Progress on Developing Value-Added Uses for Distillers Grains: Current and Evolving Opportunities

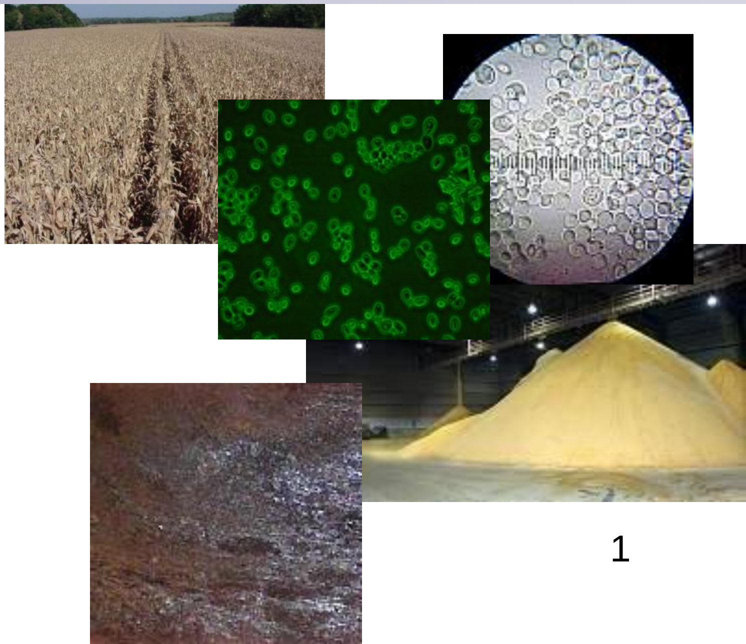
Kurt A. Rosentrater, Ph.D.

Department of Agricultural and Biosystems Engineering

Iowa State University

(515) 294-4019

karosent@iastate.edu



OVERVIEW

1. Ethyl alcohol
2. Coproducts
3. Ongoing research
4. New opportunities
5. Concluding thoughts

ETHYL ALCOHOL

Ethyl Alcohol – The Fuel of the Future

1860	Nicholas Otto (b. 1832, d. 1891), a German inventor, used ethanol to fuel an internal combustion engine
1896	Henry Ford's (b. 1863, d. 1947) first automobile, the quadricycle, used corn-based ethanol as fuel
1908	Hart-Parr Company (Charles City, IA) manufactured tractors that could use ethanol as a fuel
	Henry Ford's (b. 1863, d. 1947) Model T used corn-based ethanol, gasoline, or a combinations as fuel
1918	World War I caused increased need for fuel, including ethanol; demand for ethanol reached nearly 60 million gal/year
1940	The U.S. Army constructed and operated a fuel ethanol plant in Omaha, NE

Ethanol was extensively used as a motor fuel additive prior to the end of World War II (ca. 1933)

Ethyl Alcohol – The Fuel of the Future

The first distillation column for the production of fuel ethanol was invented by Dennis and Dave Vander Griend at South Dakota State University in 1978/1979

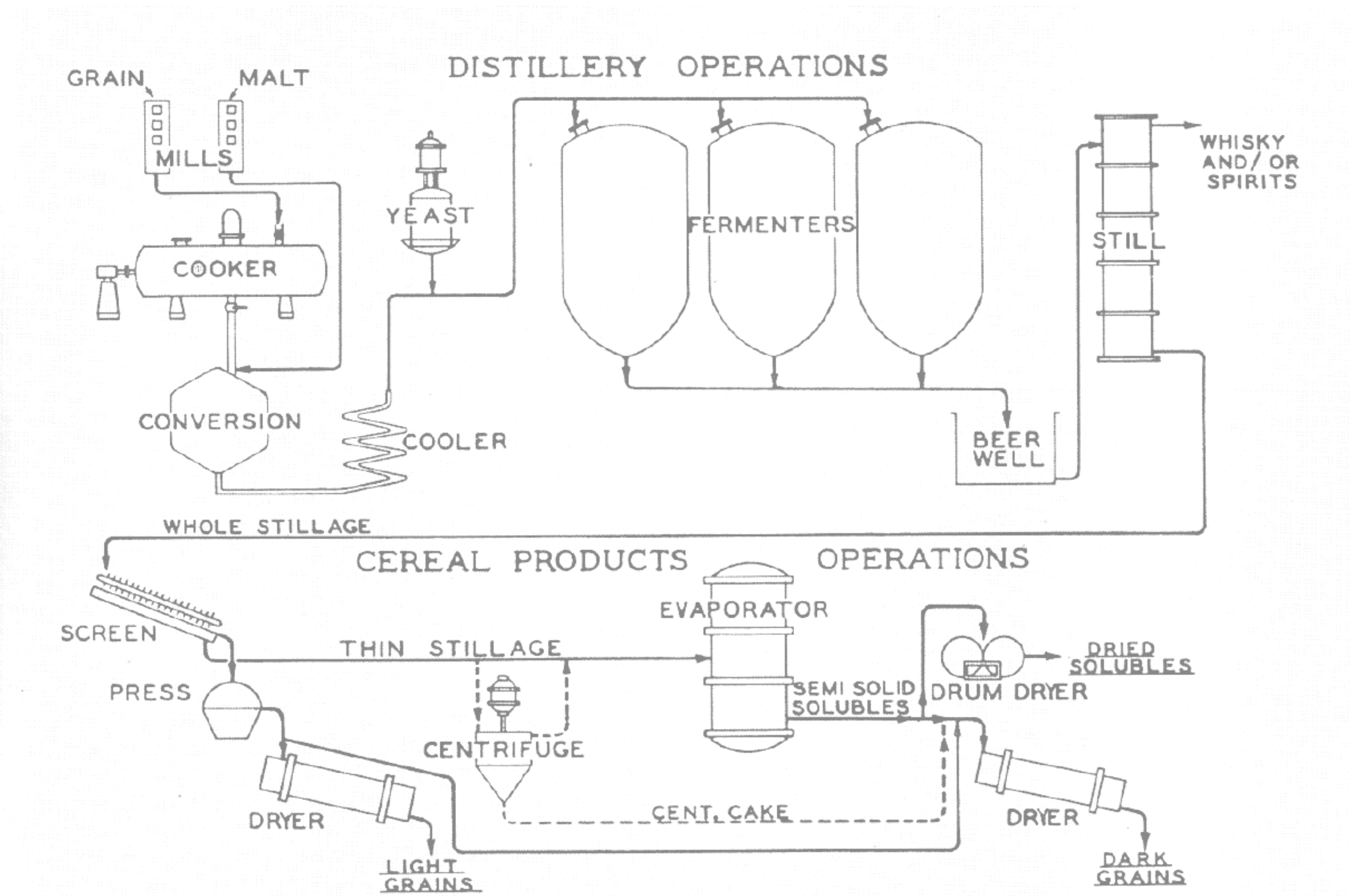
DDGS Historically

- Many people have asked what the fuel ethanol industry is going to do about the growing piles of non-fermented leftovers
  - "Grain distillers have developed equipment and an attractive market for their recovered grains" (Boruff, 1947)
  - "Distillers are recovering, drying, and marketing their destarched grain stillage as distillers dried grains and dried solubles" (Boruff, 1952)
- This question has been around for quite some time, and it also appears that a viable solution had already been developed as far back as the 1940s

