# Promises of Green Energy:
# 21st Century Snake Oil

## "Why the United States should reject biofuels as part of a Rational National Energy Strategy"

**T. A. "Ike" Kieffer, Captain, US Navy (now retired)**

http://phe.rockefeller.edu/docs/Kiefer%20-%20Snake%20Oil2.pdf

**Robert W. Endlich, Lt. Col, USAF (Ret.)**

**Cruces Atmospheric Forum, 16 Aug 2014**

# Outline

**Introduction and History of alternative energy efforts.**

**Chemistry, Biology, Physics, Agriculture:  Science of Hydrocarbon Energy**

**Energy Return on Investment: tool for analyzing energy sources (and sinks)**

**Three substitutes for Jet Fuel and Hydrotreated Renewable Jet (HRJ)**

**Examining the role of Green Energy subsidies:**

**Corn Ethanol as a Green Energy Case Study**


# Why the United States should reject biofuels as part of a Rational National Energy Strategy

# Chan-Chan's ruins, Capitol of ancient Chimu Empire, present day Peru


**During a prolonged drought, the Chimu Empire embarked on a crash program to build aqueducts to bring water to the citizens.**

**Among the ruins, we find a Fatal Flaw:**
**some aqueduct sections were constructed to run uphill; the empire collapsed.**
**Despite great payments from the Royal Treasury, water never reached the citizens of Chan-Chan.**


**Today -- similarities between Chimu engineering and the current reckless pursuit of biofuels.**

**Both began without a proper survey of the terrain and obstacles**
**Both attempt to defy unyielding physical laws,**
**Both expended prodigious resources without achieving goals.**

**Chimu tried to make water run uphill in defiance of the law of gravity.**

**The US government and military try to make energy run uphill in defiance of the Laws of Thermodynamics.**

- **PROMISES**

  Biofuels will increase our domestic supply of transportation fuel,
  … end our dependence upon foreign oil,
  … reduce military vulnerabilities on the battlefield,
  and … generally improve national security.

- **PROMISES**

  Biofuels: reduce fuel price volatility,
  reduce polluting emissions,
  reduce greenhouse gases,

  Even… stimulate the economy!

- These arguments fall apart under scrutiny**.**

http://stevengoddard.wordpress.com/2012/04/26/2008-obama-promises-5-million-green-jobs/

# 2008 : Obama Promises 5 Million Green Jobs

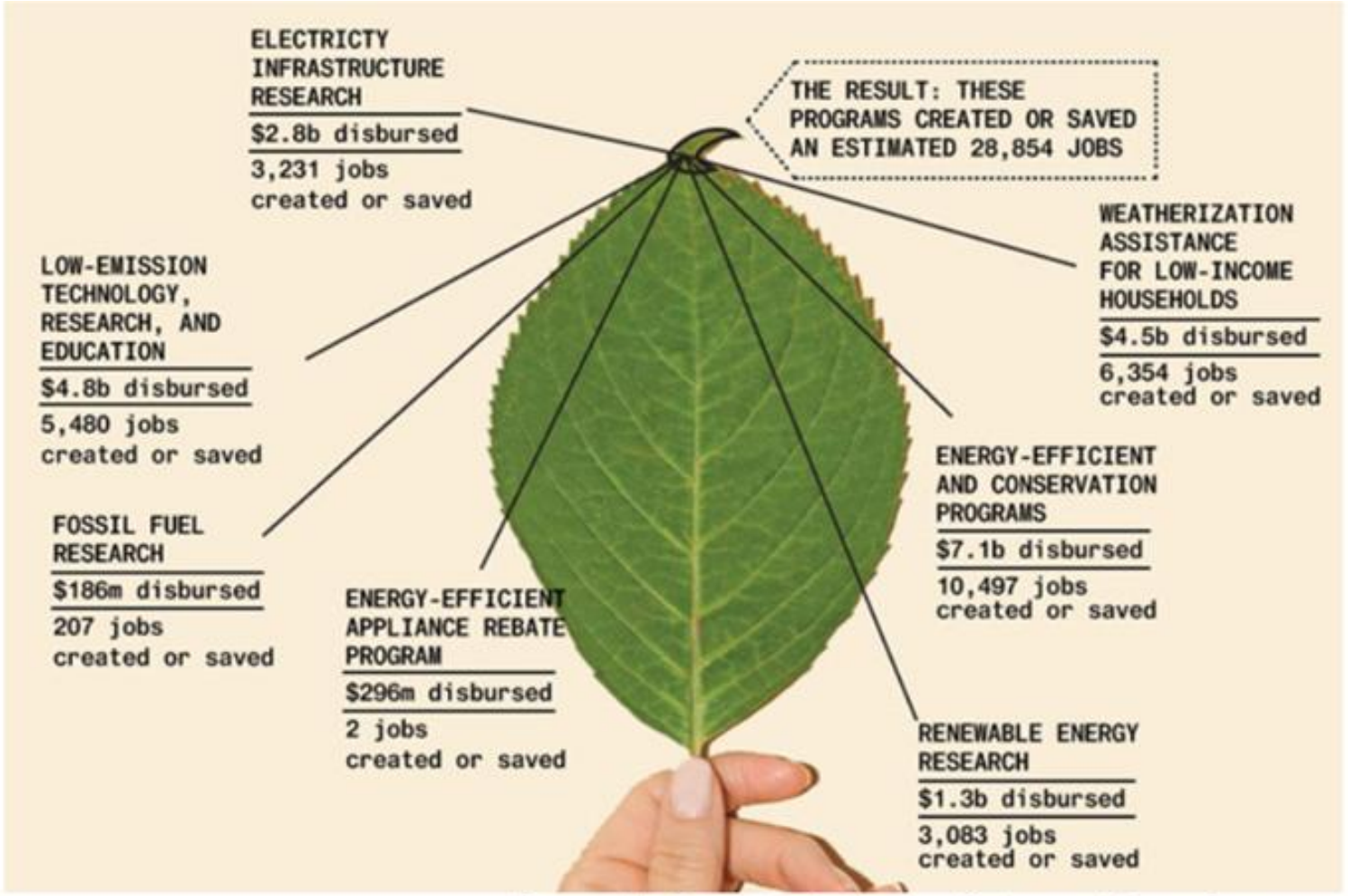
Posted on April 26, 2012

http://www.businessweek.com/articles/2012-10-11/the-5-million-green-jobs-that-werent



# The 5 Million Green Jobs That Weren't

By Ira Boudway | October 11, 2012




Photograph by Brea Souders for Bloomberg Businessweek; Source: Recovery.gov

# Principles

- Consider energy balance:  <energy output - energy input>
- Biofuels -- a modern-day attempt at perpetual motion,
    - Doomed by the Laws of Thermodynamics and
    - Biofuels' fatal dependence upon fossil fuel energy.

# Lessons from History

**Scientists –researching alternatives to petroleum fuels for over a century.**

- **First commercial cellulosic ethanol (fuel from trees, switchgrass) plant in the US opened 1910, failed after WWI.**

- **WW2: Germany synthesized diesel fuel from coal**

- **WW2: Japan distilled airplane fuel from tree root turpentine**

- **Between 1944 and 1953 the US government spent $87 million researching synthetic liquid fuel for military use before dropping the program (uncompetitive economics)**

- **1977 DoE-focused research -- ethanol as vehicle fuel.**

  **<Jimmy Carter's Synfuels>**

- **` 1980, (record high oil prices) DoE abandons "Gasohol:"**
**poor energy balance and extreme land use requirements made it impractical.**

# Lesson Summary

**Cut out wishful thinking**
**Use hard science in the analyses**

- **Chemistry**
- **Physics**
- **Biology**
- **Mathematics**

- Bob, restating Ike's summary

# Science of Energy -- Basics

**Energy** quantity of heat or work -- measured in joules.

**Power** rate which energy is produced or consumed -- joules per second, < watts.>

**Combustion** -- burning fuel with oxygen (usually from ambient air) to release energy.

**Primary energy source** -- something that can be used directly for heat or work, or be made into a fuel.

Crude oil, natural gas, coal, geothermal steam, uranium, wind, solar radiation, waves and tidal currents, food crops such as corn and sugarcane, cellulosic crops such as wood and switchgrass, and oil-yielding organisms such as soy and microalgae.

# Science of Energy Basics

• **Energy Carrier:** stores and transports energy for release under controlled circumstances.

• Examples include flywheels, electrical storage batteries, compressed gas, water collected behind a dam.
Especially-- chemical bonds of common atoms -- hydrogen and carbon.

• Chemical energy carriers are generally packaged together with other non-energy carrier substances that make them easier to store and handle and consume.

