

Energy Long Island 2007

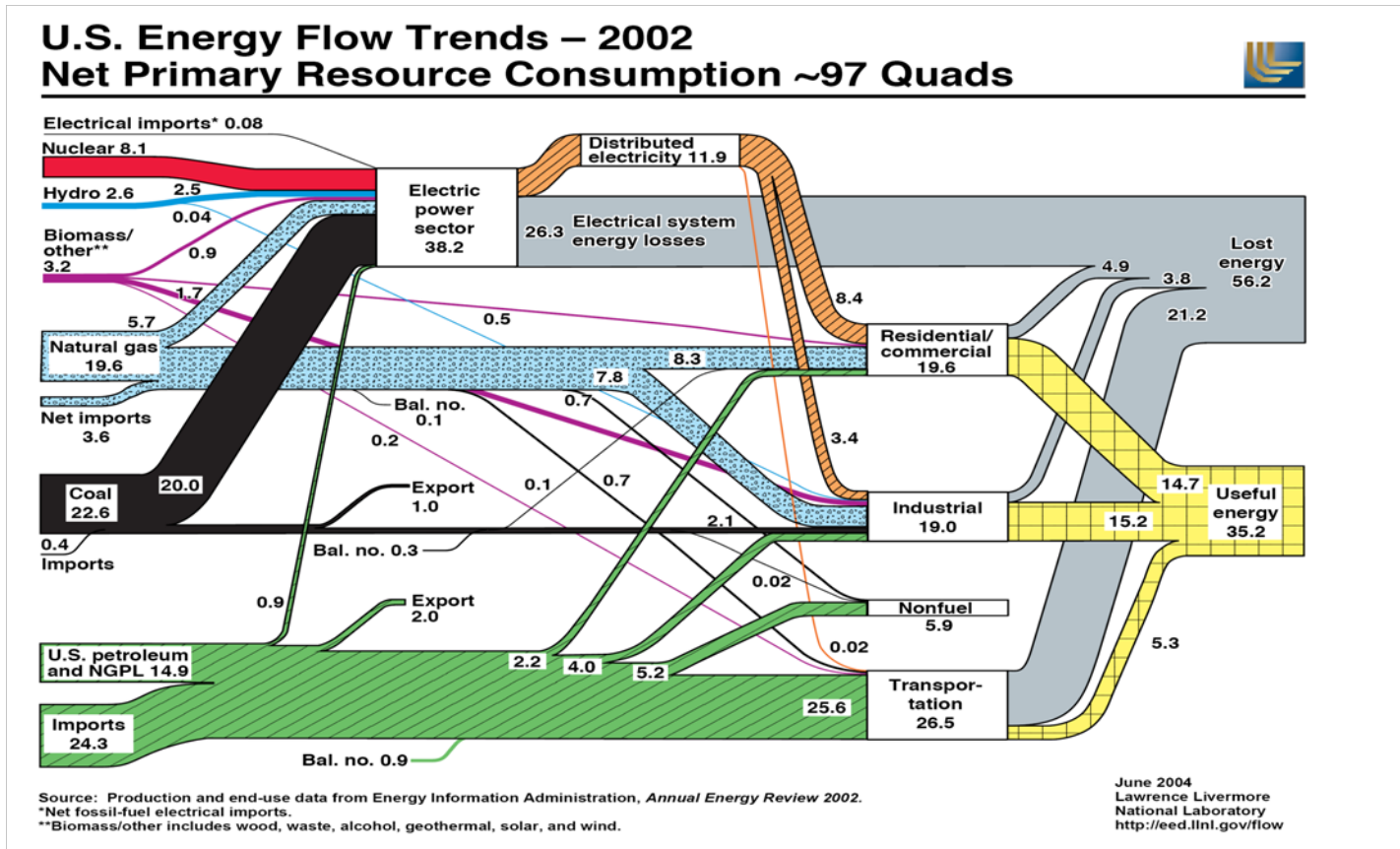
Biology and Energy Self-Sufficiency

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U.S. Energy Flows and Consumption



Largest user of petroleum is transportation (drives fuel switching)
Energy lost is greater than energy used (drives efficiency and storage)

BNL's Biology Energy Strategy

Biomass conversion

- Understand at the molecular level the fundamental mechanisms that catalyze biological conversions of materials
- Develop tools and methods for engineering plant and microbial enzyme systems
 - Enzymes for the conversion plant seed oils
 - Plant metabolic pathway analysis
 - Membrane transport systems
 - Plant disease resistance
 - Plant – microbe interactions – pathway engineering
 - Enzymes for cellulose degradation and conversion