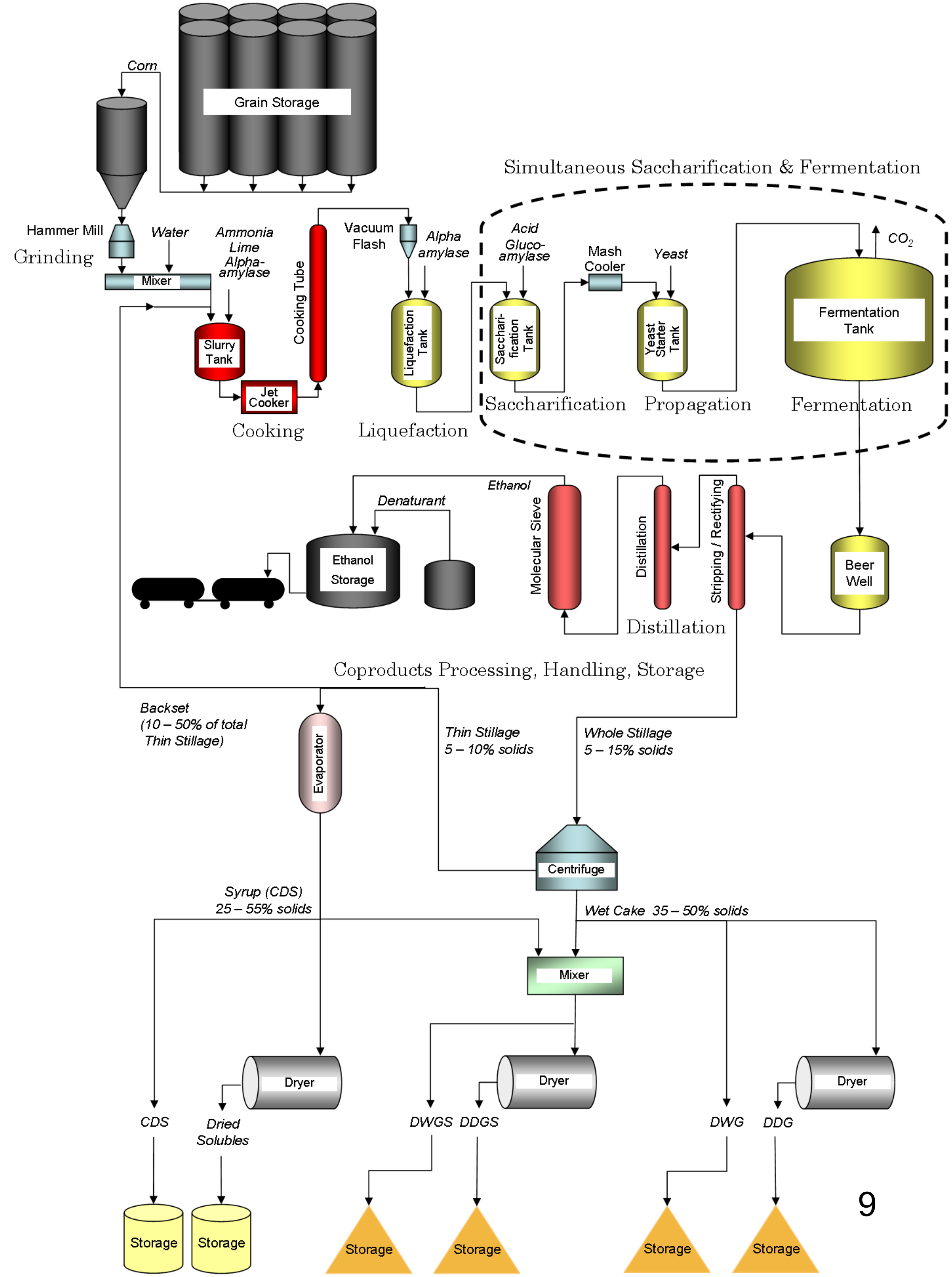
DDGS Historically

- In the 1940s / 1950s
  - 17 lb (7.7 kg) of distillers feed was produced for every 1 bu (56 lb; 25.4 kg) of grain that was processed into ethanol
    - Similar to today
  - But over 700 gal (2650 L) of water was required to produce this feed (Boruff, 1947; Boruff, 1952; Boruff et al., 1943)
    - vs. < 4 gal. of water today

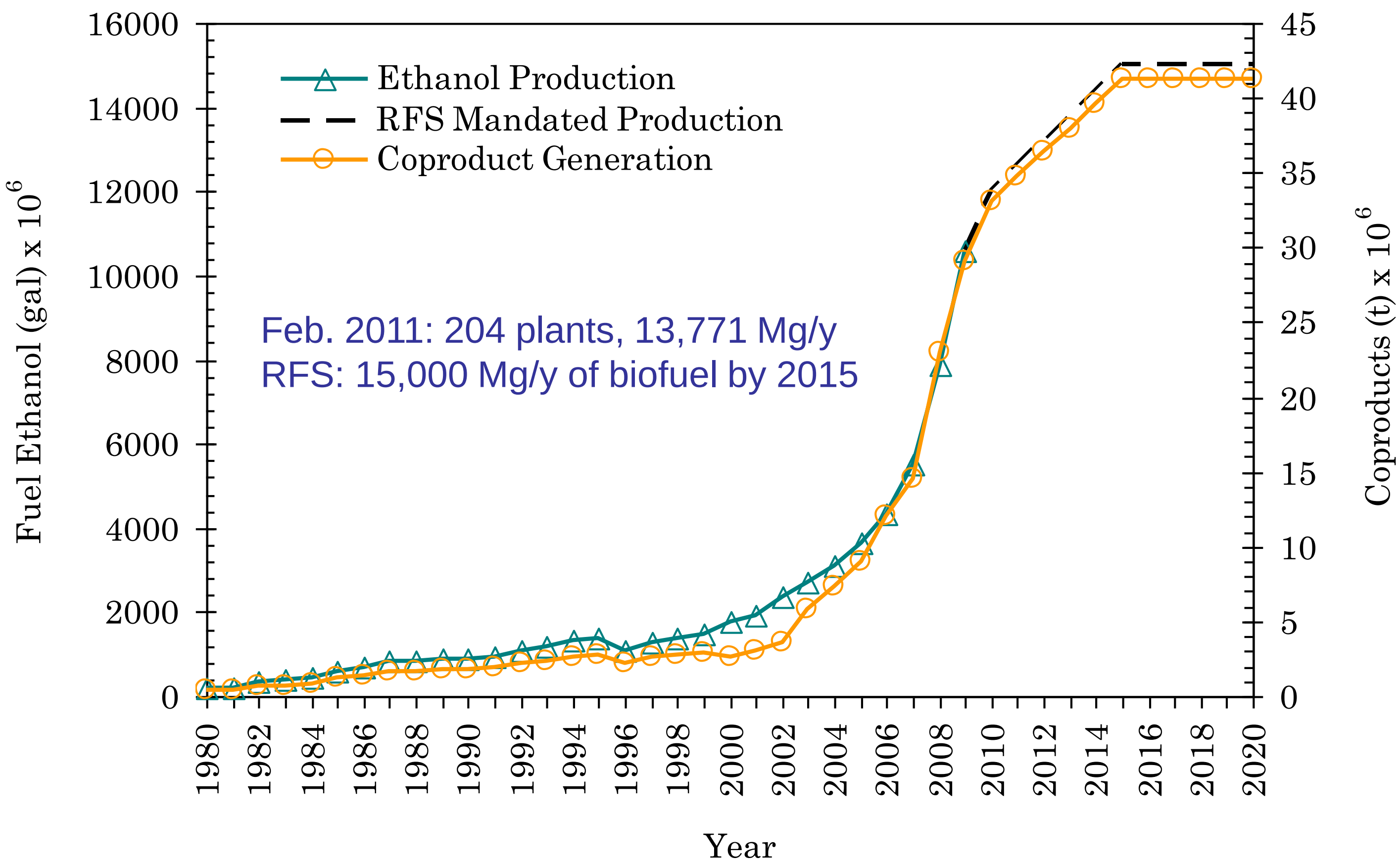
GRAIN ALCOHOL DISTILLERY (ca. 1947)



