# If Hydrogen is the answer;

# What is the question?

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# Hydrogen Energy Use Today

- Hydrogen is used as a commodity chemical in diverse applications
  - Food processing
  - Metals
  - Refining
  - Ammonia/fertilizer
  - Methanol
  - Electronics



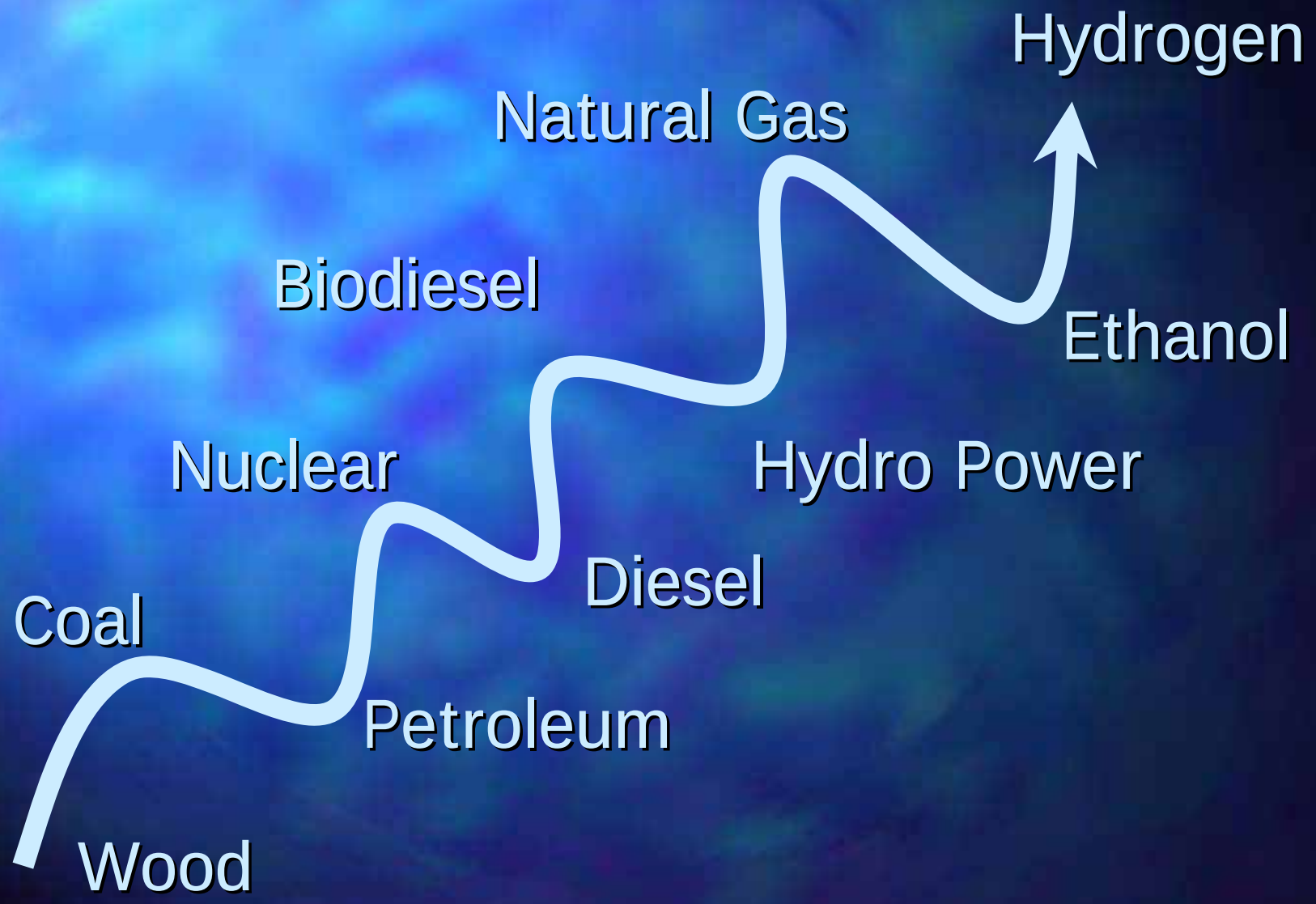




- Hydrogen is used in the transportation sector
  - Directly
    - space shuttle
    - demo $H_2$ ICE and fuel cell vehicles
  - Indirectly
    - in refined products
    - as blended fuel (CNG+$H_2$)

- Major sources
  - Natural gas reforming (>80%)
  - Purification of Chemical By-Products (20%)

# Energy Utilization Trends



# Why Change? & Why Hydrogen?

- Economics
  - Cost of oil is on a steady incline
  - Cost of Hydrogen will decrease as Technology improves
- Environmental
  - Global Warming from greenhouse gases
  - Clean burning in combustion engine
- Political
  - Decrease our dependence on foreign oil
  - Renewable energy lets us fortify ourselves form external impact through supply crisis
- Necessity
  - Approaching global shortfall of >40 million barrels per day
  - Hydrogen is the only long term fuel that makes sense

# Sounds Great; What's the Problem?

- Economics - Production Cost still an issue
  - Reasonable cost to the Consumer
- Physical Storage issue (density)
- Perception -Fear Factor
  - (actually hydrogen is a commodity)
- Lack of Infrastructure
  - Increase Gaseous Distribution
- We need large NOx reduction with limited H2

# Now we that know Hydrogen is the future, how do we get there?

- Implement a cost effective technology
- Energy efficient engines (IC, Hybrid or FC)
- Provide greater Storage Density
- Increase Gaseous Distribution
- Reasonable cost to the Consumer
- Build an infrastructure to support the the hydrogen economy when it gets here
- What can do all of this?

