

Biofuels: Facts and Fallacies

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Outline

- Stacking up the contenders
 - Ethanol
 - Crop-based (corn, sugarcane)
 - Cellulosic and Lignocellulosic (gasification)
 - Renewable Diesel
 - Biodiesel
 - Green diesel (hydrocracked, Fischer-Tropsch)
 - Miscellaneous
 - 'Renewable petroleum'
 - Di-methyl ether
 - Butanol
 - Contenders with Promise

Outline

- Can the U.S. emulate Brazil?
 - The truth about Brazil
 - The truth about the U.S.
- Fact or fiction?
 - Anything Into Oil
 - Algae to biodiesel
 - Ethanol for \$1/gal
- Where Politicians Fail
- Solutions

Corn Ethanol

- A 30-year old 'infant' industry
 - Subsidies date to 1978
 - Today there are subsidies plus mandates
- Mostly recycled fossil fuel (natural gas, coal, and oil)
- Sets up undesirable competition between fuel and food supplies
- Is essentially a jobs program for the Midwest

- Yes, but it's just a bridge...



Corn Ethanol is a Bridge...



This argument assumes there is something on the other side of the bridge

Sugarcane Ethanol

- Mainly produced in tropical countries like Brazil and India
- Produced from sucrose and from byproduct molasses
 - Byproduct economics are much better
- The key to the process is bagasse
 - A readily available energy source for fueling boilers
 - Minimal fossil fuel inputs relative to corn ethanol



Cellulosic Ethanol

- Commercial cellulosic ethanol is just around the corner – and has been for 40 years
- Suffers from a pair of big problems
 - Logistics: To operate a small 50 million gallon per year cellulosic ethanol plant (less than 4,000 bbl/day) would consume the equivalent of 850,000 mature Douglas firs per year
 - Yield: The concentration of ethanol produced is in the 3% range, requiring copious amounts of energy to purify it
- Prediction: Conventional cellulosic ethanol will only be viable in some novel applications

Ethanol from Biomass Gasification

- Pseudo-Cellulosic ethanol
- People often refer to this as cellulosic, but there is a distinct difference: It isn't limited to the cellulose
- Biomass (or coal or natural gas) is partially oxidized to synthesis gas ($\text{CO} + \text{H}_2$)
- From syngas, any number of chemicals can be produced
 - Methanol
 - Di-methyl ether (DME)
 - Ethanol or mixed alcohols
 - Diesel
- Capital costs are presently the limiting factor in scaling this technology

Diesel

- Biodiesel

- An alkyl ester, not a hydrocarbon diesel
- Requires an alcohol to produce
- Produces glycerin as a byproduct
- Cold weather performance issues

- Green diesel

- Gasification/Fischer-Tropsch
 - Any source of biomass
- Hydrocracking
 - Limited to lipids as is the case with biodiesel, but is a hydrocarbon diesel with a propane by-product

Miscellaneous Contenders

- Renewable petroleum
 - LS9 seeks to commercially produce hydrocarbons from biomass
 - Product phases out of water (reduced energy inputs)
 - Holy Grail; technically feasible, but technically challenging
- Di-methyl ether
 - Methanol can be produced from syngas
 - Methanol is converted to DME, which can be used in gasoline or diesel engines
 - DME burns with very low emissions
 - China taking the lead

Miscellaneous Contenders

■ Butanol

- An industrial chemical produced from propylene and synthesis gas
- Bio-butanol produced via the A.B.E. (acetone, butanol, ethanol) process
 - Commercial production via this route no longer viable, but hope springs eternal
 - Fermentation products are toxic to the microbes at low level concentrations
 - Butanol phases out of solution with water, but at much higher concentrations than are currently feasible

Contenders with Promise

- Solar, geothermal, and wind-generated electricity paired up with plug-in hybrid electric hybrids
 - Still some storage issues to resolve
- Biomethane as fuel
 - Easier to produce biogas; less energy intensive
- Biomass gasification to fuel
 - Choren, Coskata
- Green diesel
 - Jatropha, waste oils
- Ethanol in certain situations
 - Byproduct of sugar processing
- Renewable petroleum
 - LS9 (microbial), Virent (catalytic)

Can We Emulate Brazil?