MODERN DRY GRIND PROCESS

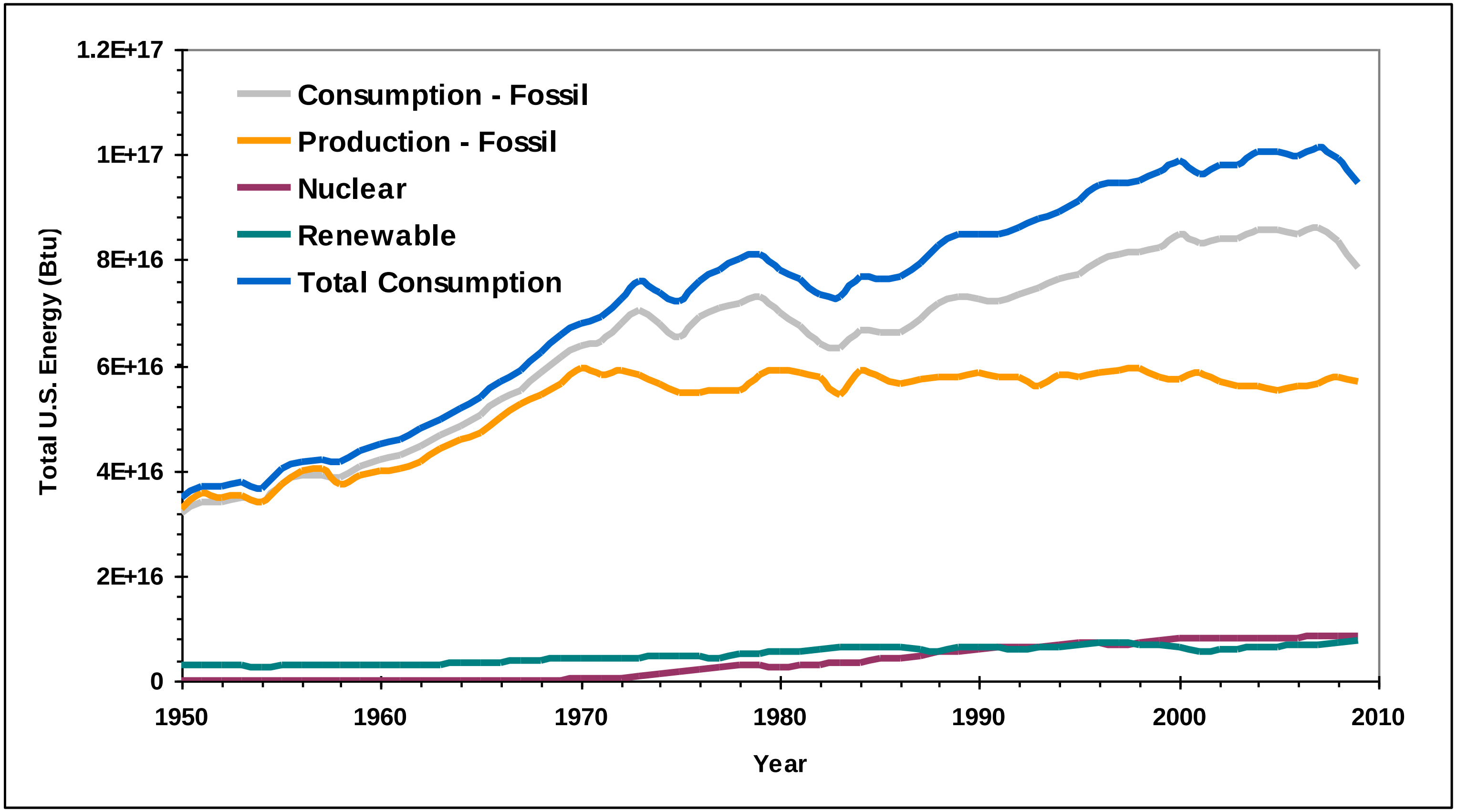


U.S. ETHANOL GROWTH



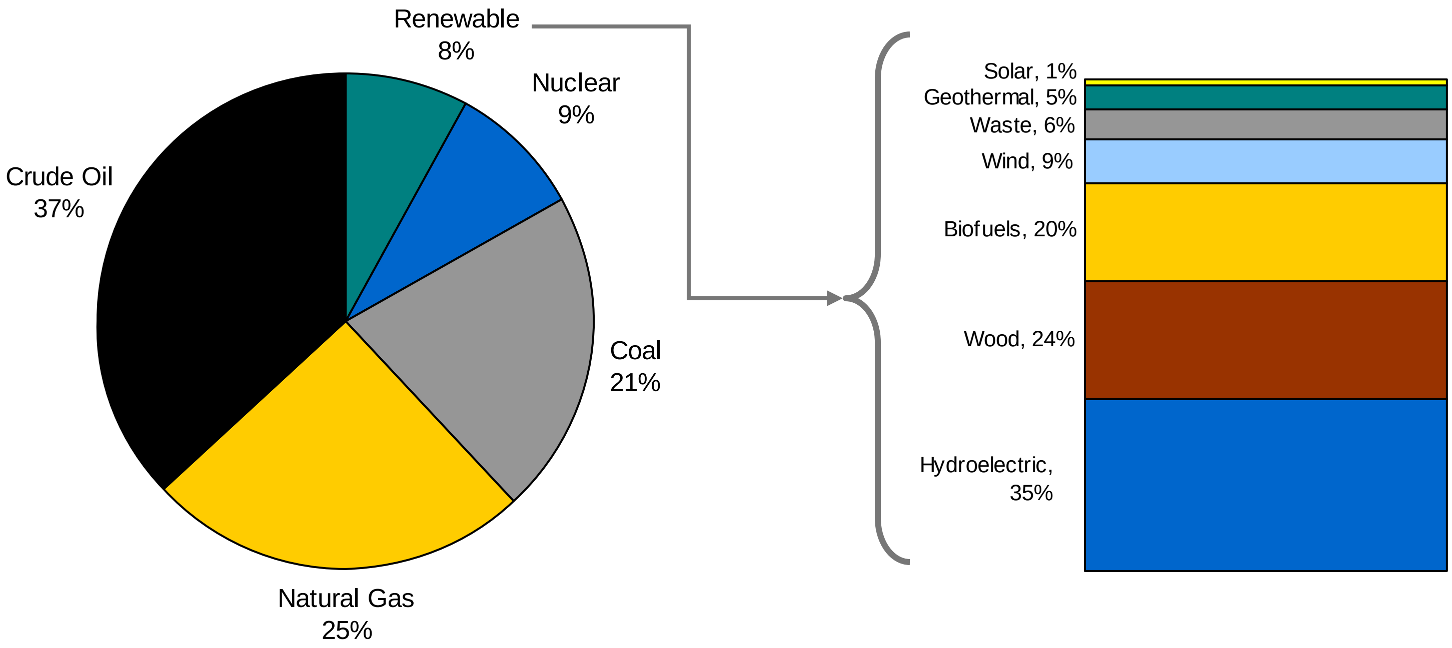
Growth of U.S. fuel ethanol industry

U.S. ETHANOL GROWTH



US EIA, 2011

U.S. ETHANOL GROWTH



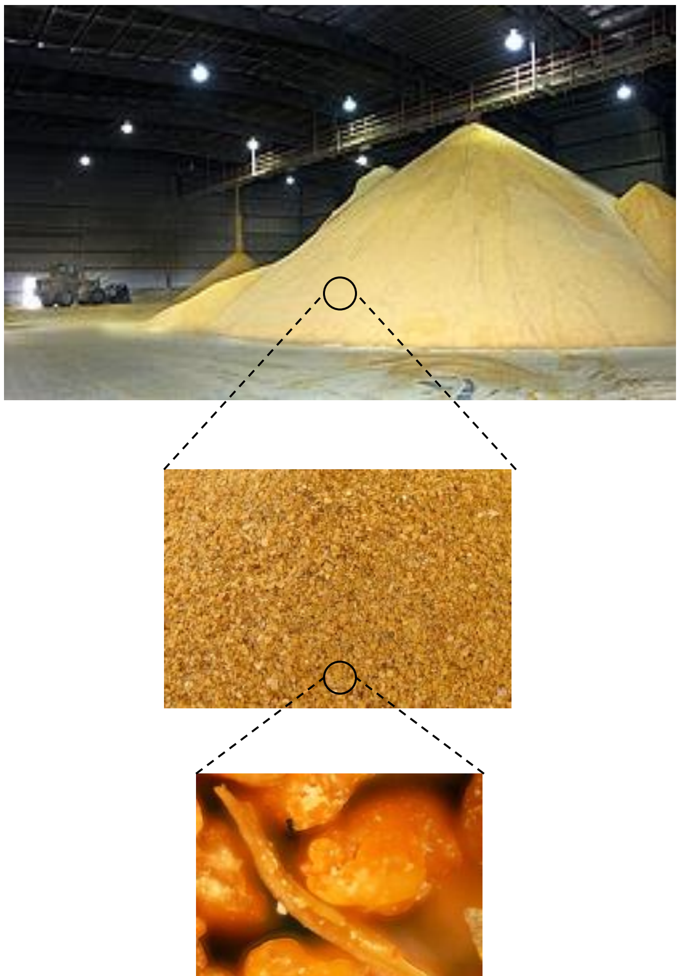
Since 1950s, generally 5 to 9 % of total U.S. energy supply has been renewable

