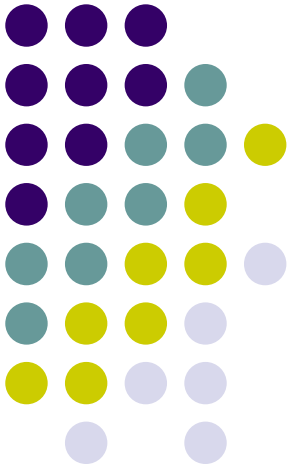
Sustainable BioEthanol

What issues impede progress on achieving this goal?



Mary Rezac
co-Director, Center for Sustainable Energy
Professor & Head, Chemical Engineering

Biomass Resources

Organic materials of recent biological origin

Biobased Products

Fuels

Chemicals

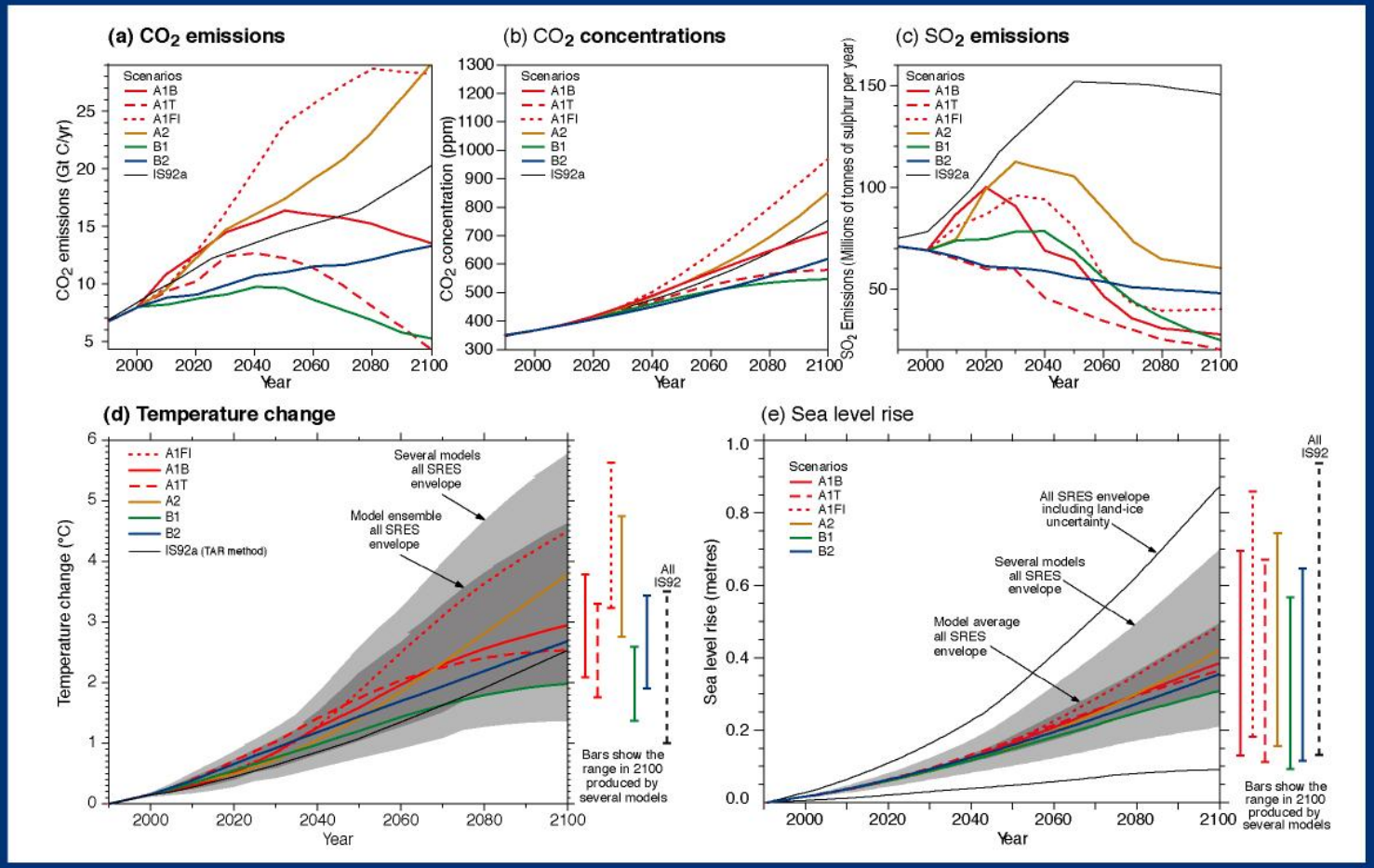
Plastics

Power

Motivations for Returning to a Bioeconomy

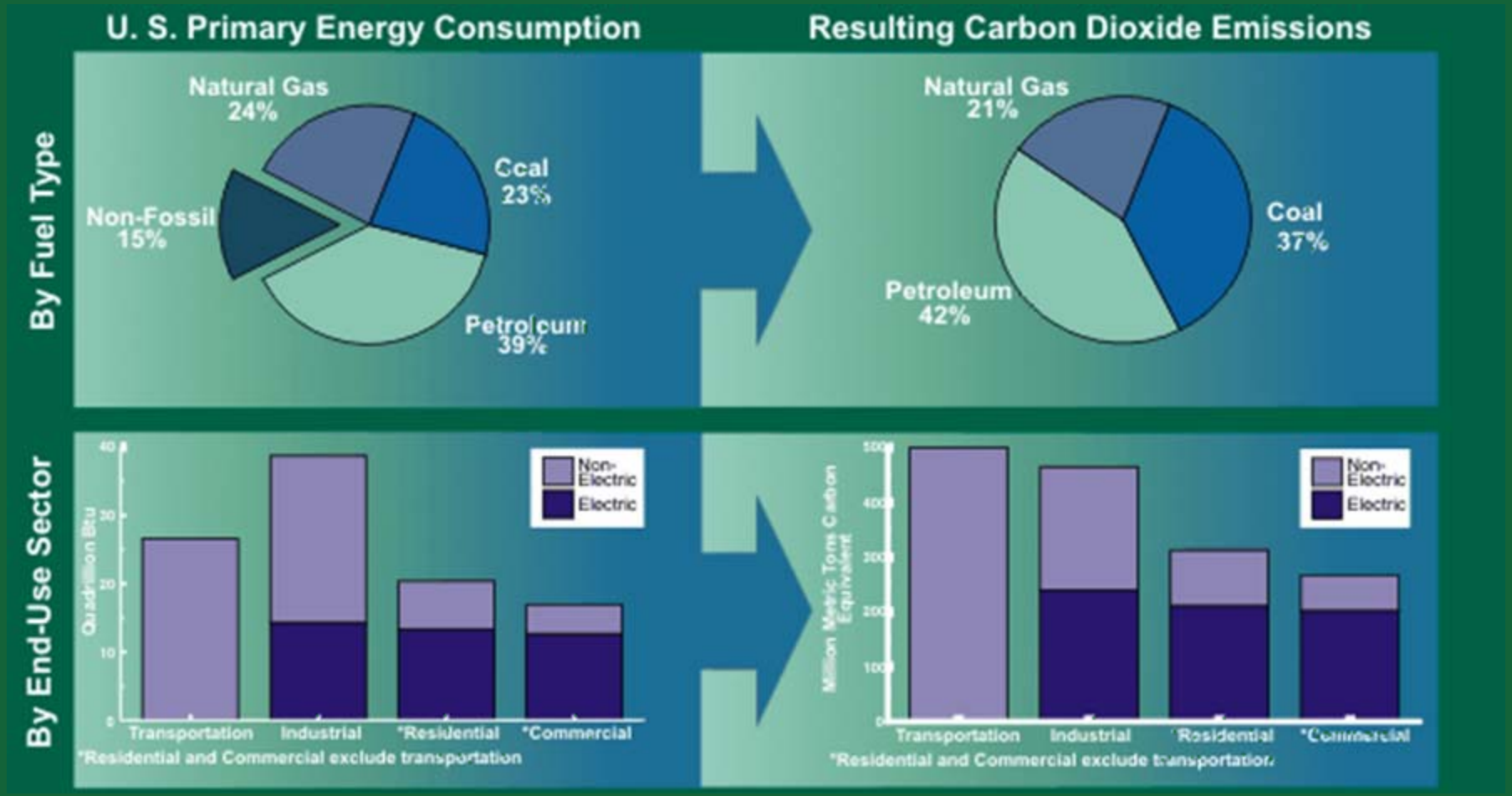
- Environmental quality
  - Local and regional (air quality, solid waste disposal)
  - Global climate change
- National security
  - Reduced reliance on foreign fuel sources
- Rural development
  - Rural economies are not thriving in many parts of the world

