Solar Energy V

Biomass

Original slides provided by Dr. Daniel Holland

- Biomass energy is that energy derived from living matter such as field crops (corn, soy beans, etc.), trees, water plants, agricultural and forestry waste, and municipal solid waste (garbage).
- Can be used as a solid (wood chips) liquid (alcohol) and gaseous (methane) fuel.
- Until ~1880 biomass was the prime fuel in the US.

Audio Link

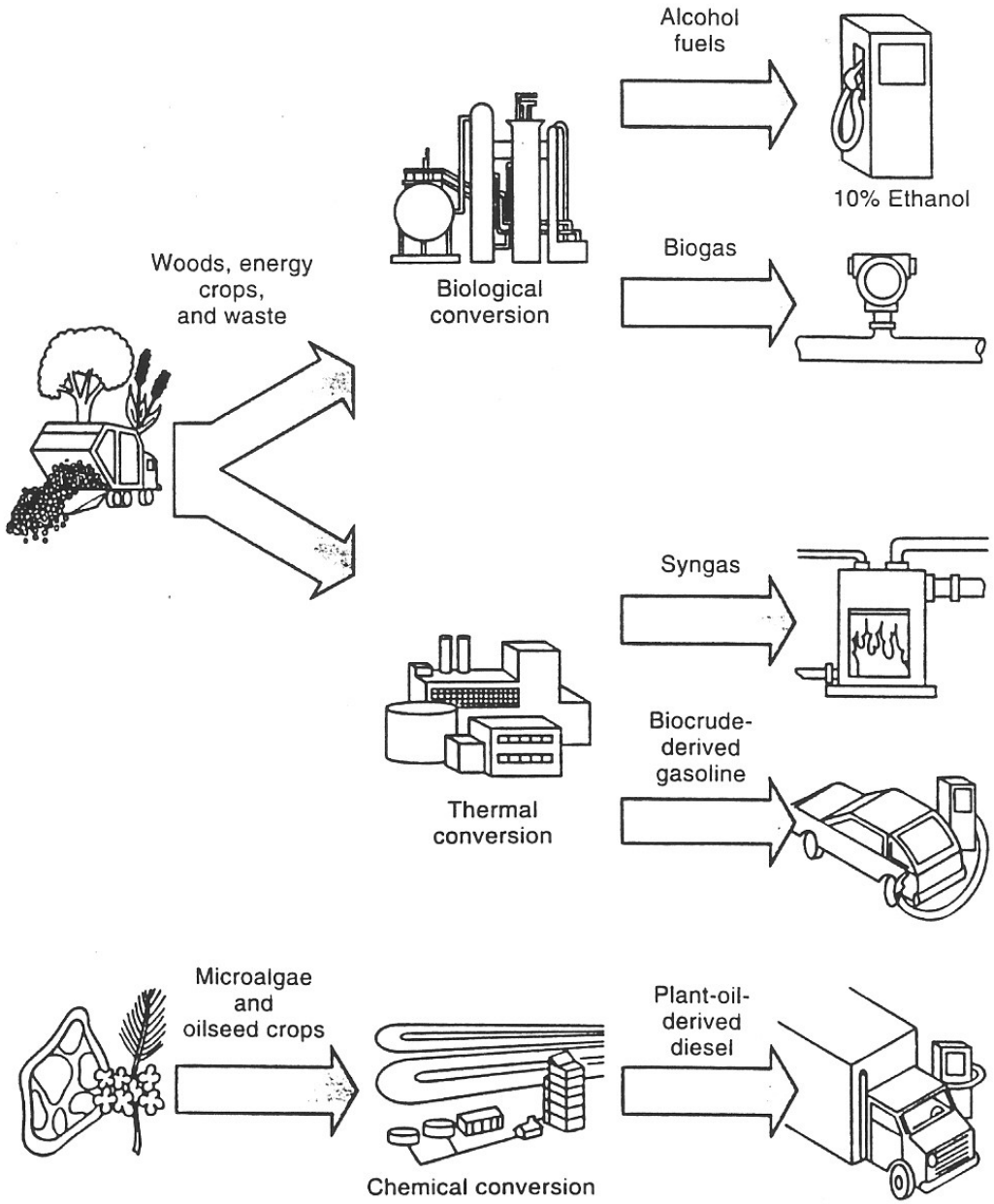


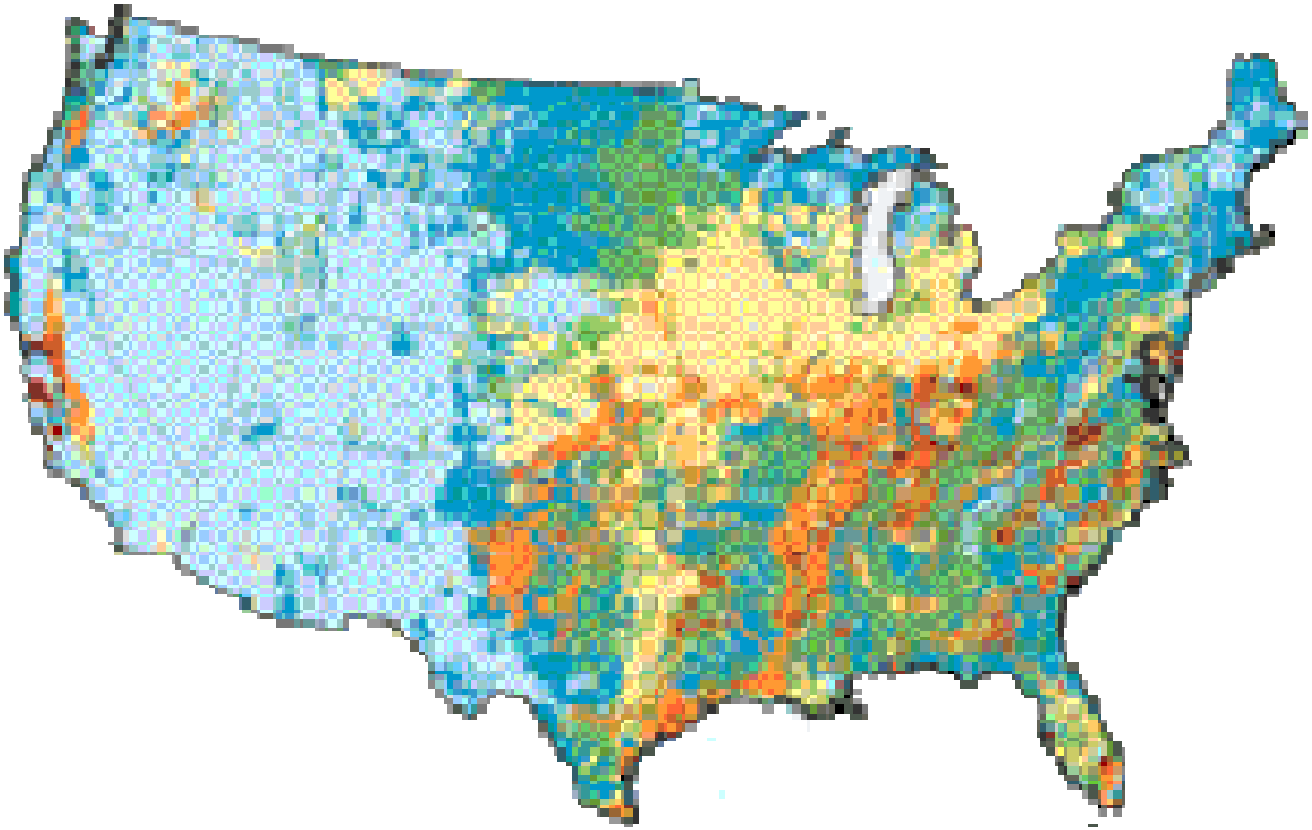
FIGURE 17.1
Conversion of biomass into useful fuels.

- Currently provides 5% of US energy needs and can provide several times the output expected from wind and photovoltaics.
- Has the potential to provide up to 25% of our energy needs.
- Sweden and Finland use Biomass for 14% of their energy needs.

Basic Energy Storage Mechanism

- Photosynthesis:
- $CO_2 + H_2O + light \rightarrow O_2 + Carbohydrates$
- Reverse Process is called respiration.
- Since Carbon is taken out of the atmosphere during photosynthesis and is put back when “fuel” is used, there is no net addition of Carbon to the atmosphere on a yearly average.

- 20% of the land in the 48 states is cropland and 30% is commercial forest and woodland.
- In terms of energy content, corn is the largest, followed by soybeans and oats.
- The US has over 1 billion acres of land suitable for growing biomass.



BIOMASS ENERGY POTENTIAL (MJ/m^2)

