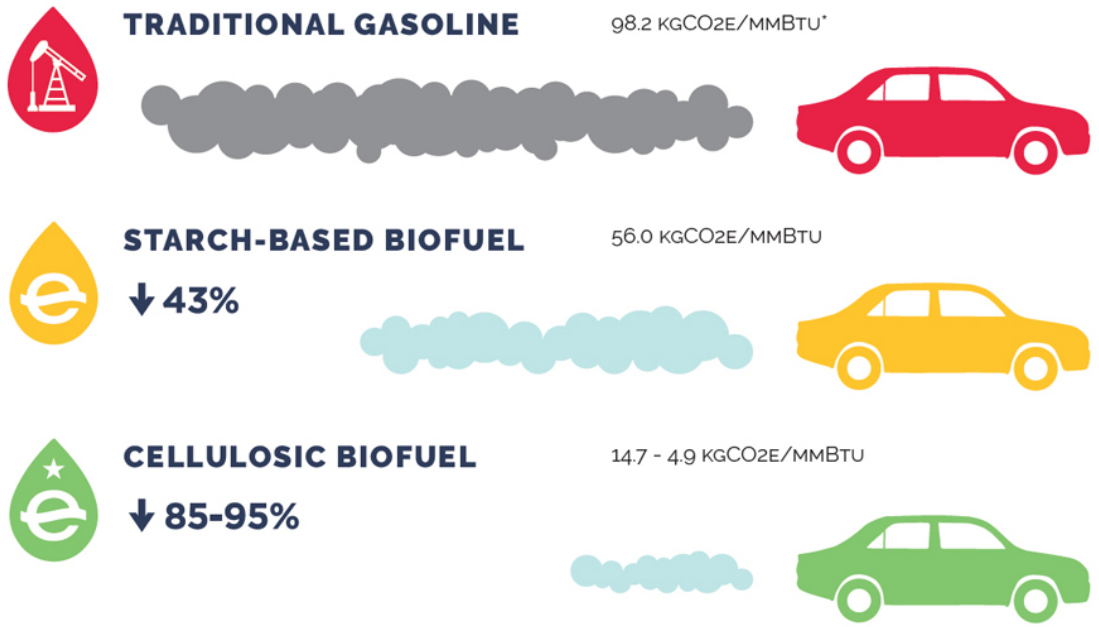
Benoit Delaveau, MS, BEAP, CEM (aka Prof. Ben)
benoit.delaveau@sjsu.edu
Office hours sign-up here: calendly.com/benoit-delaveau