The global climate of the 21st century



WG1 - SPM FIGURE 5

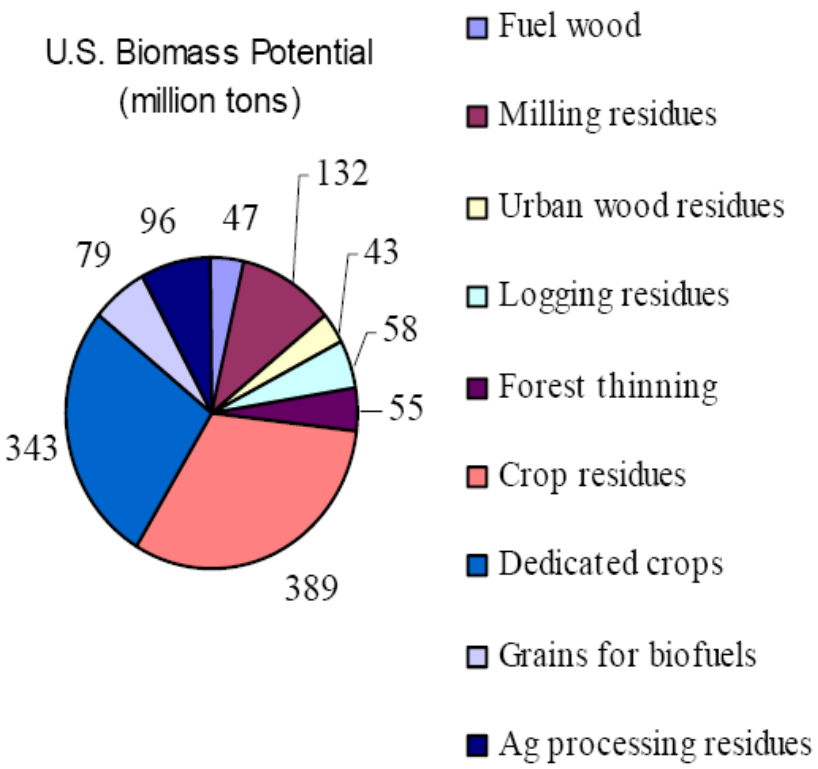
CO_2 emissions harm Environmental Quality



Biofuels have the potential to reduce CO_2 emissions

Source: Energy Information Administration

USA has significant capacity to produce biomass



Total potential in USA >1 billion tons representing

~1/5 of total US energy demand

or

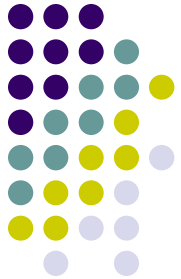
1/3 of US transportation fuel needs

Source: DoE Billion Ton Study, 2006

Kansas is a Leader in Biomass Production

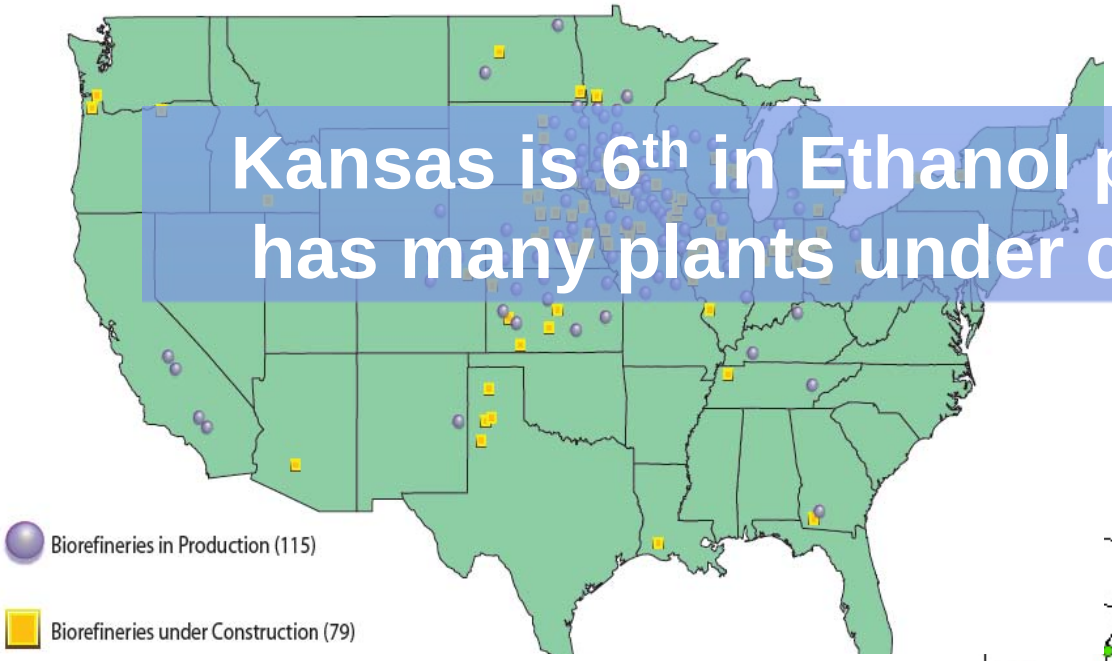
- 1st in wheat production
- 1st in sorghum production
- 2nd in beef production
- 4th in overall biomass production

Biomass conversion can lead to rural development opportunities



- An average 100 million gallon per year **ethanol biorefinergy** will
  - generate $406 million in gross output,
  - support 1,600 jobs, and
  - increase household income by $50+ million.

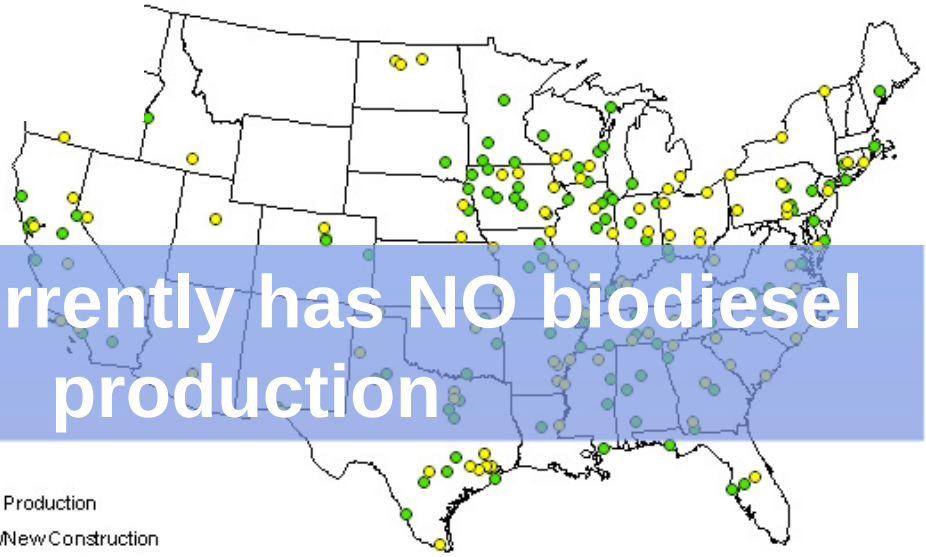
Ethanol and Biodiesel Production Facilities