• Think: Gasoline and Diesel Fuel

# Basic Thermodynamics

**Two unbreakable laws of the universe:**

- **First Law of Thermodynamics (Conservation of Energy)**
  - **Energy obeys the rules of checkbook math.**
  - **Energy balance Sum of all deposits, Less withdrawals; Withdrawals cannot exceed deposits.**

- **Second Law of thermodynamics distinguishes between two kinds of energy:**
  **useful energy that can perform work**
  **useless energy that cannot.**

- **Think gasoline: energy <for moving the car + waste (engine heat) energy.>**

- **Amount of useful energy is always less than the energy that was input.**

- **Carnot efficiency of cars 7-30% more with diesel**

- **If more steps => more usable energy lost along the way.**

# Chemistry of Hydrogen, Carbon, Nitrogen

- **HYDROGEN very reactive accepts and releases energy in chemical bonds with other atoms.**

- **HYDROGEN the lightest element, very high *gravimetric energy density (joules per kilogram)***

- **HYDROGEN -- also the most abundant element.**

- **CARBON lightweight element with very high combustion energy - excellent energy carrier and fuel component.**

- **CARBON molecular chains, <hydrocarbons> , organize many atoms into dense and neatly organized packages (like plastic rings that hold six-packs of soda cans together.)**

- **Combined with HYDROGEN, CARBON forms highly versatile and energetic liquid fuels.**

- **When it comes to hydrogen, carbon is a chemical miracle worker.**

**Think Natural Gas - Gasoline – Diesel - Paraffin**

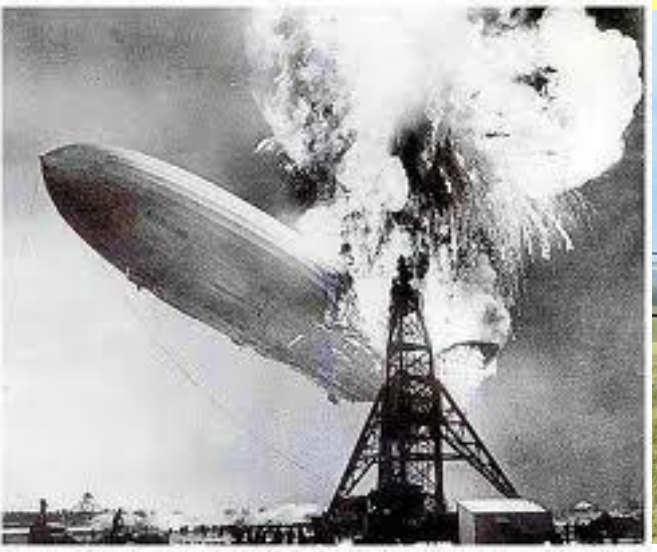
# Almost Miraculous--Chemistry of Carbon

**CARBON -- performs trick of packing hydrogen atoms together much more closely than they tolerate on their own.**

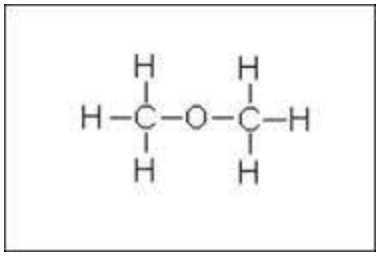
**<u>GASOLINE contains 63% more hydrogen atoms per gallon than pure liquid hydrogen.</u>**

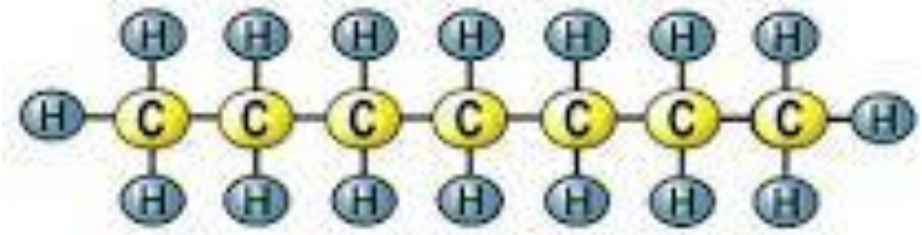
**GASOLINE has 3.5 times the volumetric energy density (joules per gallon) of liquid hydrogen.**

**Adding carbon transforms hydrogen from a diffuse, explosive gas (Hindenburg)
into an easily-handled room temperature liquid with more than <u>triple the energy density</u>**

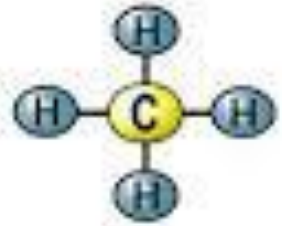


**Molecular structures of Methane, Propane, Ethanol, Heptane (Gasoline)**
**Showing hydrocarbon chemistry and its complexities.**

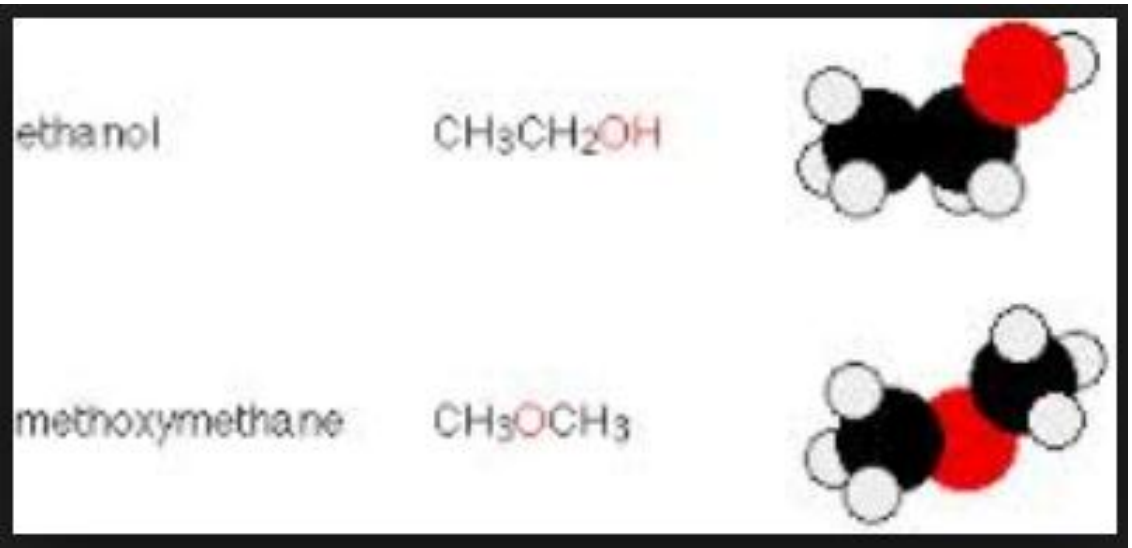


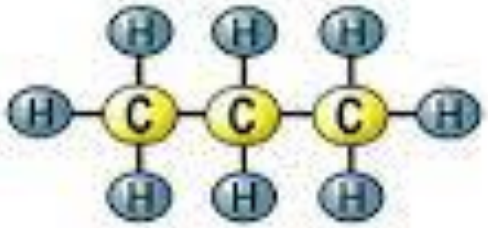


$C_7H_{16}$ – Heptane (Normal Gasoline)



$CH_4$ – Methane (Natural Gas)

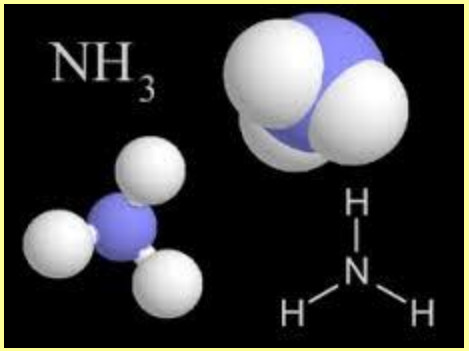


$C_3H_8$ – Propane

# Chemistry of Nitrogen

•NITROGEN , like CARBON , also tightly packages hydrogen energy carrier atoms together to make an efficient fuel.




•One nitrogen bonds with three hydrogens, forms AMMONIA (NH3).

•AMMONIA is a potent organic fuel for most bacteria and plants

• Vitally important in understanding ammonia-based fertilizer role

•Placing AMMONIA in the soil to fuel plant growth is "Nitrogen-fixing."

•Natural Examples:

- Animal urine and manure,
- Decay of protein matter from once-living things,
- Lightning,
- Soil and root bacteria decay uses photosynthesis energy borrowed from their host plant.