- *"As a result [of ethanol], Brazil has virtually stopped importing expensive foreign oil."* – Dan Rather in The Ethanol Solution
- *"If Brazil can do it, so can we."* – Bill Clinton, promoting California's Prop 87
- *"As Brazil's 'energy independence miracle' proves, an aggressive strategy of investing in petroleum substitutes like ethanol can end dependence on imported oil."* – Vinod Khosla and Tom Daschle in Miles per Cob (a New York Times editorial)
- *"I'm driving a Chevrolet in the middle of Brazil on ethanol, pure ethanol, not a drop of oil, imported oil in this tank. And here is the stuff grown all around us that is the fuel. So I'm thinking, why can't I do this in America? Why aren't we doing it?"* – Frank Sesno in CNN's We Were Warned

Reality Check

- Annual ethanol usage in Brazil: 0.34 barrels* per person
- Annual oil usage in Brazil: 4.3 barrels per person
- Oil supplies more than 90% of Brazil's energy needs
- Brazil celebrated energy independence in 2006
 - Brazilian President Luiz da Silva made the announcement on the P-50 oil rig in the Albacora Leste field in the Atlantic Ocean



* Barrels of oil equivalent on a BTU basis (BOE)

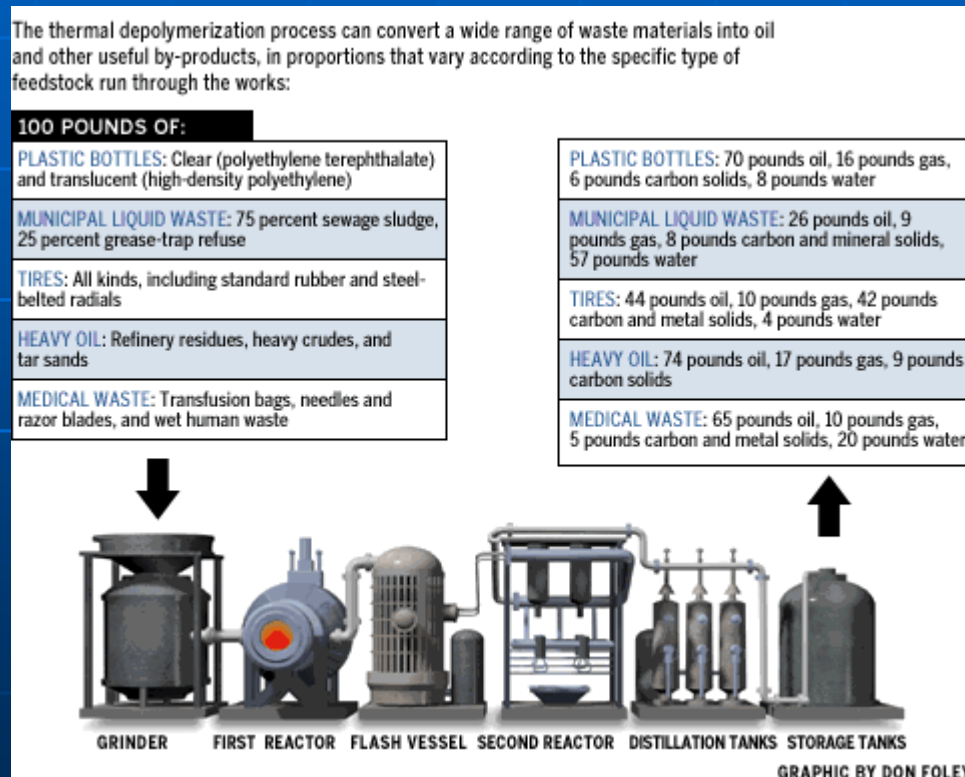
Reality Check – It Gets Worse

- Annual oil usage in US: **24.9 bbl/person***
- Annual oil production in US: **6.1 bbl/person**
- Annual oil usage in Brazil: **4.3 bbl/person**
- Annual oil production in Brazil: **3.2 bbl/person**
- Consumption and production are:
 - Grossly unbalanced in the US
 - Fairly balanced in Brazil
- So, how can the US be like Brazil?
 - By cutting oil consumption by 75%
 - Or by quadrupling oil production

* Consumption and production figures are from 2007, crude plus lease condensate

Anything into Oil: The TDP Story

“Technological savvy could turn 600 million tons of turkey guts and other waste into 4 billion barrels of light Texas crude each year” – Discover Magazine, May 2003