Kansas is 6th in Ethanol production & has many plants under construction

Ethanol

Biodiesel

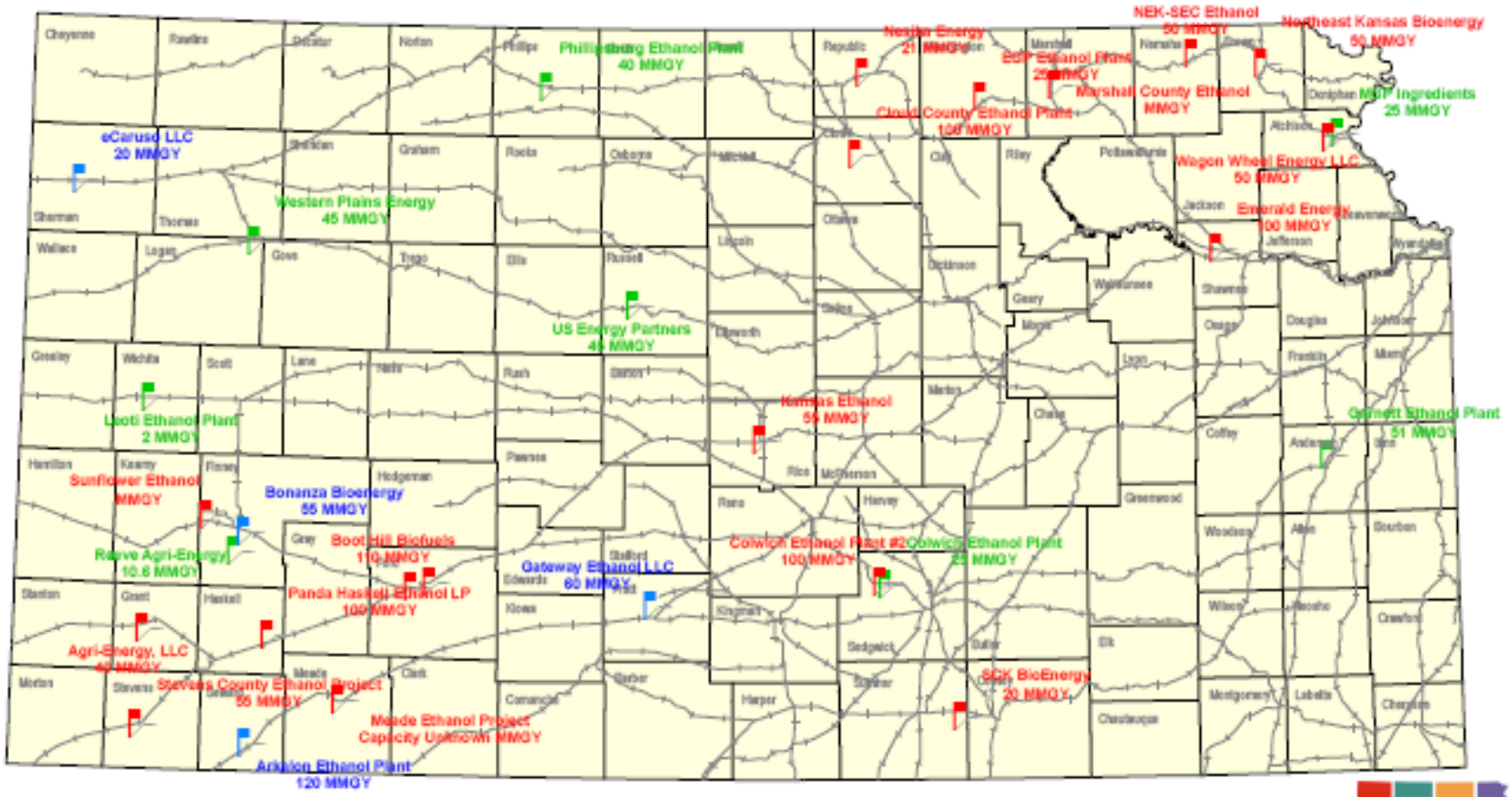


Kansas currently has NO biodiesel production

Source: Renewable Fuel Association 4.3.07

PROPOSED and EXISTING ETHANOL PLANTS in KANSAS

February 2007



Projection Information:
Name: Lambert Conformal Conic
Datum: NAD83 Spheroid GRS 1980
Distance Units: meters

Legend

Plant Status

- Existing
- Under Construction
- Proposed

Railroads also shown

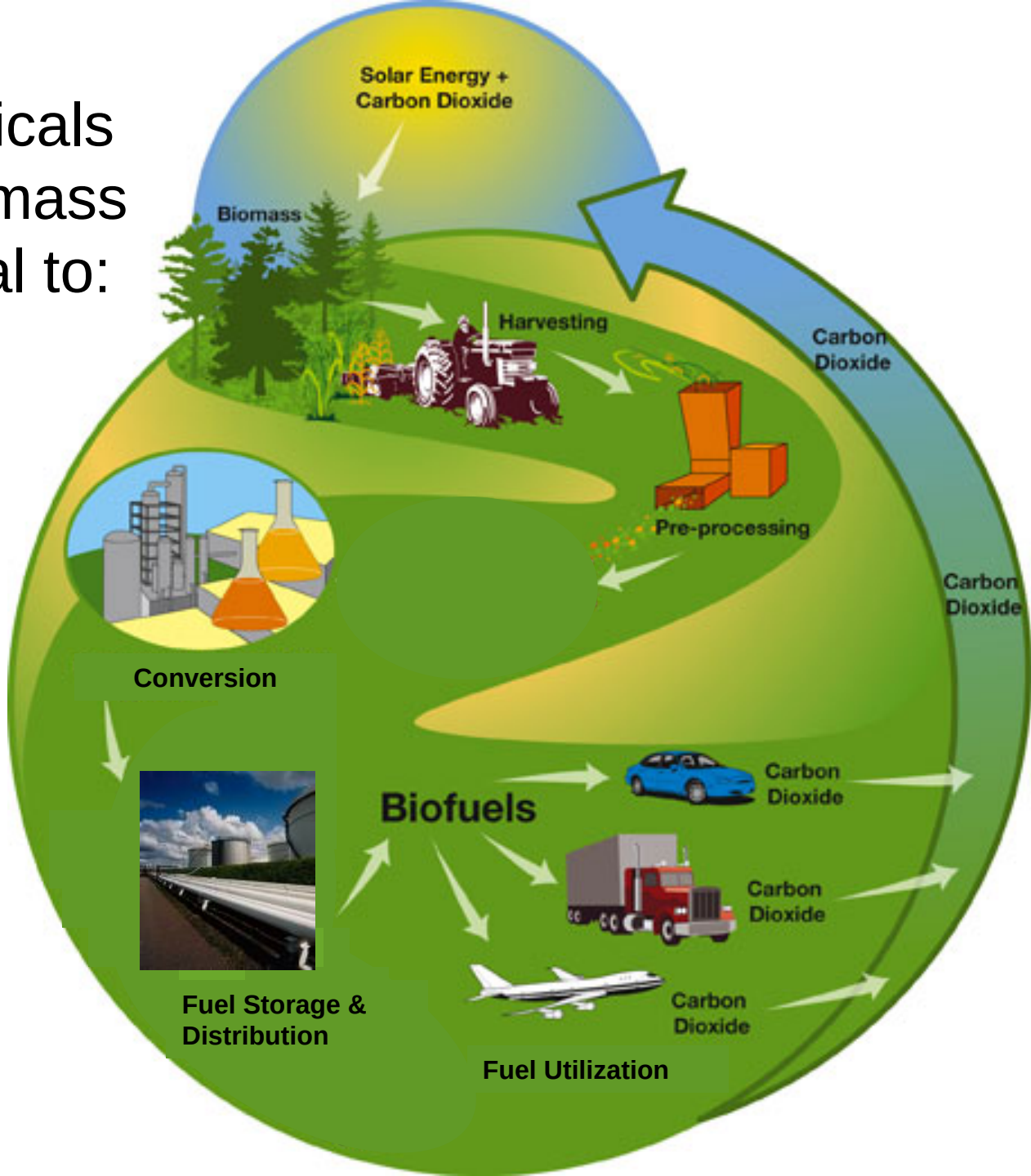
Compiled and edited by DASC (Data Access and Support Center), Kansas Geological Survey (KGS) at the University of Kansas, in Lawrence, Kansas. 08/06

All data except for the Proposed Coal sites can be downloaded from Kansas Geospatial Community Commons http://gisdasc.kgs.ku.edu

Kansas Energy Information Network
www.KansasEnergy.org
For more information on individual ethanol plants and projects, go to www.KansasEnergy.org/ethanol_projects.htm

Fuels and Chemicals derived from biomass have the potential to:

- Enhance environmental quality
- Enhance US National Security
- Provide Rural Development Opportunities



The limiting factor, for Kansas and the world, is likely to be…..

WATER

Water Concerns

- **Current energy crops require significant water for growth.**
  - corn is the most water-intensive of all the possible ethanol crops
  - 1,700 – 2,500 gallons of water are needed to grow the corn to produce every gallon of ethanol*
  - currently, sorghum requires about 40% less water than corn**
- **Conversion of grains to ethanol requires more water.**
  - Ethanol production requires 3-5 gallons of water per gallon of ethanol.
  - Groundwater tables in some states, including Missouri, have been drawn down to dangerously low levels near some ethanol plants*
- **Fertilizer runoff may negatively impact ground water quality.**

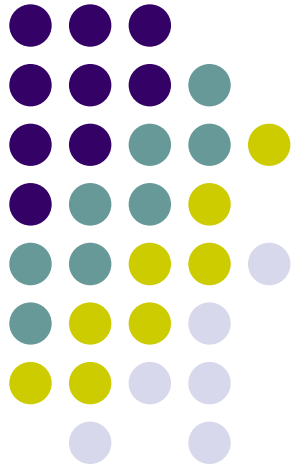
*David Pimentel, an ecology and agriculture professor at Cornell University

**Brent Bean, an agronomist with Texas A&M

Ethanol Production

Currently, corn is the DOMINANT feedstock.
Sorghum can be/is used as substitute.
Cellulose is the proposed future.

How does it work?



A Guide for Evaluating the Requirements of Ethanol Plants

Developed by:

The Clean Fuels Development Coalition

and

The Nebraska Ethanol Board

In Cooperation with

The U.S. Department of Agriculture

USDA

Summer 2006

Federal Incentive Programs

Various federal incentive programs have been designed to meet the primary objectives noted above: to encourage the production and utilization of ethanol and other biofuels. Additional factors including the implementation of a national Renewable Fuel Standard in 2006 serve as an effective catalyst for increased biofuel production and use. For the purposes of a project impact analysis, only those incentives applicable to the proposed project should be considered. Federal incentives that may be applicable to an ethanol project include the following:

Excise Tax Incentives

Since 1979, the federal government has provided various levels of exemption from federal motor fuel excise taxes for qualified alcohol fuels (specifically those not derived from petroleum, natural gas, coal, or peat). Most ethanol sold in the United States incorporates the federal excise tax incentive (VEETC) as opposed to another mechanism designed to encourage ethanol use, the income tax credit for alcohol fuels.

