Performance of a Commercial Internal Combustion Engine on Ammonia Fuel

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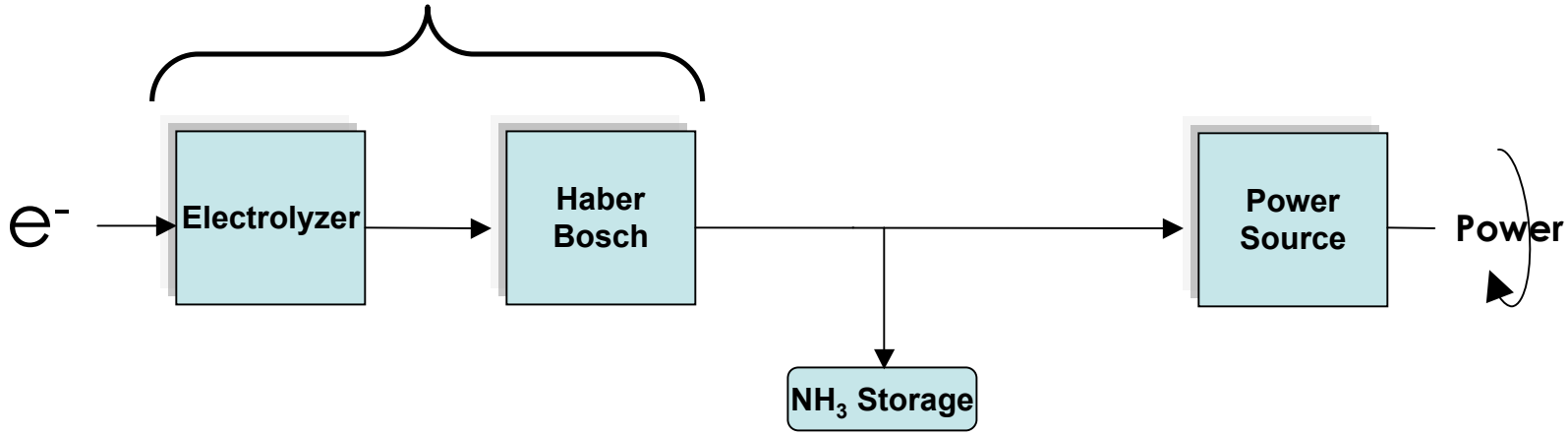
The amount of sunlight reaching the earth's surface in 10 seconds is enough to power the world for one day.

The total amount of fossil fuel used by humans since the start of civilization is less than 30 days of sunshine.

Energy is not the problem.

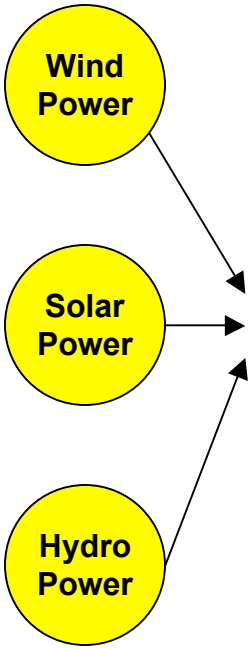
Gathering, storing and transporting this energy is the problem.

Fuel Synthesizer



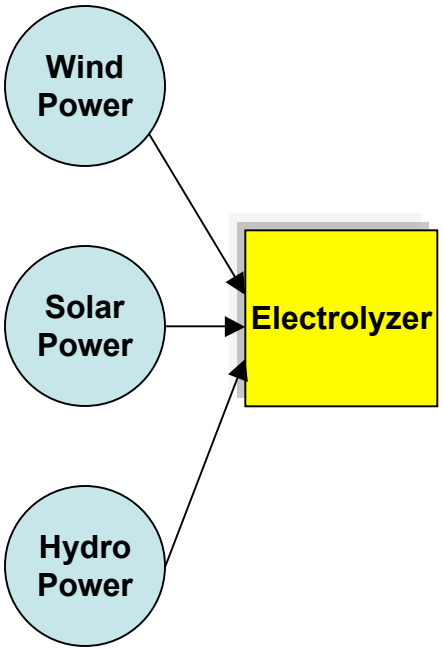
By synthesizing ammonia, you don't need fossil fuels.

Electricity Sources



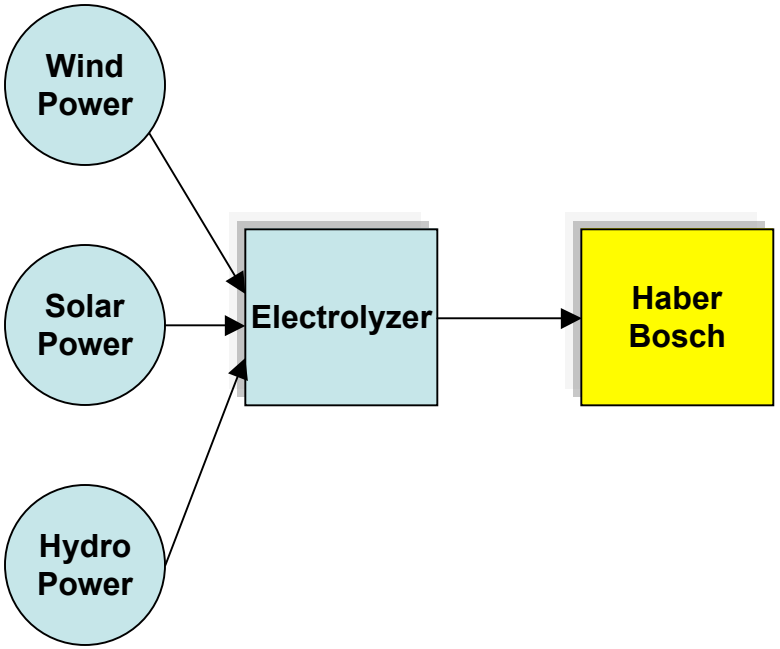
- Electricity could come from a wide range of renewable energy sources
  - Wind Power
  - Solar Power
  - Hydro Power
- Sources like nuclear can be used
- Facilities are already in place and operating successfully

