

A red gas pump nozzle is mounted on a tree trunk in a field of tall grass under a blue sky with clouds. The nozzle is attached to a metal bracket that is secured to the bark of a tree. A black corrugated hose is connected to the nozzle. The background shows a dense forest of tall, thin trees under a bright blue sky with scattered white clouds. The foreground is a field of tall, golden-brown grass.

Biomass to BioFuels Primer

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Oil at \$100 bbl = \$0.30/lb

Biomass at \$40/dry ton = \$0.02/lb

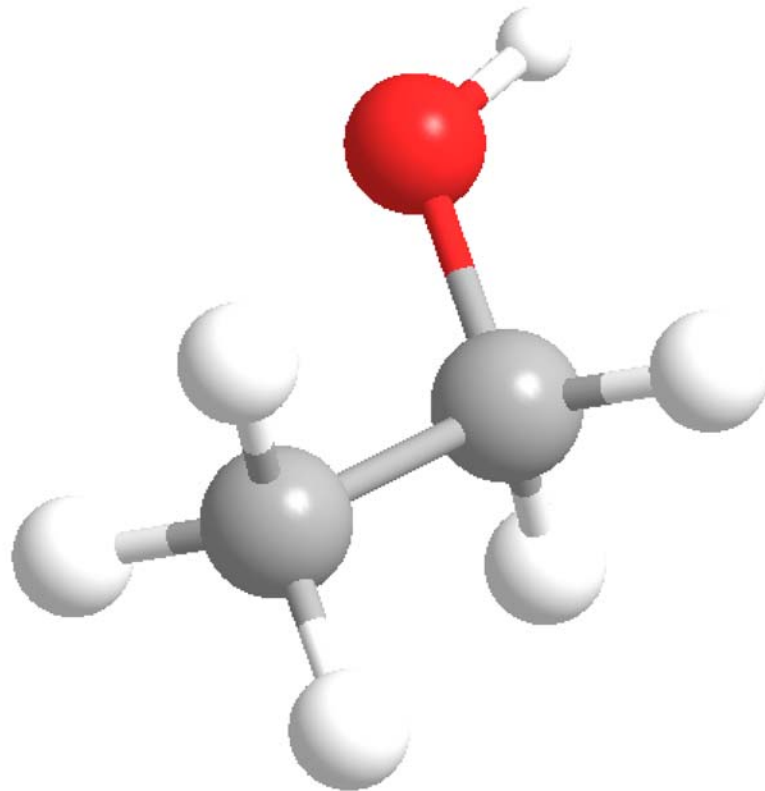
Ethanol

6.60 pounds/gallon

Density is 7% greater than conventional gasoline

1 gallon ethanol has 76,000 BTU

2/3 heating value of gasoline

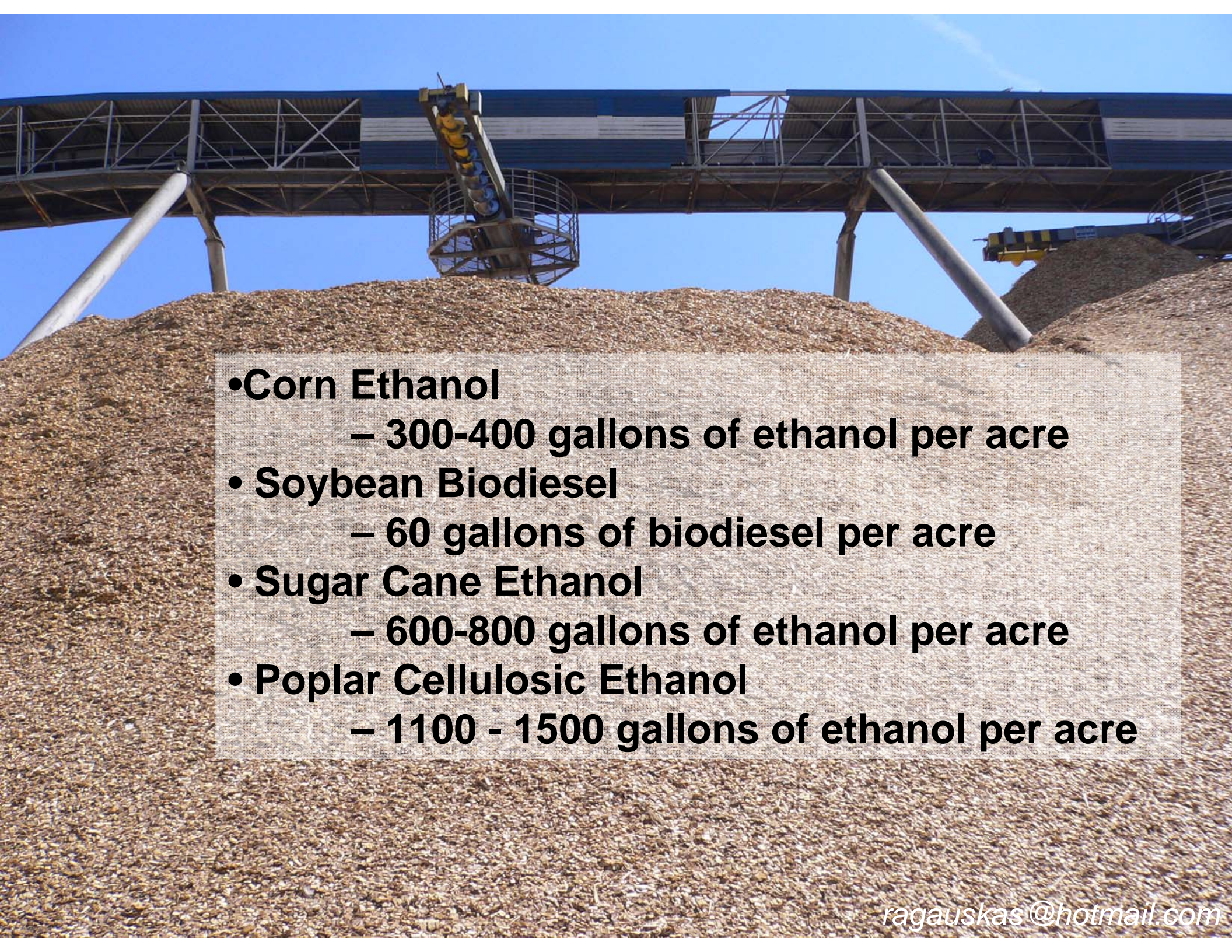


Gasoline vs. # 2 Diesel vs. Ethanol

	Gasoline	Diesel	Ethanol
Chemical Formula	C4-C12	C3-C25	C2H6O
Molecular Weight	~100-105	~ 200	32.04
C:H:O	85-88:12-15:0	84-87:13-16:0	52.2:13.1:34.7
Specific gravity, 60F	0.72-0.78	0.81-.0.89	0.80
Density 60 F (lb/gal)	6.0-6.5	6.7-7.4	6.61
Boiling Temp/F	80-437	37-650	172
Reid vapor pressure/psi	8-15	0.2	2.3
Octane #	81-90	--	92
Cetane #	5-20	40-55	--
Freezing Point/F	-40	-40-30	173.2
Viscosity 60 F/cp	0.37-0.44	2.6-4.1	1.19
Flash Pt/F	-45	165	55
Autoignition/F	495	600	793
Latent Heat Vaporization Btu/gal 60 F	900	700	2378

Theoretical Ethanol Yields

• Corn Grain	124 gallons/dry ton
• Corn Stover	113 gallons/dry ton
• Rice Straw	110 gallons/dry ton
• Cotton Gin Trash	57 gallons/dry ton
• Forest Things	82 gallons/dry ton
• Hardwood sawdust	101 gallons/dry ton
• Bagasse	112 gallons/dry ton
• Mixed used paper	116 gallons/dry ton

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- **Corn Ethanol**
 - 300-400 gallons of ethanol per acre
 - **Soybean Biodiesel**
 - 60 gallons of biodiesel per acre
 - **Sugar Cane Ethanol**
 - 600-800 gallons of ethanol per acre
 - **Poplar Cellulosic Ethanol**
 - 1100 - 1500 gallons of ethanol per acre

Research test plots of Switchgrass

- Up to 15 tons dry biomass/acre
- 5-year average 11.5 tons/acre
- 1150 gallons bioethanol/acre

Established Giant Miscanthus yields 14 to 17 tons/acre.