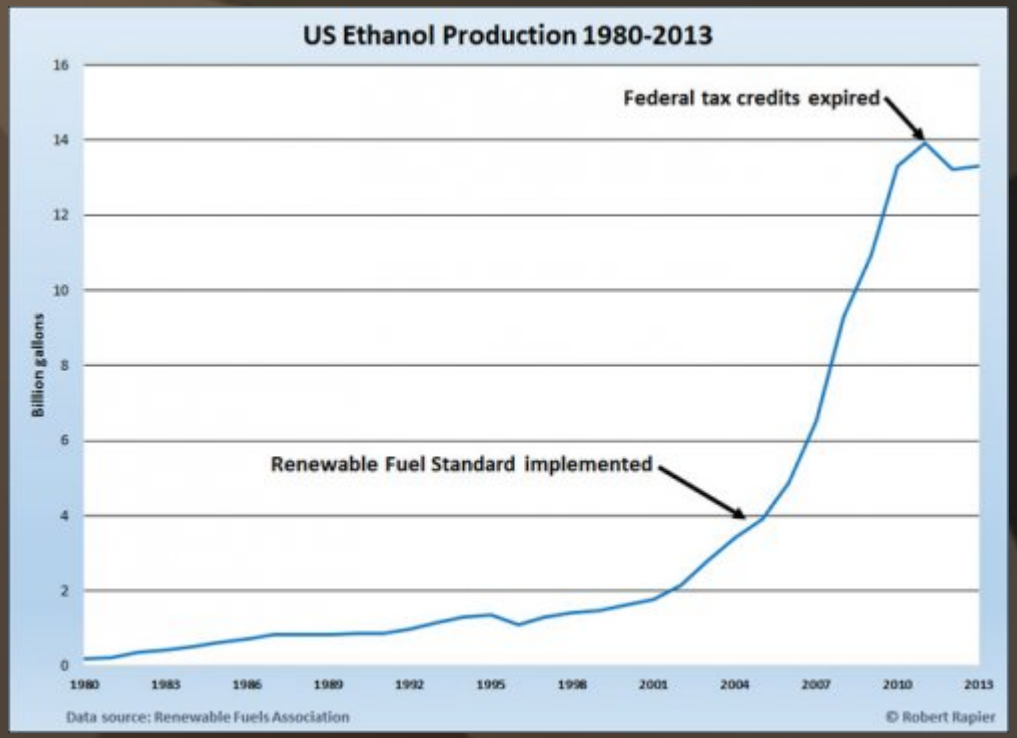
0-10	20-30	40-50
10-20	30-40	>50

- Forestland and agricultural land could potentially supply 1.3 billion tons of dry biomass per year.
- This is enough to replace one third of our current demand for transportation fuel.
- This would significantly cut imports as well as reducing pollution.

- Biomass fuel would require only modest changes in growing practices and should not impact food, feed and export demand.
- Very positive effect on rural economy since it produces new markets.
- In actuality it has had a significant impact on the price of food grains.

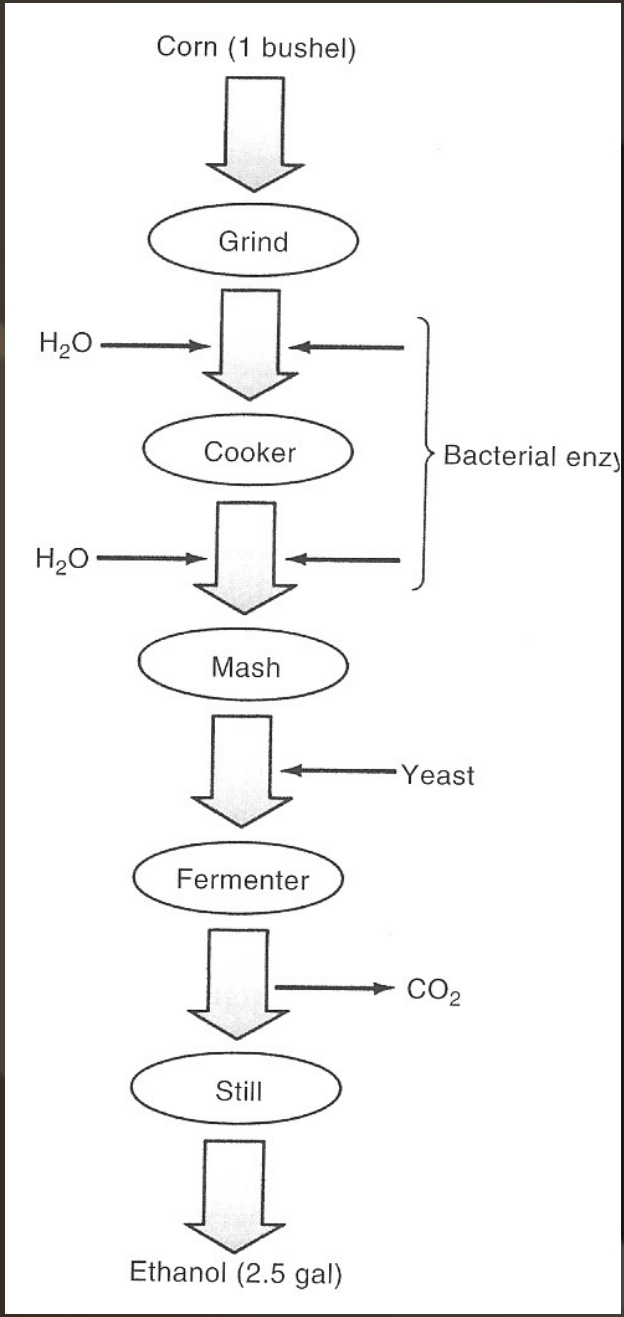
Ethanol

- Ethanol production was about 13 billion gallons in 2013.
- Based on the fermentation of plant mater.
- It can be made from a lot of different crops. US uses mostly corn, Brazil uses sugarcane, France uses wheat and sugar beats



https://www.financialsense.com/contributors/robert-rapier/u-s-dominates-globe-biofuel-production

- Flow diagram for the production of ethanol.