ENVS 119 - Energy & the Environment

16 - Biomass, biogas and biofuels

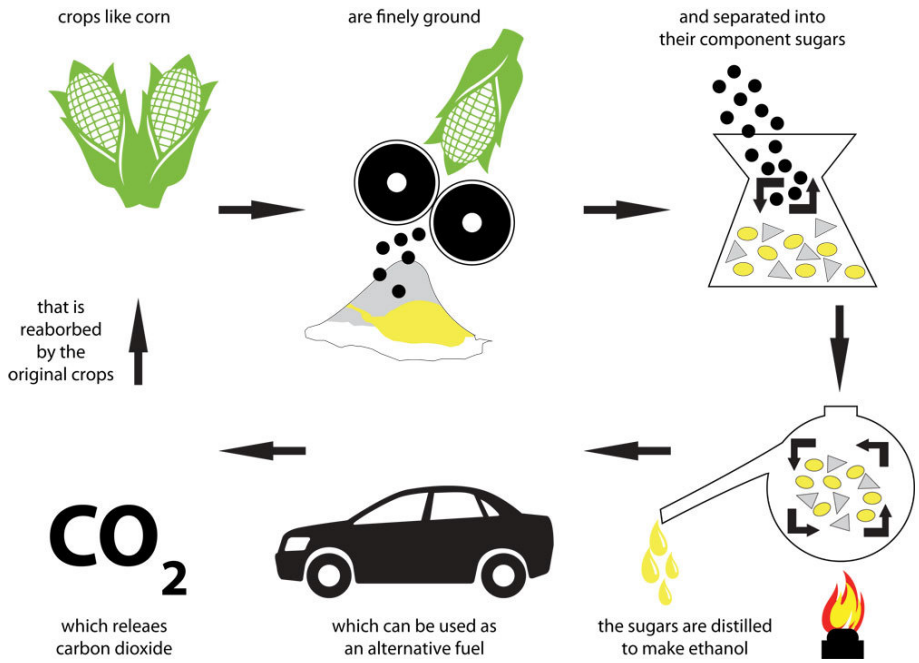
Today

- What's bioenergy?
- The (surface) carbon cycle
- Waste-to-biogas-to-electricity
- Corn-to-Ethanol
- Cellulosic Ethanol (switchgrass)
- California LCFS
- Fuels from algae



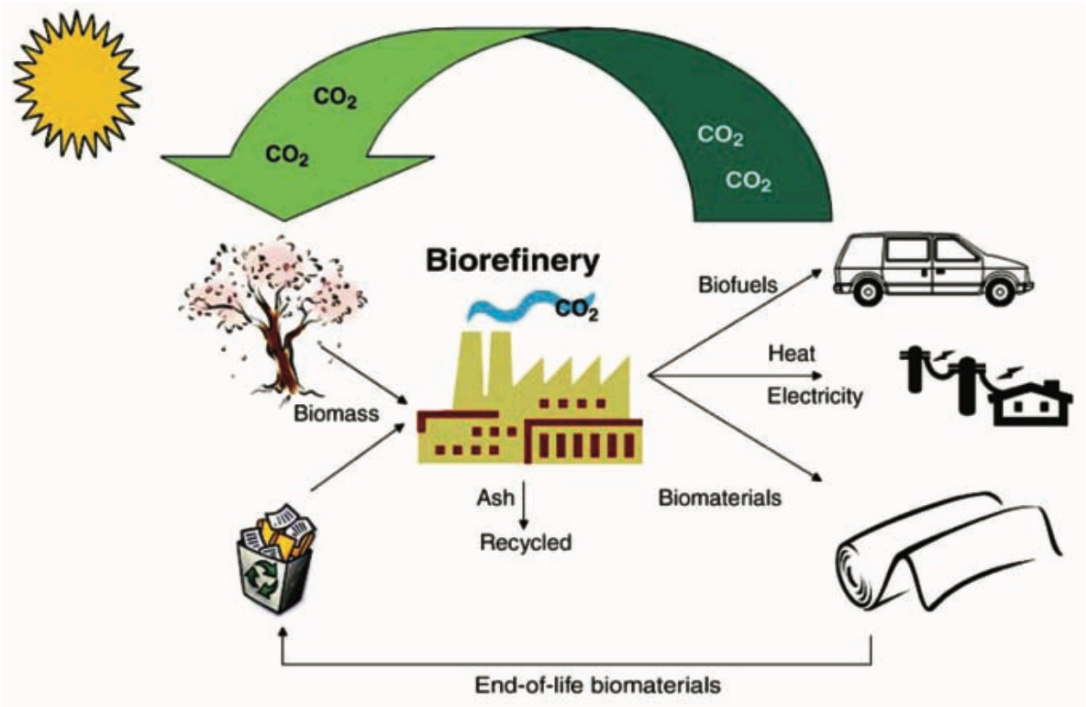
Definition of bioenergy = the carbon cycle

- Plants and animals (biomass) on Earth fix and store solar energy (through photosynthesis) in the form of carbon chains.
- Most energy stored in biomass will be eventually radiated as low temperature heat or be combusted (breaking the carbon chains).
- **Direct combustion:** wood, or…
- **Biofuels**: Solid/liquid/gas = man-made fuels from organic material (ethanol, biodiesel, bio-methane, …)



Biofuel benefit = No “old” carbon input

- Old fossil fuels carbon stays underground
- Human relies on surface-level carbon for energy
- No climate change impact (in theory)