Highest experimental yield 27 tons/acre

80 to 120 gallons of ethanol/ton of dry matter



Typical Switchgrass Yields

5 – 10 tons dry biomass/acre

70 gallons ethanol/dry ton

A large stack of white hay bales, wrapped in white plastic, is shown under a clear blue sky. The bales are stacked in a way that creates a sense of depth and volume. The foreground shows some green grass and weeds, slightly out of focus.

Hay

1 Bale ~ 970 lbs ~ 50 gallon ethanol

Dry hay crop yielded 1.8 – 2.0 tons per acre

14 lbs. of sugar = 1 gallon of ethanol

Ton	Gallons Ethanol
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Corn	98
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Sugarcane	20
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Sugar Beets	25
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Molasse	70
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Raw Sugar	135
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Refined Sugar	141
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Corn Grain as a Feedstock

- 122 - 160 bushels/acre
- 2.6 - 2.8 gallons of ethanol/bushel of corn
- 317 - 440 gallons of ethanol per acre

Canola as a Feedstock

- 1560 pounds/acre
- 77 gallons biodiesel/acre

Soybean as a Feedstock

- 36 - 43 bushels of soybeans per acre
- 54 - 63 gallons of biodiesel/acre

Rapeseed as a Feedstock

- 1500 pounds/acre
- 80 gallons/acre

Sunflower as a Feedstock

- 1563 pounds/acre
- 83 gallons/acre

Typical Tree Yields

5 – 10 tons/acre/year

Wood at \$35/dry ton = \$17.00 green ton
Cellulosic Ethanol 100 – 90 gal/dry ton wood

Typical Hard Wood Yields

European Alder	4.6 dry tons/acre/year
Cottonwood	4.2 dry tons/acre/year
Yellow birch	3.7 dry tons/acre/year
Silver maple	3.3 dry tons/acre/year
Poplar hybrid	6.6 dry tons/acre/year
Poplar	3.8 dry tons/acre/year
Willow	2.5 dry tons/acre/year

- ~ 45% Cellulose
- ~ 25% Hemicellulose
- ~ 25% Lignin
- ~ 5% Extractives/Ash





Takes about 13,000 tons green biomass to generate 1 MW

During Timber Harvesting 25-45% of Woody Biomass is Left on Site

~ 65% of Total Logging Residues could be Easily Recovered for BioEnergy/Biofuels