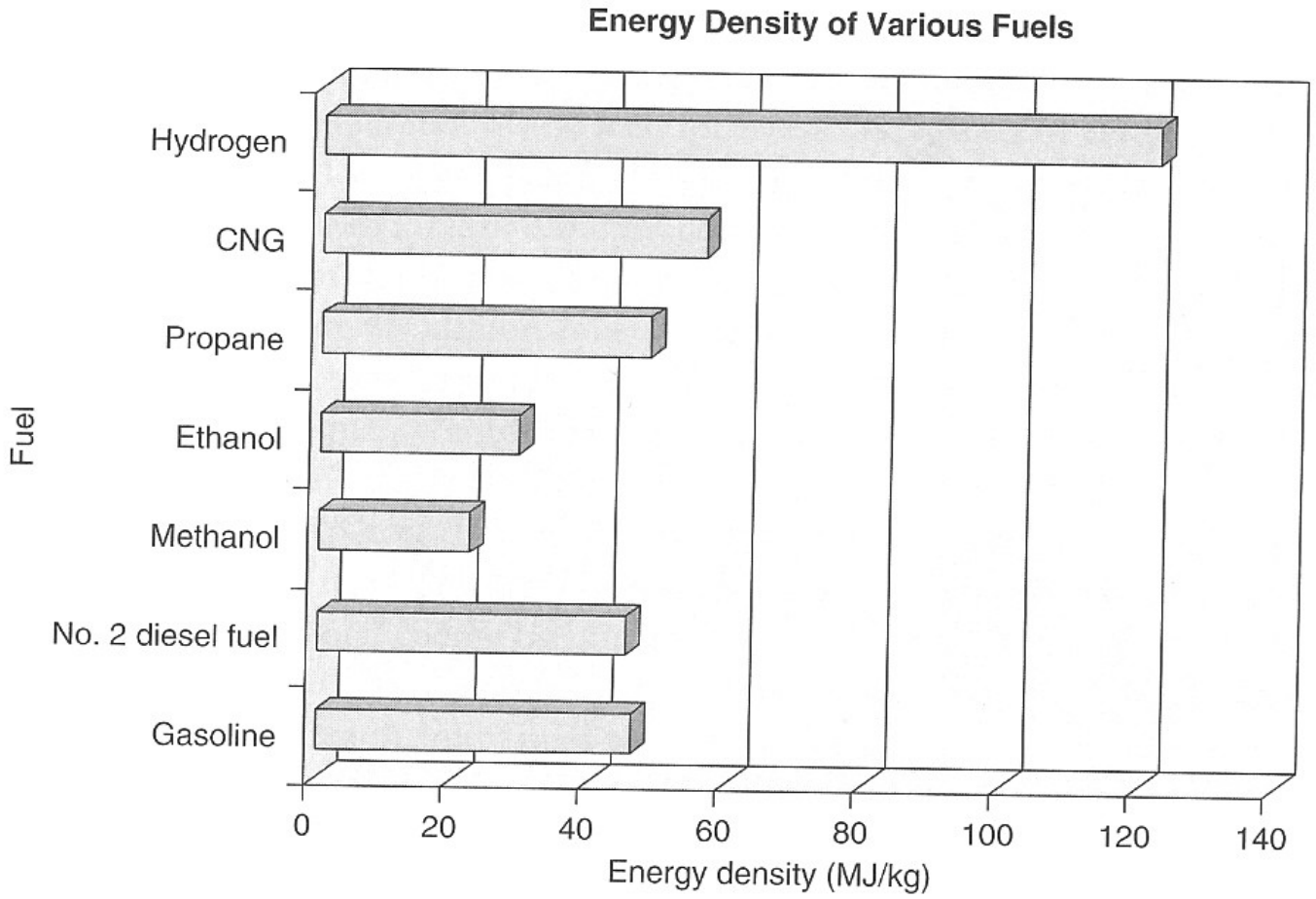
Ethanol Plants in the US

- Speaker of the House Dennis Hastert dedicating a new ethanol plant in Illinois.

- Most ethanol is used as a transportation fuel/gasoline additive.
- Currently we use E10 fuel. 90% gasoline and 10% ethanol.
- No special requirements for using E10.
- Flex-fuel cars can use up to E85.
- Potential to use ethanol in fuel cells in the future.

Comparison of Gasoline/Ethanol

- Ethanol has the higher octane rating.
- Ethanol is cleaner burning (less soot)
- Ethanol has no visible flame (potential hazard)
- Ethanol has ~1/2 the energy content per gallon as gasoline.
- Ethanol is less expensive per gallon.
- Ethanol is highly corrosive (Need special engines to run on pure ethanol.)
- Ethanol has a lower evaporation rate. (Harder to start on cold days.)


Energy Density of Various Fuels
Fuel
Hydrogen
CNG
Propane
Ethanol
Methanol
No. 2 diesel fuel
Gasoline
0
20
40
60
80
100
120
140
Energy density (MJ/kg)

Municipal Solid Waste

- ~30% of all municipal waste is recycled.
- We still need to process the other 70%.
- Either bury it in landfills or burn it.
- Energy content per pound of MSW is ~1/3 that of good coal (4300 Btu/lb)

- Major concerns deal with air pollution during combustion.
- A lot of potential “bad stuff” in garbage.
- Pollution control devices are very expensive.
- Many plants essentially break even on their energy production