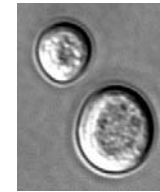


Currently corn to Ethanol



Convert
to Sugars

Ferment
to Ethanol



Bakers
Yeast



Biology Energy Strategy

Biomass conversion

- **Corn to Ethanol – Roadblocks**
 1. Available high quality cropland with sufficient water
 2. Energy input to break down starch vs energy output in ethanol
 3. Cost of food – impact on developing nations
 - corn livestock feed
 - soybeans – oil vs. food role of China

Biology Energy Strategy

Biomass conversion

- **Corn to Ethanol – Ways to Overcome Roadblocks**

1. **Use only stalks – cellulosic ethanol – new crop tropical maize can be used in corn rotation 15ft. High stalks no ear, stalk essentially converts cellulose to sugars naturally thus no energy intensive breakdown of cellulose. Go from sugar to ethanol directly**

2. **Better energy efficient breakdown of cellulose via bacteria**

Eg. TMO Renewables in Britain has produced a thermophilic bacteria geobacillus TM242 directly converts cellulose to ethanol at 65° Celcius. Other bacteria die at 65°

Energy Biosciences Programs

Engineering **Biomass** to **Lipids**

Primary effort:

Modification of Plant Lipids – **John Shanklin**

New Initiatives:

Quantitative Analysis of Central Metabolism and See Biomass Synthesis – **Jorg Schwender**

Understanding the Molecular Basis of Pathways that Prevent Losses from Insects and Disease – **Chang-jun Liu**

New Initiatives: Biohydrogen

Structural features of the oxygen tolerant hydrogenase from *Thermatoga neapolitana* – **D. van der Lelie**

Biodiesel

- Biodiesel has a gasoline-like high energy density, much higher than ethanol
- Biodiesel is made from plant oil by a simple chemical reaction
- Plant waxes are natural biodiesel and don't require modification



Sugar to Biodiesel?