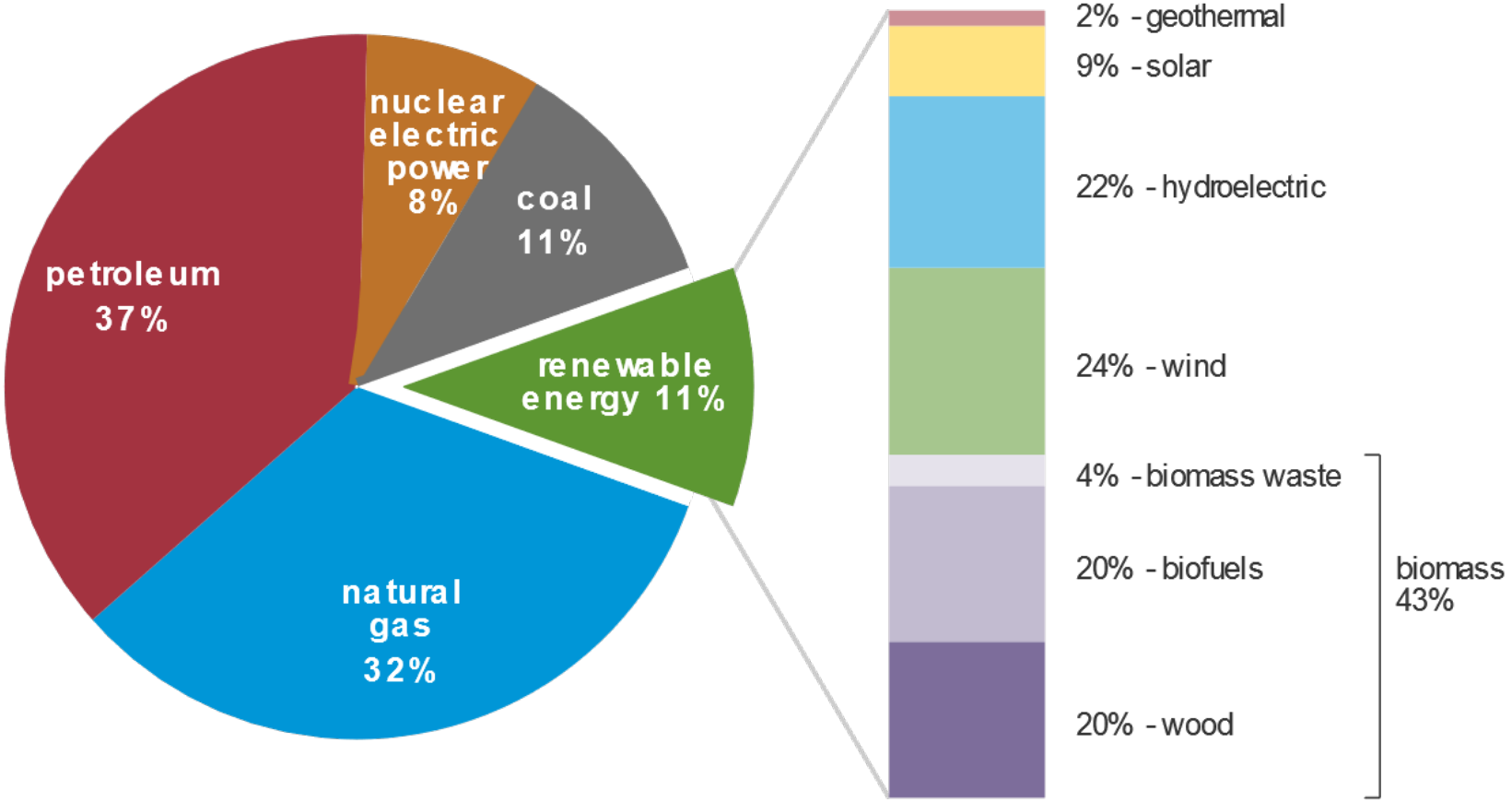
Randolph and Master Chap. 14 p 544

Biomass energy (US) = 43% of renewables

U.S. primary energy consumption by energy source, 2019

total = 100.2 quadrillion British thermal units (Btu)