Income Tax Credit for Alcohol Fuels

Like the federal excise tax noted above, the federal income tax credit for blenders of gasoline and ethanol is currently in the law until 2010. The incentive is presently fifty one cents per gallon. While the credit can be carried forward, it is non-refundable and non-transferable. Therefore, it is of little value to entities that have no federal income tax liability.

Ethanol Production Incentive

Incentives discussed above have focused on mechanisms intended to increase the use of ethanol fuels. These incentives may be of limited value to new ethanol projects. However, various incentives have been crafted to encourage development of production facilities. During the past fifteen years a variety of incentives have been available through federal government programs. These incentive programs are summarized below.

Income Tax Credit

The income tax credit discussed above has generally been considered as an incentive to increase ethanol use. This perception is based on the fact that the application of this incentive is tied to the blending of all components of the finished fuel, i.e., ethanol and gasoline. Although seldom applied as a production incentive, this credit may be narrowly viewed as an incentive for ethanol production.

Income Tax Credit for Small Ethanol Producers

Effective January 1, 1991, certain small fuel ethanol producers are eligible to receive an income tax credit of ten cents for each gallon of qualified (denatured) ethanol fuel produced. The provision limits the qualified ethanol fuel production of any producer for any taxable year to no more than 15 million gallons per year produced at a facility whose total production capacity does not exceed 60 million gallons per year. The tax credit is included in income and is therefore taxable, is nonrefundable and nontransferable, but can be carried forward into future taxable years.

Loans and Loan Guarantee Programs

Fifteen years ago Congress authorized a series of programs to encourage development of alternative energy enterprises in the U.S. Among the primary incentives available

Ethanol Tax Credit: $0.51/gallon

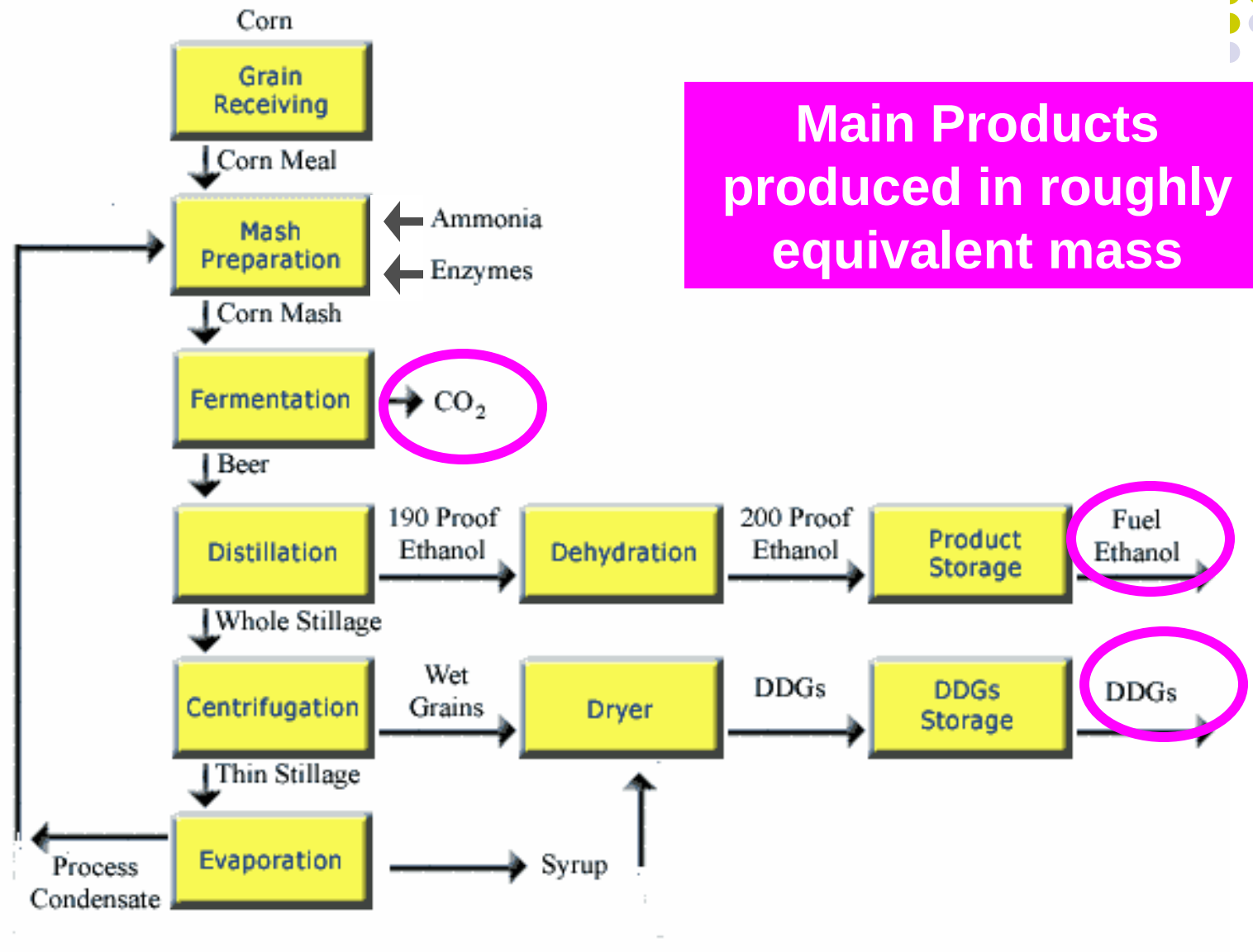
Any person contemplating an investment in an ethanol plant should evaluate a variety of criteria to determine suitability of the investment under consideration. Agribusiness lenders with Farm Credit Services of America offer the following tips for evaluating investment in an ethanol plant:

- Equity-to-asset ratio of at least 40%. That means investors should own 40% of the total value of the plant and inventory, with no more than 60% financed by loans.
- Working capital for buying and hedging inputs of at least 10¢ for every gallon of plant capacity.
- Adequate corn supply. Ideally, a plant should use no more than 50% of the net exportable bushels of corn in a 35- to 50-mile radius.
- Find management with industry experience, something that's difficult to do during rapid expansion. Some plant builders/designers will train staff and manage start-ups.
- Have a risk management strategy. The goal is to lock in a margin by hedging inputs of corn and natural gas used in distilling. Plants hedge or contract outputs of ethanol and distillers' grains when possible.
- Use technology. With high natural gas prices, some new plants are looking to coal or methane from manure. Capital cost for these energy sources can be higher.
- Have a competitive break-even cost. Energy inputs are pushing that up. Typical breakevens currently run from $1.10 to $1.30 a gallon.
- Use marketers. Many plants sell ethanol through marketing companies.