US EIA, 2011

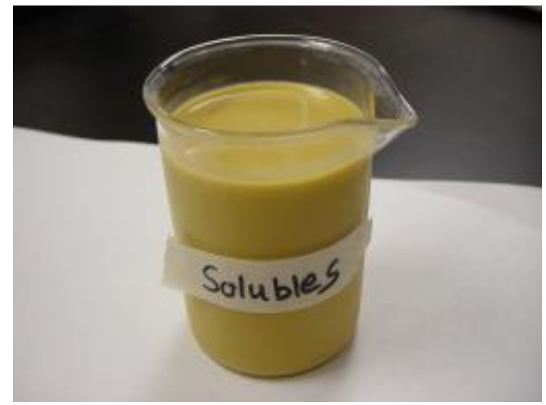
COPRODUCTS

ETHANOL COPRODUCTS

Distillers Dried Grains with Solubles

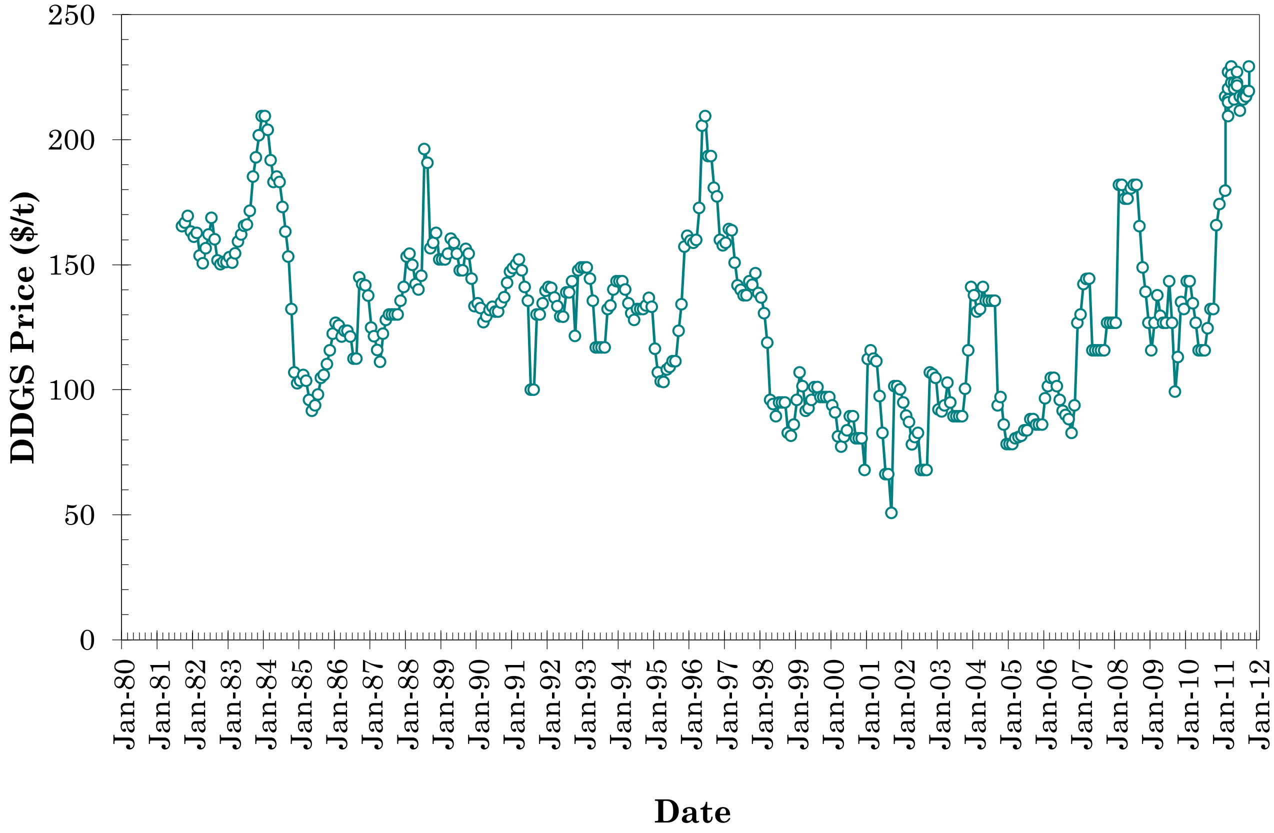


Condensed Distillers Solubles

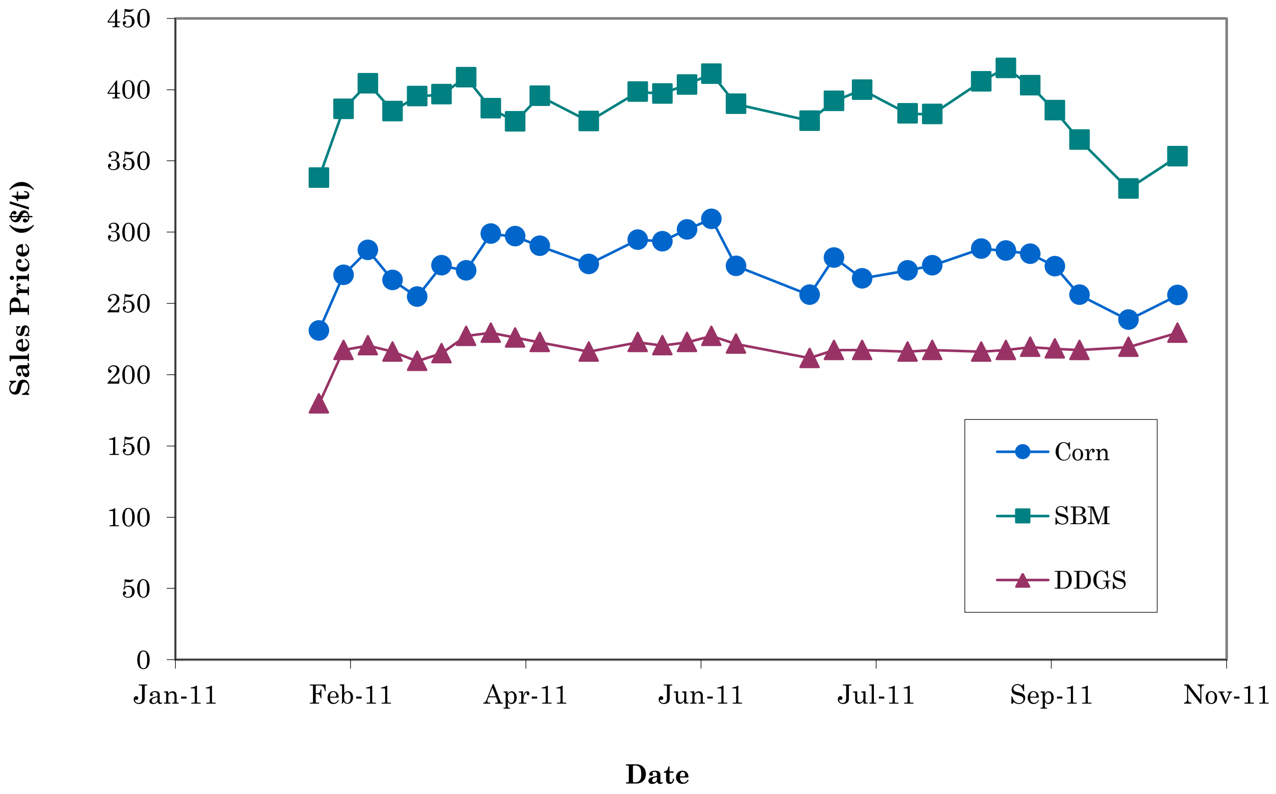


Distillers Wet Grains

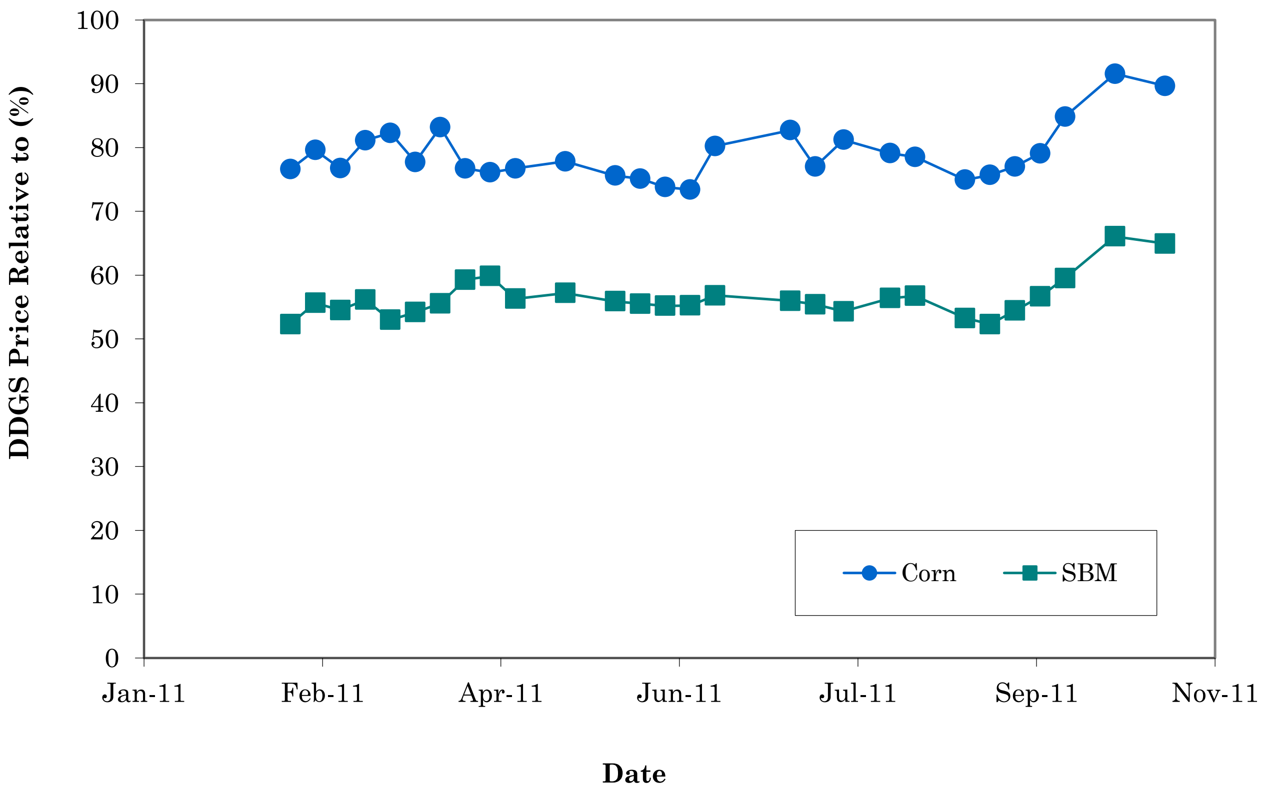
COPRODUCT PRICES



COPRODUCT PRICES

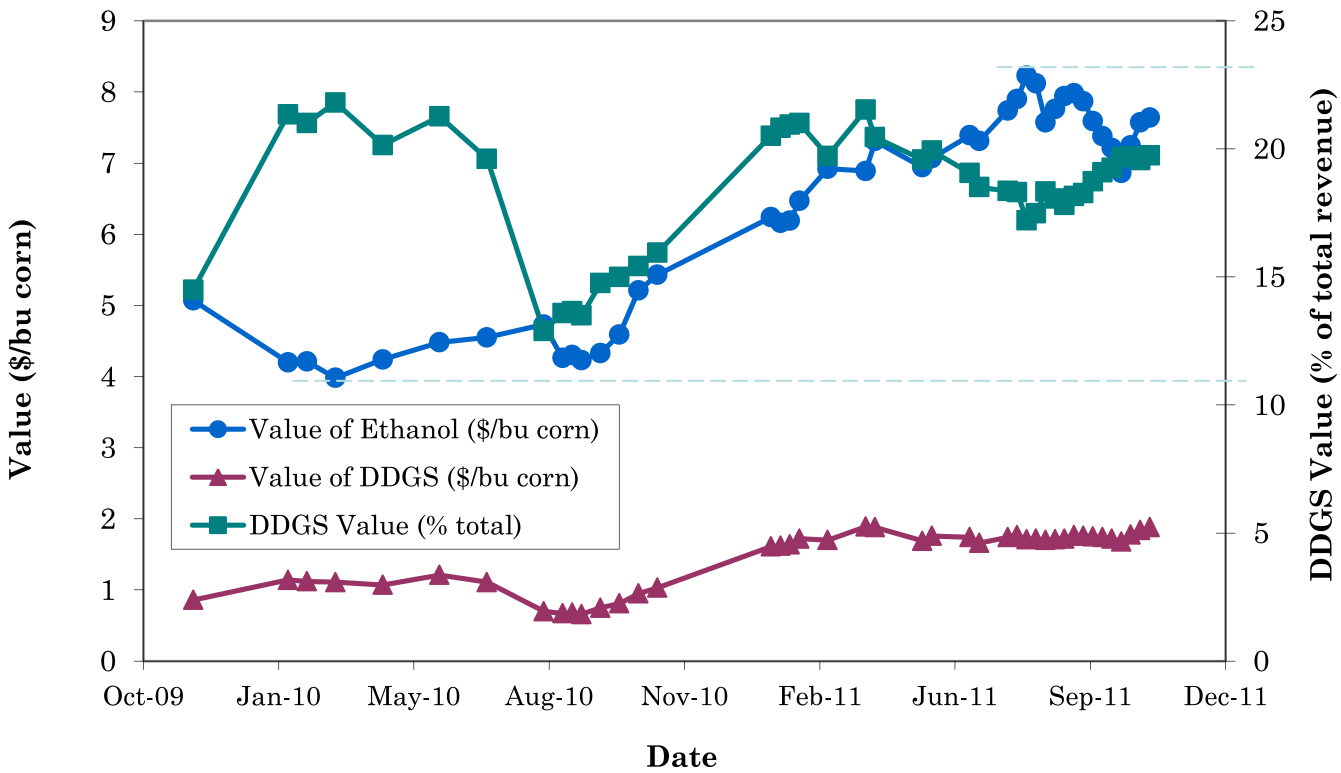


COPRODUCT PRICES



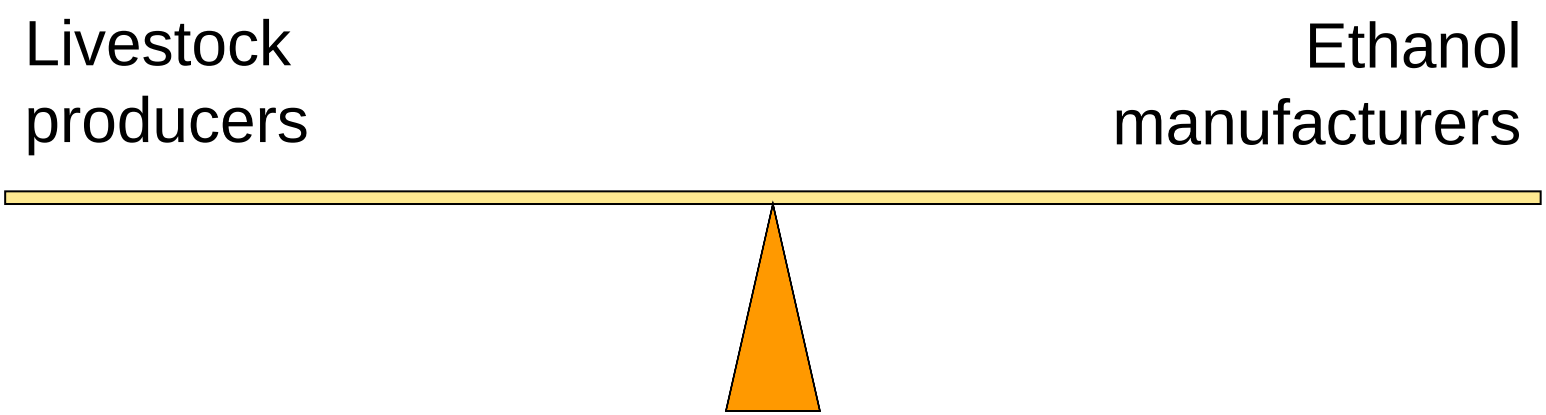
COPRODUCT VALUES

COPRODUCT VALUES



COPRODUCT RESEARCH

- As ethanol industry grows, supply of coproducts will grow
- Balance = key to sustainability



ONGOING RESEARCH

ONGOING RESEARCH

- Fuel
  - vs.
- Food
  - vs.
- Feed
  - vs.
- Plastics
  - vs.
- Chemicals
  - vs.
- Other uses

Goals:

- Augment current uses
- Develop new market opportunities
- Develop/optimize processes and products
- Improve sustainability

Context:

- Application of physics and chemistry to biological systems
- Manufacturing with biological polymers: proteins, fibers, lipids

ONGOING RESEARCH

- Material handling
- Pelleting/densification
- Aquaculture
- Human foods
- Plastic composites

MATERIAL HANDLING

MATERIAL HANDLING

Sieve Opening Size (mm)

