OERC and Transport Research Network

A short history of the use of renewable ethanol as a transportation fuel

William J. Wells, Ph. D.
University of Otago Foundation Year

Presented at

OERC Symposium & Transport Colloquium 2016
OERC Symposium

November 10-11, 2016
The Hutton Theatre, Otago Museum
Dunedin, New Zealand

Aims for this presentation:

- To review a brief history of ethanol fuel.
- To get an understanding of how public policy and human interaction interacts with bioethanol fuels (socio-economic issues).
- To examine the fields of influence in which the ethanol industry “plays.”

Humans have used ethanol for centuries

- Use of grains for beer-brewing predated bread making by several hundred years.
- The ancient Egyptians made beer and wine. Beer was most popular and was part of wages.
- The Iranians made beer 7000 years ago in a commercial, industrial process.
- More concentrated ethanol by distillation began started about 2000 BC.

Henry Ford was Sold on Ethanol

"We can get fuel from fruit, from the sumac by the roadside, or from apples, weeds, saw dust; almost anything. There is enough alcohol in one year's yield of an acre of potatoes to cultivate that field for a hundred years. And it remains for someone to find how this fuel can be produced commercially -- better fuel at a better price than we now know." *Henry Ford*

Early Ethanol Automotive History

- “The first prototype internal-combustion engine in 1826 used alcohol and turpentine.”
- “…alcohol powered the first engine by the German inventor Nicolas August Otto, father of the four-stroke internal-combustion engine…”
- “Henry Ford built his very first car to run on what he called farm alcohol.”
- “Tests in 1906 by the Department of Agriculture underscored its (ethanol) power and economy benefits.”
- “In 1907 and 1908 the US Geological Survey and the Navy performed 2000 tests on alcohol and gasoline engines…concluding that higher engine compression could be achieved with alcohol than gasoline.

J.L. Kitman, “The Secret History of Lead,” The Nation, 3/20/2000, p. 11.

Early Ethanol Automotive History

Tetraethyl Lead *versus* Ethanol

1917: Charles Kettering and assistant Thomas Midgley, Jr. focus on ethanol for gasoline anti-knock.

13 April 1918: "It is now definitely established that alcohol can be blended with gasoline to produce a suitable motor fuel." *Scientific American*

October 1921: Midgley tells SAE "Alcohol has tremendous advantages and minor disadvantages."

9 December 1921: Midgley reports to Kettering that tetraethyl lead (TEL) reduces knock.

Ethanol in England: 1930's

- Cleveland Discoll - 30% ethanol
- Kool Motor - 16% ethanol
- Statement of Standard Oil in England in advertising pamphlets: Ethanol-blended, no-lead petrol was "the most perfect motor fuel the world has ever known, (providing) extra power, extra economy, and extra efficiency."

Brazil: Ethanol Pioneer

- Compulsive use during World War I
- Ethanol blended without interruption since 1939
- Proalcool program begins in 1975
- All lead (TEL) removed from gasoline in large refineries by 1988
- Ignored intensive petroleum refining for lost octane from TEL removal, used ethanol instead
- Renewable resources considered best option to fossil petroleum

Estimated worldwide fuel ethanol production Calendar year 2015

Country	Millions of Gallons
United States	14,806
Brazil	7,093
European Union	1,387
China	813
Canada	436
Thailand	334
Argentina	211
India	211
Rest of World	391

Source: RFA analysis of public and private estimates

USA annual ethanol production 2005-2015

Year	Millions of gallons
2005	3.904
2006	4.884
2007	6.521
2008	9.309
2009	10.938
2010	13.298
2011	13.929
2012	13.218
2013	13.312
2014	14.340
2015	14.810