50 mile radius for feed supply recommended maximum

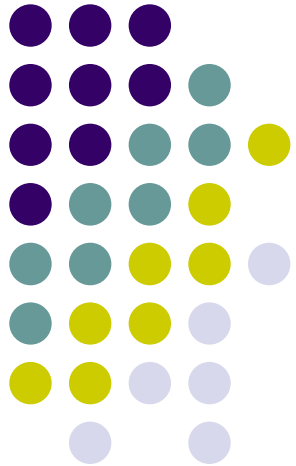
No mention of water……

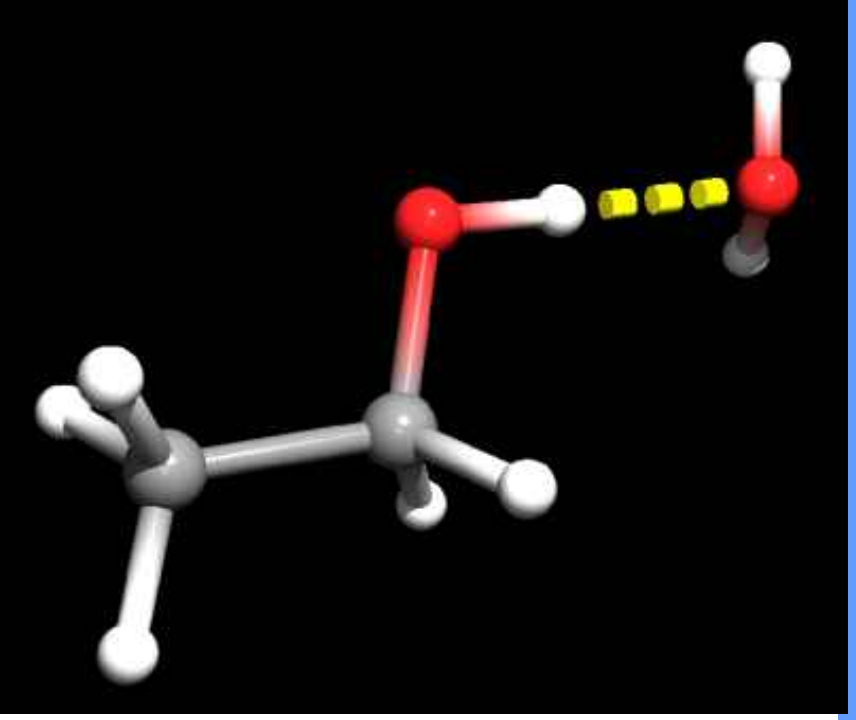
Typical Ethanol Production Process



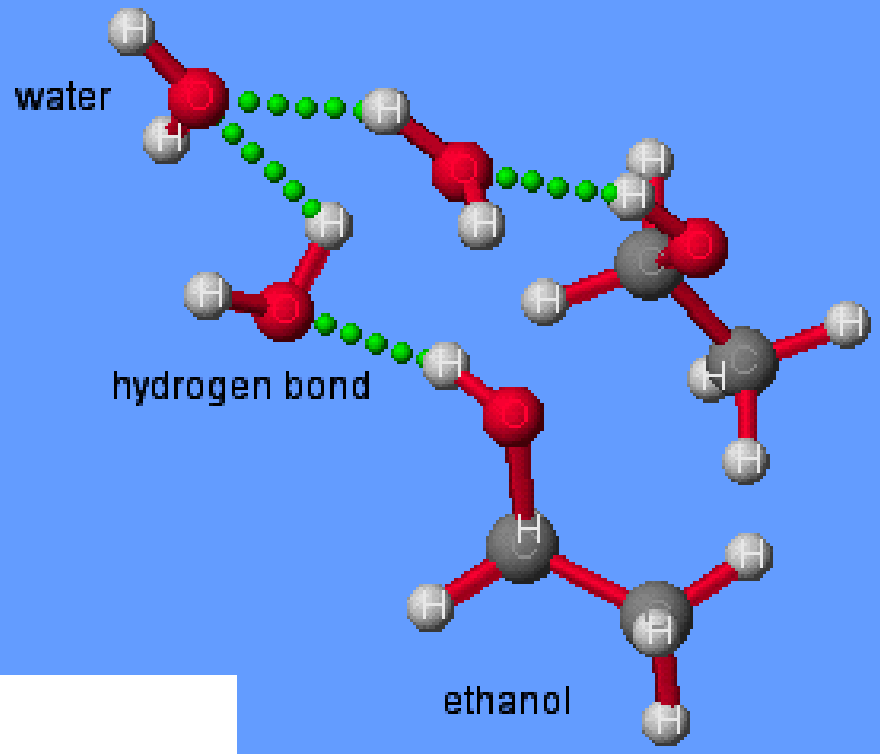
Main Products produced in roughly equivalent mass

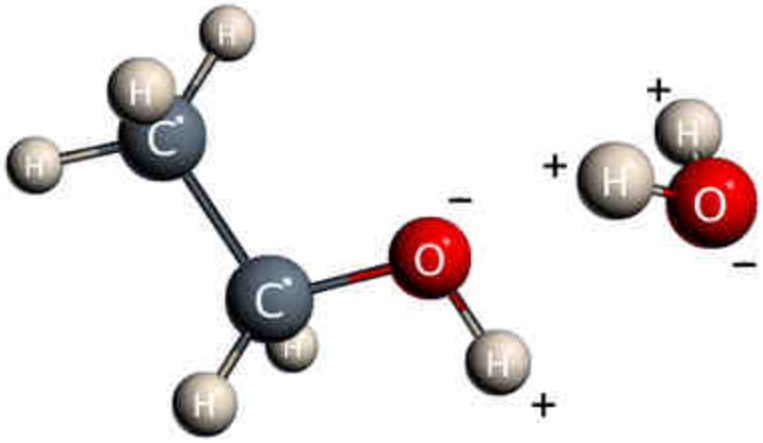
Why are ethanol and water special?