total = 11.4 quadrillion Btu



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 2020, preliminary data

Biogas (replacing natural gas) from waste

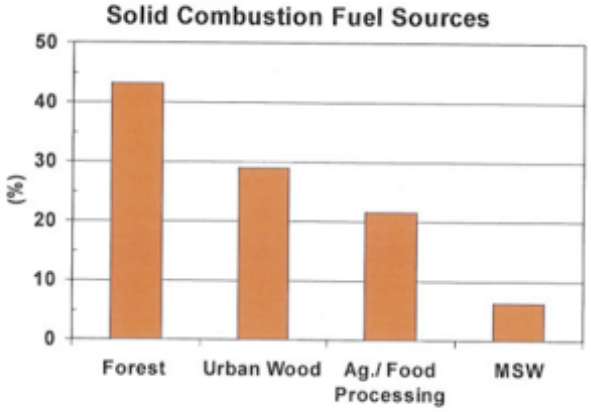
- San José, CA biowaste digester produces biogas from food scraps collected from campus and restaurant.
- The biogas is used next door in a small powerplant.
- The electricity produced is used too power the wastewater treatment plant.

http://zerowasteenergy.com/san-jose-biogas-facility-will-turn-food-waste-into-energy/ — Video

Biogas in California is expanding

Current Biomass Power Capacity in California

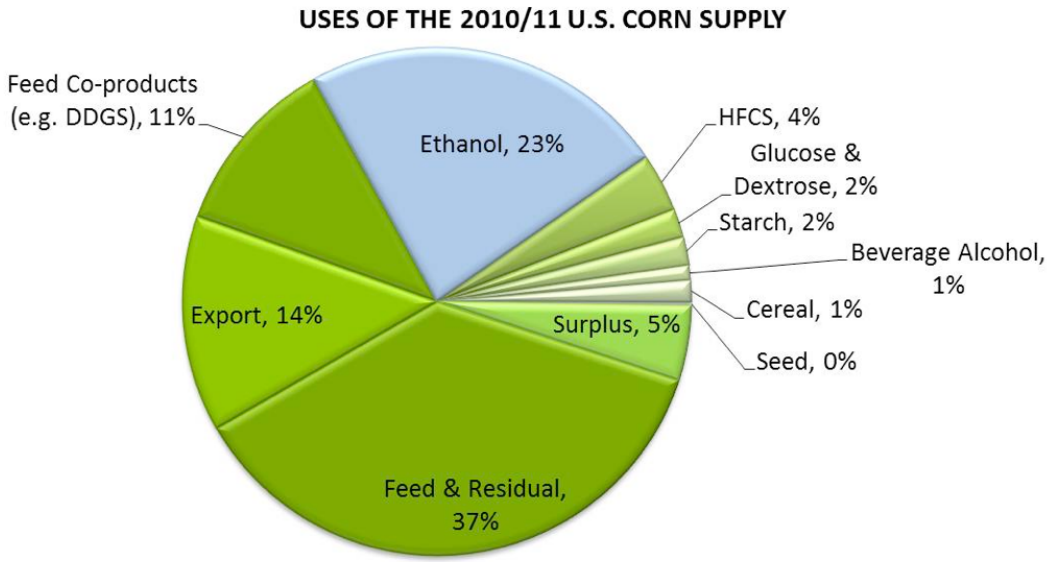
Technology/ Fuel Source	Number of facilities	Gross Capacity (MW)
Solid Fuel Combustion (includes 3 MSW facilities)	30	640
Landfill gas-to-energy	60	275
Wastewater treatment *	20	64
Animal and food waste digester	22	5.7
Totals	132	985
* Suspect - Probably higher		



