Biofuels and their Environmental Impacts

Report from the Gummersbach Rapid Assessment Workshop

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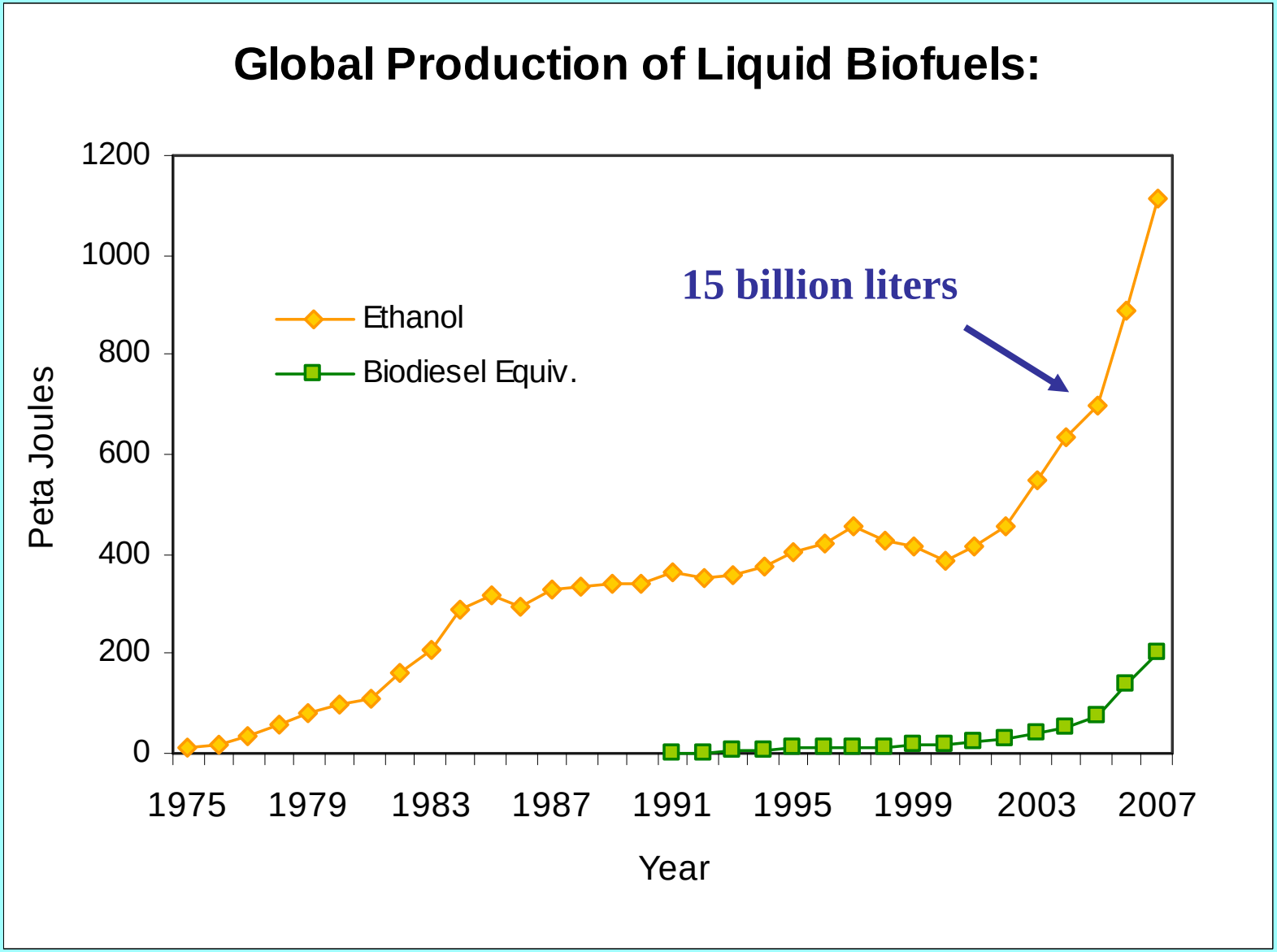
Global Production of Liquid Biofuels:
1200
1000
800
600
400
200
0
Peta Joules
Ethanol
Biodiesel Equiv.
15 billion liters
1975
1979
1983
1987
1991
1995
1999
2003
2007
Year

In 2007 liquid biofuels were 0.4% of global energy use
(1.1% of liquid fuel use; 1.8% of transportation fuel use)

Required 6% of all grains harvest globally, 8% of vegetable oil, and 28% of sugar cane.

United States was largest producer (48% of global biofuels)

Required 26% of corn to produce ethanol for 2.5% of liquid transportion fuel use (1.3% of total liquid fuel use).