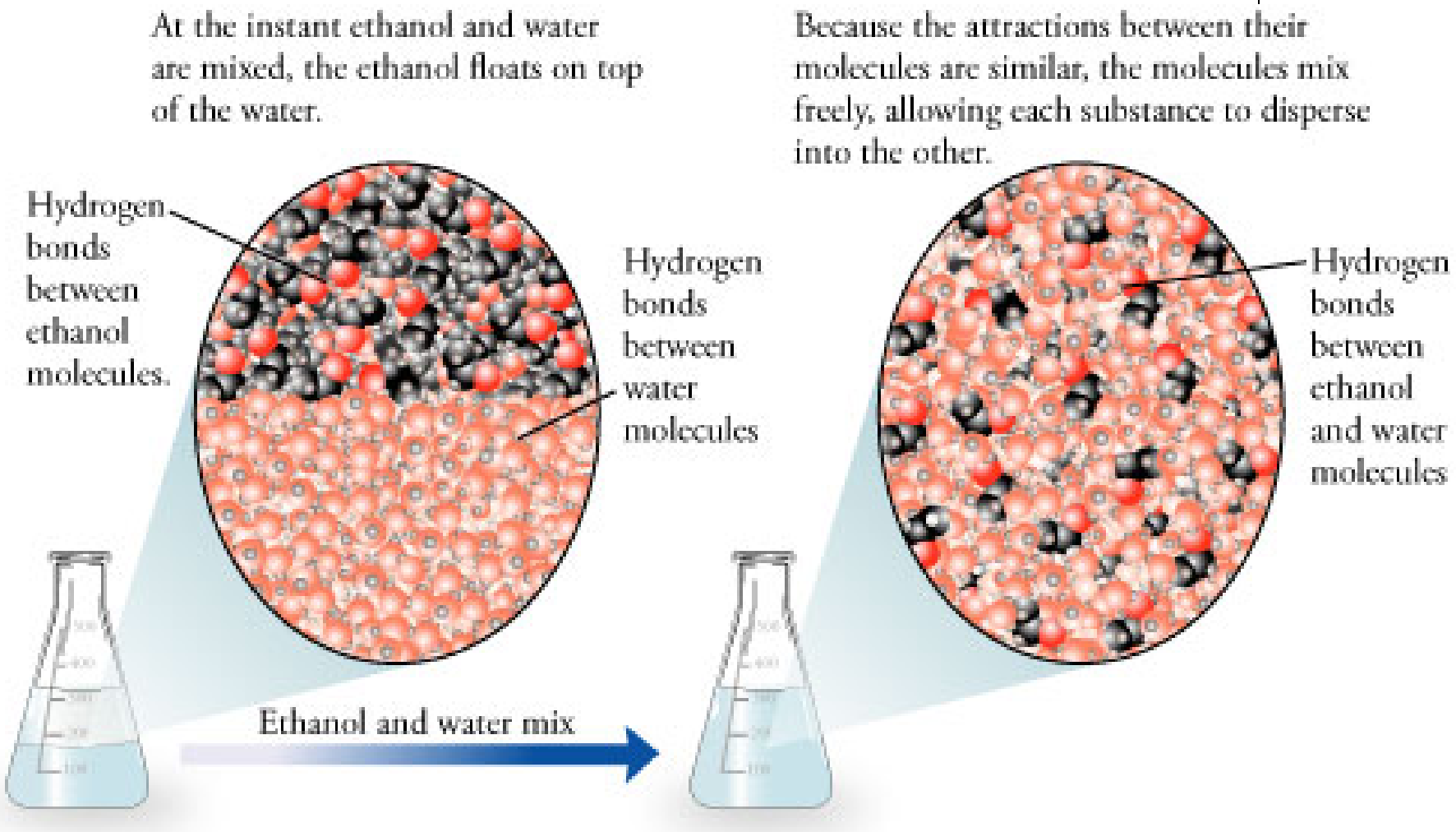


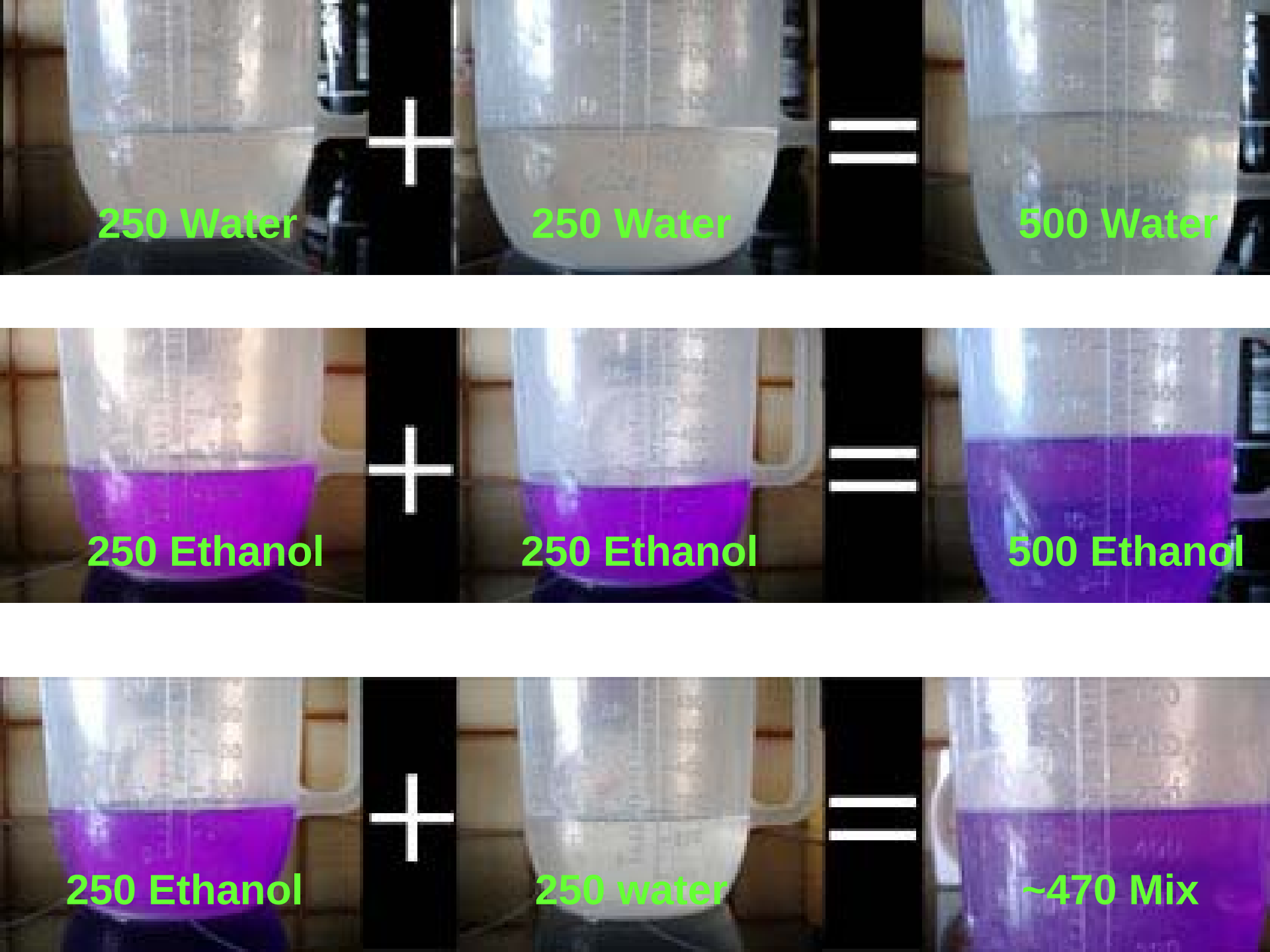


Ethanol - Water Hydrogen Bonding

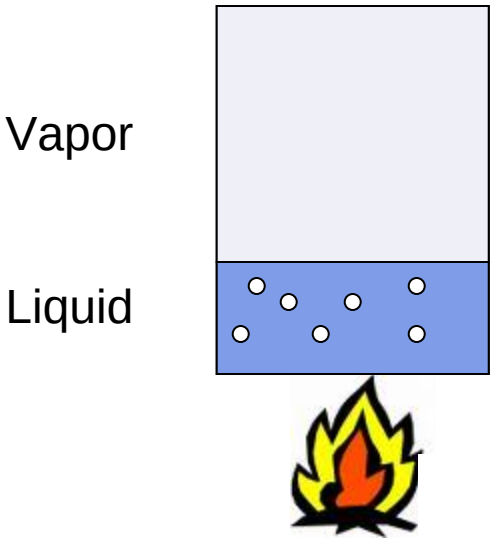


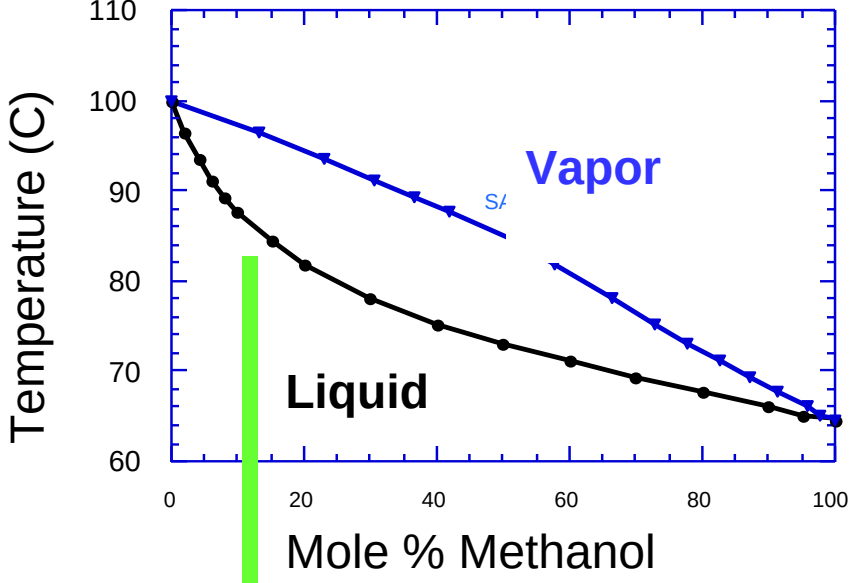


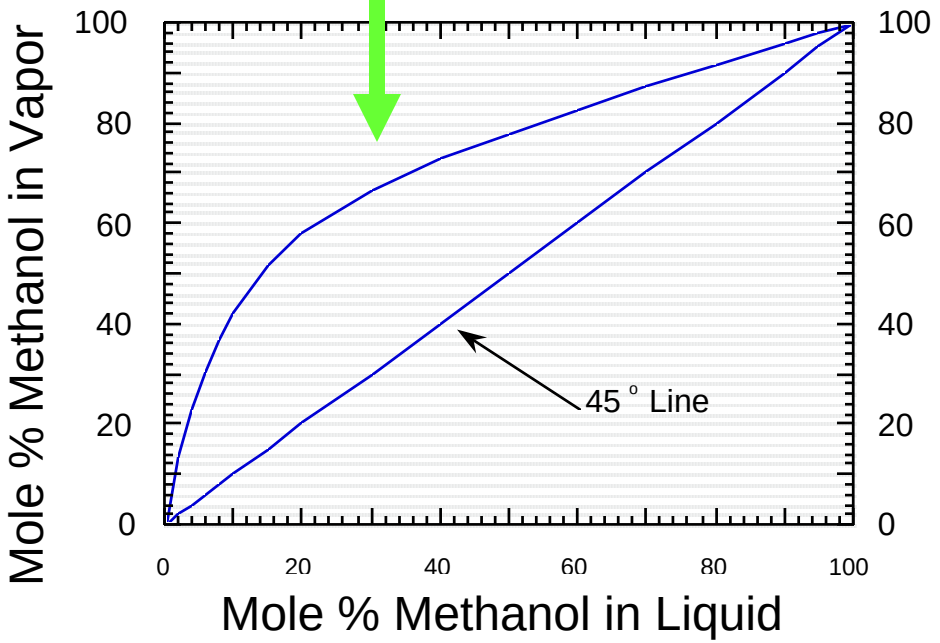

At the instant ethanol and water are mixed, the ethanol floats on top of the water.
Because the attractions between their molecules are similar, the molecules mix freely, allowing each substance to disperse into the other.
Hydrogen bonds between ethanol molecules.
Hydrogen bonds between water molecules
Hydrogen bonds between ethanol and water molecules
Ethanol and water mix


250 Water
250 Water
500 Water
250 Ethanol
250 Ethanol
500 Ethanol
250 Ethanol
250 water
~470 Mix

What is ideal?



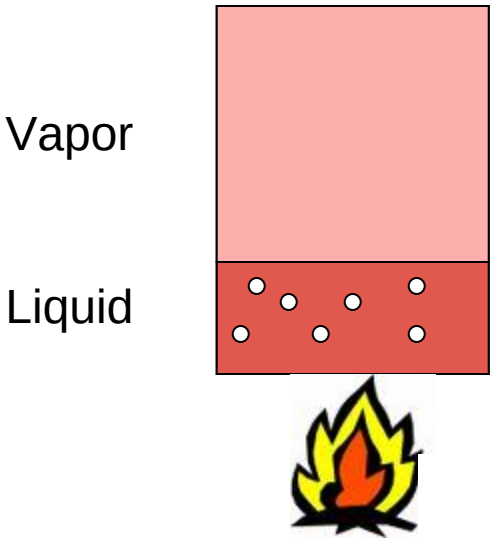


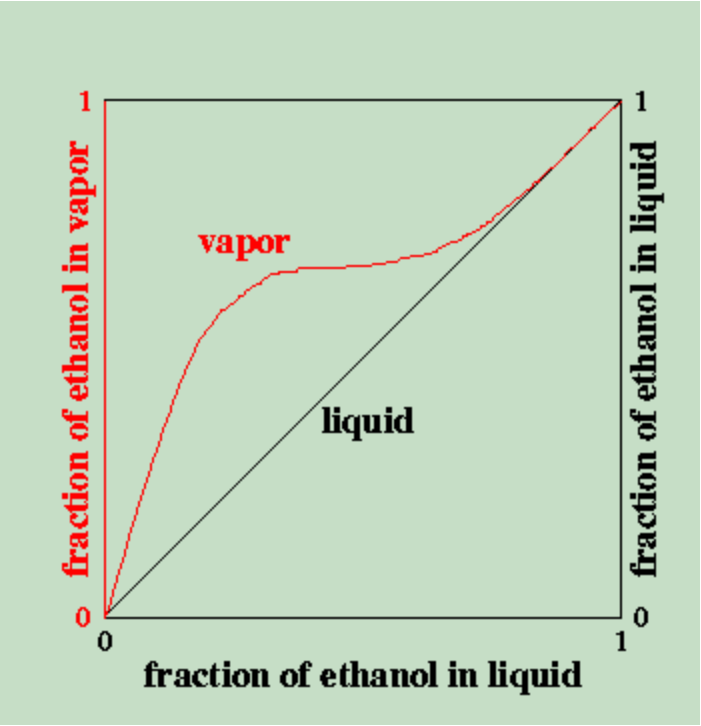


- Heat to desired T
- Sample Vapor and Liquid
- Enhanced composition of a more volatile component in the vapor phase provides a separation between the two compounds

IDEAL: One component is more volatile than the other over the entire concentration range.