Electrolyzer



- Split water into hydrogen and oxygen
- Produced by many companies including:
  - Hydrogenics
    www.hydrogenics.com
  - Norsk
    www.hydro.com
  - ITM Power
    www.itm-power.com

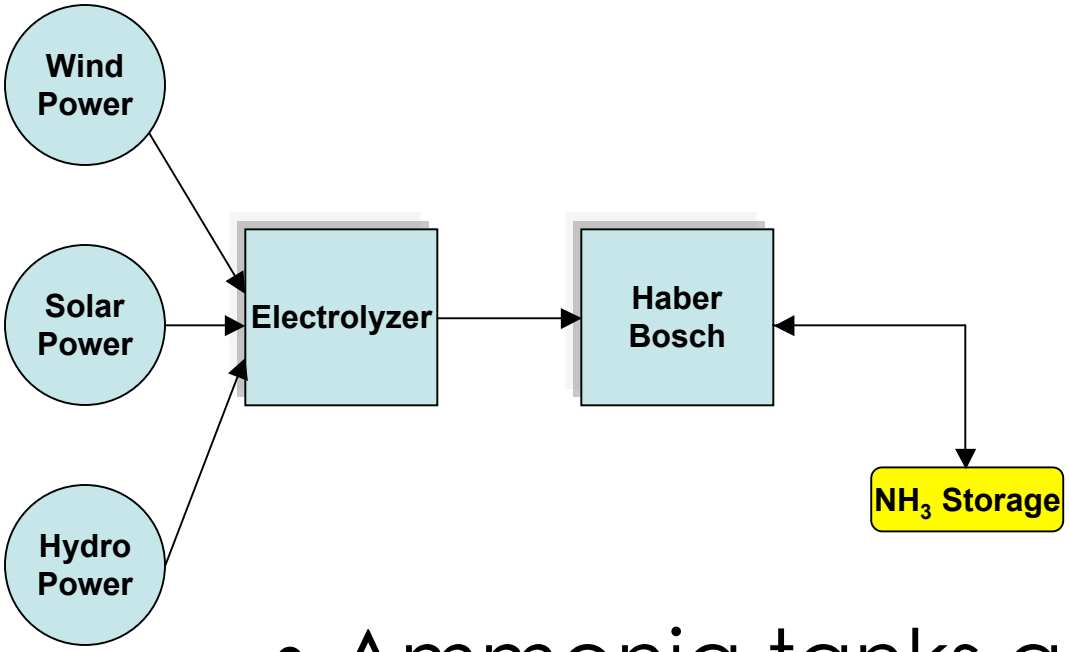
Haber Bosch Process



- Combine nitrogen and hydrogen to create ammonia
- Presentation, ***Ammonia as a Transportation Fuel II***, Argonne National Labs, Norm Olson-Iowa Energy Center