Many countries have ambitious liquid biofuel goals -- 10% or more of transportation fuels by 2020 to 2025.

Represents a global increase of 5- to 6-fold.

It will be difficult at best to meet these biofuel targets using traditional crops.

What about novel crops (ie, cold pressed oil from jatropha)?

"Second-generation" biofuels, using cellulose as feedstock (from switchgrass, corn stover, wood, etc.)?

-- cellulosic ethanol

-- hydrocarbon fuels such as "biomass to liquid fuels," or BtL

Included in our analysis, but unproven and developing technologies, so much greater uncertainty.

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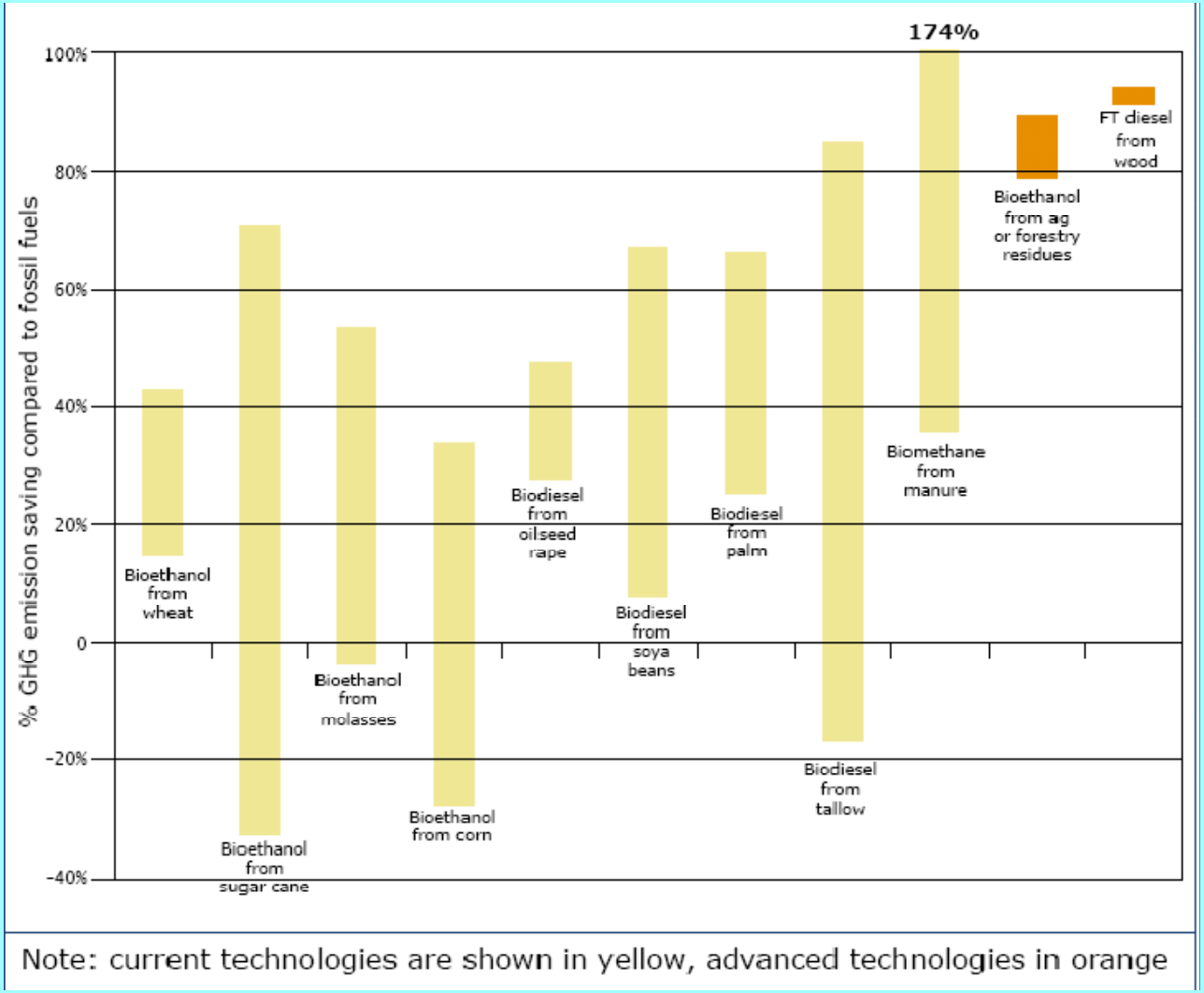
Net effects on greenhouse gas emissions (compared to gas or diesel)

Based on steady-state life-cycle analysis

good

Break-even point

bad



Gallagher 2008

Current life-cycle analyses have two major failings:

- Underestimate N2O fluxes
- Assume steady state – what happens as production rapidly grows?