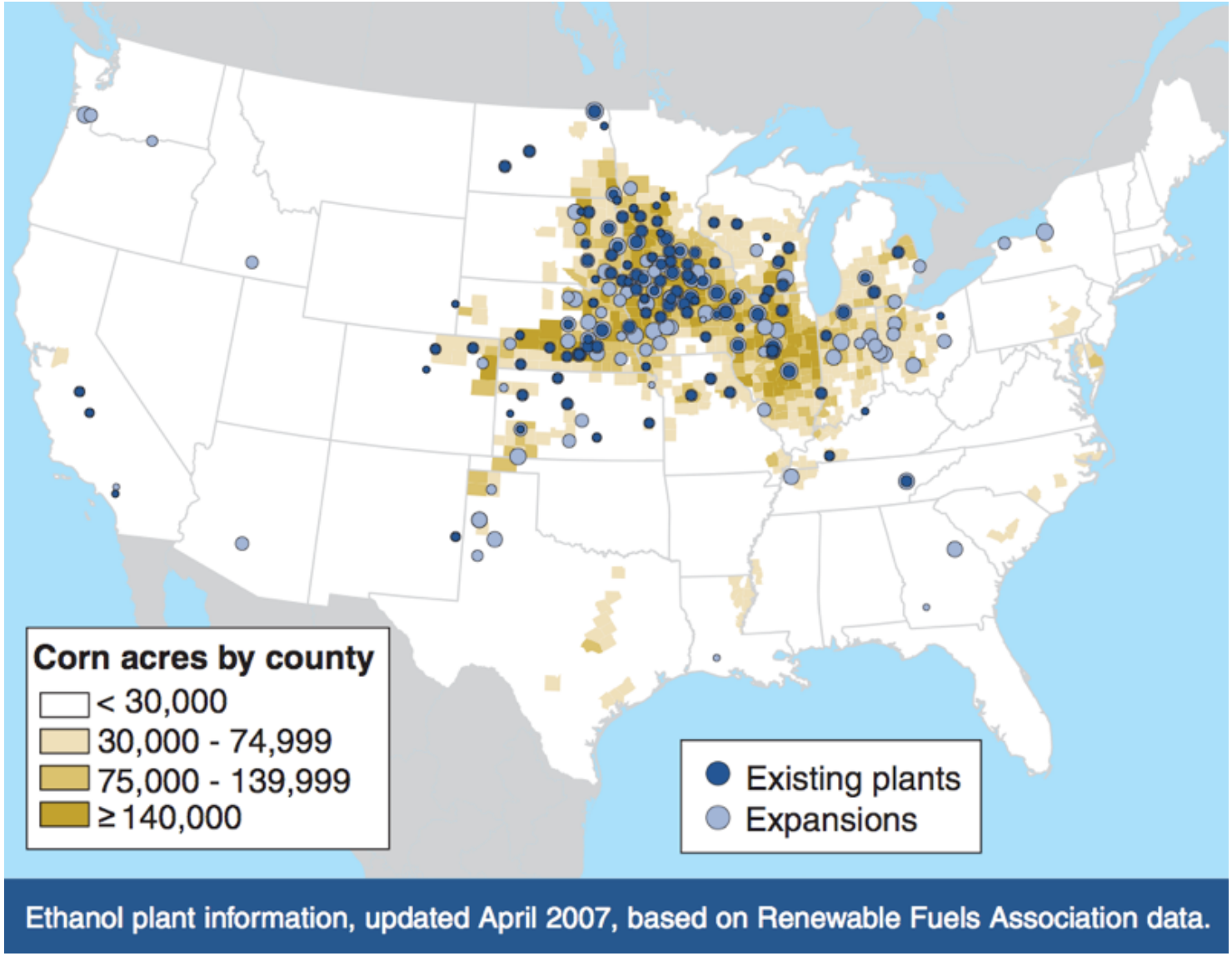
Source: Williams, 2007

Biofuel (replacing gasoline) with ethanol (US)

- Renewable Fuel Standard (RFS) mandates 5 -10% of gasoline (E10) be made from domestic ethanol.
- Ethanol is made mostly from Corn (Iowa)
- Ethanol farmers are subsidized by US fed. gov.
- The US “secured” 10% of “emergency” gasoline supply