2.38

Scale bar = 3.91 mm

1.68

Scale bar = 2.50 mm

1.19

Scale bar = 2.34 mm

0.841

Scale bar = 0.987 mm

0.595

Scale bar = 0.689 mm

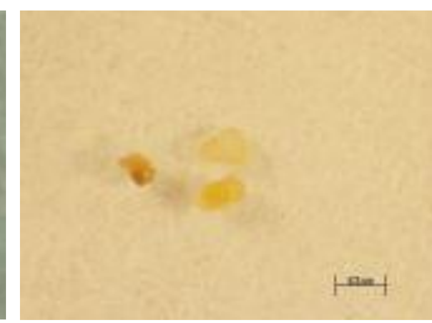
0.420

Scale bar = 0.52 mm

0.297

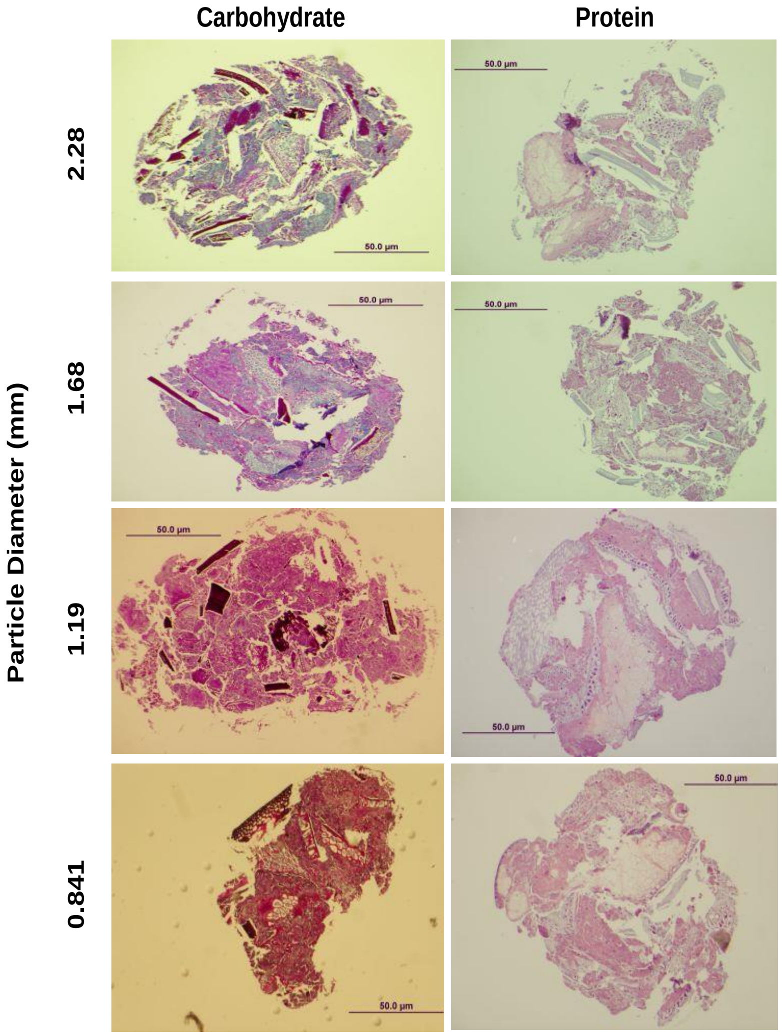
Scale bar = 0.36 mm

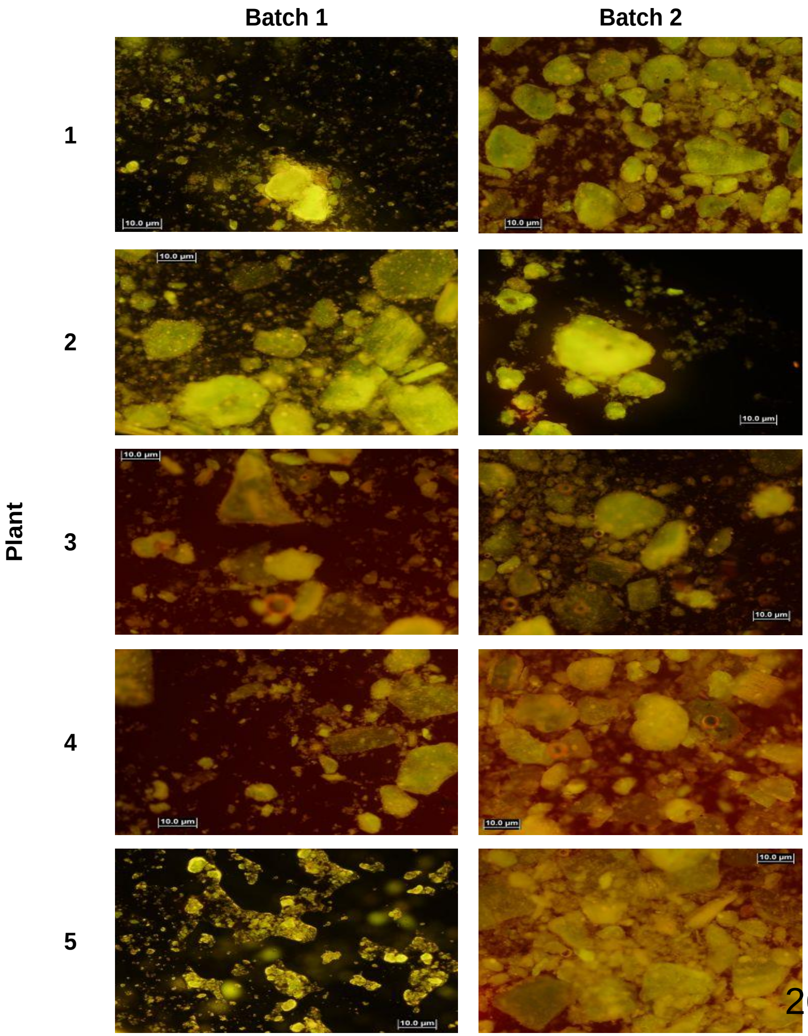
0.210



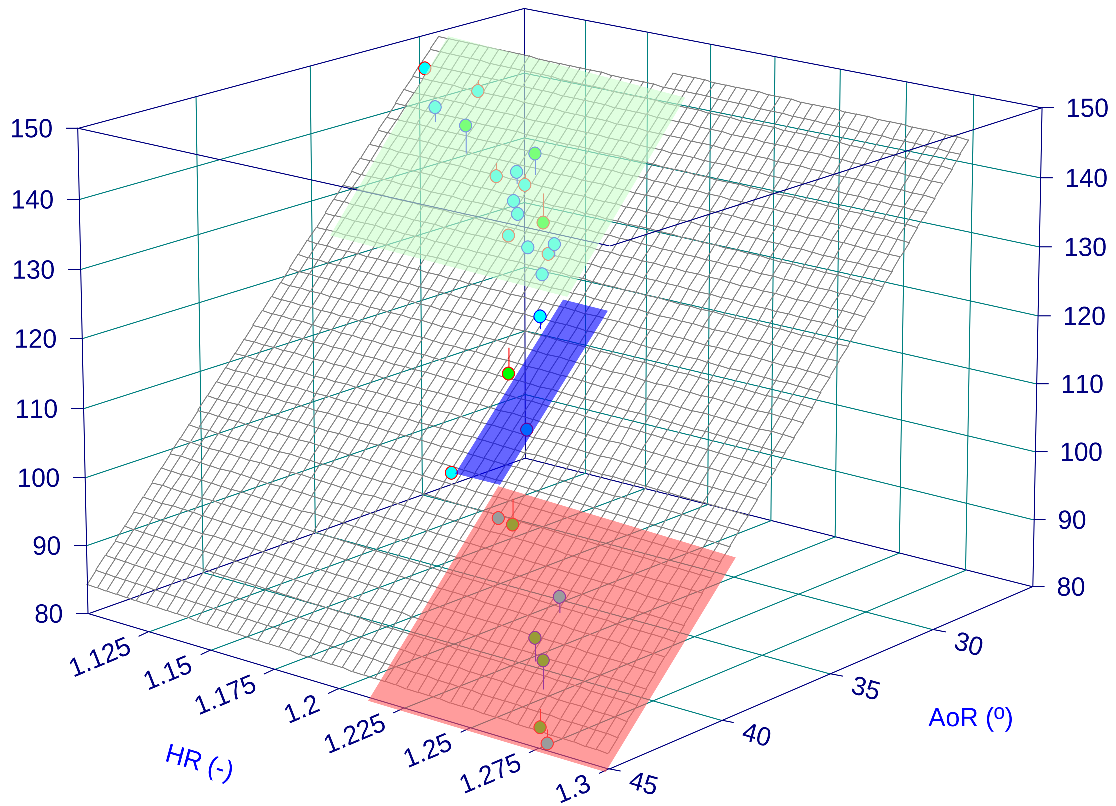
Scale bar = 0.26 mm

MATERIAL HANDLING





MATERIAL HANDLING



z= a + bx + cy

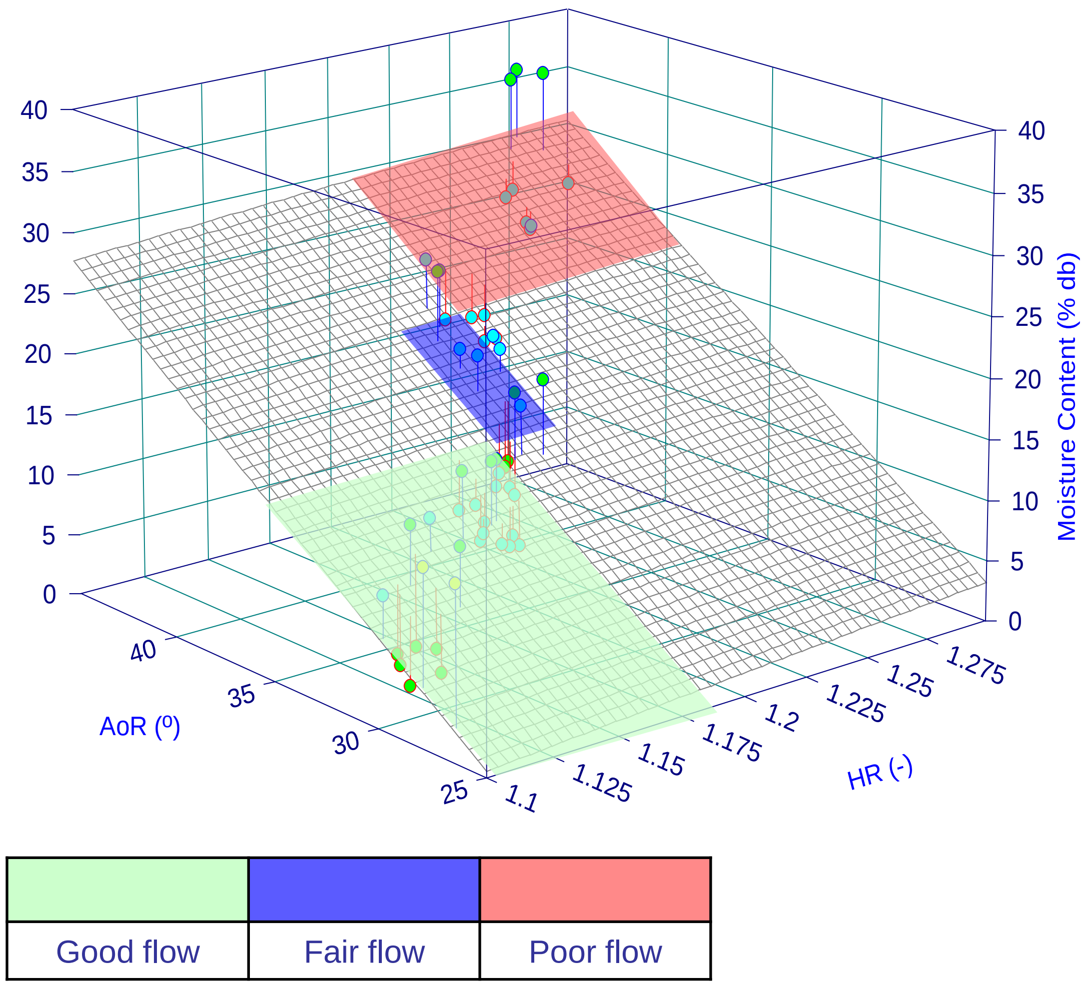
x= AoR (°)
y = HR (-)
z= MFR (g/min)