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Atmos. Chem. Phys. Discuss., 7, 11191–11205, 2007
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Atmospheric Chemistry and Physics Discussions

N_2O release from agro-biofuel production negates global warming reduction by replacing fossil fuels

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~ 4% of all nitrogen added to the environment by humans ends up in atmosphere as N_2O (Galloway et al. 2004).

IPCC methodology (used in life-cycle analyses) assumes ~ 1% to 1.5 %

Rapid growth, not steady state!

Searchinger et al. 2008. Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land use change. ***Science*** (10.1126/science.1151861)

- **Previous "analyses have failed to count the carbon emissions that occur as farmers worldwide respond to higher prices and convert forest and grassland to new cropland to replace the grain (or cropland) diverted to biofuels."**

- **"… corn-based ethanol, instead of producing a 20% savings, nearly doubles greenhouse gas emissions …."**

Conclusions on greenhouse gases:

- **Biofuels grown on cleared forests or grasslands -- release of greenhouse gases from clearing usually exceeds decades worth of fossil fuel offsets.**

- **If global warming is the primary concern, leaving natural ecosystems (particularly forests) alone is usually a better strategy than clearing them to grow crops.**

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- **Diverting land previously used for food crops to biofuels can result indirectly in clearing of forests or grasslands, as farmers clear other lands for food production.**

- **The greenhouse gas emissions from this clearing, sometimes in different countries or continents, can be quite large.**

- **These indirect consequences make many biofuel systems net releasers of greenhouse gases over several decades as biofuel production is increasing.**

- **Using wastes and agricultural and forest residues for biofuels is likely to produce greenhouse gas benefits.**

- **Care must be taken to assure that enough residuals are left behind to protect soil health and carbon levels.**

- Marginal and degraded lands -- an opportunity to produce biofuel crops while restoring the landscape.
- Often requires substantial investment in irrigation and fertilizer.
- Some of these regions include areas of high biodiversity.
- Great uncertainty over the magnitude of lands that could be farmed in a sustainable, environmentally beneficial way.

SCOPE Project conclusions on other environmental effects:

Biofuel production and consumption have a variety of effects on the local and regional environment. Growing crops is essentially the same for biofuels as for other agricultural purposes. However, the environmental impacts of agriculture often increase as more land is used, land is farmed more intensively, and marginal lands are placed into agriculture.

• **Biodiversity is greatly threatened by deforestation and conversion of grasslands and savannas to biofuel crops. Conservation reserve lands are also threatened with conversion to agriculture in support of biofuel production. On the other hand, natural grasslands and forests may be managed for harvest of biofuel material at moderate levels, providing reasonable protection for biodiversity.**

• **Freshwater is increasingly in short supply and may not meet future demands for food production in many regions. Using irrigation to grow biofuel crops will aggravate these shortages, reducing water available for other uses and further impacting freshwater and coastal marine ecosystems.**

• Air pollution from the burning of sugar cane before harvest contributes smoke, fine particles, and nitrogen gases to the atmosphere, causing acid rain and a variety of human health impacts.

• Ethanol and biodiesel can reduce the emissions of some pollutants from vehicle exhaust (such as fine particles and carbon monoxide), but tend to increase other pollutant emissions (such as nitrogen gases).

Sept. 19, 2008 -- Piracicaba/SP /Brazil

(Luiz Martinelli)

- **Severe water pollution can result from runoff from agricultural fields and from wastes produced during the production of biofuels. Nutrient losses from corn fields and organic wastes from sugar cane processing are particular problems.**

- **When perennial crops such as switchgrass are used instead of annual ones such as corn, water pollution is much less.**

Corn is a particular problem for nitrogen pollution, due to shallow root system and short active period of nutrient uptake (~ 60d)

Tile drainage and lack of winter cover crops aggravate nitrogen pollution.

Corn-ethanol goals in US predicted to increase nitrogen inputs to Mississippi River by 37%. National goal is to reduce nitrogen by at least 40% to mitigate the "dead zone" in Gulf of Mexico.

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- **must be distilled to remove water (energetically costly)**
- **high in oxygen, leading to greater nitrogen emissions**

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- high in oxygen, leading to greater nitrogen emissions

Liquid hydrocarbons from cellulose probably far better fuel.

Better yet, burn cellulosic biomass instead to co-generate heat and electricity. Greater efficiency, so less land needed, less environmental problems.

Per area of land:

- **1 unit of energy for ethanol from corn**
- **3.5 units for ethanol from switchgrass**
- **9 units from burning switchgrass**

Direct combustion of solid biofuels reduces fossil fuel oil, since 40% of global use of oil is for stationary, non-transportation uses.

