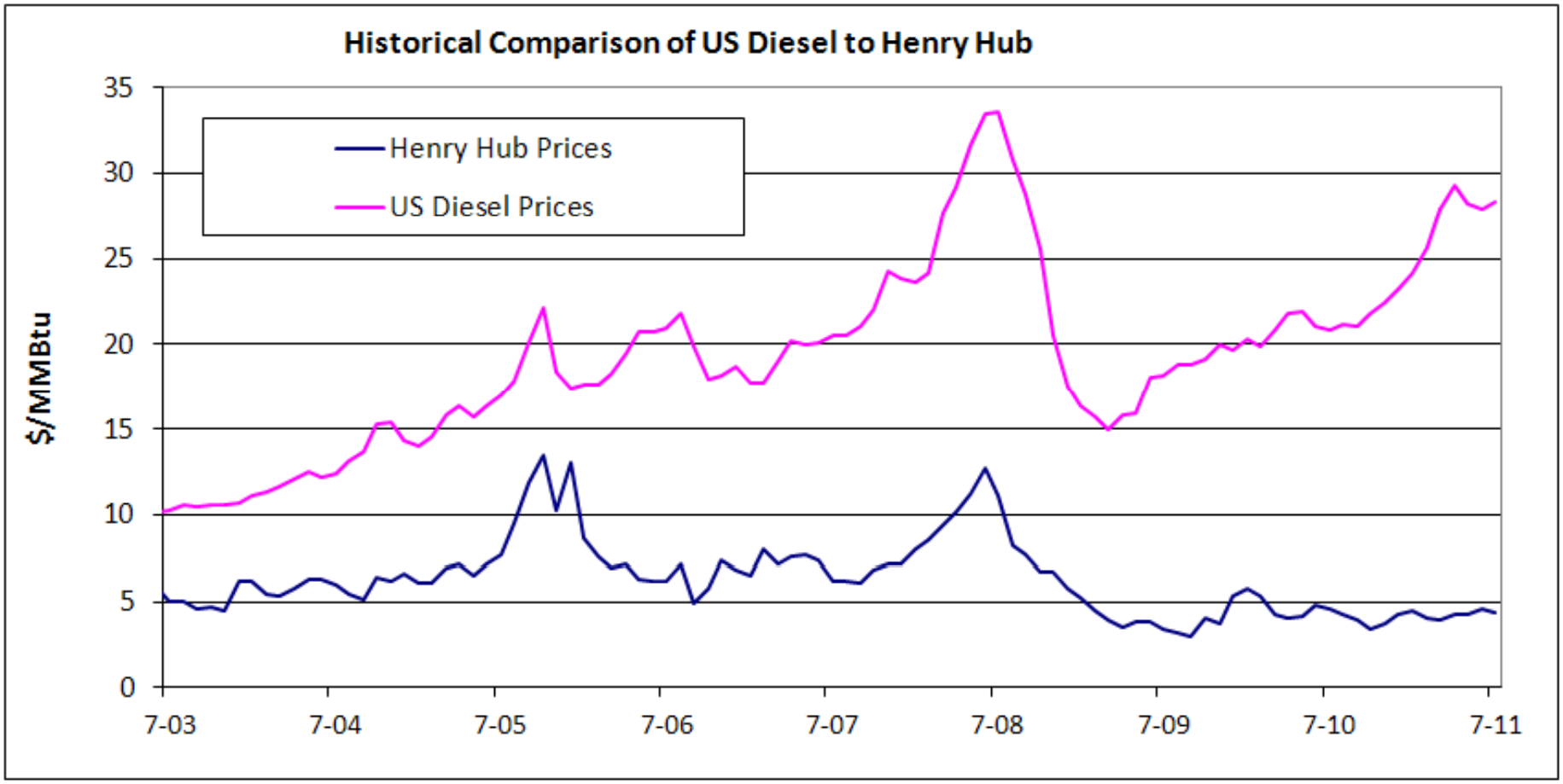
4,100 Kilometer LNG Supply Chain One-Way Driving Distance

Driving Distances							
From Potential Supply Locations		To Potential LNG Receiving Locations					
		Watson Lake	Wolverine	Whitehorse	Coffee Creek	WC Casino	Selwyn
Driving Distance (km)	Fort Nelson	513	695	950	1333	1308	1193
	Kitimat LNG	894	1138	1288	1675	1650	1536
	Eagle Plains	1298	1080	862	744	715	1230

LNG Receiving

- LNG Truck Unloading
- LNG Storage
- Regasification (Vaporize LNG to Natural Gas)

- Simple, Compact, Scalable
- Low Energy Use
- Heat Recovery from Power Generation