**Convert
to Sugars**

**Ferment
to Biodiesel**

**Problems with corn
Food costs rise**

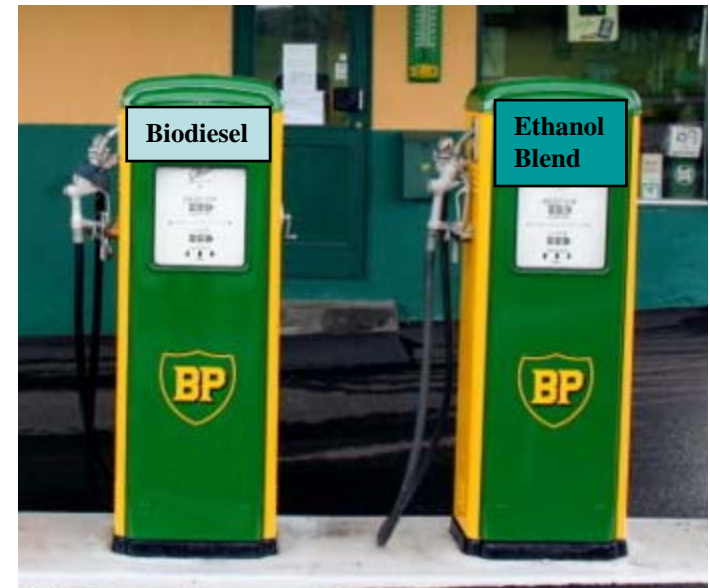
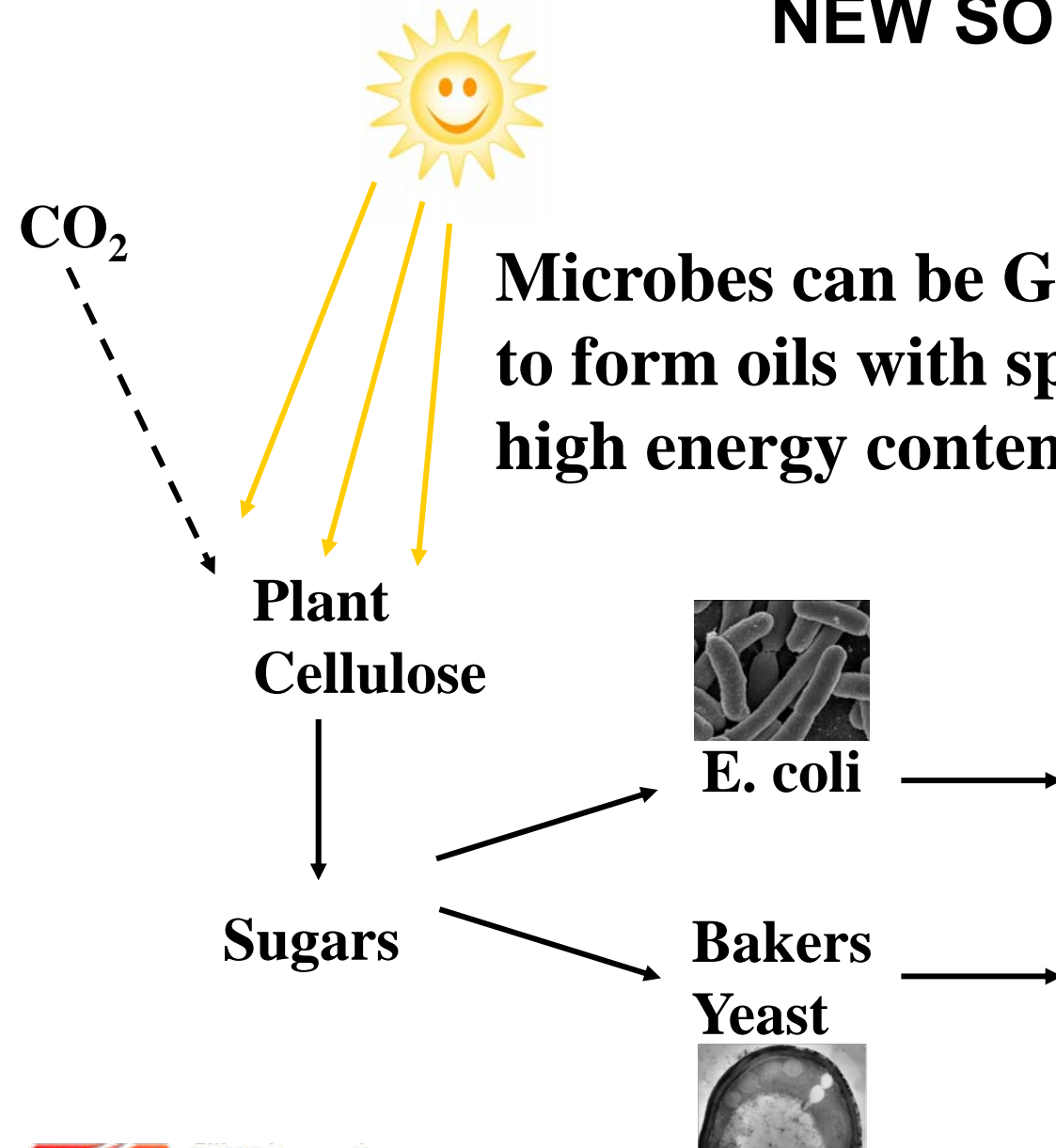
**Energy balance
not very good**