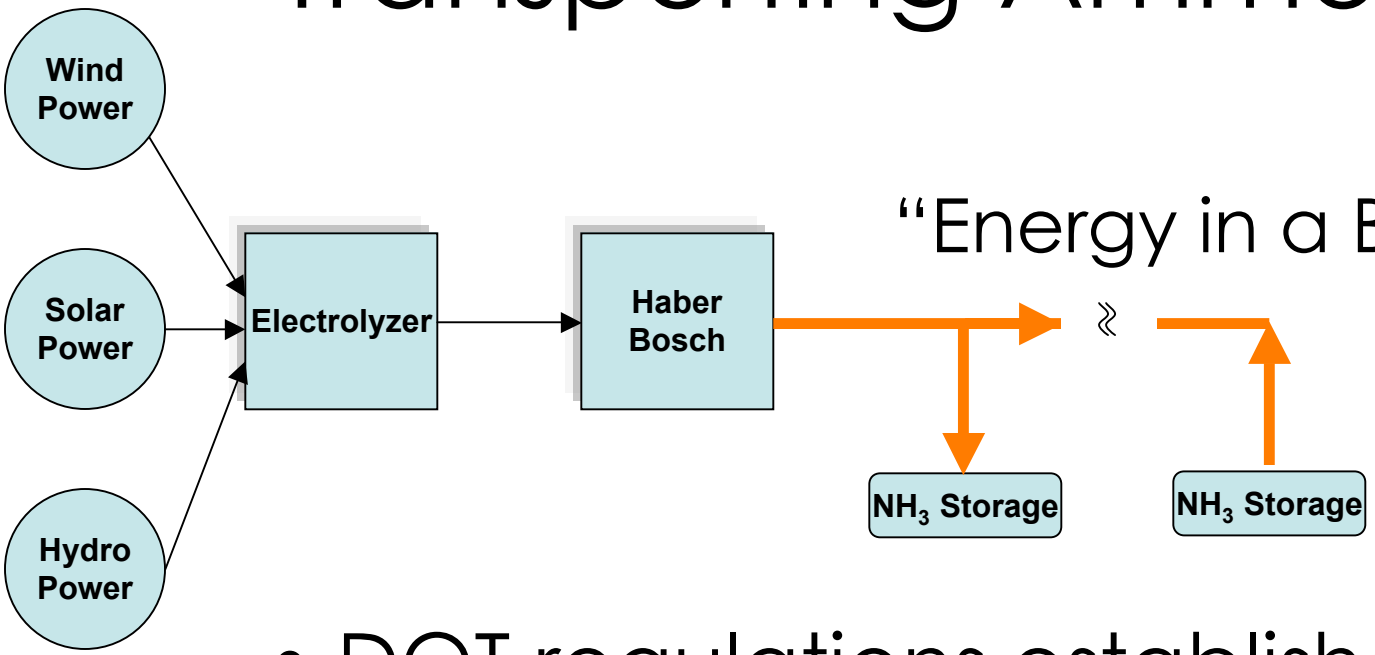
Link to Presentation:
http://www.energy.iastate.edu/renewable/biomass/download/2005/Olson_Transportation.pdf

Storing Ammonia



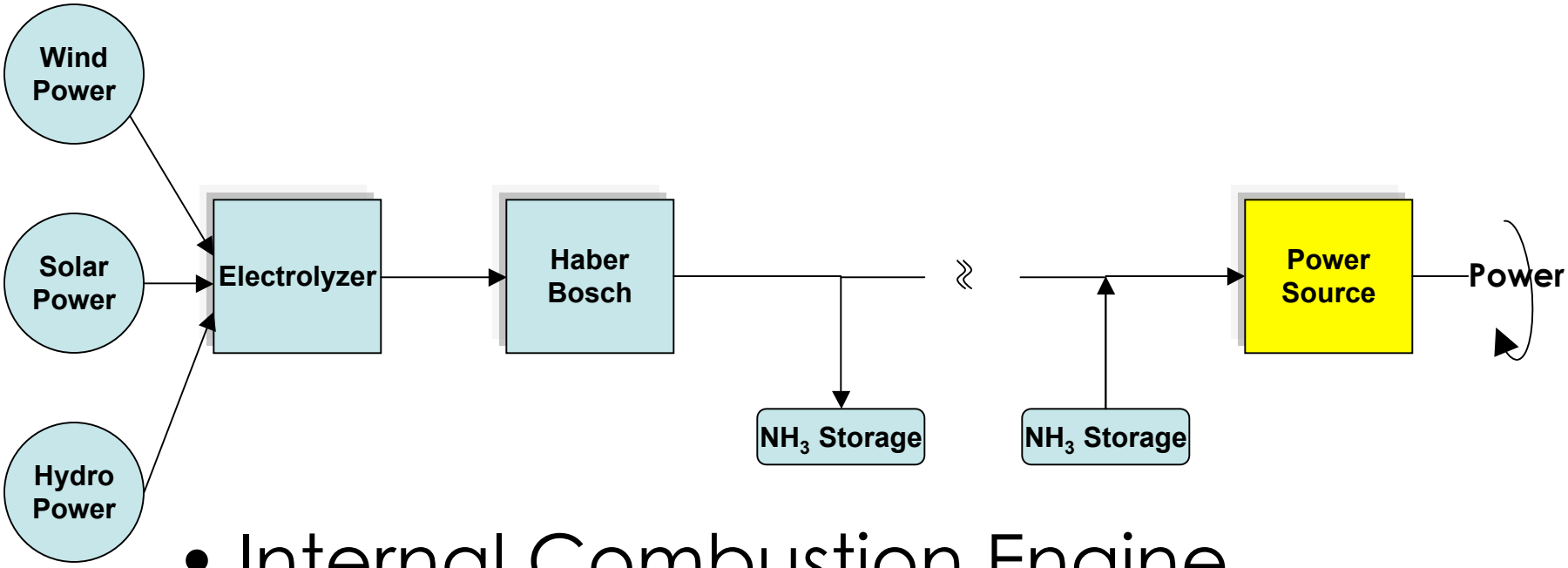
- Ammonia tanks and infrastructure in place
- Solves hydrogen storage problem