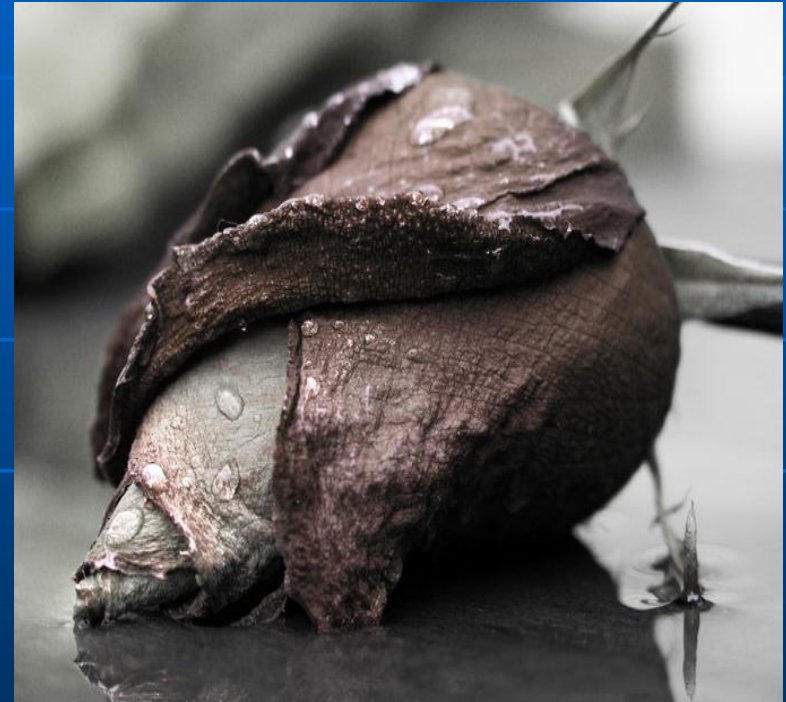
Everything's Coming Up Roses

- From May 2003 Discover Magazine
 - The price is right
 - "We will be able to make oil for \$8 to \$12 a barrel"
 - The technology sounds futuristic
 - "thermal depolymerization process"
 - The cast is interesting
 - "a tall, affable entrepreneur"
 - "a team of scientists, former government leaders, and deep-pocketed investors"
- The awards and accolades rained down...



The Bloom Comes Off

- Discover Update, April 2006
 - “We were too aggressive in our earlier projections”
 - “Production costs turned out to be \$80 per barrel” (as crude oil was trading at \$40/bbl)
 - “Construction problems”
 - “Odor problems”



Lessons Learned (or not)

- It is easy to fool people with 'technology'
- The potential problems of scaling up a process tend to be underestimated
- Small problems in the lab are big problems at scale
- Technical vetting and critical analyses are often lacking
- Failure to understand the idea that:

Killing cancer cells in the lab is not the same as curing cancer

Fast-Forward to 2008

- Press releases announce a technology that
 - “can convert any carbon source into ethanol”
- The cast includes
 - “Scientists, big business, and entrepreneurs”
- Cool technology
 - “Plasma gasification” and “membrane separation”
- A price that is almost too good to be true:
 - “We can make ethanol for under \$1/gallon”
- Partially demonstrated in the lab
- Next step: Piloting, where nothing unexpected ever happens.

What About Algal Biodiesel?

- Under optimal growth conditions, algae could produce 15,000 gallons of oil per acre per year – Aquatic Species Program Close-Out Report, 1998
- “The technology faces many R&D hurdles before it can be practicable”
- “Even with aggressive assumptions about biological productivity, we project costs for biodiesel which are two times higher than current petroleum diesel fuel costs”

Algal Biodiesel: Future Fuel?