**? Enough rain to
Increase cropland**

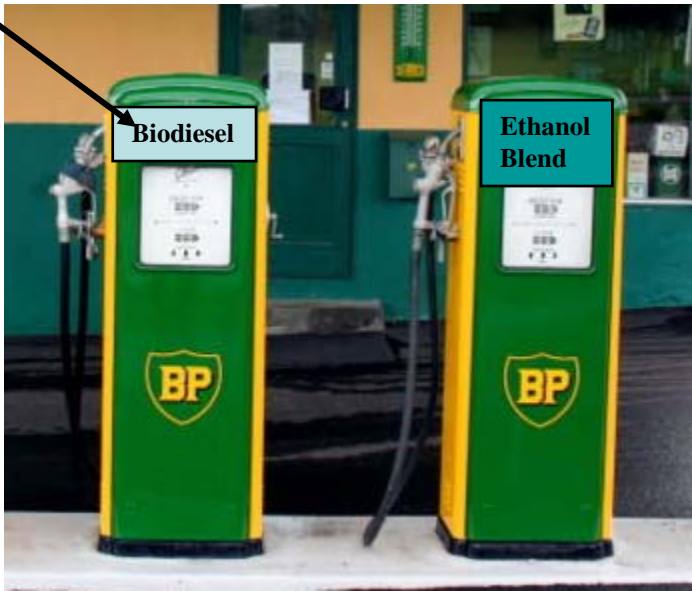
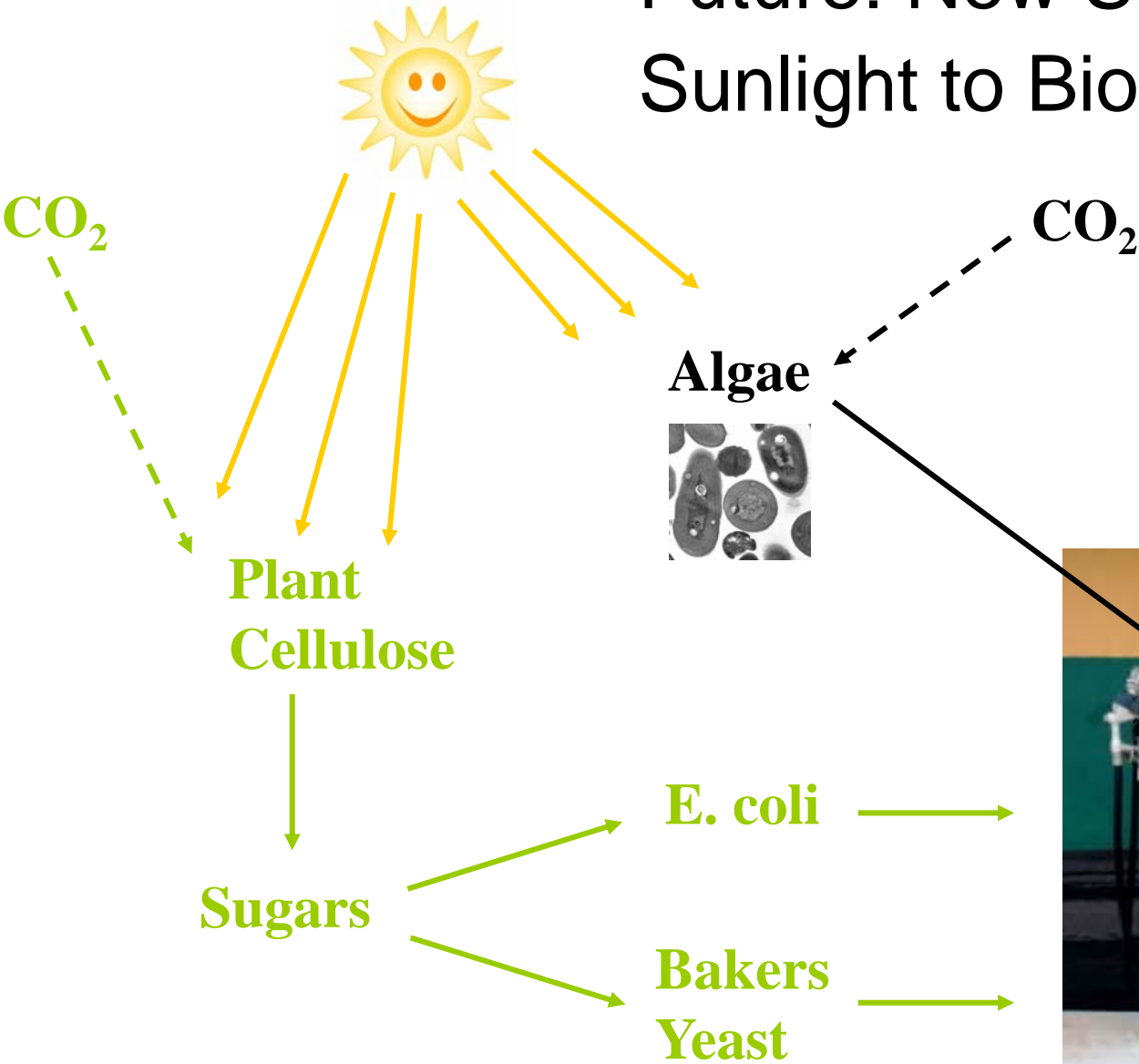


NEW SOURCES

Microbes can be Genetically Engineered to form oils with specific properties – high energy content and clean combustion



Future: New Sources Sunlight to Biodiesel?