= 56.1 billion litres

Bio-Ethanol in Petrol, Brazil and the USA

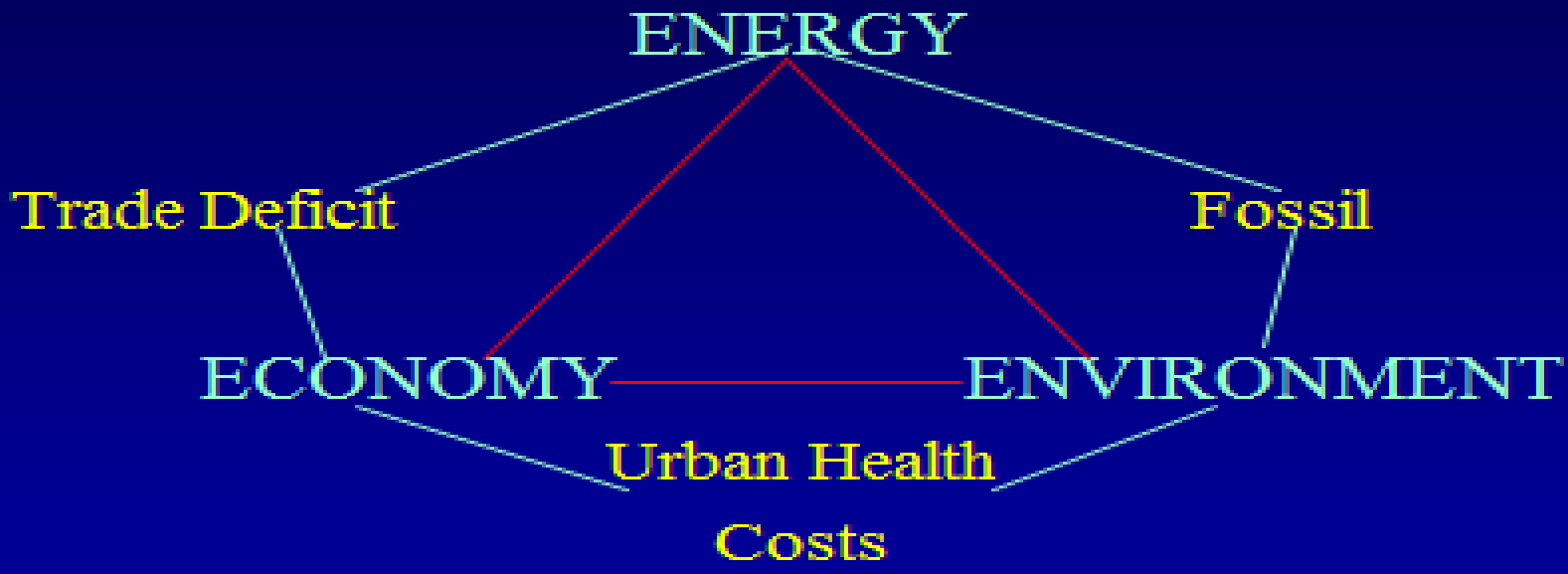
Brazil is 100% petrol with ethanol

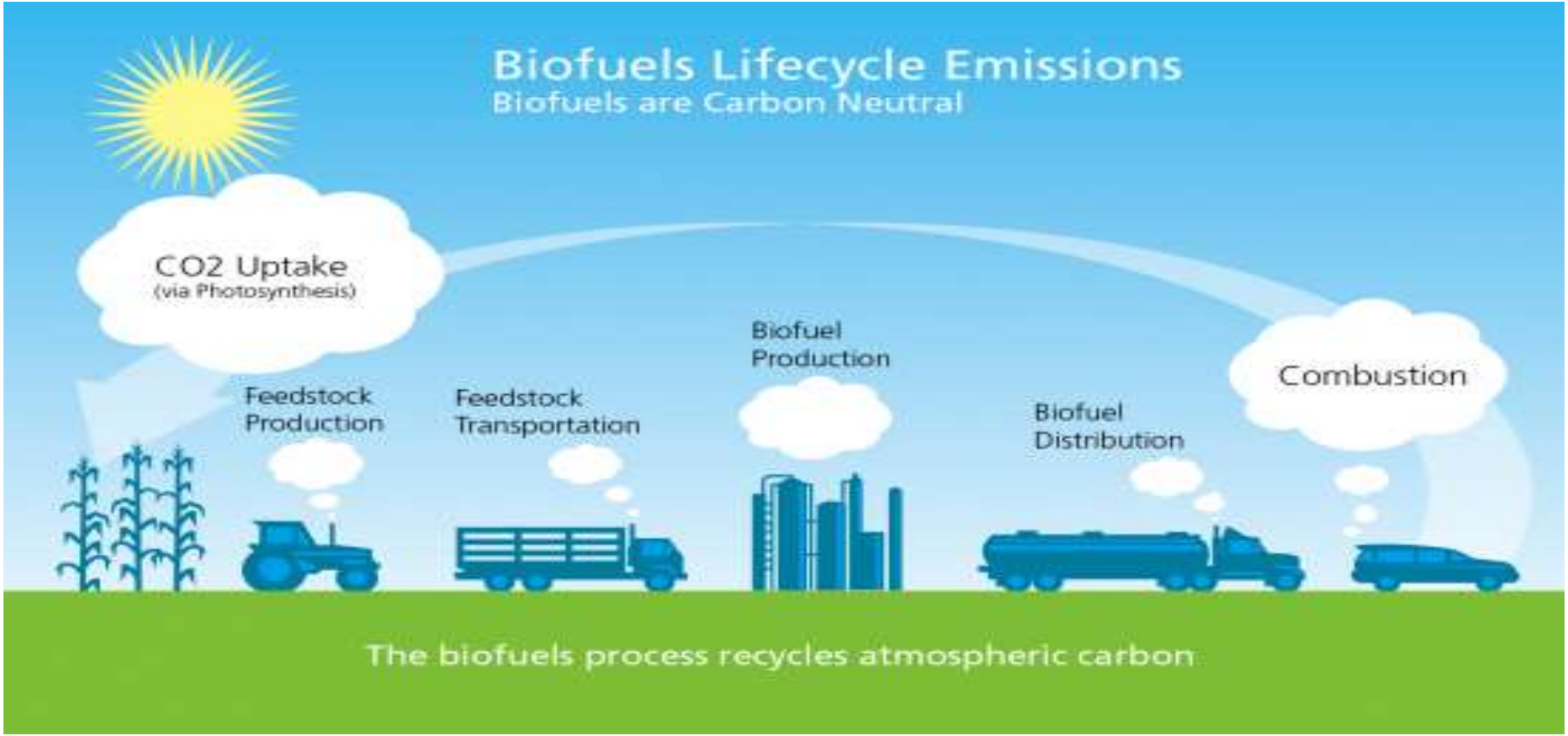
- Hydrous "neat" ethanol: *ca*. 92% EtOH, 5% H_20, and 3% hydrocarbon (HC) petrol
- Anhydrous "gasohol" with 22 to 25% ethanol content, depending of supply availability
- 2010 production= 26 billion litres (200MM population)

USA is nearly 100% petrol with ethanol

- Only anhydrous EtOH used
- Percentages from 5 to 85%
- 10% "gasohol" most common, 15% growing
- Greater than 15% requires Fuel Flexible Vehicle
- 2010 production = 50 billion litres (300MM population)

What attracts people to the fuel ethanol business?



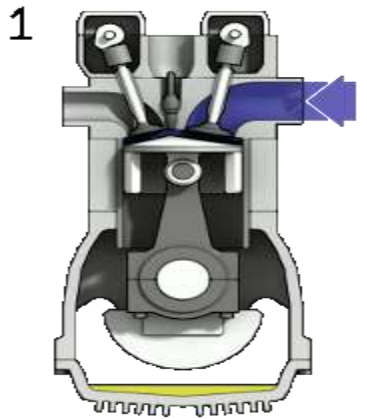

Biofuels Lifecycle Emissions
Biofuels are Carbon Neutral
CO2 Uptake
(via Photosynthesis)
Feedstock Production
Feedstock Transportation
Biofuel Production
Biofuel Distribution
Combustion
The biofuels process recycles atmospheric carbon

Drivers for Fuel Ethanol-The Three E's

- Energy
  - Reduce crude oil imports
  - Diversify fuel mix
  - Hi-Octane conserves crude oil
- Environment
  - Cleaner emissions profile; CO, UBH, NOx, particulates
  - Greenhouse Gas friendly
  - Lower urban health costs
- Economy
  - Reduces trade deficit (60% of USD 50bn US deficit = foreign oil)
  - Create new jobs, broader tax base
  - Create new investment
  - Supports agriculture with significant new crop use

Four Stroke Engine, Otto or Diesel Cycle

From Wiki Commons



Four Stroke Engine, Diesel or Spark (Otto)

1. **Intake (pull in air, fuel)**
2. **Compression (ratio = Initial vol/final vol)**
3. **Combustion (drives cylinder down, work done)**
4. **Exhaust (pushes out combusted gases**

Compression Ratio (CR) =

Max cylinder volume/min cylinder volume

During the four-stroke cycles