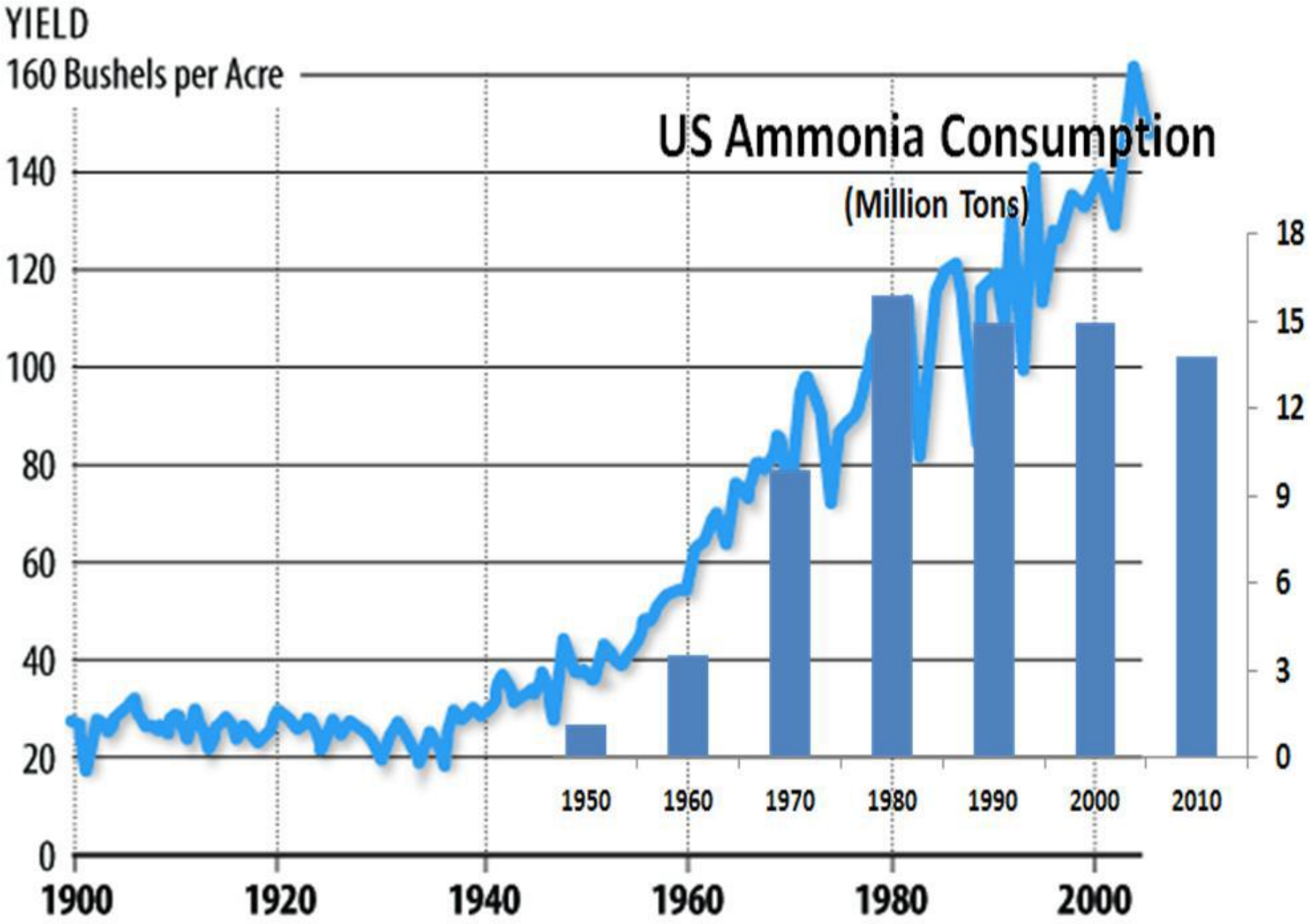
• US corn farmers reached the limits of photosynthesis and natural nitrogen-fixing by the turn of the 20th century.

• Yields plateaued @30 bushels/acre until "pumping energy into plants" adopted.

# Chemistry of Agriculture

- **All starts with incoming solar radiation 1361 Watts/ Sq Meter**
- **Plants convert 0.3 Watts/Sq Meter of sunlight into plant material, using CO2, H20.**
- **Photosynthesis "un-burns" CO2 and H20.**
- **"Free" energy from sun -- <sunlight+CO2+H2O> => useful fuel**
- **Photosynthesis: "horribly inefficient," but gets help from energy in the soil (remember fertilizing effect from decay of plants using bacteria?)**
- **Ammonia in the soil helps this process (natural fertilizer)**
- **"Combat Multiplier" discovered by Fritz Haber in 1909:**
- **<u>NATURAL GAS can be turned into AMMONIA –supplies energy directly to the plants.</u>**
- **Spectacular Yield Increases-- still being created**

# U.S. Corn Grain Yields, 1900-2005



# Crops obey Laws of Thermodynamics!

- Yield energy output from biofuels significantly less than energy input to grow them.

- Switchgrass takes 30 years to fully develop on unmanaged land.
  - 3 years to produce a full yield as a cultivated monoculture
  - depletes soil nutrients like any other vigorous crop.

- Without boosting from artificial fertilizers, biofuel crops yields not sustainable.

  <Brazil is finding this out>

- No free lunch.

- Fossil Fuel (natural gas) is used as the starting point to generate the high Yields/Acre seen in Corn ( key element in corn ethanol production)

- Same applies to biofuels technologies.

# Examples: US military operations in Kuwait, Iraq

•Transport /deployment of Army, Air Force, Navy personnel / equipment. Maneuver troops and equipment to achieve mission objectives:

Facts:

•Gasoline, Avgas, Diesel and Jet Fuel are Gold Standard in terms of Energy density, handling safety, transport, low toxicity, troop usability.

•>100 years of chemical engineering has developed this Gold Standard.
•Jimmy Doolittle (Shell) => Avgas pre-WWII
Allies > Advantage over Axis.

•Three Biofuel Alternatives to petrochemicals:
- •Biodiesel tends to solidify @ low temps (Jets flying at altitude)
- •Ethanol is corrosive to fuel lines and systems
- •Pyrolysis Bio-oil is highly acidic and chemically unstable

- Doesn't this sound stupid from the Get-Go?

# Three Biofuel Alternatives to petrochemicals:

**Biodiesel tends to solidify at low temperatures (Jets flying at altitude)**
**Ethanol is corrosive to fuel lines and systems**
**Pyrolysis Bio-oil is highly acidic and chemically unstable**

**These alternatives**

- **Contain Oxygen, Soluble in Water => rust in fuel systems**
- **Conduct Electricity (Think flying near thunderstorms with this fuel in your plane's tanks)**

- **Using Ethanol would require 65% more tanker trucks and soldiers to convoy a given amount of energy around, e.g., Kuwait or Iraq.**

- **Only way to reduce convoys is to make military equipment more fuel efficient or to buy fuel locally.**

  - **Iraq and Afghanistan combat showed need for Heavy HMMWV's, Bearcats, and MRAPs.**
  - **Proved this is the wrong approach**

## Hydrotreatment –
## Hydrotreated Renewable Jet (fuel) ' HRJ '

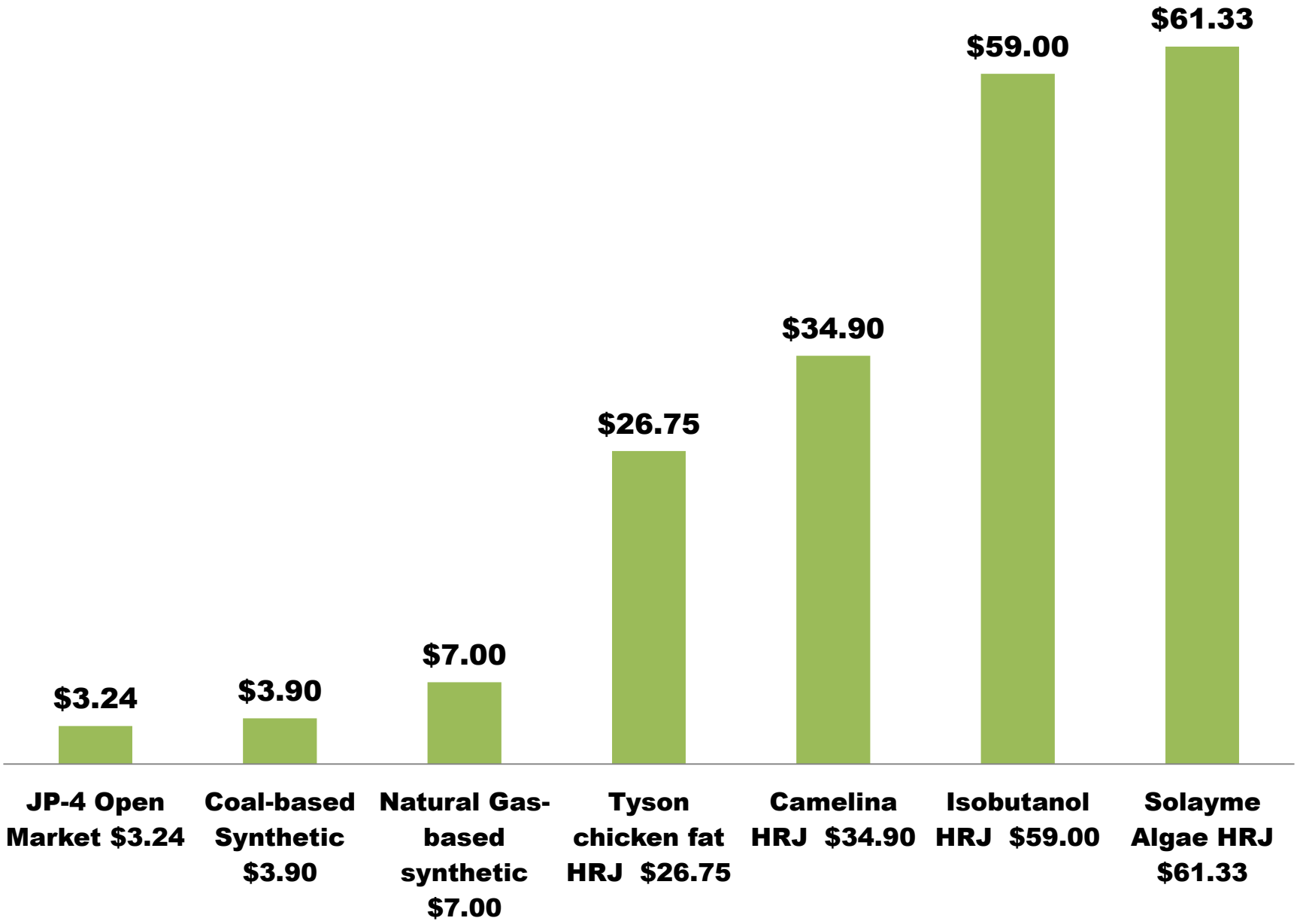
- Only way to make biofuels interoperable with petroleum products
- Chemical manipulation of the Biodiesel, Ethanol, and Pyrolysis bio oil
- HRJ-- makes it a "drop in" replacement

Jet fuel bulk purchase $3.24/gallon, HRJ very costly!