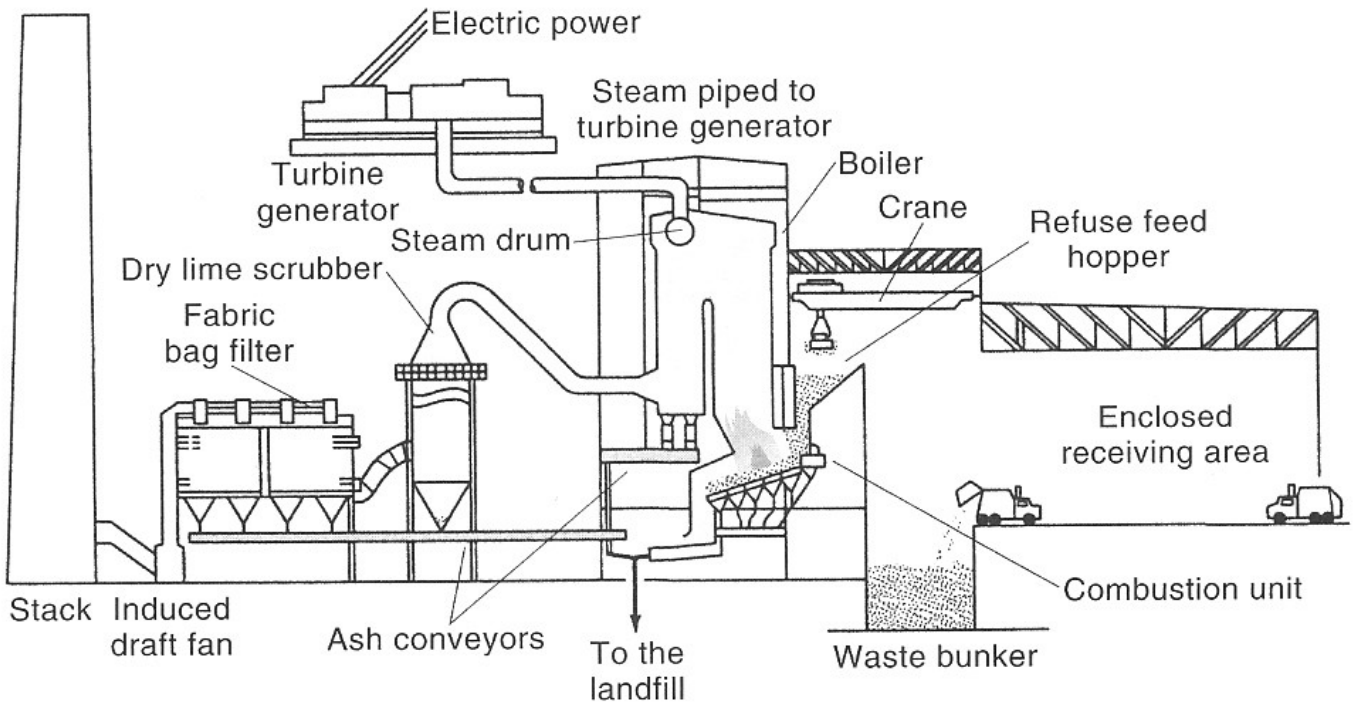


Figure 17.7
Waste-to-energy facility. The steam produced can be used to drive a turbine-generator or to provide process heat to a nearby customer.

Big Stone MSW Power Plant in South Dakota.

Wood burning power plants

- Typically smaller scale power plants. (10’s of MW.)
- In house energy production