Transporting Ammonia



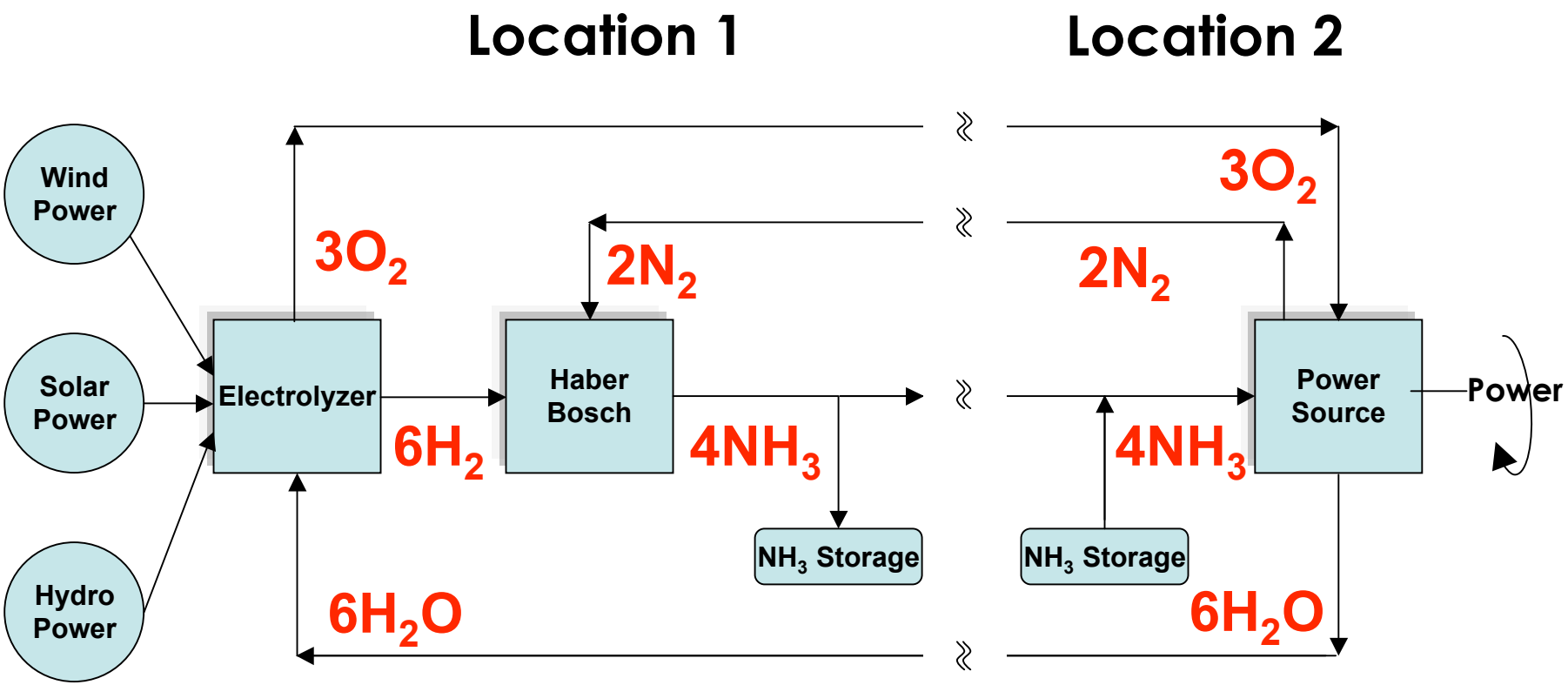
- DOT regulations established
- Equipment readily available
- Safety requirements widely known
  - Transport and handling experience

Creating Power from Ammonia



- Internal Combustion Engine
  - Manufacturing and servicing in place
  - Ammonia burns cleanly and efficiently
- Fuel cells can also provide the power

Material Neutral Process



Effects of Engine Efficiency

CR	Eff	P_{out}	P_{loss}	P_{total}
~10:1	30%	120hp	280hp	400hp
~30:1	50%	200hp	←	400hp

NO!

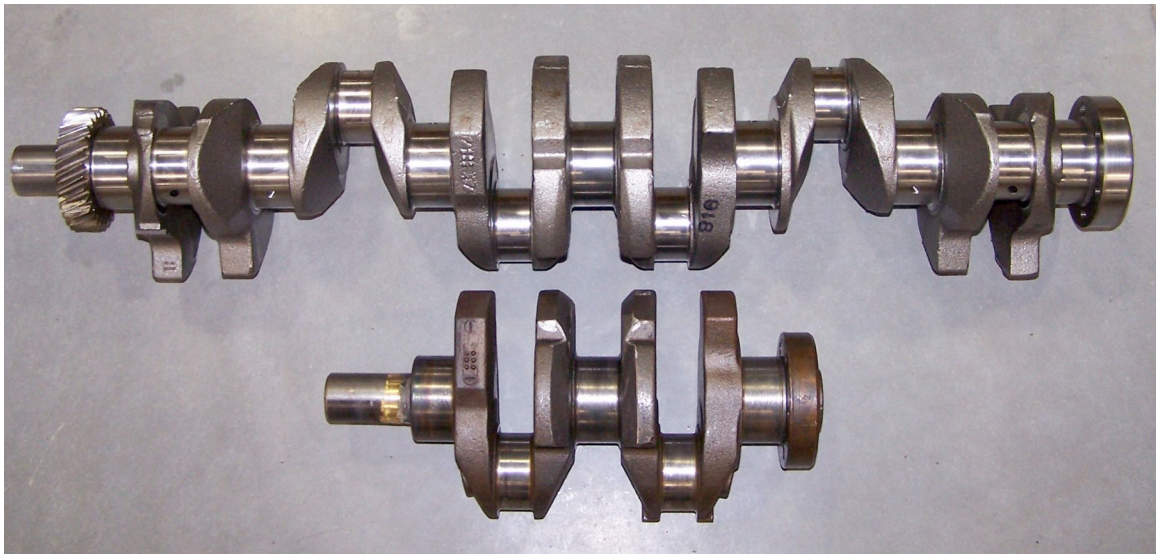
~10:1	30%	120hp	280hp	400hp
			↓	
~30:1	50%	280hp	← 280hp	

YES!