What's non-ideal?

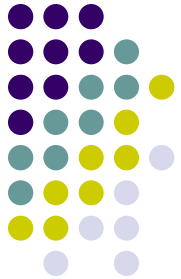




- Heat to desired T
- Sample Vapor and Liquid
- Enhanced composition of a more volatile component in the vapor phase provides a separation between the two compounds

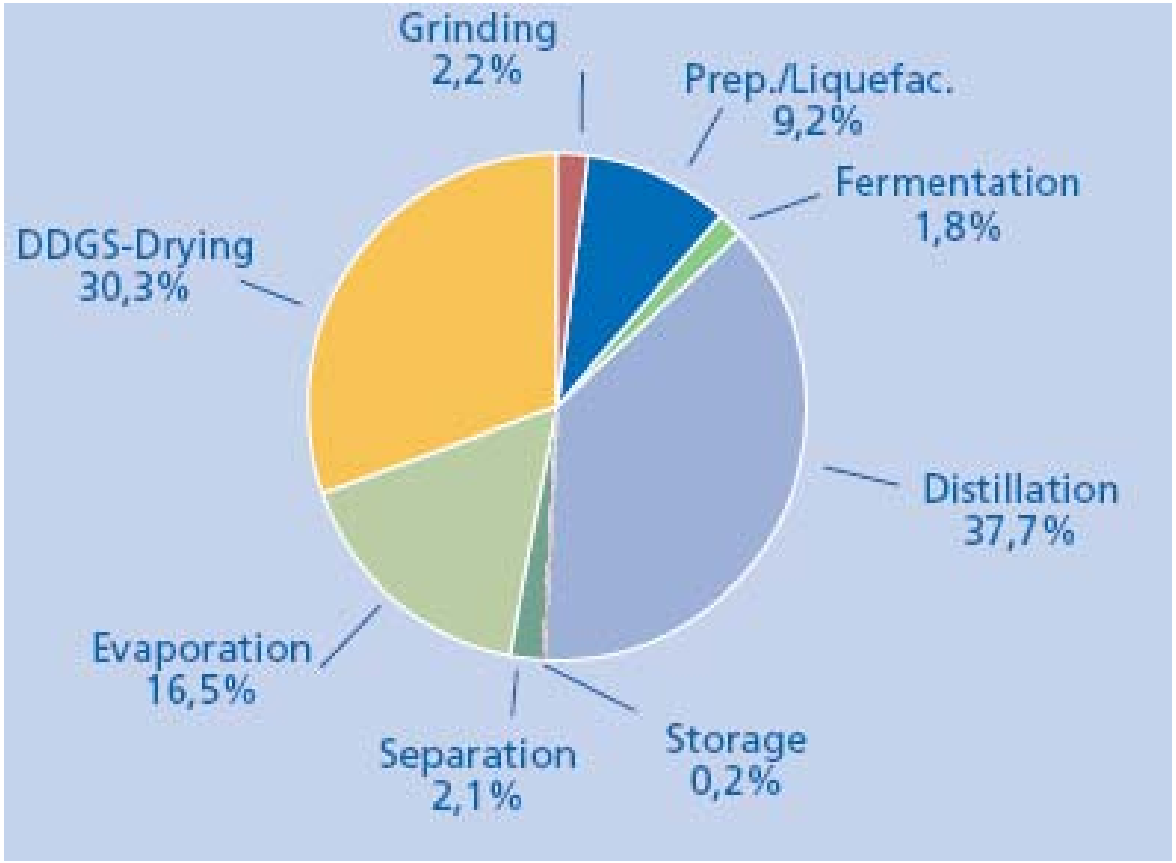
NON-IDEAL: At some composition(s) there is no difference in the vapor and liquid content.

Why does it matter?



- Separation (via distillation) is only possible if there's a difference in the vapor and liquid composition
- As the compositions become closer, more and more energy will be required.
- When the compositions become identical, distillation won't work any longer….. This is called an azeotrope.

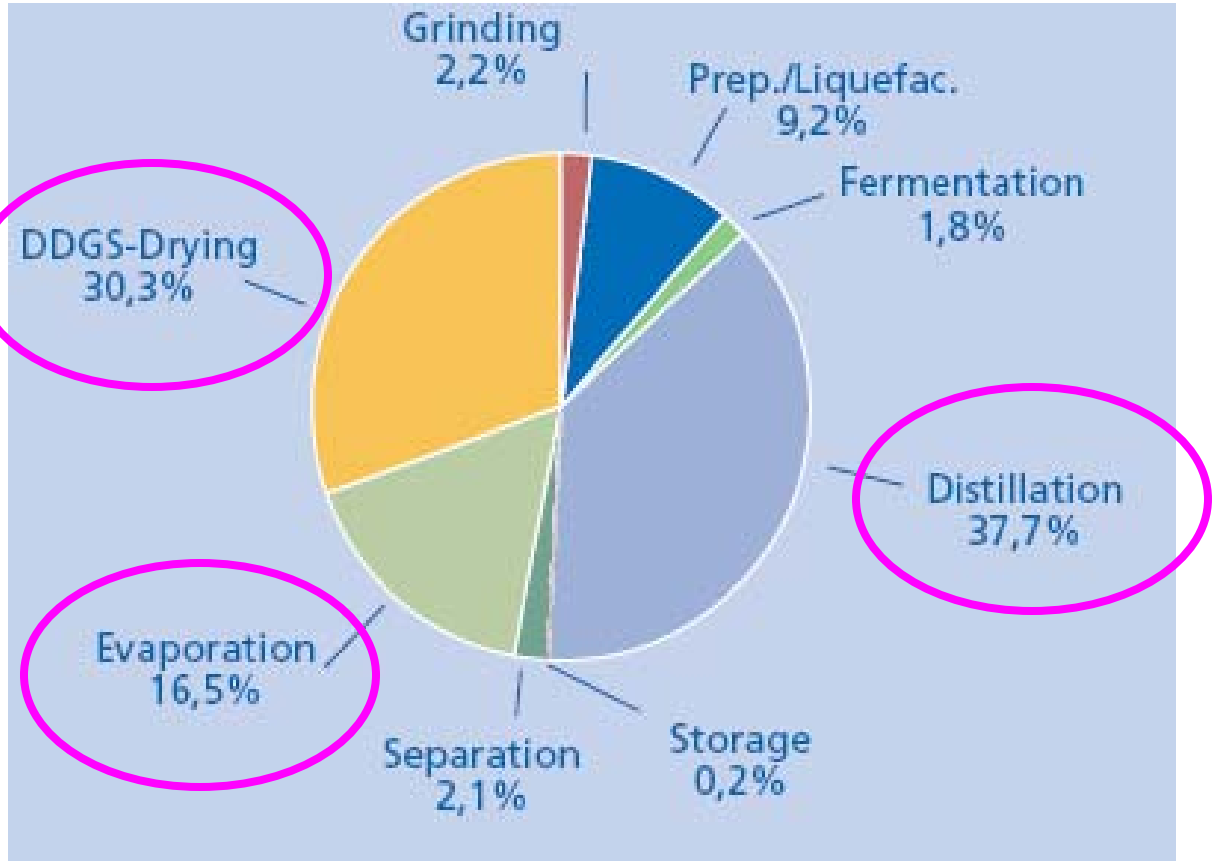
Energy Usage in Conventional Ethanol Plants



Current, State of the Art, plants use ~35,000 BTU / gallon of ethanol produced – essentially all of it provided by natural gas (CH_4, methane)

Many older facilities use more than 60,000 BTU/gallon

Energy Usage in Conventional Ethanol Plants



Current, State of the Art, plants use ~35,000 BTU / gallon of ethanol produced – essentially all of it provided by natural gas (CH_4, methane)