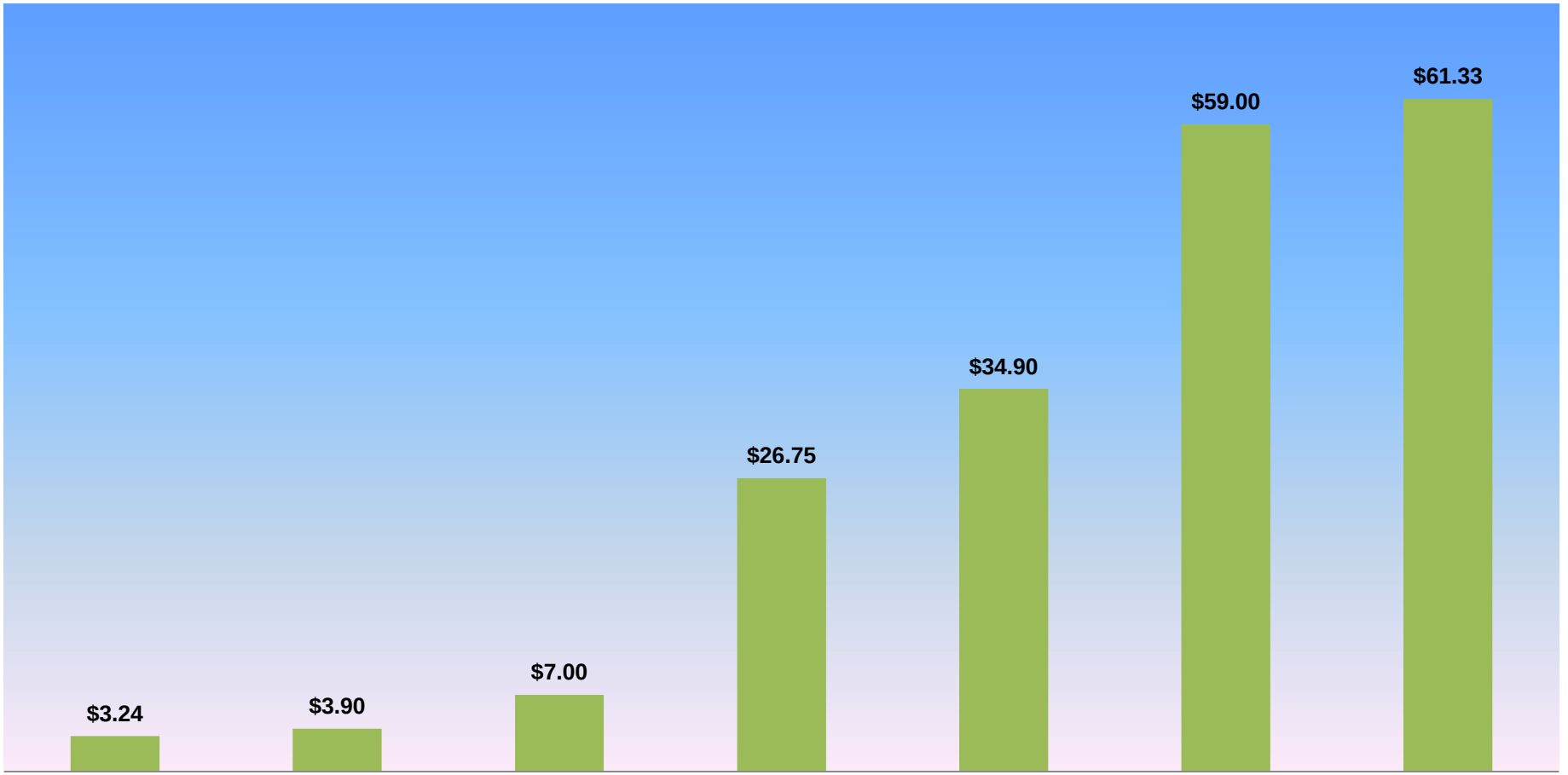
Actual prices our Government paid for HRJ fuels:

**$3.90 a gallon to SASOL for coal-based synthetic,**
**$7.00 a gallon to PM Group for natural gas-based synthetic,**
**$26.75 a gallon to Dynamic Fuels for Tyson chicken fat-based HRJ**
**$34.90 a gallon to Sustainable Oils for camelina HRJ,**
**$59.00 a gallon to Gevo for isobutanol-based HRJ,**
**$61.33 a gallon to Solazyme for algae HRJ,**
**$4,454.55 a gallon to Albemarle for converting Cobalt n-butanol to HRJ**
**$11,248.99 a gallon Honeywell UOP converting Gevo isobutanol to HRJ.**

# Cost: JP4, Synthetics, HRJ



# Cost: JP4, Synthetics, HRJ




**Off the chart:**
**$4,454.55 a gallon to Albemarle for converting Cobalt n-butanol to HRJ,**
**$11,248.99 a gallon to Honeywell UOP for converting Gevo isobutanol to HRJ.**

# ENERGY RETURN ON INVESTMENT (EROI)

$$\text{EROI} = \frac{\text{USABLE ENERGY in newly produced fuel}}{\text{ENERGY CONSUMED in producing the new fuel}}$$