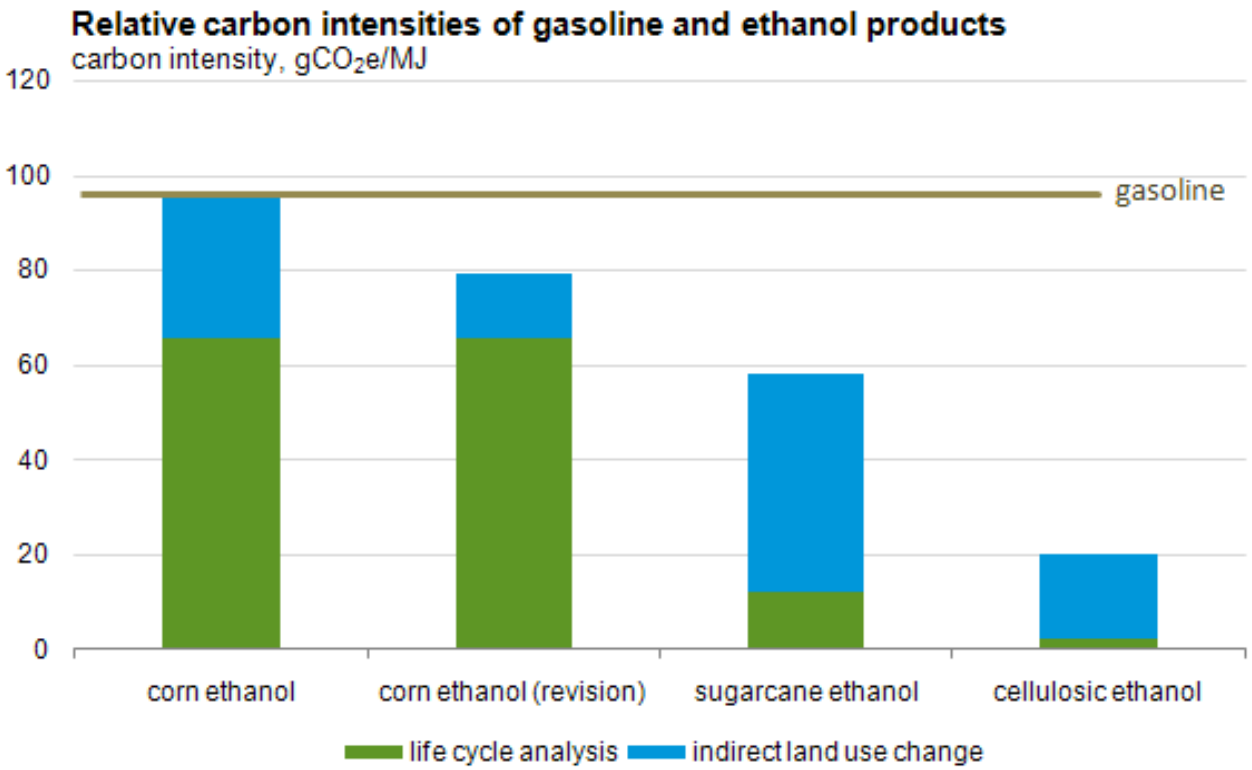


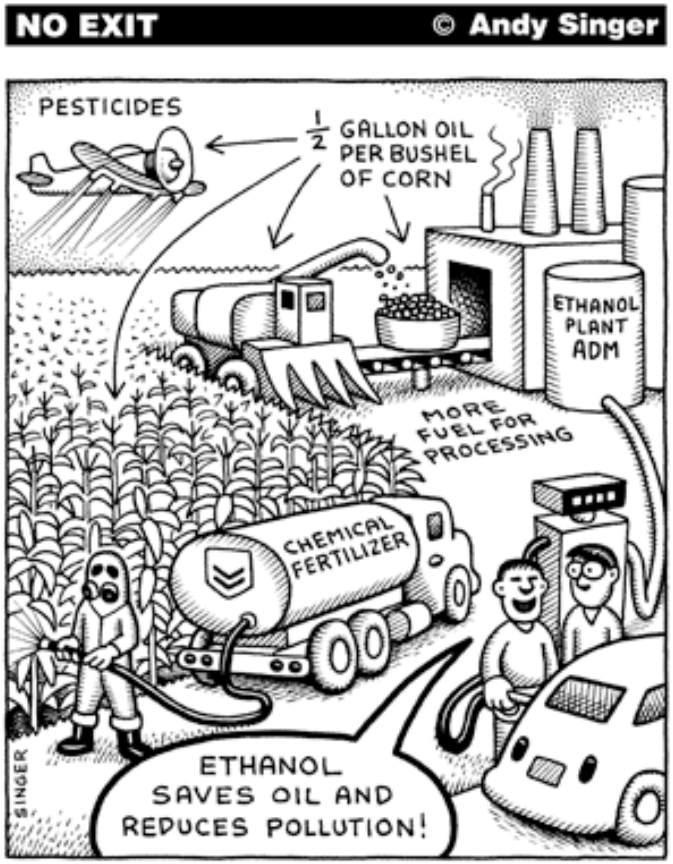
Ethanol: supporting US farmers with tax $