		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
US Diesel	($/MMBTU)	7.96	7.93	8.82	8.57	7.46	8.00	10.67	10.03	9.40	10.78	12.91	17.14	19.33	20.59	27.20	17.60	21.36	27.35
Henry Hub	($/MMBTU)	1.77	1.73	2.75	2.48	2.09	2.27	4.31	3.96	3.36	5.50	5.91	8.81	6.74	6.98	8.86	3.95	4.39	4.18
Margin	($/MMBTU)	6.19	6.20	6.07	6.09	5.37	5.73	6.36	6.07	6.04	5.28	7.01	8.32	12.58	13.60	18.34	13.65	16.97	23.17

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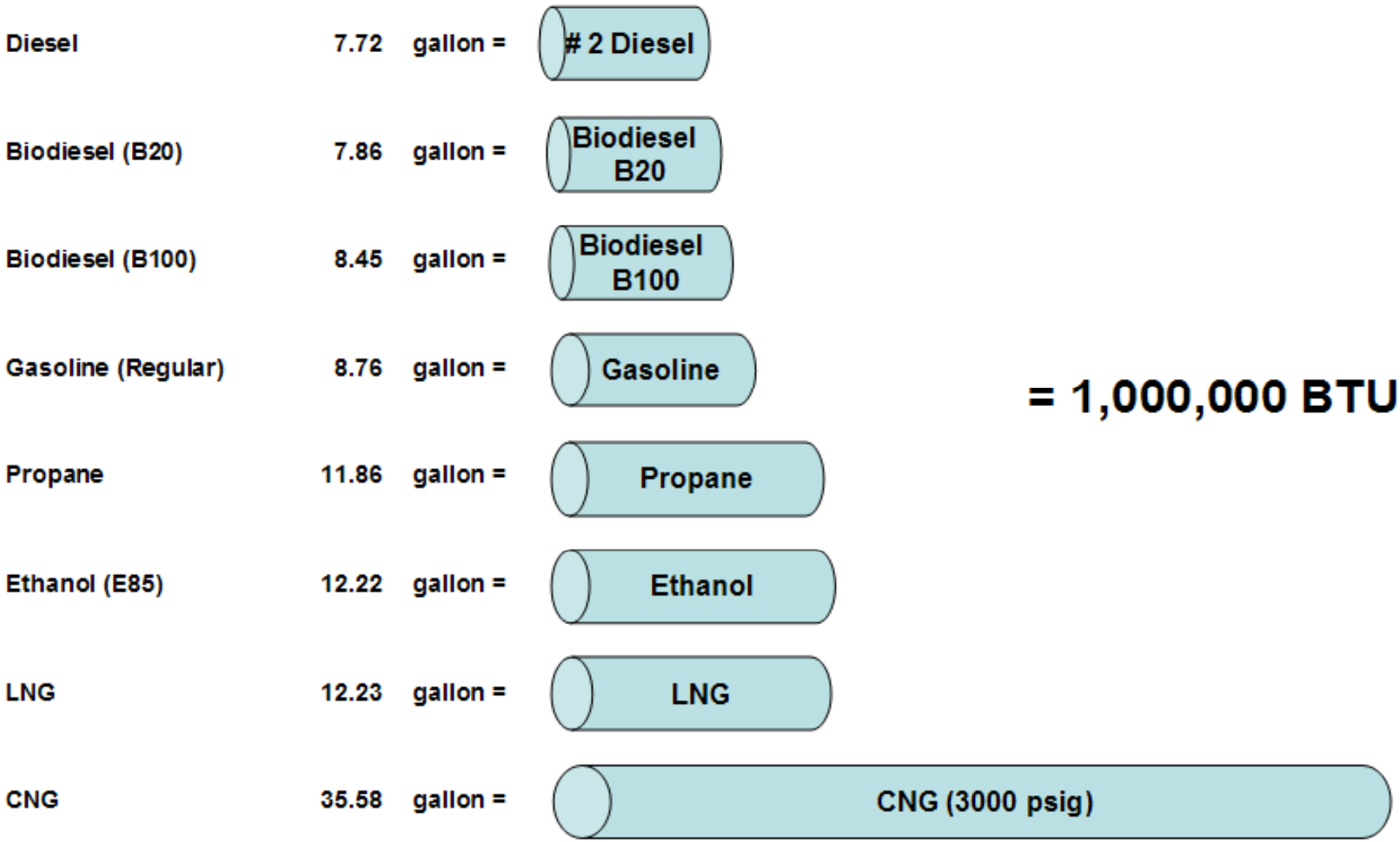
Fuel Volume Comparison on a BTU Basis



Questions?

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