**Think: Energy required to drill an oil well compared with the amount of energy that you can extract from that well.**

**Is it worth it to drill?**

**EROI of 1:1 useful energy in new fuel equals energy consumed to produce it.**

**EROI of 1:1 is a losing proposition. EROI 3 to 6 energy recession**

**EROI 6 break-even point**

**EROI 10-30 Bull Market**

# EROI : Shows why Corn Ethanol is 21ST Century Snake Oil

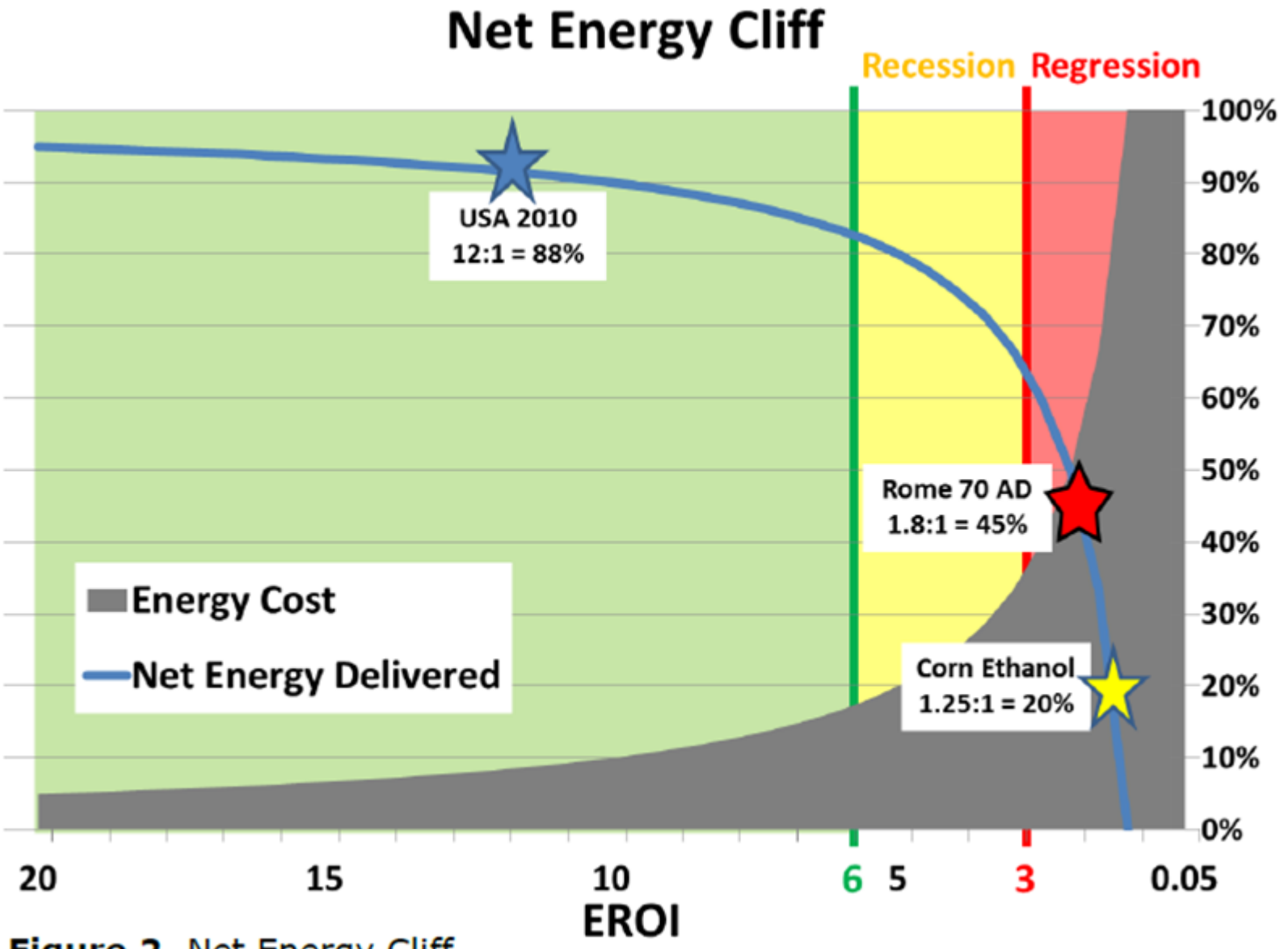



**Figure 2.** Net Energy Cliff

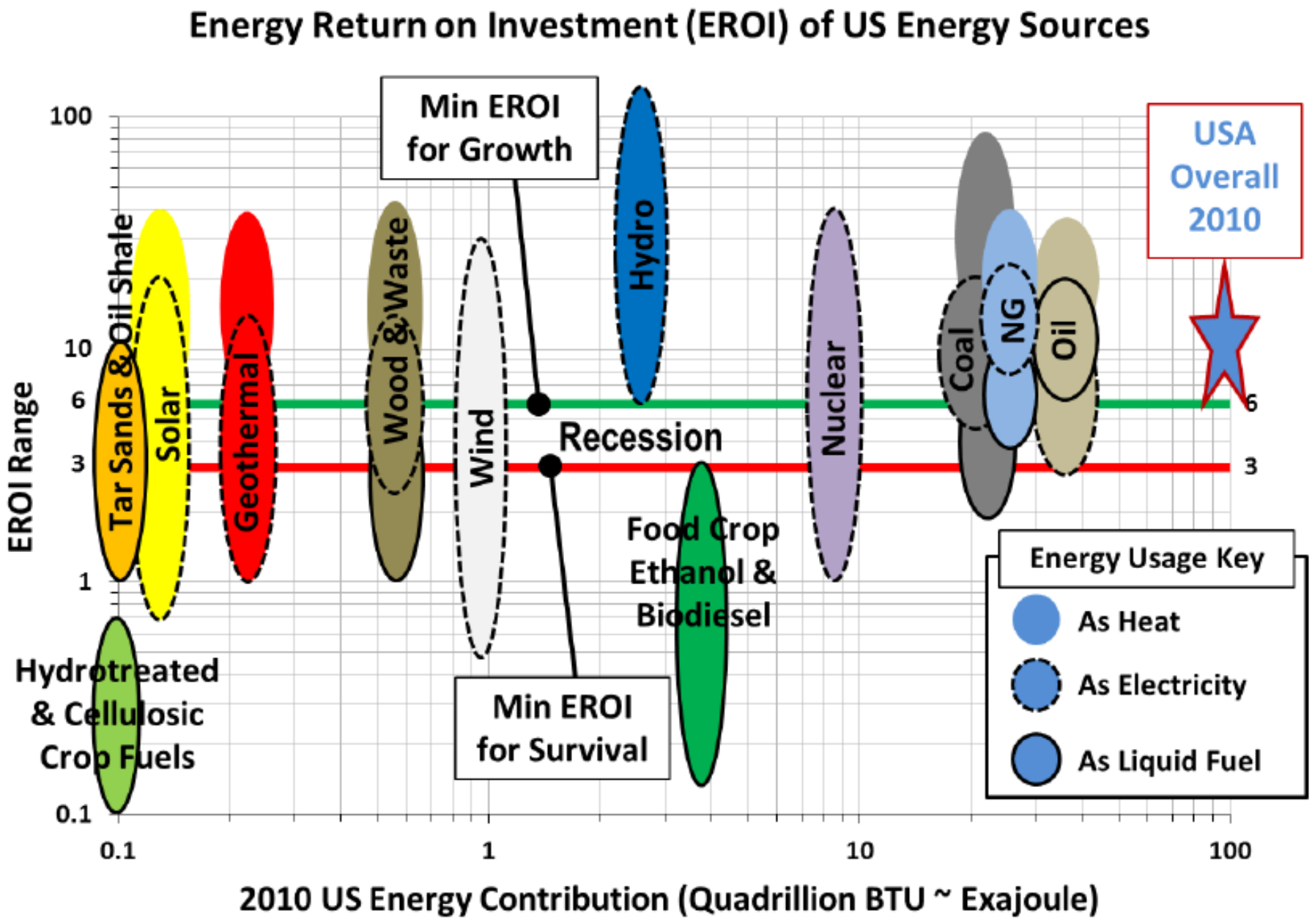



**Figure 3.** Energy Return on Investment (EROI) of US Energy Sources

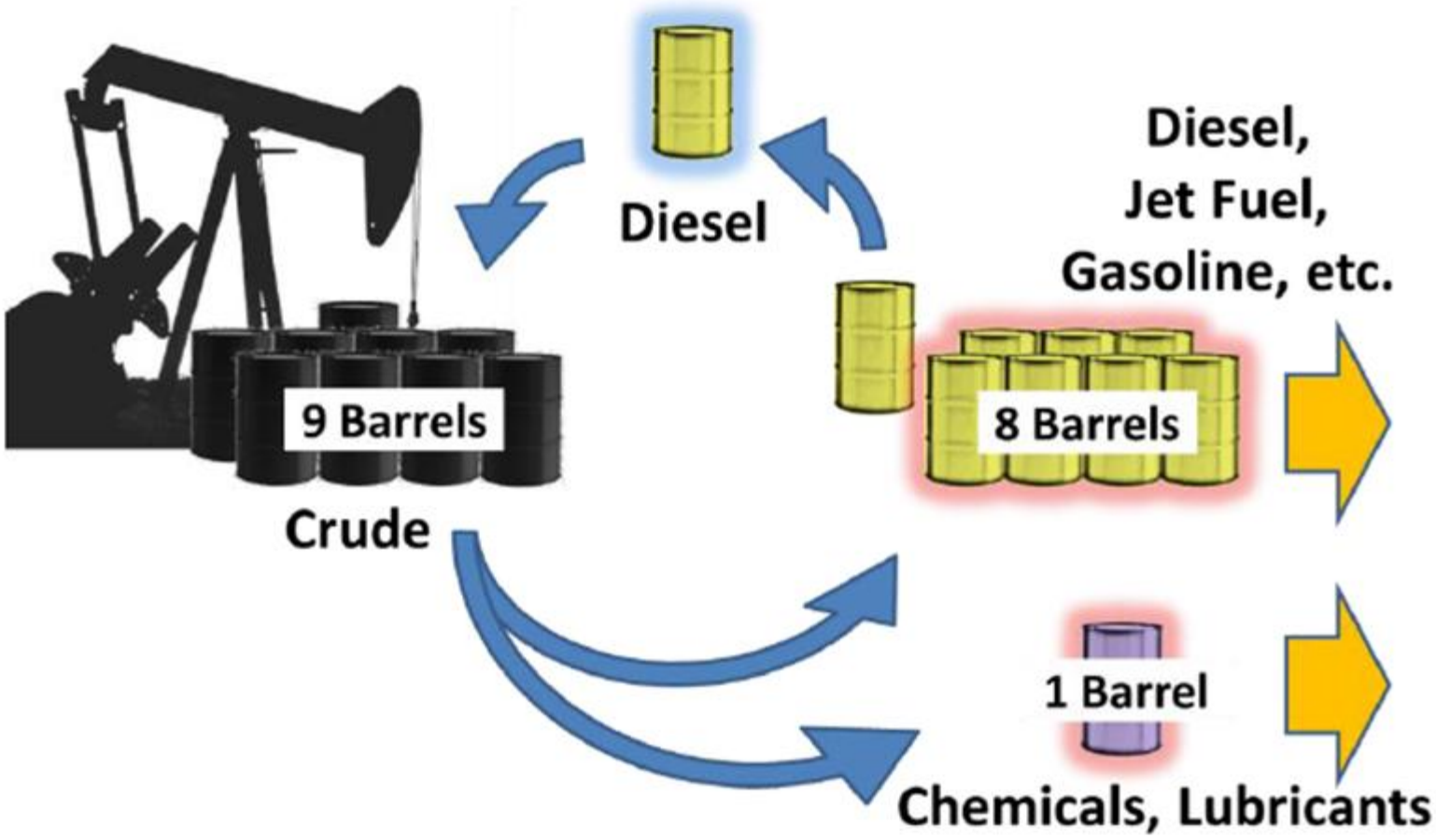



**Figure 4.** Petroleum Motor Fuel Lifecycle

# What the Corn Ethanol mandate means -- real energy cost terms

- Previous Petroleum graphic shows that one barrel of diesel produces 8 barrels of fuel and 1 barrel of tar, asphalt, or similar.

- Corn Ethanol requires 32 barrels of diesel energy to produce 52 barrels of low quality corn ethanol energy (corrosive) and leaves 2 tons of swine food
  - Produces 3X the amount of $CO_2$
  - Uses 1000 times more fresh water in the process.
  - Have to use natural gas (fossil fuel) to produce the corn

- Biofuels advocates use propaganda; here you see the whole picture

- Entire picture, not combustion-only comparison

- Shows energy consumption (civilizations use energy, not bushels)

- Shows mass and energy input and output required by Laws of Thermodynamics

- Shows how wasteful it is to produce corn energy just to meet a mandate; Energy that could be used for more productive uses.