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http://cip.cornell.edu/biofuels

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The way forward….

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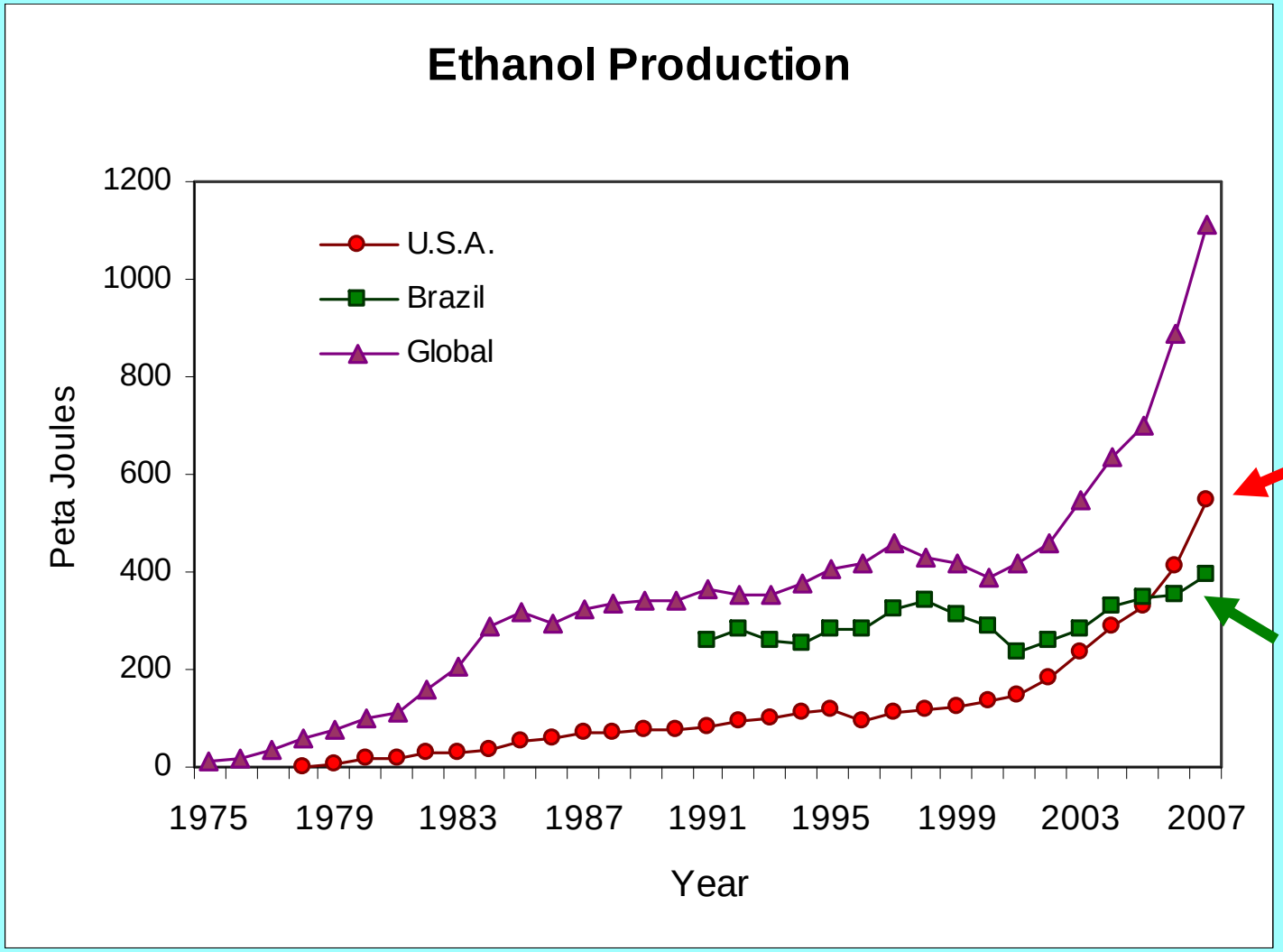
- **Energy plans must start with conservation, greater efficiency, and reduction in demand.**

- **Biofuels are not able to replace oil.**

Biofuels as contributors of total global energy use:

- **liquid biofuels = 0.4 %**
- **solid biofuels (wood, charcoal) = 10 – 13 %**



Almost all corn

Almost all sugar cane

Environmental effects (including greenhouse gas emissions) vary, depending upon issues such as:

- **Which feedstocks**
- **Which biofuel**
- **Where the feedstocks are grown**
- **Where the fuels produced**
- **Conversion methods**
- **What energy powers these conversions and transportation**
- **Interactions with other drivers for land use and land cover changes**