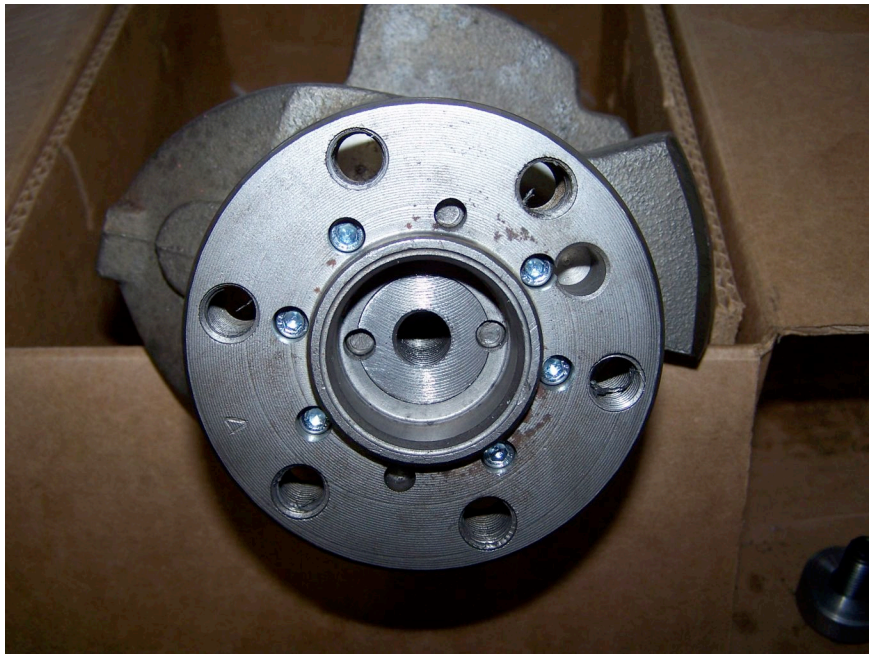
2.33 times more hp

Crankshaft Designed for 120hp

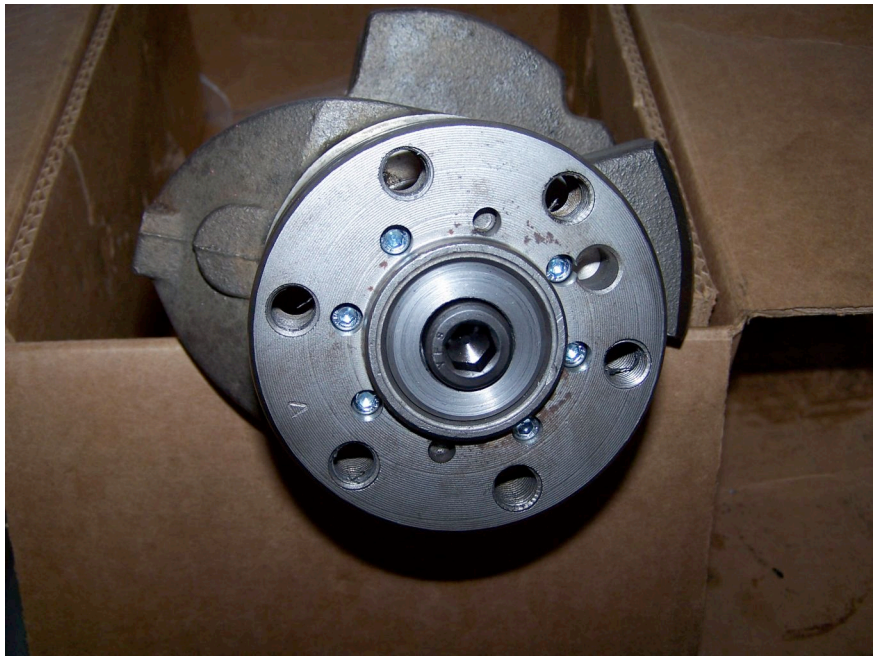
- 6 cylinder expected power = 280hp
- 3 cylinder expected power = 140hp
- 2 cylinder expected power = 93hp ←
  - 2 cylinder allows for higher future power