**Definition: DDGS**

**Distillers Dried Grain and Solubles:**

**A byproduct of corn ethanol production often used as food in swine production as a replacement for the corn used in Ethanol Production .**

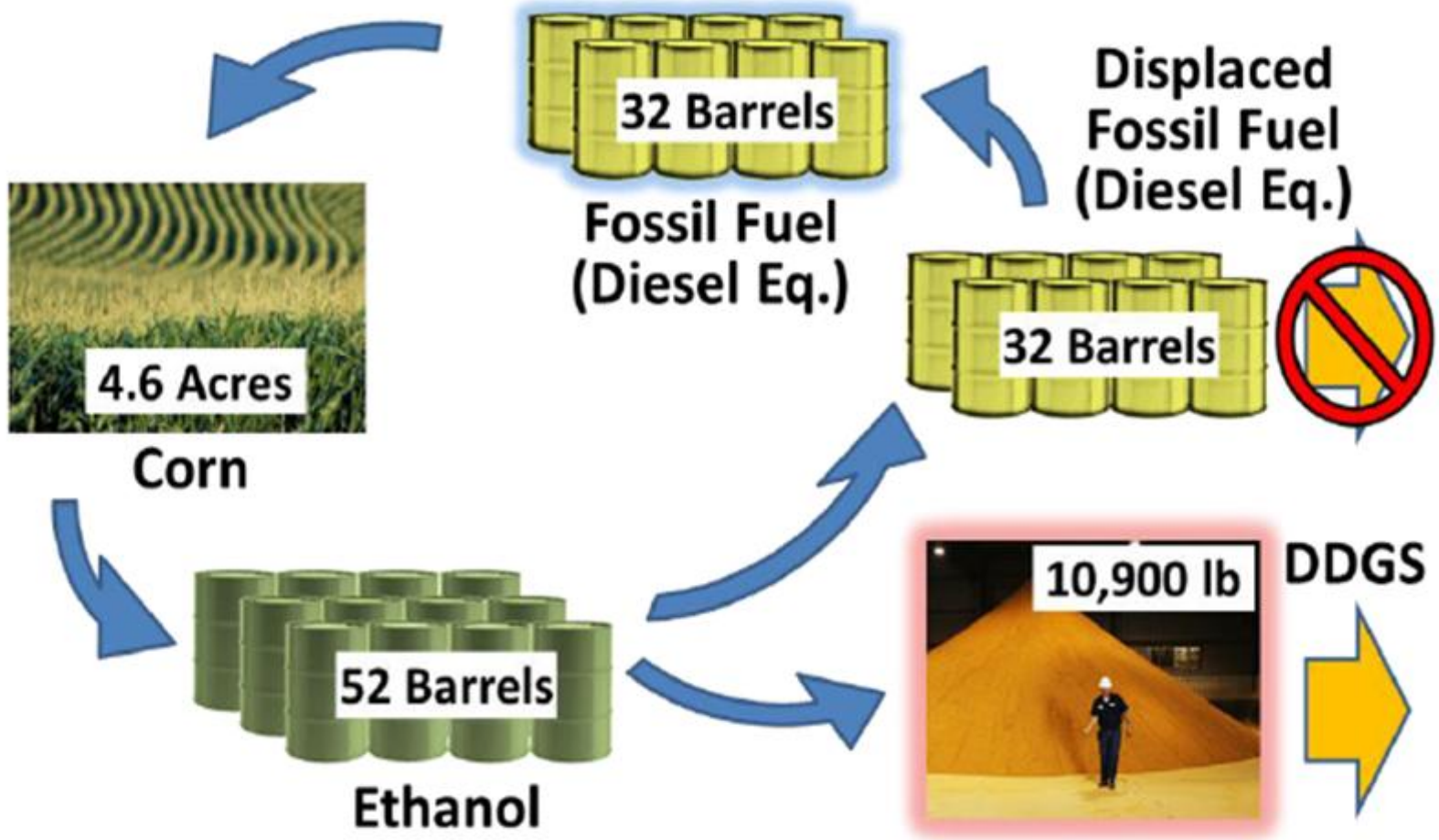



**Figure 5.** Corn Ethanol Motor Fuel Lifecycle

# Unintended Consequences -- Corn Ethanol Mandate

- **Need for corn-energy production increases demand for fossil fuels.**

- **We use fossil fuels to create nitrogen-fixed ammonia for fertilizer, so we need fossil fuels to create the corn used in the ethanol mandate.**

- **Applying ammonia fertilizer to any crop intended for biofuel is an indefensible waste of energy**

- **Accelerating fossil fuels use by wastefully using them to make much lower EROI biofuels brings any day of future fossil fuel scarcity that much closer.**

  - **3X the $CO_2$ output.**

  - **Counterproductive to "clean" and "green" energy goal.**

- **What is true for corn ethanol is true for all cultivated crop biofuels.**

# Real Costs of Corn Ethanol Mandate:

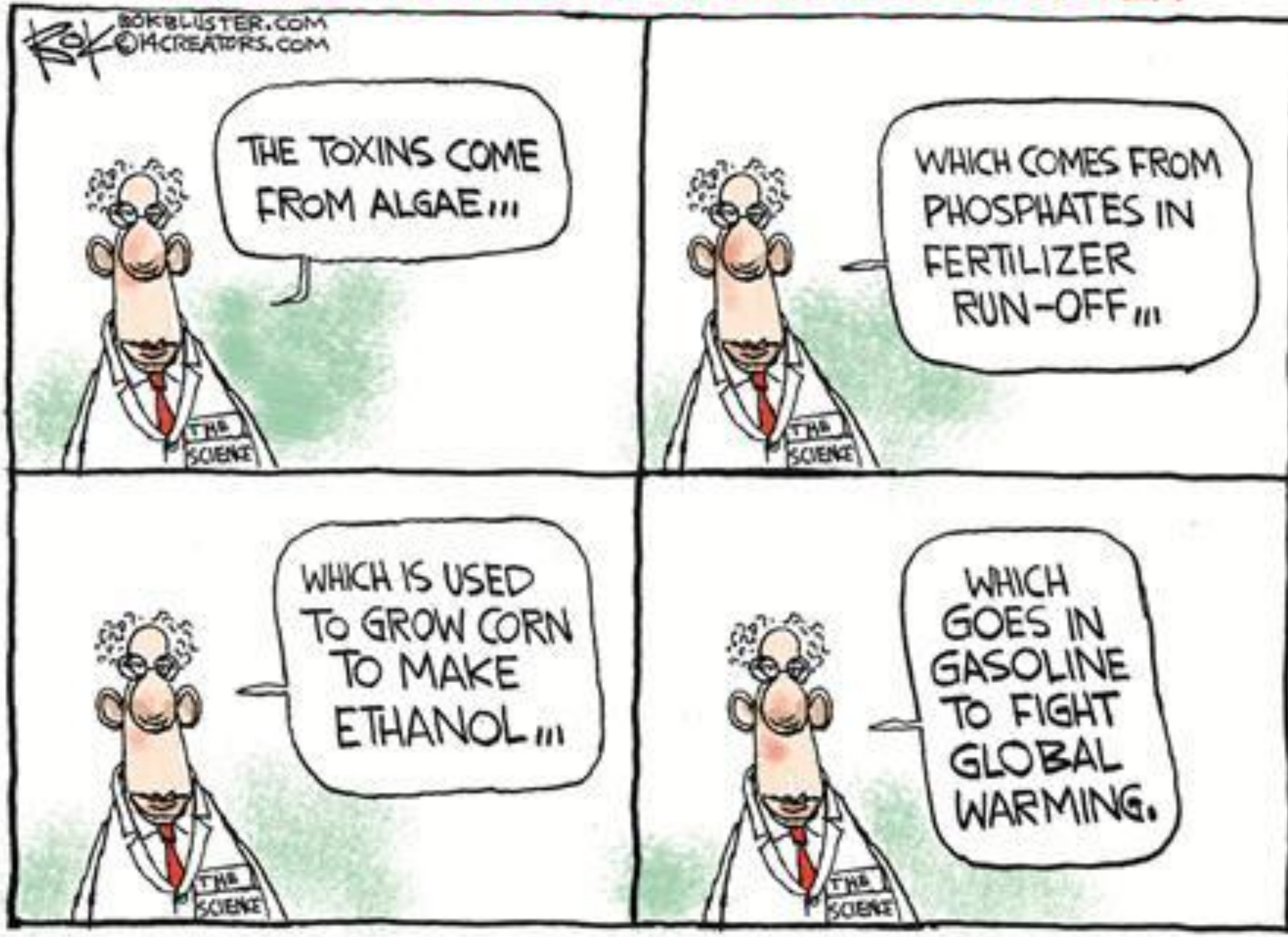
- **Excessive Energy to produce corn ethanol is parasitic.**

- **Biofuels in USA -- not displacing fossil fuels, but accelerating their use.**

- **Only way to displace imported petroleum, <improve national security>:**
  - **Domestically produce fuels with higher EROI than refined petroleum.**
  - **Such fuel will be instantly adopted > higher EROI lowers prices**

- **US economy would get 6X usable energy from the same investment of fossil fuel energy-- IF that energy was used to produce refined petroleum instead of being diverted to making ethanol and DDGS.**

# HOW CLIMATE CHANGE POISONED TOLEDO'S WATER



# Mandating a renewable standard for fuel use

- **Our FUEL is now susceptible to weather (drought, cold, flood, hail )**
- **All Pain, no Gain.**