R^2 = 0.99
Error= 2.42

MFR < 100 = Poor Flow
100 < MFR < 120 = Fair Flow
MFR > 120 = Good Flow

Good flow	Fair flow	Poor flow

MATERIAL HANDLING



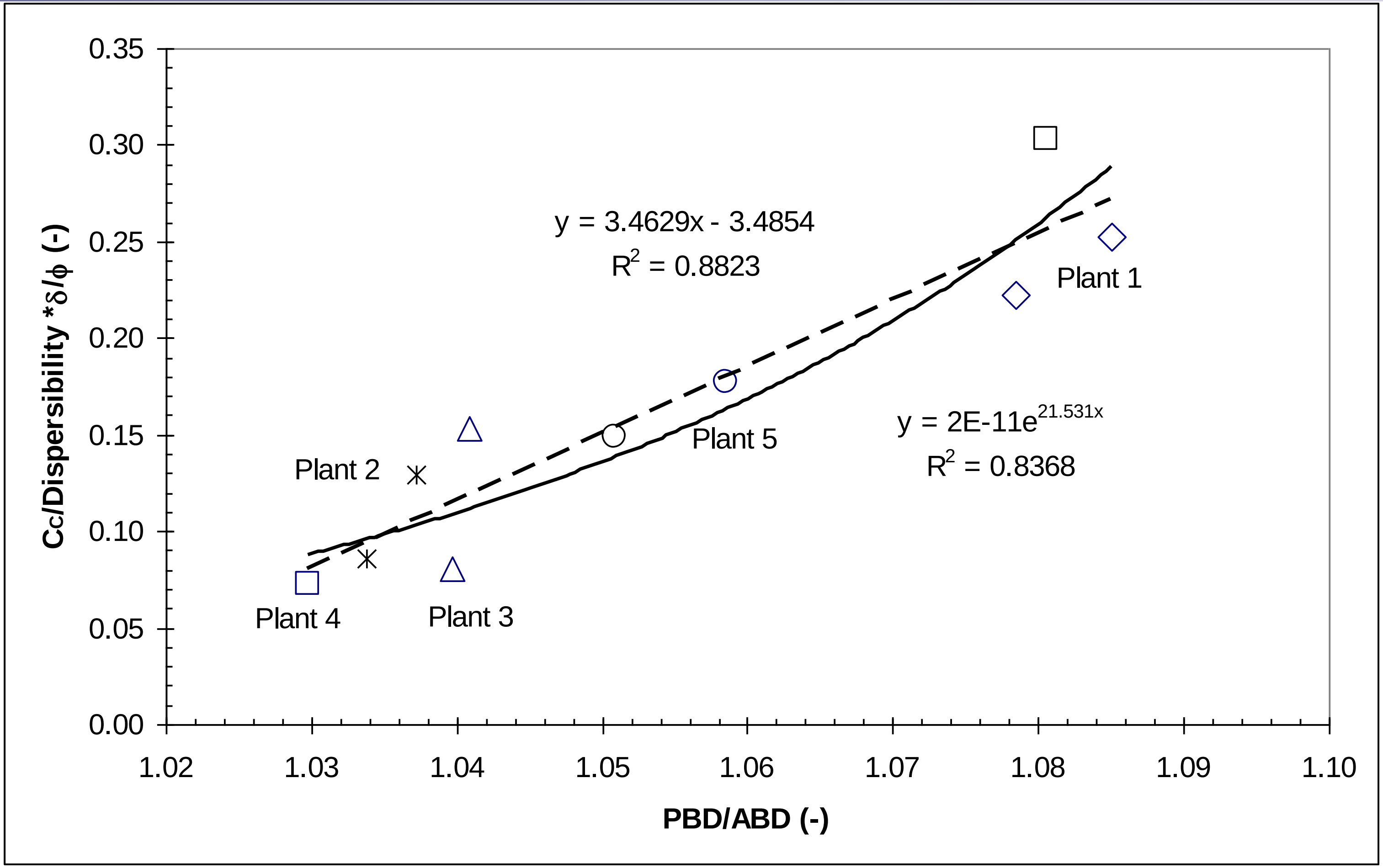
z= a + b/x + cy

x= AoR (°)
y = HR (-)
z= Moisture content (%, db)

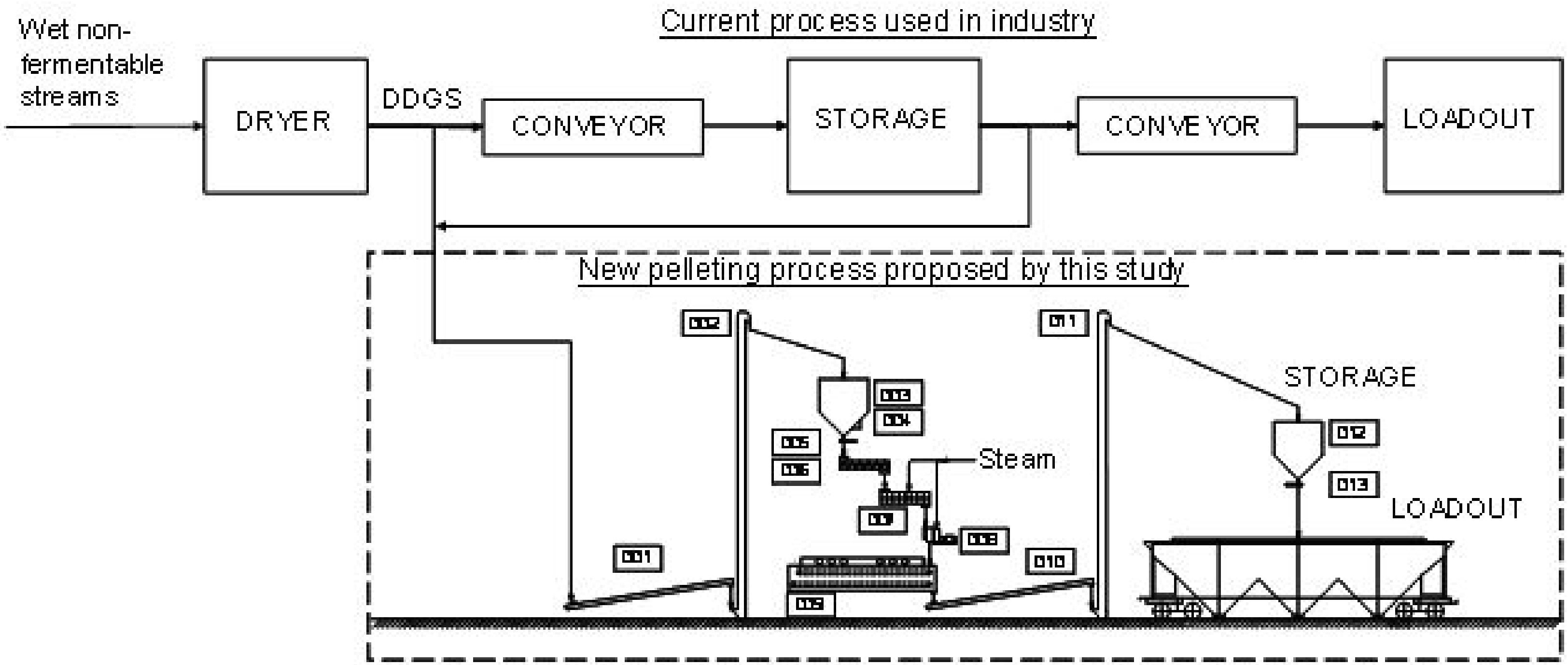
R^2 = 0.71
Error= 4.50

Moisture < 9.9 (Good Flow)
9.9 < Moisture < 17.5 (Fair Flow)
17.5 > Moisture (Poor Flow)

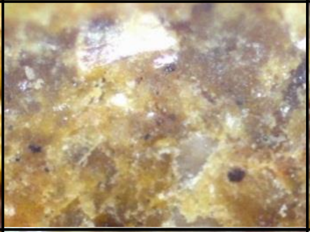
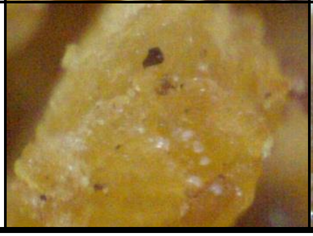
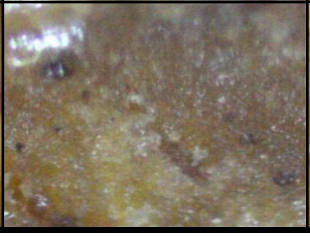
MATERIAL HANDLING