Crank Strengthening



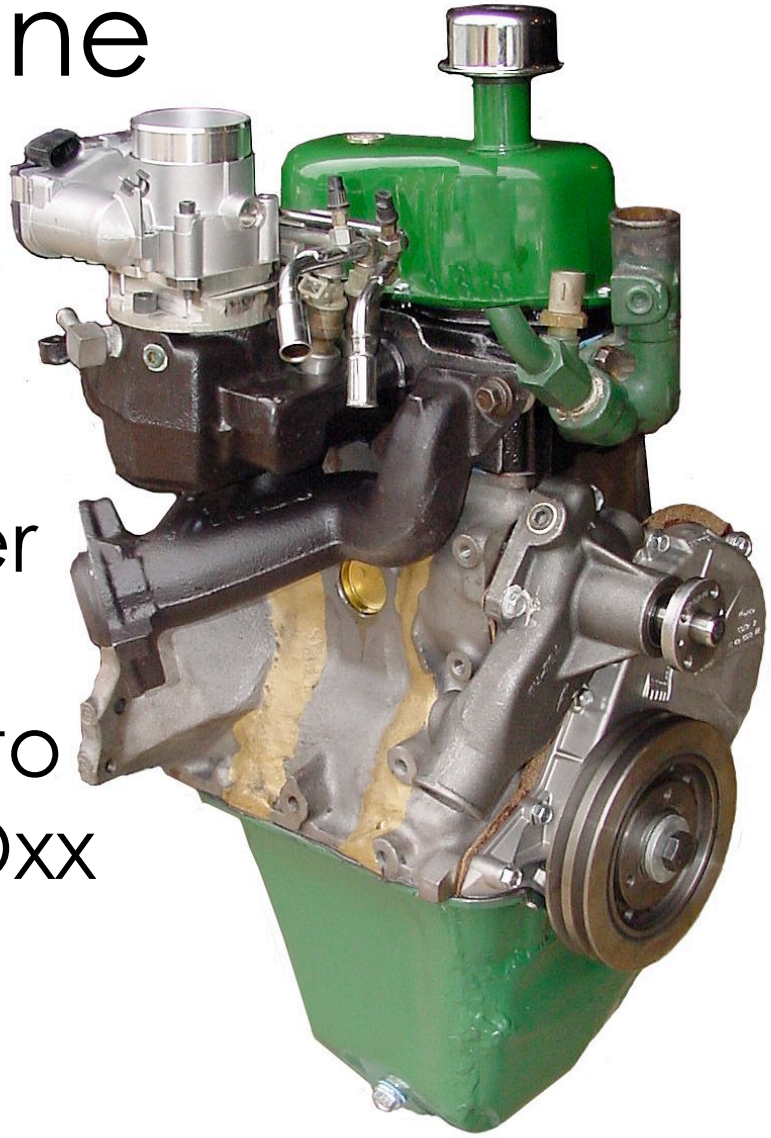
Note the 2 dowel pins



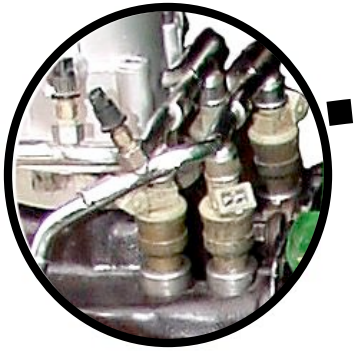
Note the dowel retainer

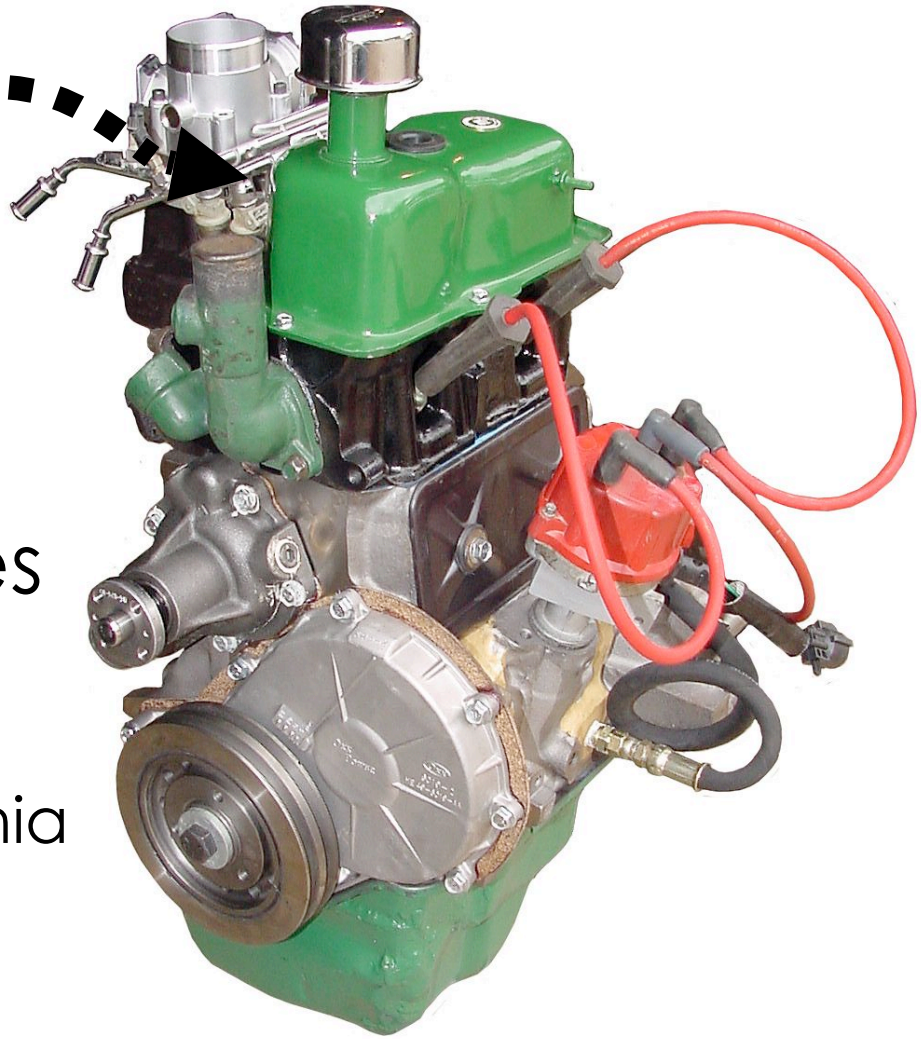
2 Cylinder Engine

- 1.6L engine
- Constructed by cutting a 6 cylinder engine down