**What happens when US Corn Ethanol reaches "Peak Ethanol" <Hubbert Curve?>**

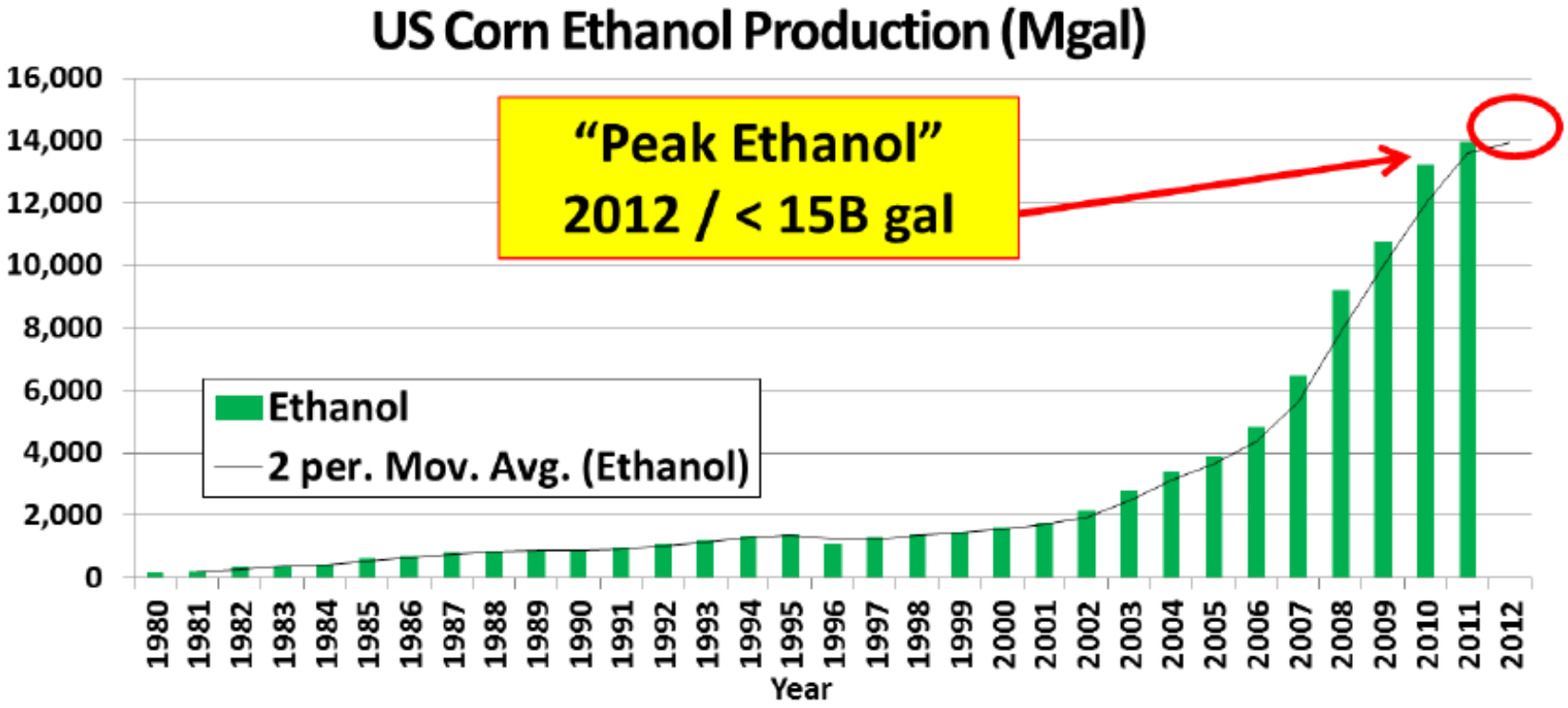


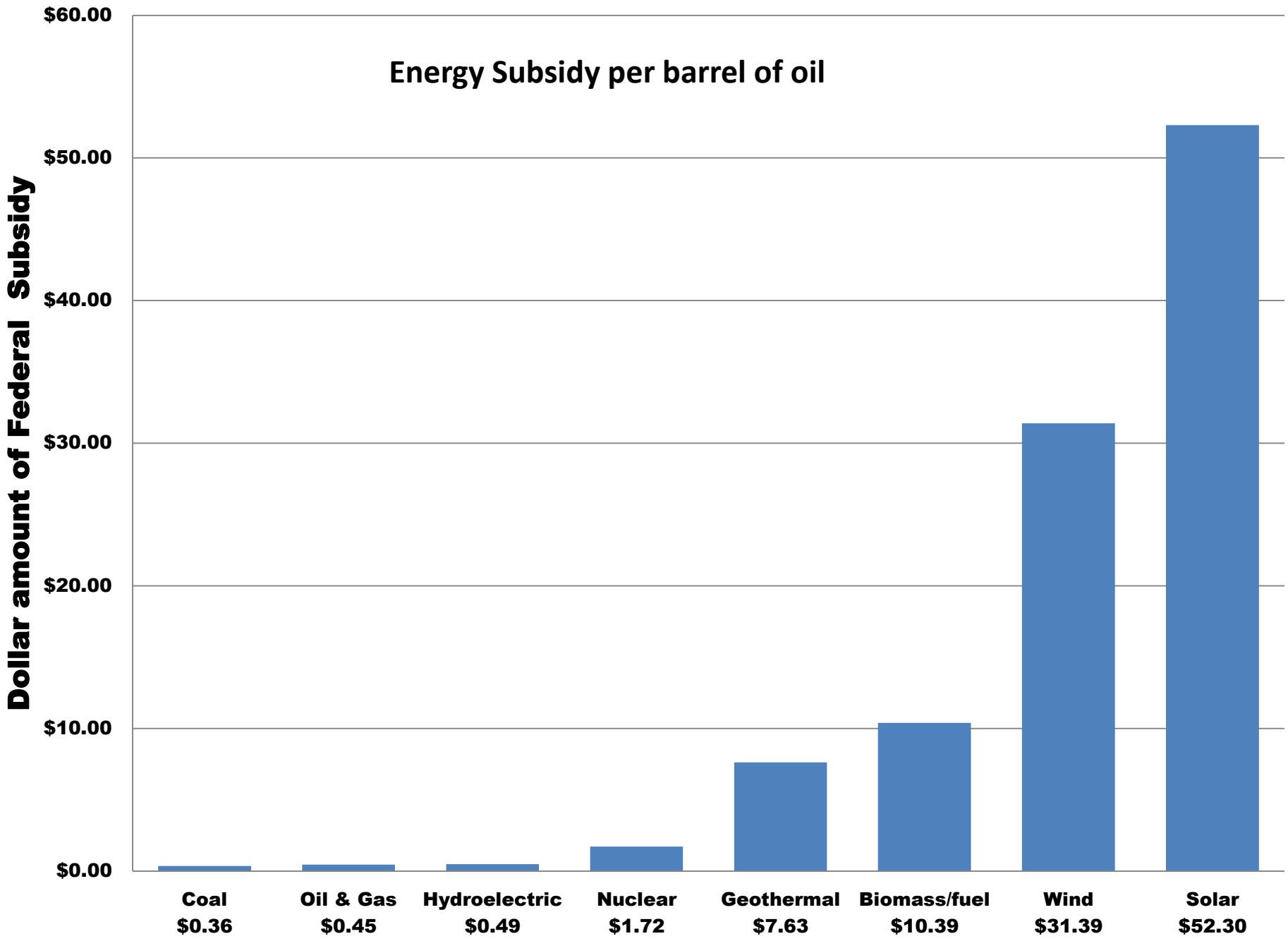

**Figure 6.** US Peak Ethanol

**Table 2**: US Federal Government Energy Subsidies in 2010

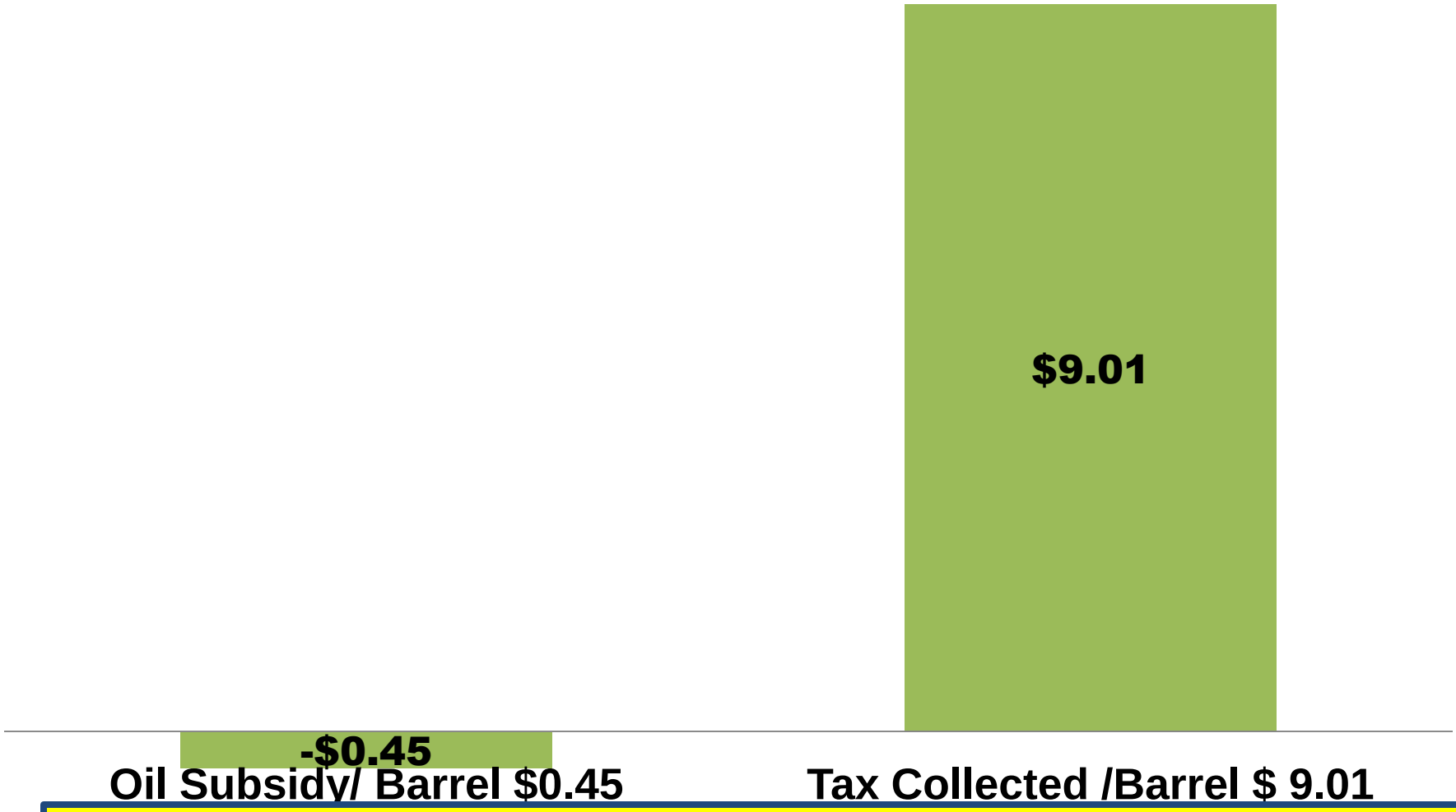
| US Federal Government Energy Subsidies in 2010 | | | |
|---|---|---|---|
| ***Energy Source*** | ***Federal Subsidies ($M)*** | ***Domestic Production (million barrels of oil equivalent)*** | ***Subsidy per barrel of energy produced*** |
| Coal | 1,358 | 3,793 | $0.36 |
| Oil & Gas | 2,820 | 6,229 | $0.45 |
| Hydro | 216 | 437 | $0.49 |
| Nuclear | 2,499 | 1,451 | $1.72 |
| Geothermal | 273 | 36 | $7.63 |
| Bio-mass/fuel | 7,761 | 747 | $10.39 |
| Wind | 4,986 | 159 | $31.39 |
| Solar | 1,134 | 22 | $52.30 |
| ***Total*** | ***21,047*** | ***13,921*** | ***Average = $1.63*** |

**Federal subsidies and tax breaks for oil and natural gas, 2010, totaled $2.82 billion, equaling 45 cents per barrel produced domestically.**

**Federal government collected $56.1 billion in oil company corporate taxes and excise taxes on retail gasoline and diesel,$9.01 per barrel a 2,000% return!**


Energy Subsidy per barrel of oil
Dollar amount of Federal Subsidy
$60.00
$50.00
$40.00
$30.00
$20.00
$10.00
$0.00
Coal
$0.36
Oil & Gas
$0.45
Hydroelectric
$0.49
Nuclear
$1.72
Geothermal
$7.63
Biomass/fuel
$10.39
Wind
$31.39
Solar
$52.30

# Big Oil Subsidy: 45 cents/barrel




**There is whining about the subsidy for fossil fuels, but no mention Of the tremendous amount of taxes collected.**

# Corn Ethanol. Are these success stories?

**After 6 years of huge subsidies, a joule of corn ethanol energy today is still more expensive than a joule of gasoline energy.