# Hythane®-The Transition Fuel

- 5-7 % by Energy of $H_2$/Natural gas blend
- piggy backs on CNG/NG infrastructure
- Proven technology
- Up to 50% NOx emission reductions
- Possible Emissions benefits through Fungible Assets
  - Kyoto Protocol commencement of E.U. Carbon Credit Trading
  - NOx emission credits
- Clean $H_2$ Enriched NG Fuel is available NOW!

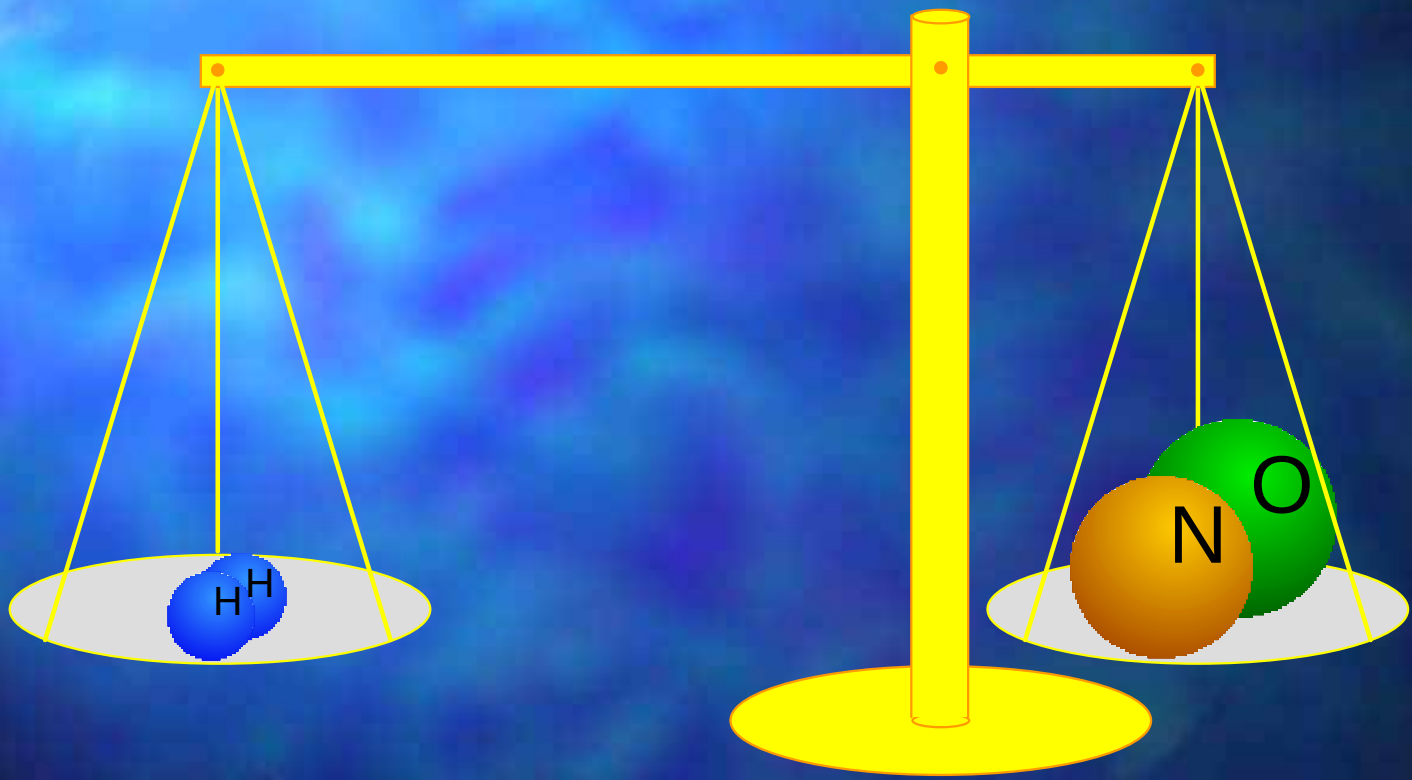
# How can Natural Gas Help?