Energy Biosciences Programs

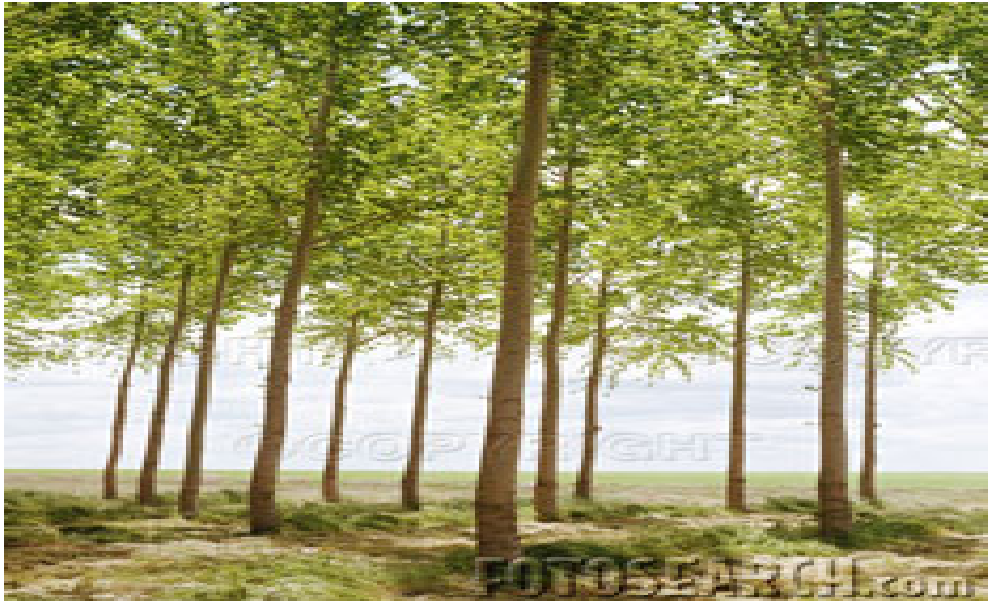
Engineering of Plant Products & Biomass

Move from using starch to using cellulose as the starting material “cellulosic ethanol”

Corn → Trees

Poplar Trees grow on marginal land, methods to genetically engineer weaker cellulose, easier to get sugar out, know entire genome, methods to radically increase growth rate. Less water demand

Manipulation of Soil Bacteria and Genetic Changes in Bacteria



Bacteria living around the roots – endophytes determine growth rate, changing these bacteria to Optimize growth has increased the rate of growth of the trees by 40% at BNL

Biomass Breakdown



Poplar Chips

Must find the most energy efficient way to breakdown biomass into starch and convert this to sugar

- 1. Alter structure of lignan and cellulose in the plant cell wall**
- 2. First step gene sequence of poplar – DONE**
- 3. Understand the structure of cell wall in poplar – essentially done**
- 4. Genetically alter the structure for easy breakdown with low temperature or enzymes – partially done**

Improved growth and pretreatment of poplar biomass for bioethanol production: a collaboration between BNL and NREL

Daniel van der Lelie (BNL), Safiyh Taghavi (BNL) and Mike Himmel (NREL)



Poplar plantation



Poplar biomass



Bioethanol production



Fuel

Microbial plant growth promoting activity: 40%



Microbiology of biomass decay:



Improved pretreatment



Energy Biosciences Programs

Engineering of Plant Products & Biomass **Biohydrogen**

New Initiatives: Biohydrogen

Structural features of the oxygen tolerant hydrogenase from *Thermatoga neapolitana* – N. van der Lelie, S. Taghavi

Aim: Create bacteria which can tolerate normal atmosphere (O₂) and produce H₂ from water. This can be used to power cars with an exhaust of pure water.

Problem Distribution system for hydrogen does not exist and would be very expensive.

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What is the Gain - Corn

Corn to ethanol energy balance

Pimental Cornell 131,000 BTU in
77,000 BYU out

Wang ANL get 1 million BTU from ethanol
for every 740,000 BTU's put in

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Crop land Food Prices and Sustainability

**Oak Ridge Study - 1 billion tons of biomass annually
Assumptions assume 50% gain in yield and adequate rainfall,
Use of corn stalks etc not food products ie corn itself**

**If we assume ½ billion tons of biomass and a good conversion rate
of 80 gal. of ethanol/ton we get 40 billion gal of ethanol**