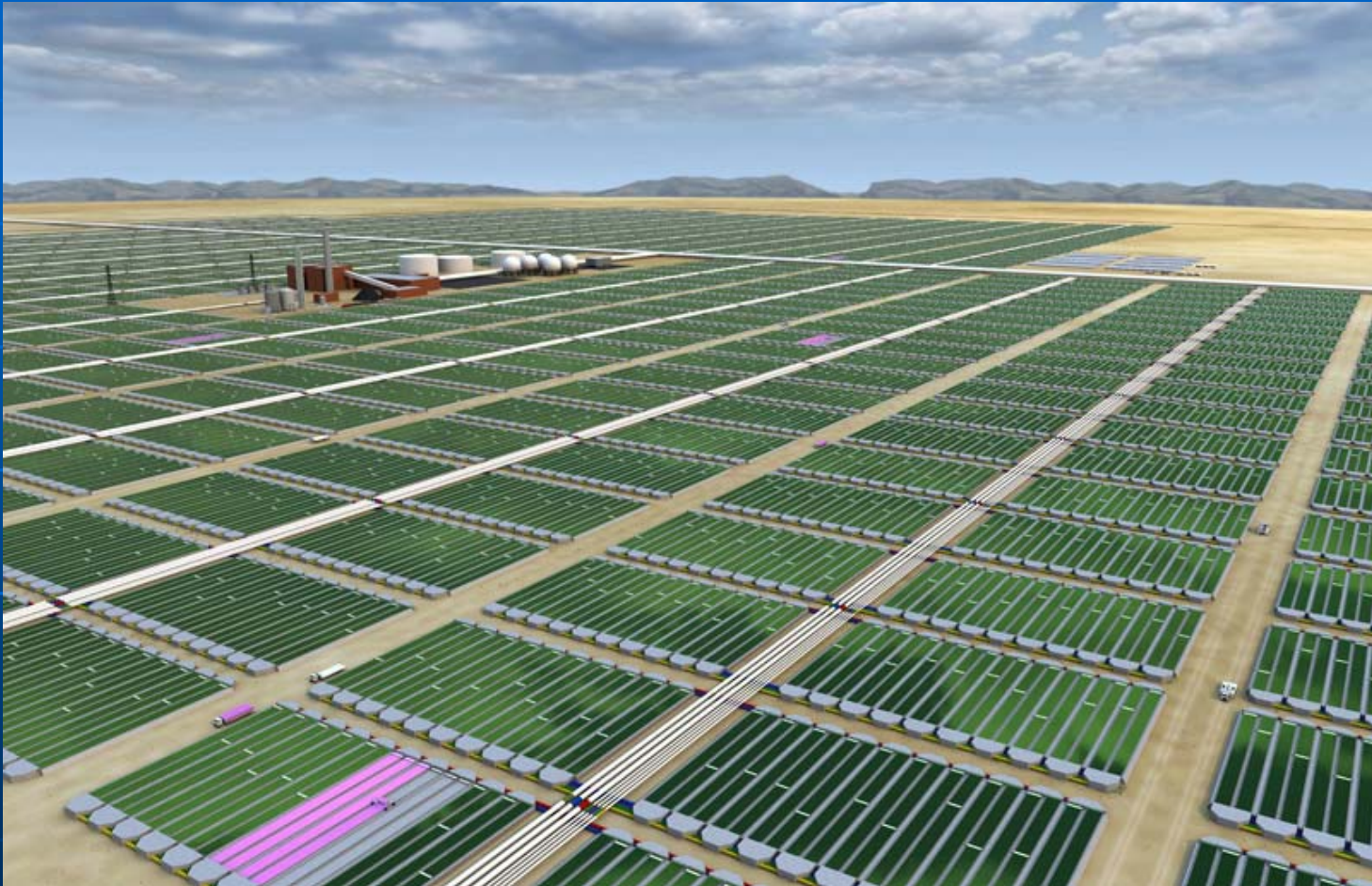


Image courtesy of the imagination of Solix Biofuels

Techno-Hustling

- “De Beers Fuel Showcases Algae as Feedstock for Biodiesel” – 12/6/2006
 - Plans to produce between 16 and 24 billion liters of biodiesel over five years
 - Reactor prototype developed by GreenFuel Technologies
- “Investors in 'fuel-from-algae' scheme left high and dry” – 6/8/2007
- “Could seriously dent the credibility of the algae biodiesel industry”
 - What credibility?

Where Politicians Fail

- By misleading the public
 - “We can be just like Brazil”
- By changing energy policy every year
 - Uncertainty of tax policies inhibits investment
 - Lack of long-term planning is detrimental
- By attempting to choose technology winners
 - Which is influenced by:
 - Misleading arguments from various ‘experts’
 - Vested interests
 - Desire to please constituents

Why Politicians Fail

- Lack of knowledge
 - Misinformation from government agencies
 - Inability to separate hype from reality
- Fear
 - Don't want to be voted out of office for making unpopular choices
- Conviction
 - They are certain that their energy proposals are just what the country needs

Solutions

- Cease the delusions of 'cheap gas for everyone'
 - Cheap gas encourages fossil fuel consumption
- Time for a frank discussion with the public
- Political courage to make some difficult decisions
- Increase fossil fuel taxes
 - Rebate income taxes to make it revenue neutral
 - Encourages energy conservation
 - Encourages alternatives
 - Encourages mass transit

Solutions

- Stop waging war with the oil companies
 - They have the most experience at delivering mass volumes of energy
- Encourage behaviors that reduce energy consumption
 - Rebates for solar water heaters, fuel efficient cars

Thank You