Biomass

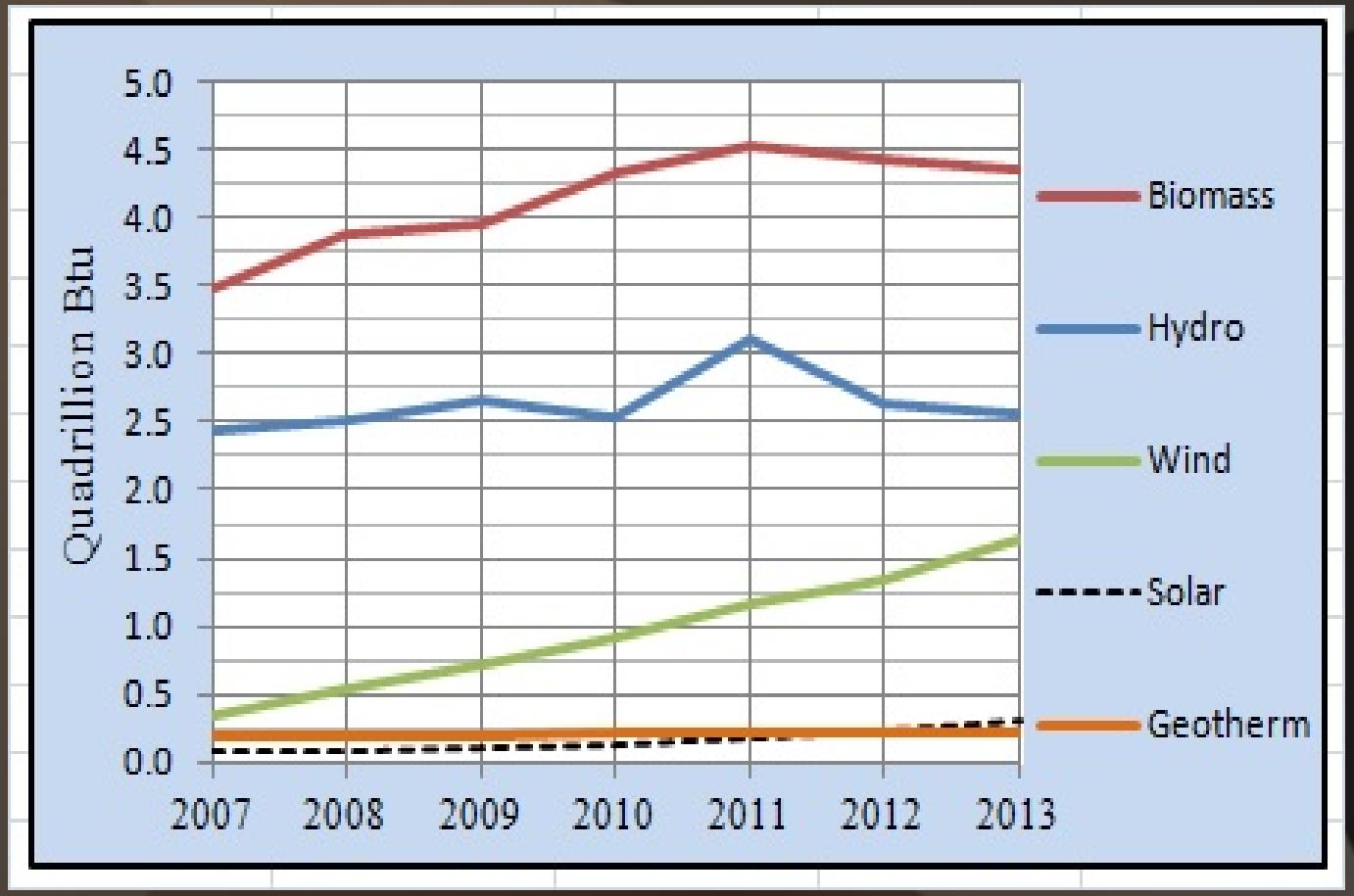
Data For: 2004
Release Date: August 2005
Next Release Date: 2006

Table 6. Biomass Energy Consumption by Energy Source and Energy Use Sector, 2000-2004
(Trillion Btu)

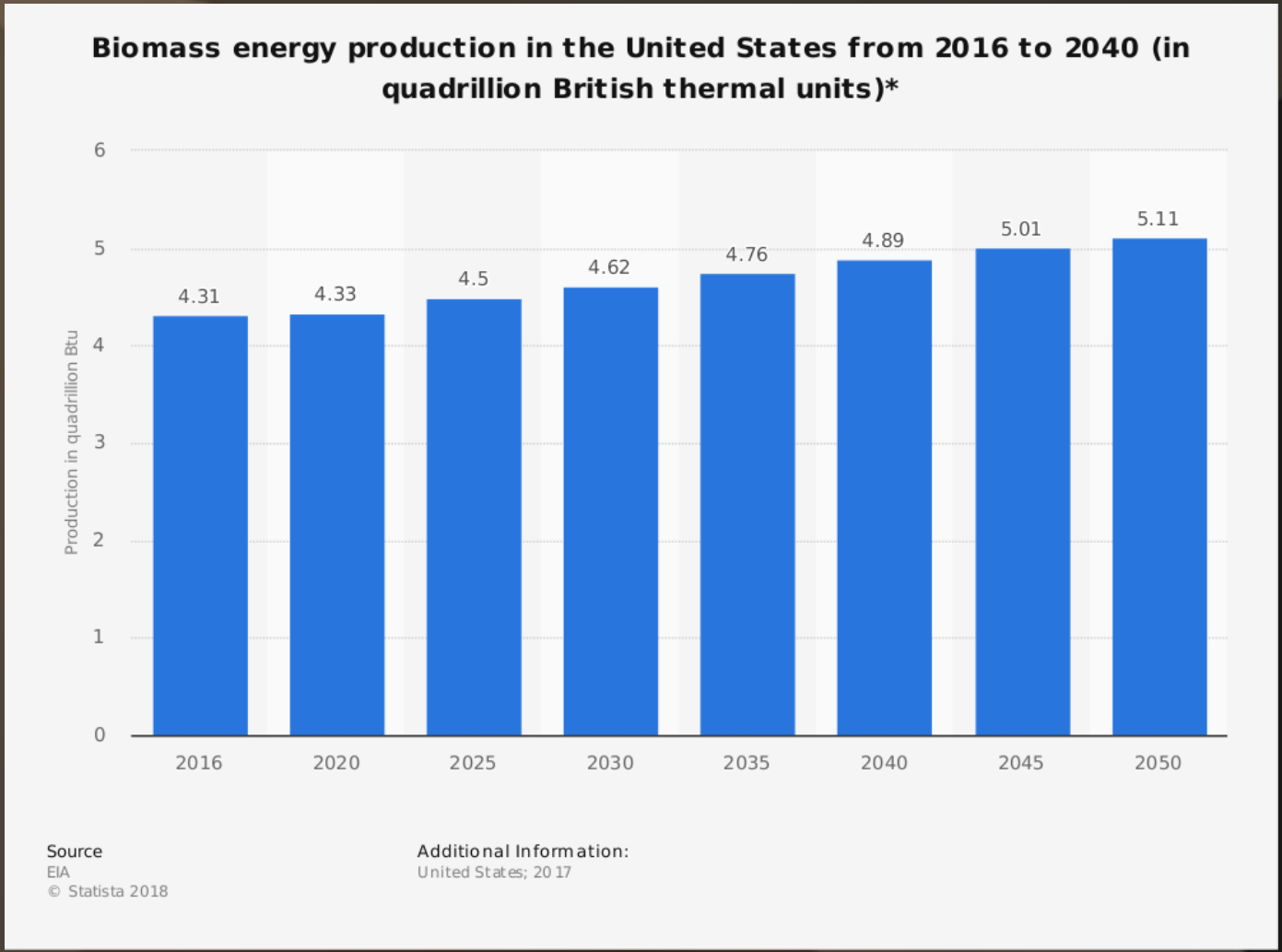
Sector/Source	2000	2001	2002	2003	2004[P]
Total	**2,907**	**2,640**	**2,648**	**2,740**	**2,845**
Wood Energy Total	**2,257**	**1,980**	**1,899**	**1,929**	**1,989**
Residential	433	370	313	359	332
Commercial	53	40	39	40	41
Industrial	1,636	1,443	1,396	1,363	1,448
Electric Power[a]	134	126	150	167	168
Waste Energy Total	**511**	**514**	**576**	**571**	**560**
MSW/Landfill Gas	400	419	467	440	443
Commercial	41	35	37	42	43
Industrial	64	74	87	85	88
Electric Power[a]	295	310	343	314	312
Other Biomass[b]	111	95	108	131	117
Commercial	6	4	5	6	5
Industrial	81	76	81	85	84
Electric Power[a]	23	14	22	41	28
Alcohol Fuels[c]	**139**	**147**	**174**	**239**	**296**
Transportation	139	147	174	239	296