**Use of transportation fuel in US in 2005
was about 185 billion gal.**

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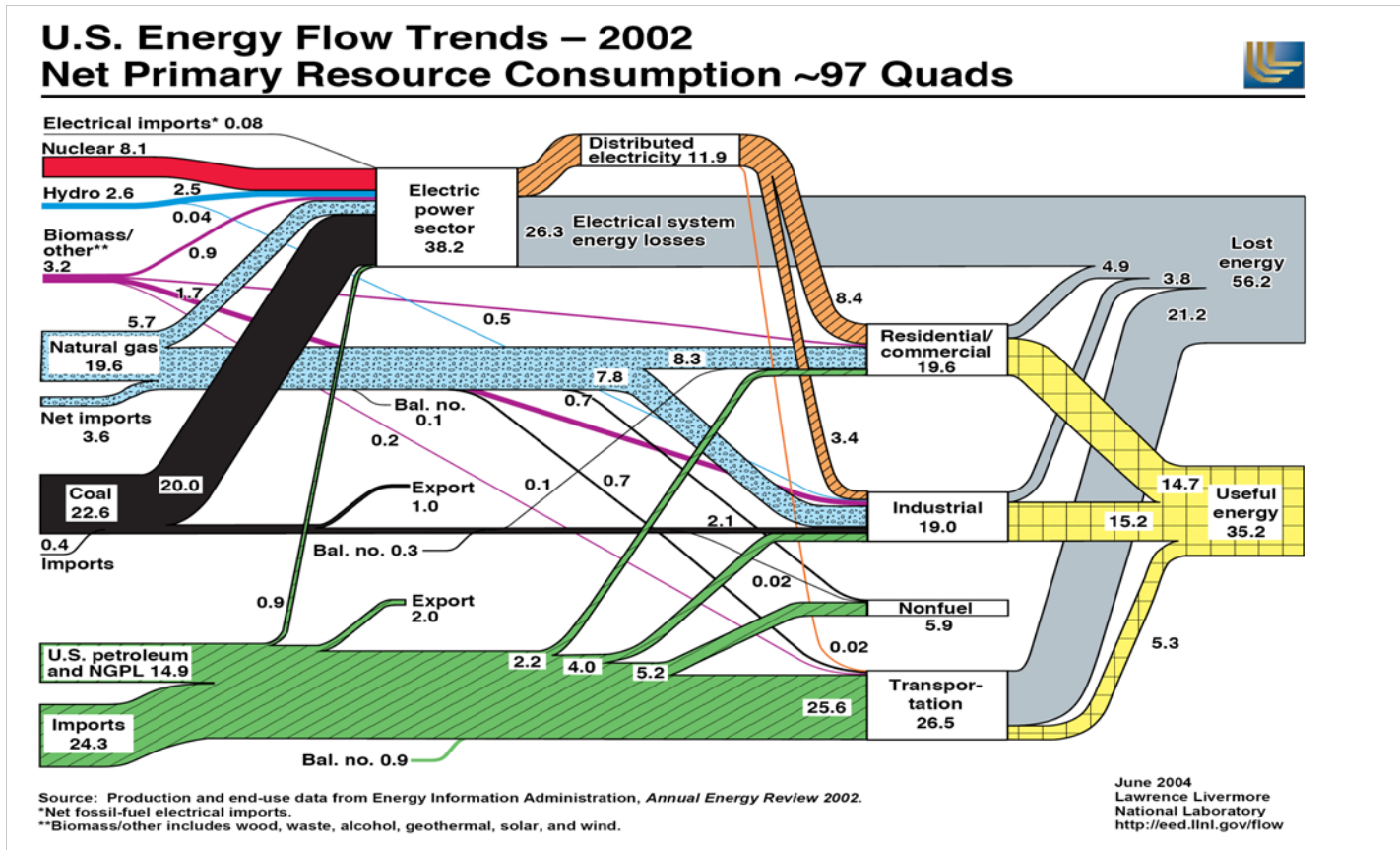
Green fuels can contribute in the short term to transportation needs... will impact food prices

.
In terms of world energy needs this will always be under 10% of total

Conservation is vital!

**Currently we waste half of our energy and produce unnecessary product –
Eg. plastic bags in the supermarket.**

U.S. Energy Flows and Consumption



Largest user of petroleum is transportation (drives fuel switching)
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Use of genetically altered trees, and altered soil bacteria have the potential to reduce cost of fuel and decrease pressure on imported oil

Biotechnology alone, in this area will probably not be sufficient to deal with Energy needs – need life style changes