and welding together to create the Baby Oxx



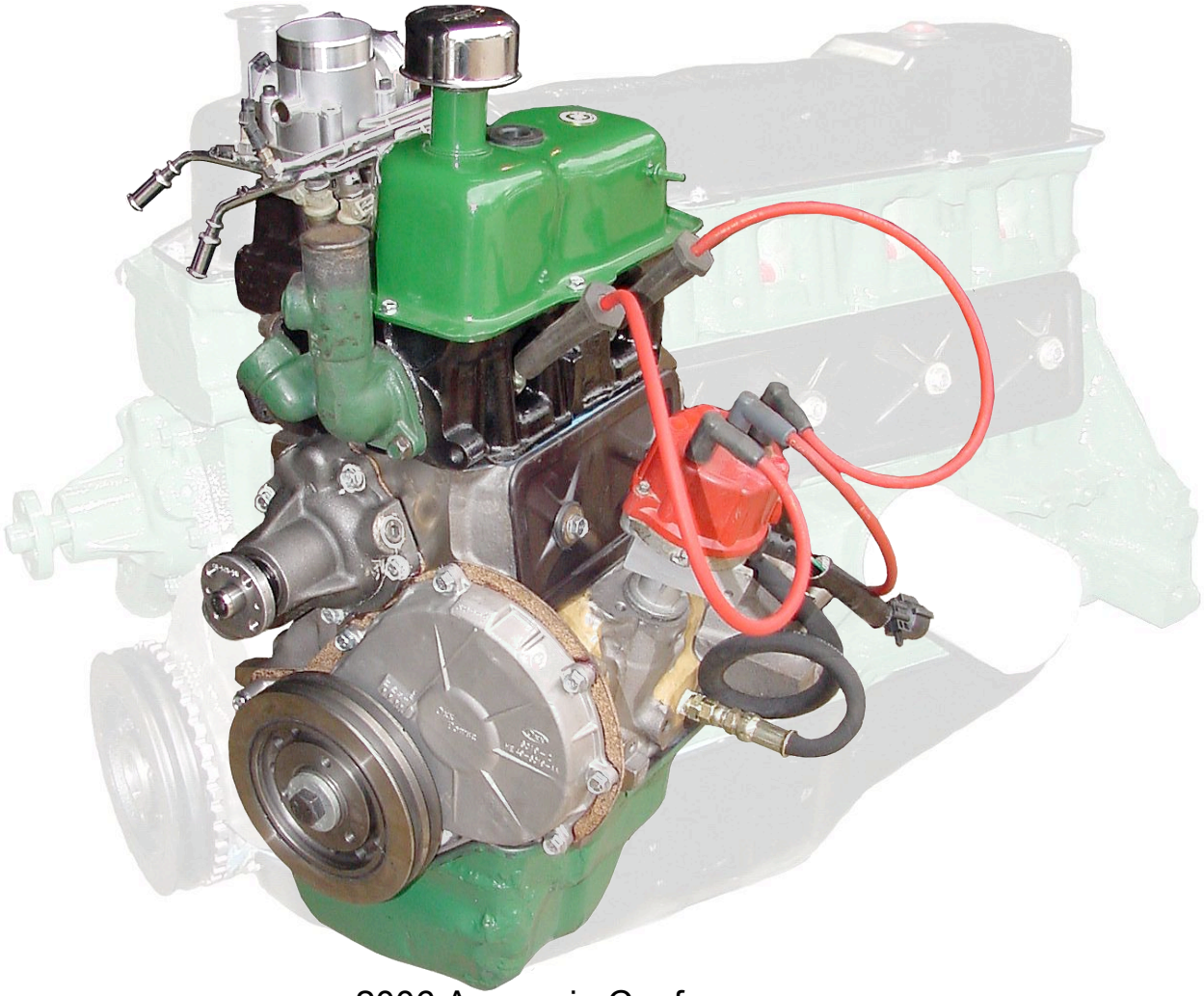
Fuel Injectors





- 2 cylinder engine has two sets
- Can run 3 fuel types at one time
  - For example, run hydrogen and ammonia through fuel injectors and combine with carbureted gasoline