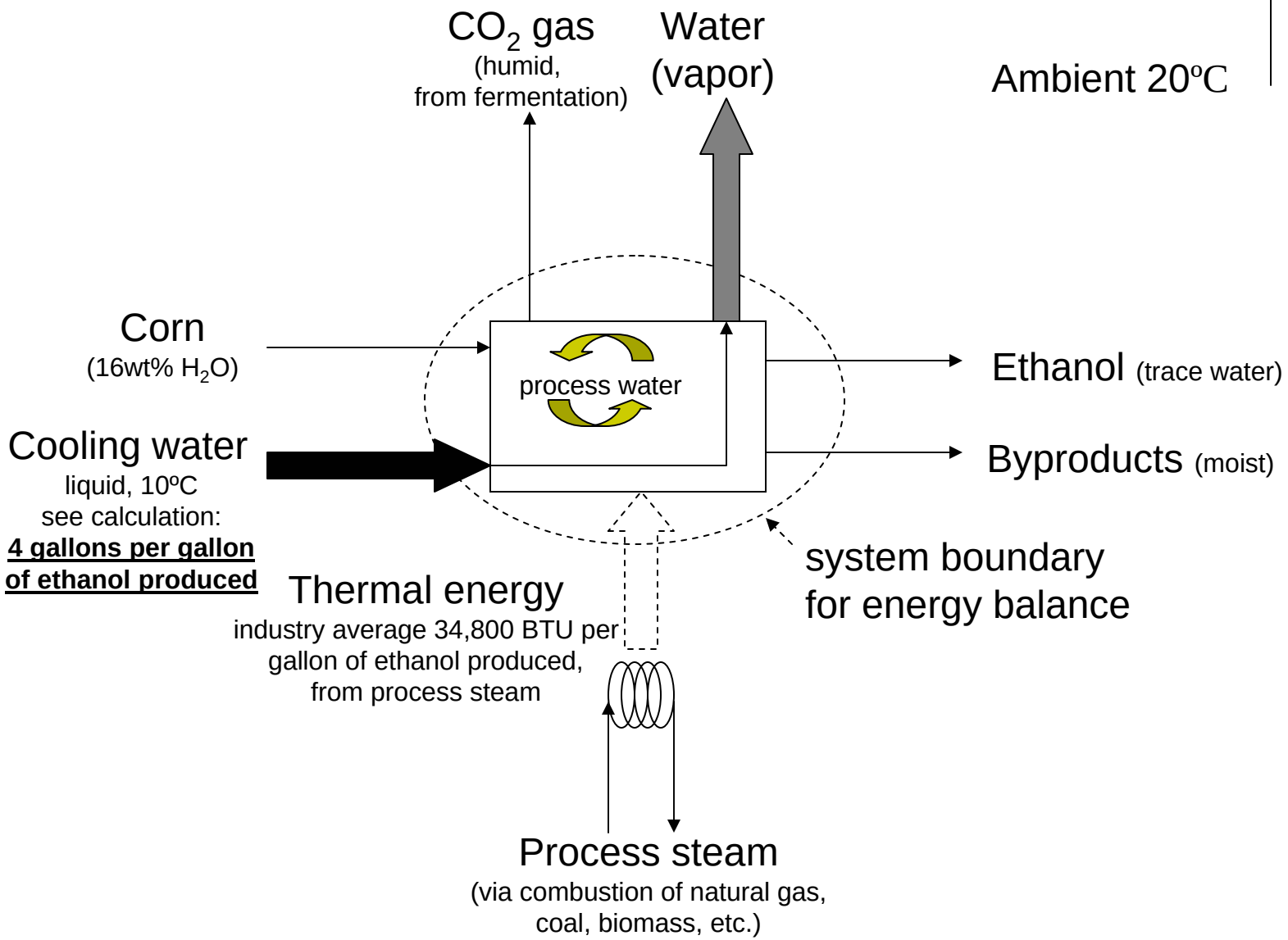
Many older facilities use more than 60,000 BTU/gallon

Product Clean-up accounts for ~85% of Energy Demand

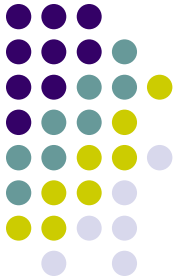
KANSAS

IOWA

What's happening to the water?



How to help improve sustainability of this system

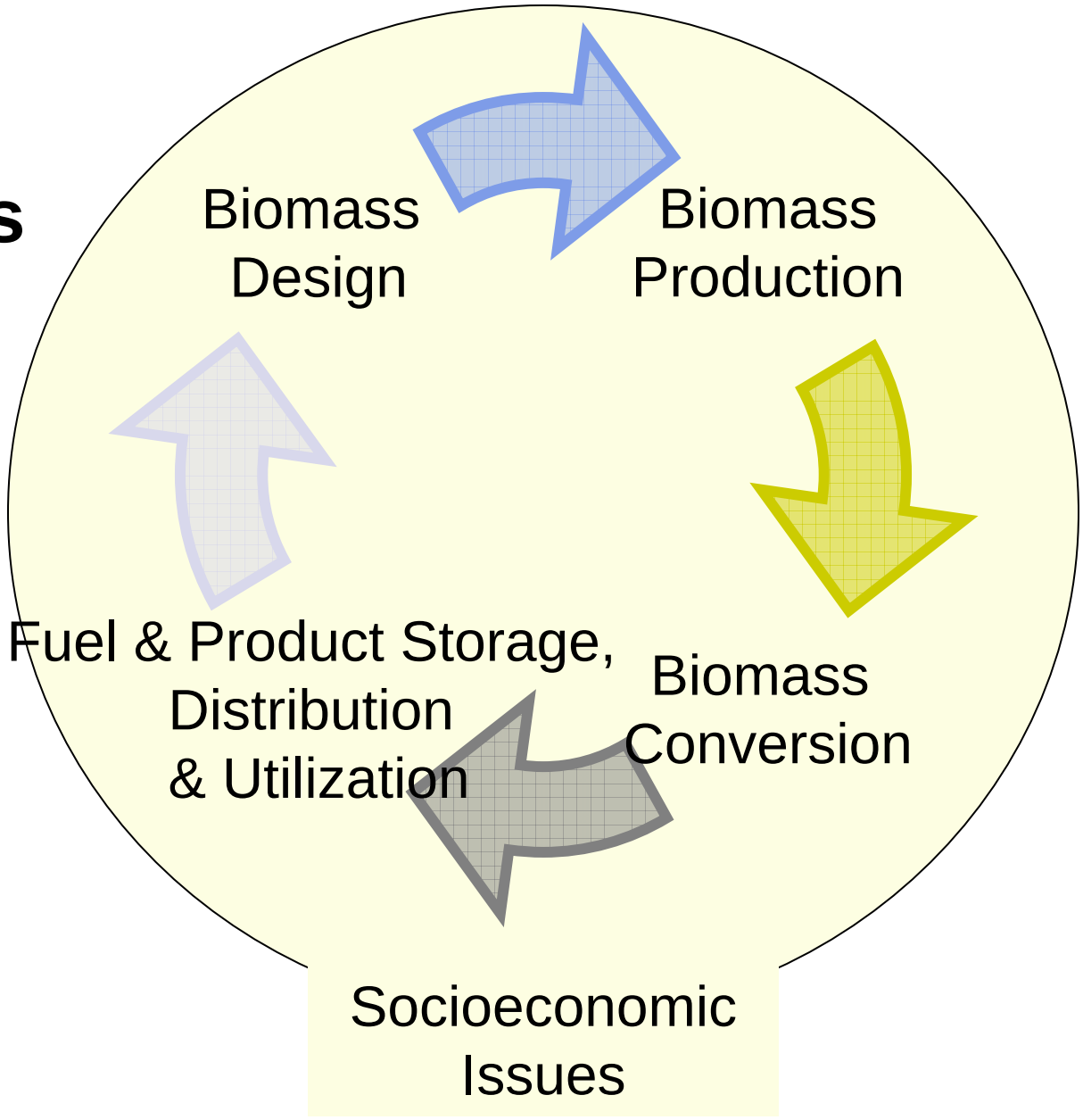


- Reduce fuel utilization
- Which will reduce water utilization
- By….
  - Finding a use for distiller's WET grains
  - Improving the separation technology
  - Using more drought resistant feedstocks

- KSU's Center for Sustainable Energy is Working on ALL of these approaches

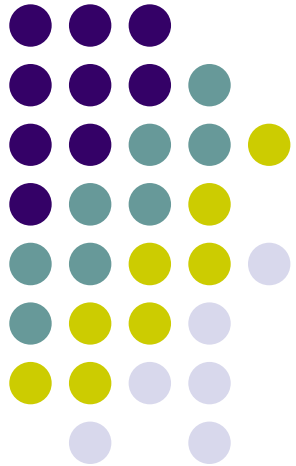
Biofuels as Sustainable Energy Carriers

The role of water is analyzed in each step of the process.



Thank You

Questions?



Simplified Process Flow Sheet of the Lurgi Bioethanol Process