**

**The American Automobile Association -- December 2012: MPG-corrected price of E85 ethanol at the gas pump is 40 cents a gallon higher than premium gasoline.**

**When added to the $6.1 billion in federal subsidies given out the by US Treasury and taxpayers as ethanol tax credits…**

**The US paid a $14.2 billion premium to displace 6.4% of gasoline energy with ethanol**
**—and the cheaper gasoline that was displaced <u>was exported!</u>**

# Power Density:
# "Energy Sprawl"

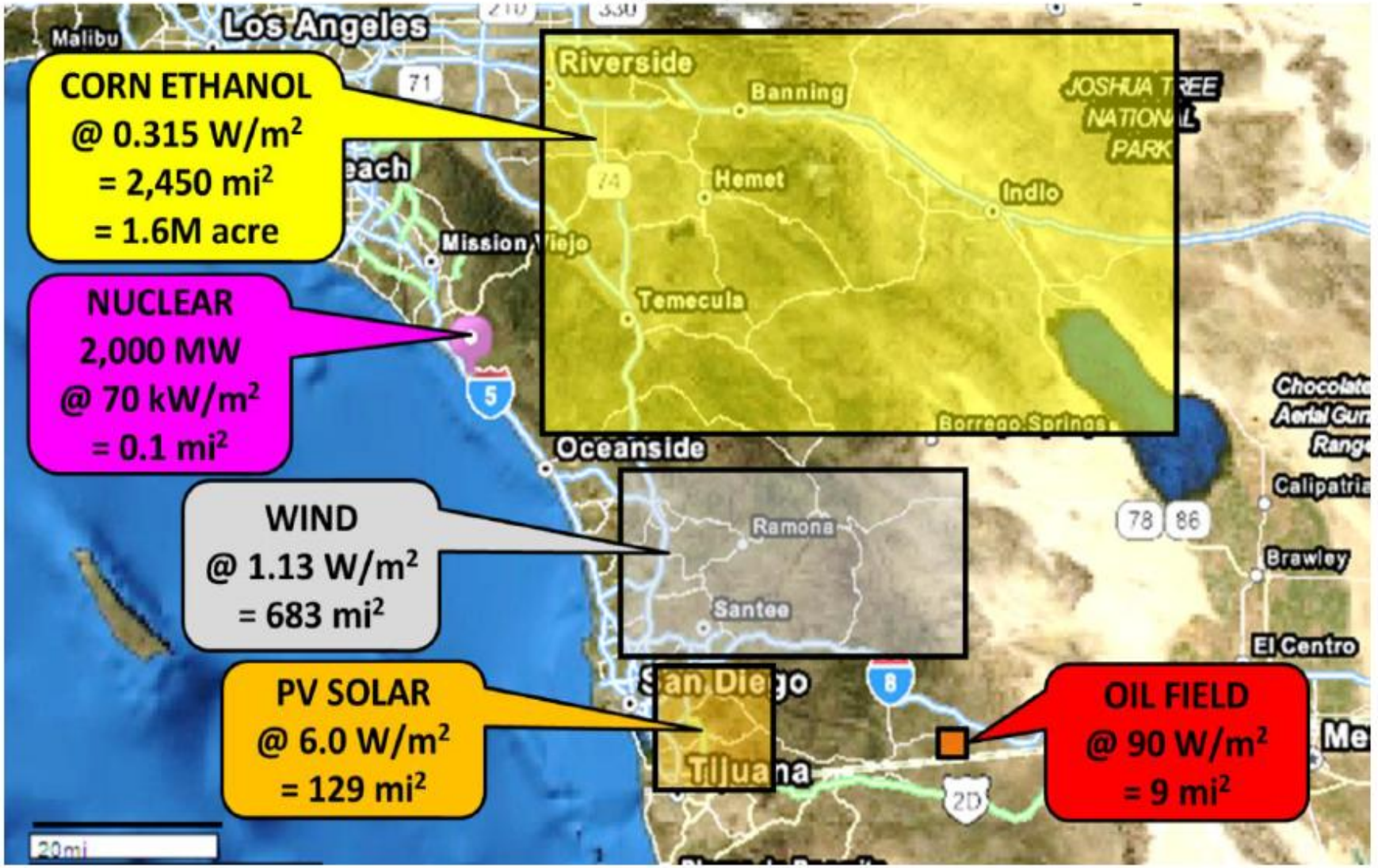



**Figure 7.** Power Density and "Energy Sprawl"

**Biofuels' huge appetite for land already puts the wealthiest nations in global competition with food production for the hungriest.**

# More Corn Ethanol Facts to consider

**Because of subsidies, USA today produces more corn for ethanol than for food or cattle feed.**

**<u>Ethanol reduces the fuel economy</u> of every gasoline vehicle in direct proportion to its blending ratio**

**increases emissions of some smog precursors, and requires a standing waiver from the EPA for their own air quality standards.**

**Blue Ribbon panel of experts commissioned by EPA in 1999 recommended discontinuing the use of all oxygenates in gasoline.**

# Summary

**Green Energy's promise of 5M green jobs has failed**

**US and German economies littered w/failed green energy projects**

**Chemistry, Biology, Physics: Hydrocarbon Energy is marvelous and safe**

**Methane and Ammonia-based fertilizers responsible for huge gains in agricultural food production; fossil fuel success.**

**EROI analysis shows green energy can never be profitable for a long time, likely forever.**

**Hydrotreated Renewable Jet turns $3.25/ gal fuel to > $11K/gal $ sink**

**Green Energy a perpetual money sink; important drain on economy**

**Green Energy fails Obama goals of reducing imports and emissions.**