PELLETING/DENSIFICATION



PELLETING/DENSIFICATION

Mag. x	DDGS	Mfg	
		A	B
10			
60			
200			

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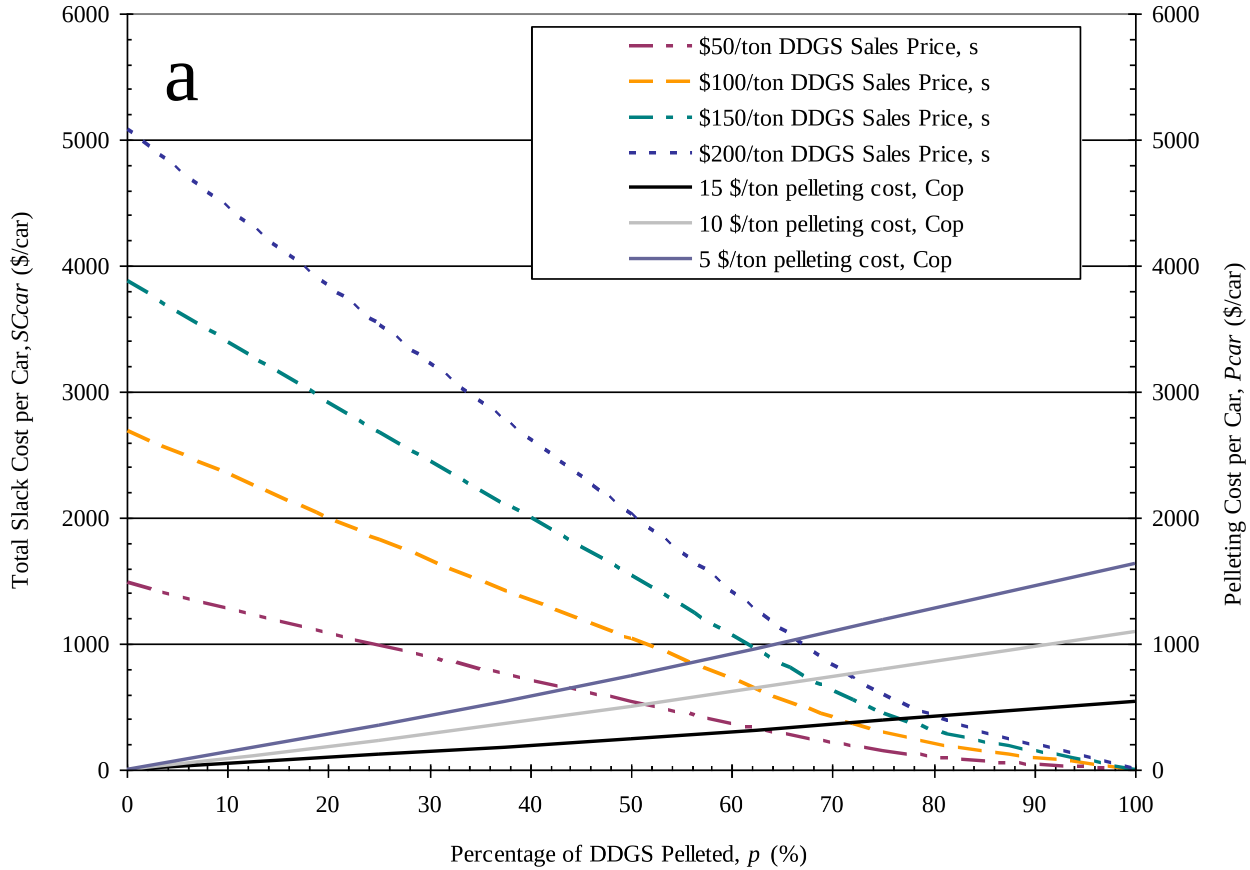
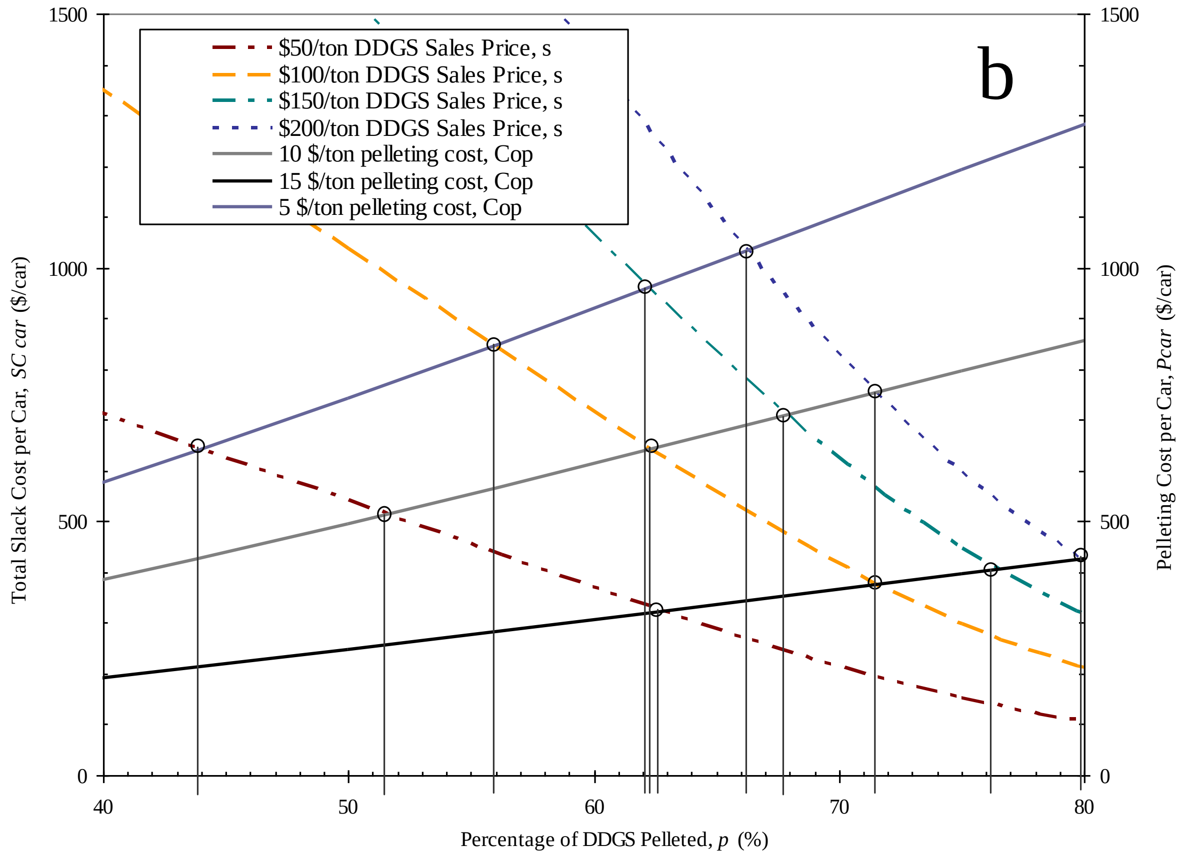


Resulting slack costs and costs of pelleting for each rail car due to differing DDGS sales prices and annualized pelleting cost
a) breakeven occurs at points of intersection

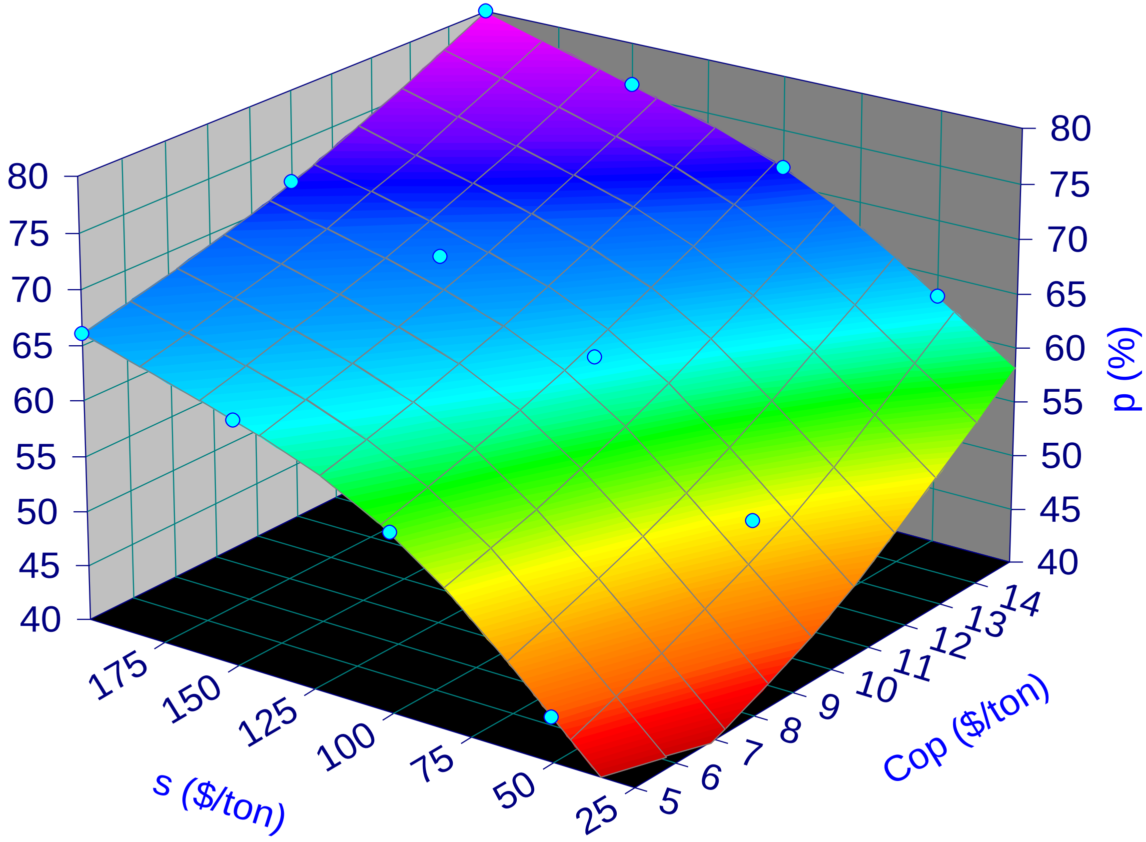
PELLETING/DENSIFICATION



Resulting slack costs and costs of pelleting for each rail car due to differing DDGS sales prices and annualized pelleting cost

b) magnification of the intersections clearly shows the proportion of DDGS which needs to be pelleted to achieve breakeven

PELLETING/DENSIFICATION



Percent of DDGS pelleted, *p* (%), required to achieve breakeven increases as both DDGS Sales Price, *s* ($/ton), and Pelleting Cost, *Cop* ($/ton), increase