WORLD POPULATION

6.5 Billion people

3.7 Billion malnourished

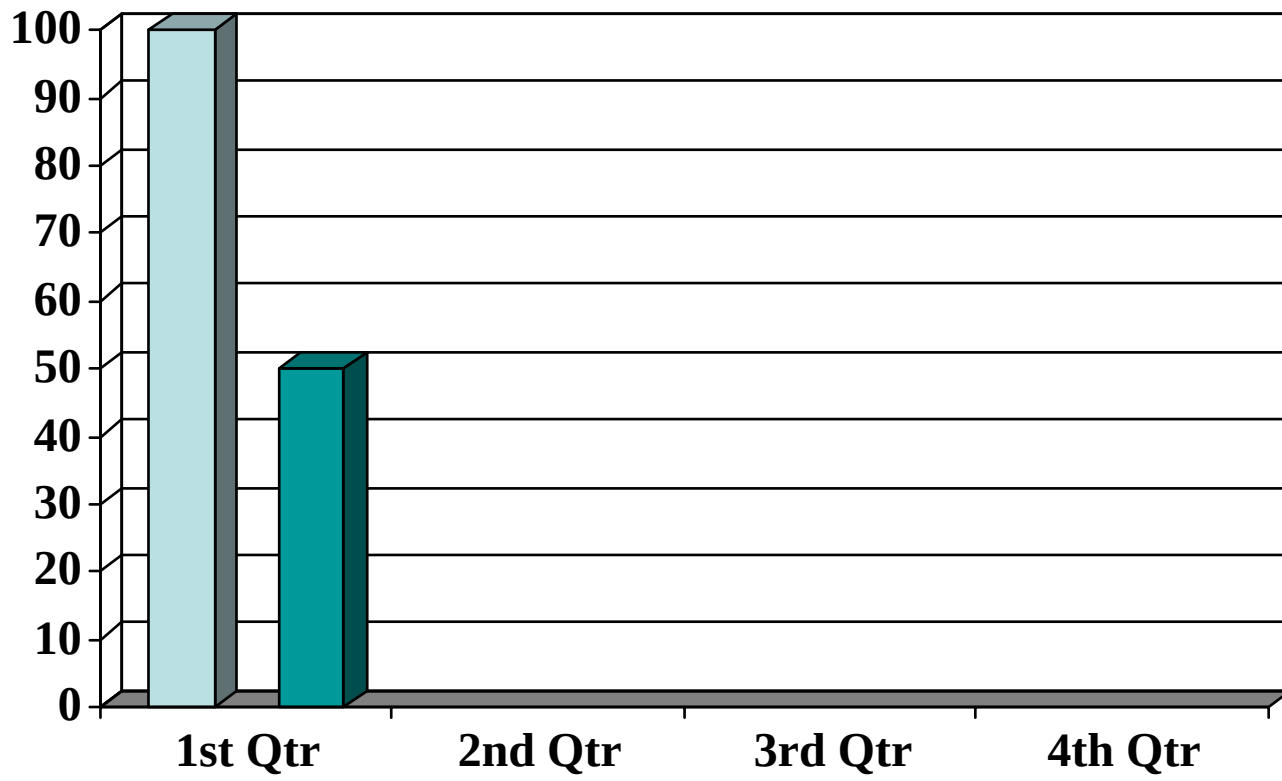
U.S. FOOD CONSUMPTION

2,200 pounds/person/year

Solar Energy Captured by Crops

All Plants = 0.1%

FOSSIL vs BIOMASS



Biomass vs. Hydropower

Biomass Thermal = 3%

Hydropower = 3%

Corn Production Inputs

Energy = 14 Inputs

For average corn production

Energy Inputs in Corn Production

Energy inputs to produce corn

8 million kcal /hectare

30,000 kcal/gallon

Ethanol Processing

Corn (2.7 kg) 2,520 kcal/liter

Steam 2,550 kcal/liter

Processing Ethanol

“Beer” = 10% ethanol

Waste Water = 90%

Ethanol for Gasoline

95% ethanol (water content)