Randolph and Master Chap. 14 p 553

Corn based Ethanol - No carbon benefit





Why are we still producing US Corn Ethanol?

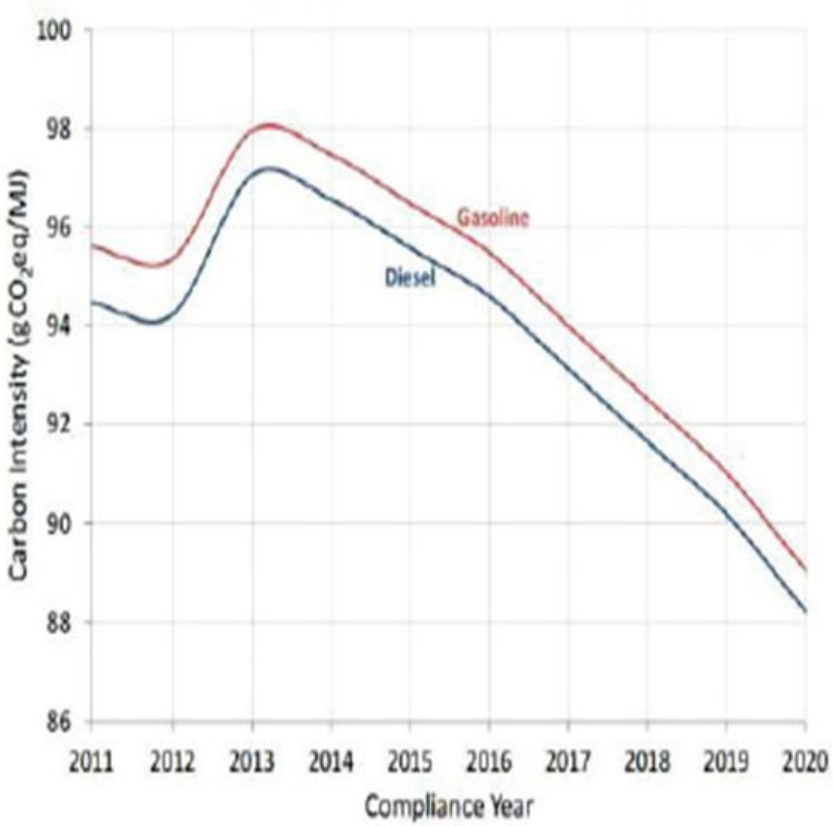
- "Big farm" lobbying Congress and Presidency
- US "dream" of gasoline independence
- Lack of focus on the Climate change aspect
- Outdated policies impossible to change due to public consensus in place (Iowa primaries calendar)

New options?

- Move from Corn to Switchgrass (no-farm land) or 2nd gen. cellulosic Ethanol.
- 1/5 of the Carbon footprint, but expensive to implement.

California Low Carbon Fuel Standard (LCFS)

- **Cellulosic Ethanol** have low carbon values (LCA certified).
- **Ethanol from Corn** on productive land have higher carbon values assigned (LCA certified).
- Refineries have CA state mandate to reduce "**life cycle carbon intensity**" of California's transportation fuels by 10% by 2020.