Relative Sizing



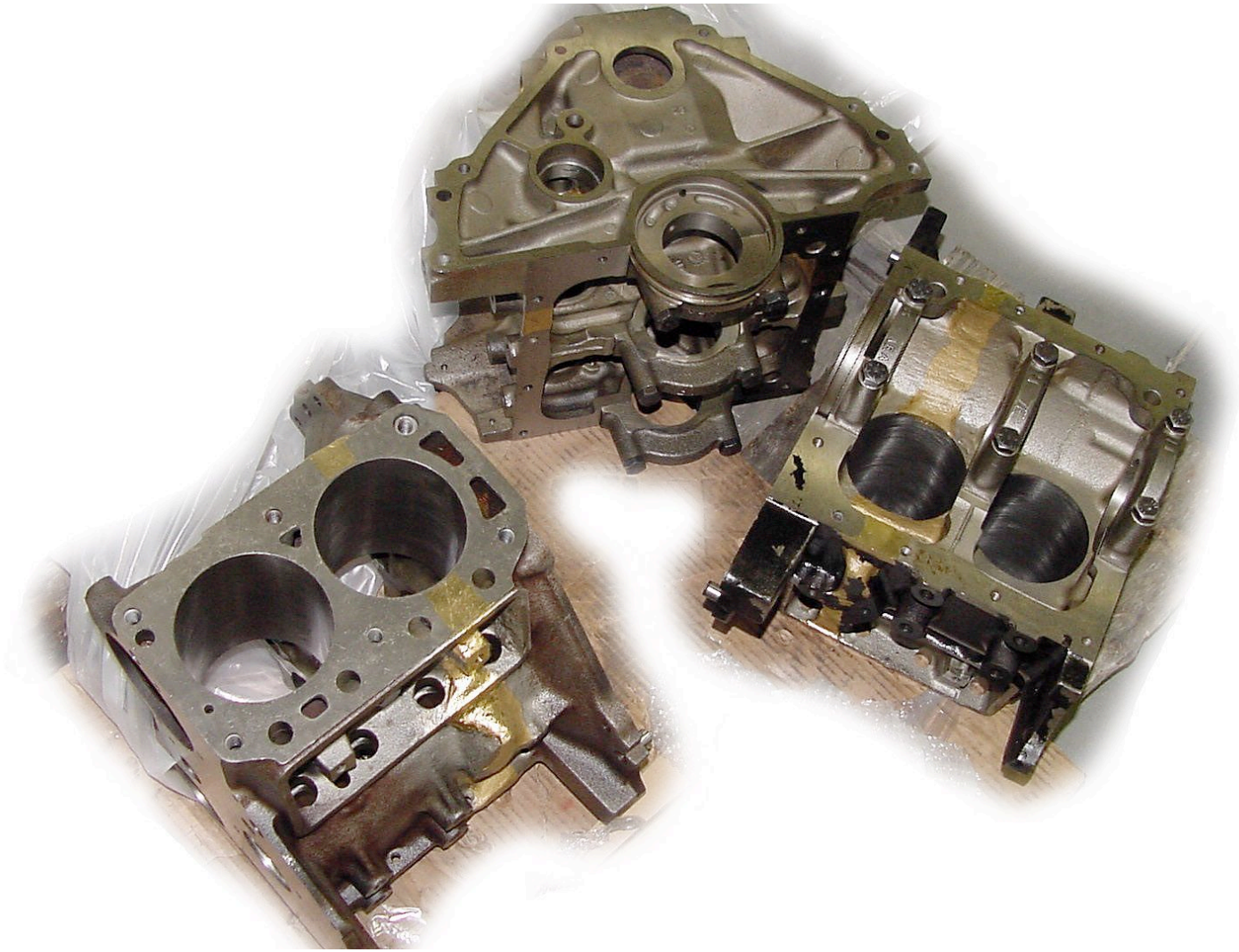
Engine Testing Process

Alter fuel type in 5% increments until running on 100% Ammonia

Findings will be reported at a later date

Fuel Type:	H_2	NH_3
	100%	0%
	95%	5%
	90%	10%
	↓	↓
	0%	100%

2 Cylinder Blocks



Issues Solved

- Emissions
  - Ammonia as a fuel = no emissions
- Time & location of use
- Energy problem

Issues Solved

- Emissions
- Time & location of use
  - Wind turbines in Patagonia can harness energy, use the process to convert energy into ammonia and transport to final location for required time of use
- Energy problem

Issues Solved

- Emissions
- Time & location of use
- Energy problem
  - "Energy in a Bottle"
  - Off-peak heights in renewable energies can be stored for peak usage in any location for any time of use

Summary

- Ammonia is the "Other Hydrogen"
  - Solves hydrogen storage issue
- Processes in place and companies established
- We CAN put "Energy in a Bottle"
- Ammonia fueled power source (ICE or FC) provides missing key to make NH_3 as the renewable fuel of the future

Commercial Application of 2 Cylinder

HEC will work together with Sawtelle & Rosprim, Inc. to design and build an Ammonia-Fueled Irrigation Pump System

- Prototype system being designed to run 24 hours a day
- Expect system to be tested during 2007 irrigation season

Thank You

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