Must be 99.5% ethanol

Ethanol Energy Costs

Total Energy Inputs = 25,000 kcal/gal

Ethanol Energy Output

19,400 kcal/gal

Minus 29%

Omissions Help Ethanol Return

- Farm labor omitted
- Farm machinery omitted
- Processing machinery omitted
- Hybrid corn omitted
- Irrigation omitted
- Environmental Impacts omitted
- Excess by-product credits 40% to 60%

Environmental Impacts

- 1,700 gallons of water / gallon of ethanol
- Soil erosion more intense than any crop
- Nitrogen fertilizer
- More insecticides
- More herbicides
- More carbon dioxide

Sewage Effluent

12 liters of sewage effluent per ethanol liter produced

Ethanol Production

DOE = 4.5 billion gallons

Total oil = 1%

18% of all corn

100% U.S. Corn

Total oil = 6%

ORGANIC CORN

No Nitrogen fertilizer

No Insecticides

No Herbicides

CORN YIELDS

Organic Yield = Conventional

30% less fossil energy

Costs to Beef Production

Removal of Corn from Beef Production

Costs Consumers $1 billion/year

By-Product Credits

Byproducts = 40% to 60%

Replacement for Soybeans = 9%

Subsidies for Ethanol

Corporations = $7.00 per bushel

Farmers = 2¢ per bushel

Ethanol subsidy 45-times greater/gas

Burning Corn/Food

Ethics

3.7 billion humans malnourished

Higher meat prices

SWITCHGRASS FUEL

10 t/ha/yr yield

Energy input/output 1 kcal:14 kcal

Ethanol = minus 50%

WOOD FUEL

3 t/ha/yr

Ethanol = minus 57%

Ethanol from Wood

2.0 kg to 13.3 kg per liter

5 kg per liter

57% more fossil energy

Lignin Fuel

25% of Wood is Lignin

“Backbone” of trees

LIGNIN FUEL

Acid or Enzyme Dissolves Lignin

Frees Cellulose Cells

Lignin Fuel

Lignin in Water

Separation Energy

1 kg Lignin = 1,250

Ethanol from Wood

8,000 kcal per liter

of ethanol produced

57% more fossil energy

Environmental Impacts

Global warming

Soil erosion

1,100 liters of water per liter

Cellulosic Potential Fuel

100 million hectares of forest

600 liters of ethanol per hectare net

1% of U.S. gasoline

Ethanol from Wood

Fertilizers = 4,000 kcal

Steam = 17,000 kcal

Electricity = 6,400 kcal

SUNFLOWER OIL

Production = 1.3 kcal: 1 kcal

Sunflower = 26% oil

Biodiesel = minus 118%

CANOLA OIL

Canola yield = 1,600 kg/ha

30% oil

CANOLA OIL

Input/Output 1.7/1

Energy = minus 65%

Soybean Production

Production = 1 kcal: 2.5 kcal

Soybean oil = 18%

Biodiesel = minus 32%

SOYBEAN OIL

Soy Meal Credit

Positive Energy = 664 L/ha

Truck Diesel = All U.S. Land

Diesel Fuel Production

2 BTU Coal = 1 BTU Diesel

No agricultural disturbance

No oil imports

BIOMASS ENERGY

Thermal = 3% U.S. Energy

Electric = 1 kcal: 7 kcal

6¢ / kWh

BIOMASS ENERGY

City of 100,000 people

200,000 ha forest

1 person = 2 hectares

HYDROPOWER

10,000 kWh = person/year

40,000 gals of water/person

1 kcal: 24 kcal 2¢ / kWh

HYDROPOWER

75,000 ha

Agricultural Land

Aquatic Ecology

WIND POWER

2% of U.S. Electric

1 kcal : 5 kcal

7¢ / kWh

WIND POWER

13,000 ha (5%)

Birds, Noise,

Esthetics

PHOTOVOLTAICS

1 kcal: 7kcal

25¢ / kWh

Cleaning

PHOTOVOLTAICS

3,000 ha

Chemicals

Transmission = $290,000/mile

HYDROGEN

1.4 kWh = 1 kWh Hydrogen

3 kWh coal = 1 kWh Electricity

4.2 kWh = 1 kWh Hydrogen

Hydrogen

Tank 3 X

$3 gasoline = $6 hydrogen

Difficult to handle

Renewable Energy

Renewable Energy = 46 quads

17% of total U.S. land area