California Low Carbon Fuel Standard (LCFS)

Creates market for transportation fuel innovation

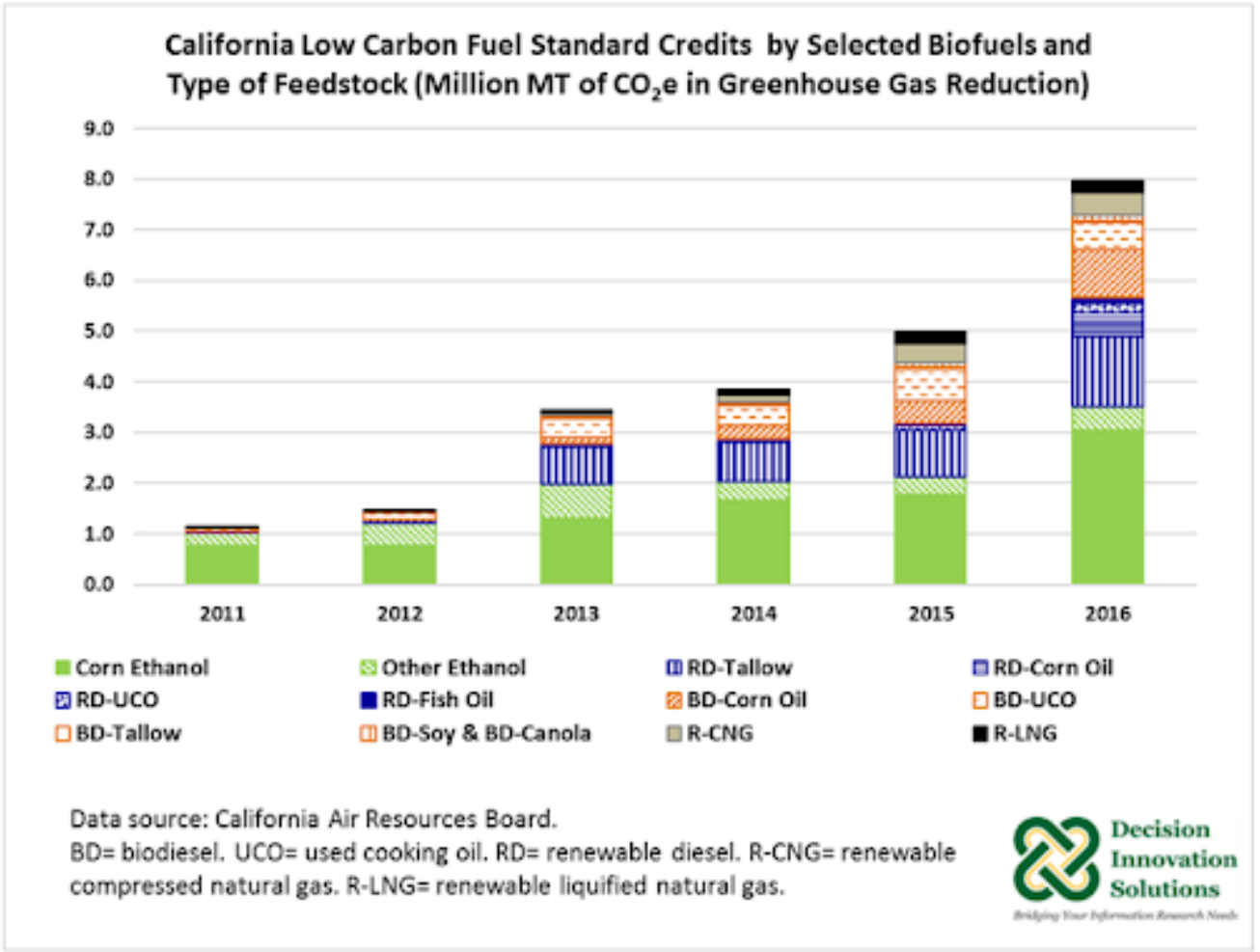


Figure 1.California Low Carbon Fuel Standard Credits by Selected Biofuels and Type Feedstock (Million MT of CO_2e in Greenhouse Gas Reduction

Future: Jet fuel, diesel, gasoline from algae

3rd gen. biofuels - very high output from algae