[a] The electric power sector comprises electricity-only and combined-heat-power (CHP) within the North American Industry Classification System (NAICS) 22 category whose primary business is to sell electricity, or

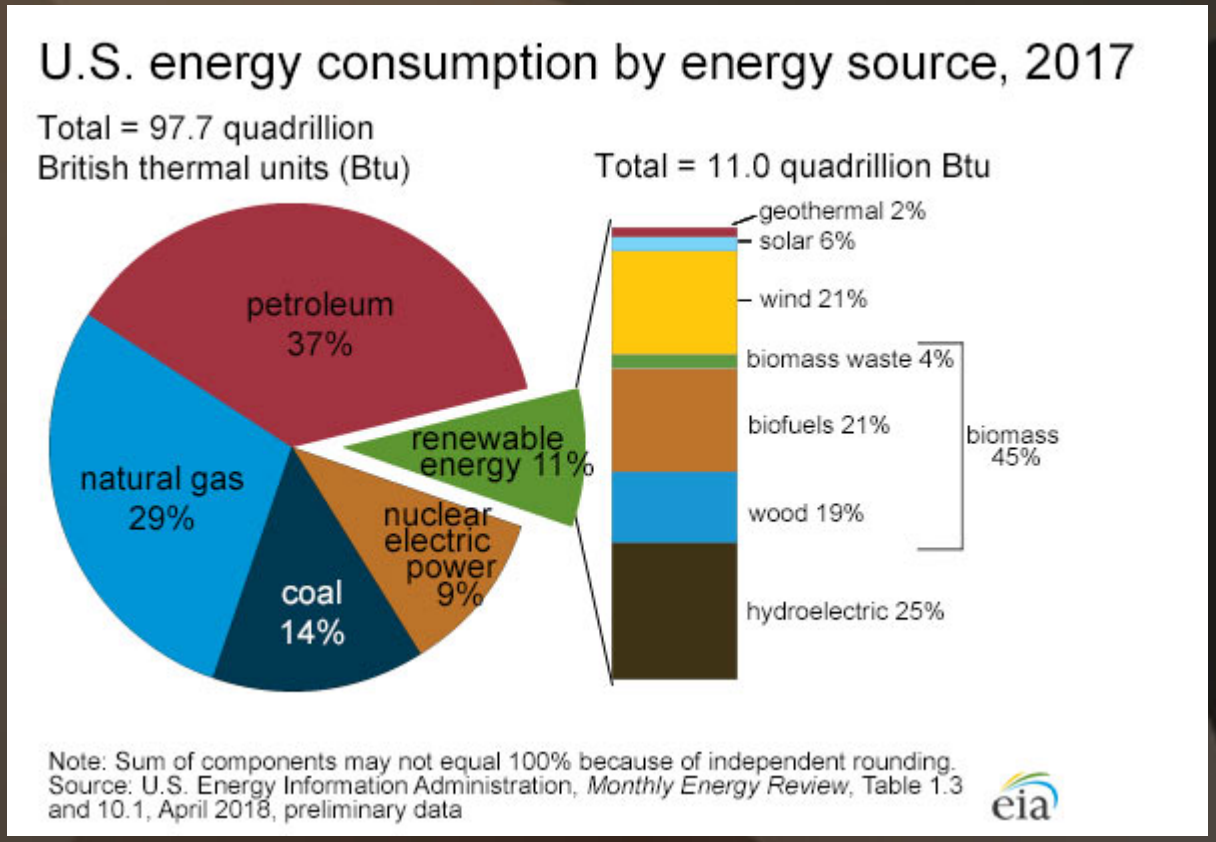
U.S. Renewable Energy Supplies 2007-13

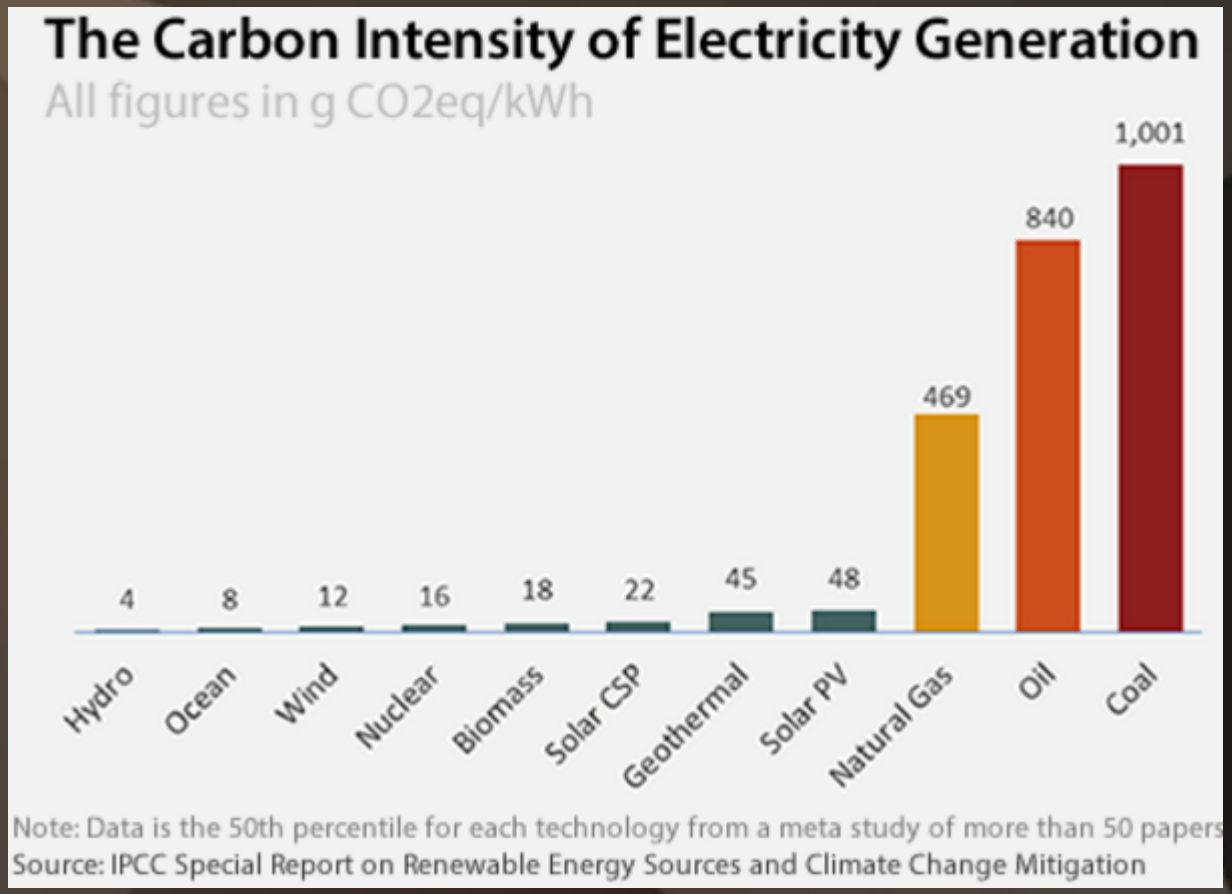


http://theenergycollective.com/jemillerep/329676/us-2013-domestic-energy-supplies-growth-scorecard-part-1



https://www.statista.com/statistics/264029/us-biomass-energy-production/


U.S. energy consumption by energy source, 2017
Total = 97.7 quadrillion British thermal units (Btu)
petroleum 37%
natural gas 29%
coal 14%
nuclear electric power 9%
renewable energy 11%
Total = 11.0 quadrillion Btu
geothermal 2%
solar 6%
wind 21%
biomass waste 4%
biofuels 21%
wood 19%
hydroelectric 25%
biomass 45%
Note: Sum of components may not equal 100% because of independent rounding.
Source: U.S. Energy Information Administration, Monthly Energy Review, Table 1.3 and 10.1, April 2018, preliminary data
eia



http://www.viaspace.com/biomass_versus_alternatives.php

Hydrogen

- There is a lot of future potential for using Hydrogen.
- It is a good way to store energy, but it is NOT a new energy resource.
- Potential use in fuel cells.
- Transportation/storage is a concern.