- Via Time to Market
  - No longer experimental- over 3 mil vehicles on the globe now
  - CNG is growing a robust infrastructure, with many sources, stations, capabilities, engines
  - Provides customers already accustomed to running on a gaseous fuel
- Hydrogen is a renewable gas selected as the future Energy Carrier be of it's abundance
  - It can be described as the "Forever Fuel"
  - But it may be many years before pure Hydrogen becomes a technical and economic reality

# In the beginning…

- Supply of hydrogen will be limited and the cost will be high
- Vehicles numbers will grow in time
- Alt Fuel stations can supply all 3 fuels
  - Natural Gas, Hythane, and Hydrogen
- Cleaner air is needed now
- We need to:
  - Get large NOx reduction with limited $H_2$
  - Always use “Leverage”

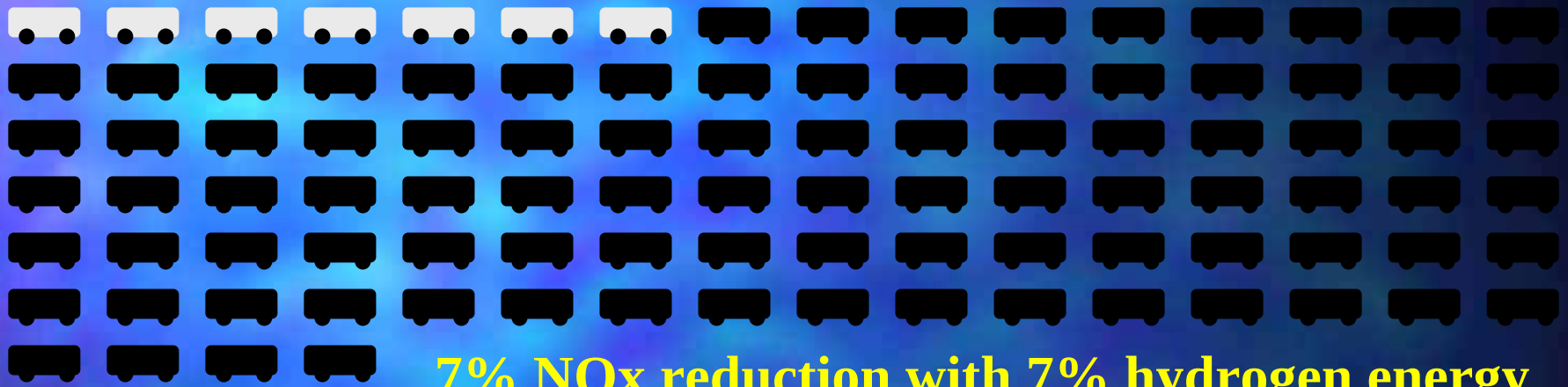
# Hythane® Leverage




**MOST COST-EFFECTIVE USE OF $H_2$**

# What is the best use of 7% Hydrogen Energy?

Hydrogen Bus
CNG Bus
Hythane Bus



7% NOx reduction with 7% hydrogen energy

50% NOx reduction with 7% hydrogen energy

# Conclusions

- Hythane is the transitional step to getting hydrogen introduced into our transportation infrastructure now
- Hydrogen presents a significant economic opportunity for U.S. Industry, including the transportation sector
- Technological innovation, National cooperation, and strategic thinking can make the hydrogen economy a reality
- The hydrogen economy is within sight. How fast we get there will depend on how committed we are to weaning ourselves off of oil

- What are we waiting for?


# Thank You from Hythane Company!

**Questions?**

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# Hythane® History

- Invented in 1989 by Frank Lynch and Roger Marmaro
- Studies and demonstrations through 1990s

Montreal 1995

- By 2003 extensive testing validated the “sweet spot” for heavy-duty Hythane® engines at 7% $H_2$ by energy (20% by volume).

# Legacy of Hythane® Achievements

- 1st Hythane® Vehicle Burns “HY5”, 1990
- 5% Hydrogen (by Energy Content), Balance CNG
- Tanks Under Truck Give 250 km Range
- CARB tests showed ULEV emissions

- 3-Vehicle Denver Hythane® Project, 1992
- Gasoline Truck, Compressed Natural Gas (CNG) Truck and “HY5” Truck (5 energy % H2 in CNG)
- CDH Tests show 50% NOx reduction


- Montreal Hythane® Bus Project (1995)
- Environment Canada test shows 45% NOx reduction

# Legacy of Hythane® Achievements (cont.)


**SunLine's Second Hythane Bus Project (2004)**

- First engine manufacturer involvement in Hythane (Cummins-Westport)
- Best emissions reduction to date (50% NOx decrease with 7% hydrogen energy)
- SunLine's hydrogen is from renewable solar energy

# Hythane® Strategy

There are 3 interdependent parameters in adjusting a lean burn CNG engine for Hythane®. Changing any one of them affects the other two. We can:


- Lower NOx, at the expense of NMHC and efficiency
- Lower NMHC, at the expense of NOx and efficiency
- Higher Efficiency, at the expense of NOx and NMHC

The Hythane strategy for reducing urban smog is “Reduce NOx as much as possible without making NMHC or efficiency worse than CNG”.

# YUCHAI HYTHANE ENGINE NOVEMBER 2005 DATA