Biodiesel R&D Potential

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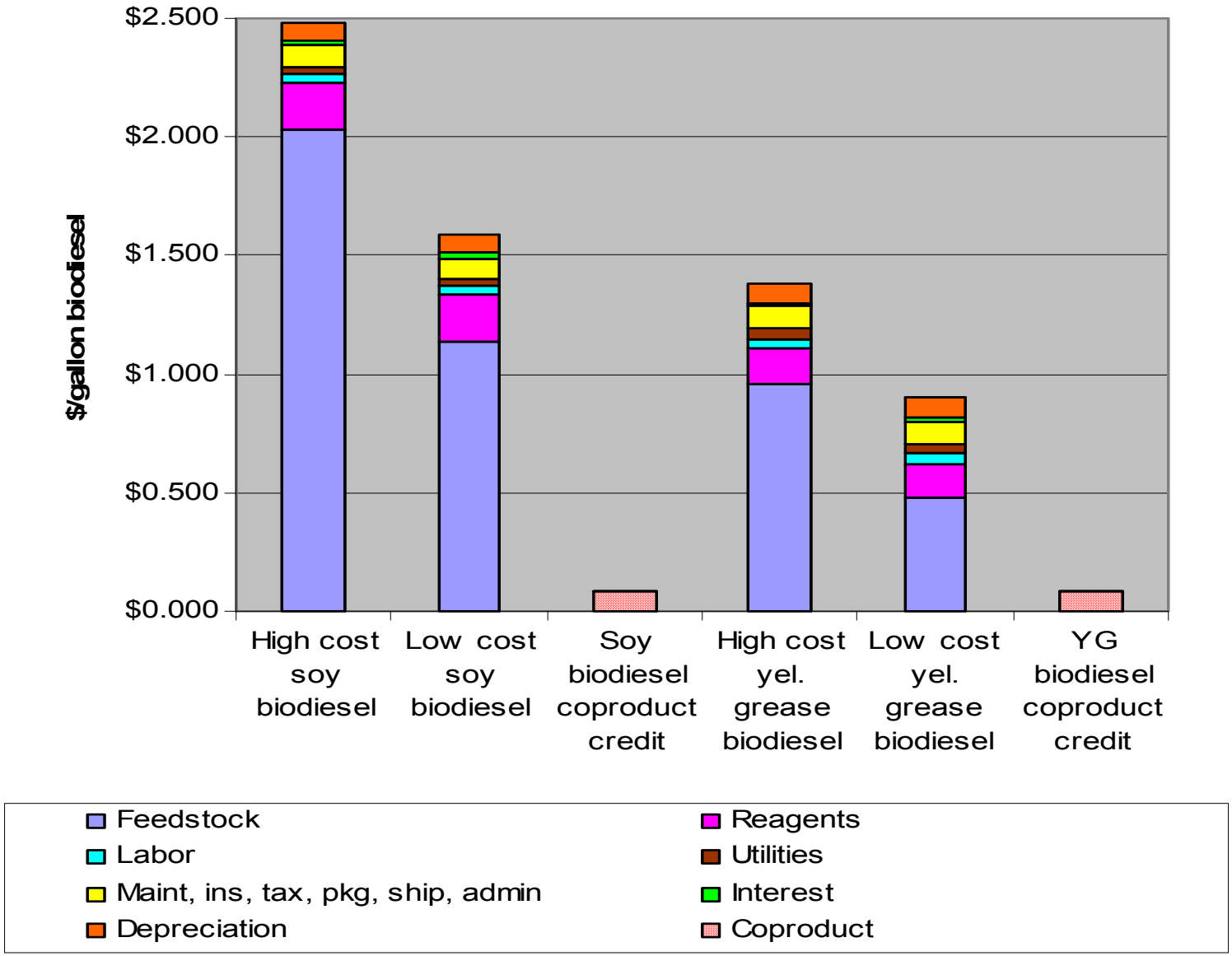
No DOE Investment - 2012

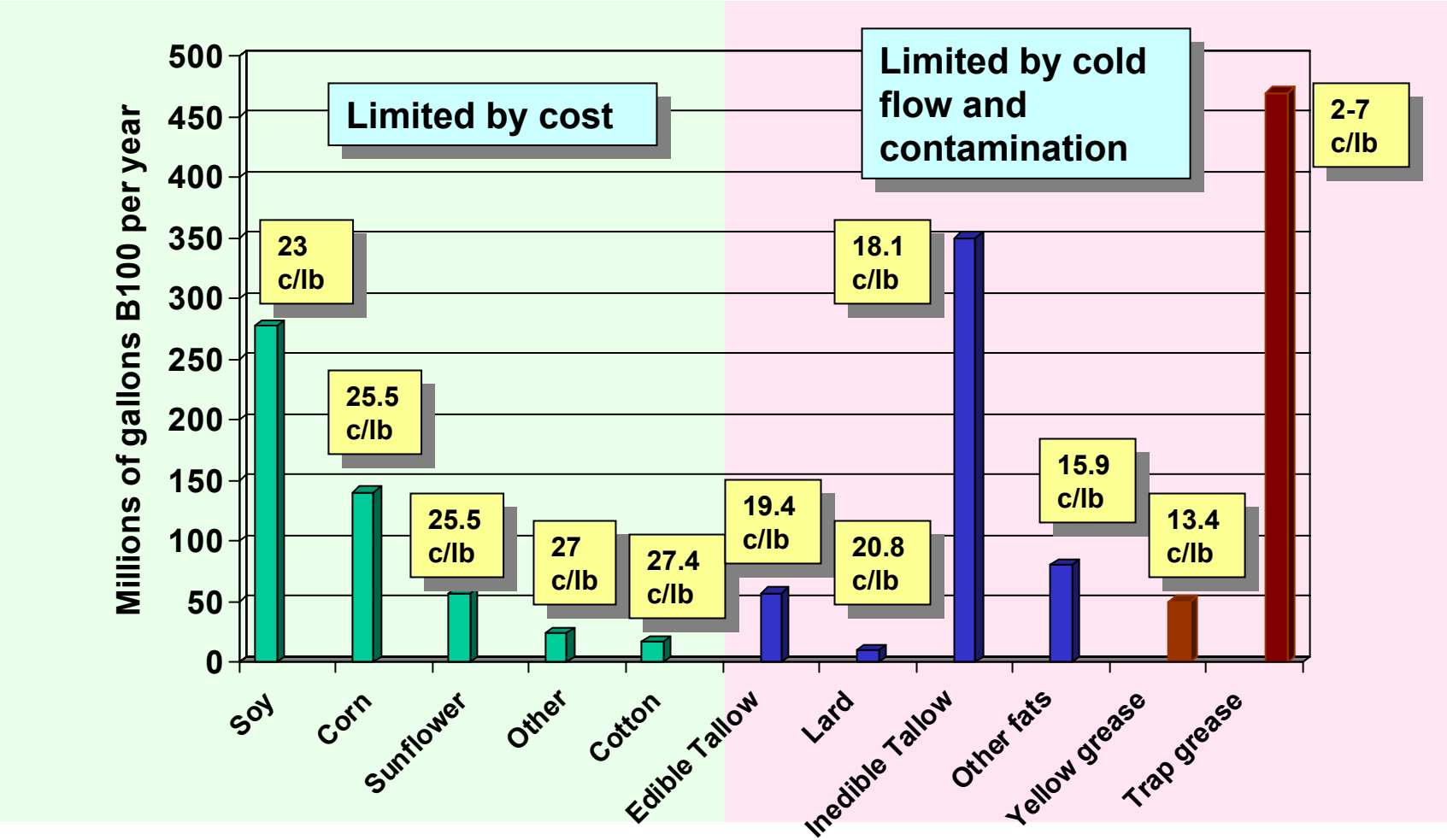
- Supplies limited to soy and yellow grease ~ 328 million gallons per year
  - Other feedstocks limited by high cost or cold flow
- U.S. Glycerol production increases by 114%
  - Price may drop from $0.50/lb to $0.35/lb by 2010
- Biodiesel production costs rise from $2.32 to $2.41 per gallon of B100
  - Glycerin glut will drive down coproduct credits, putting burden of costs on biodiesel
- Biobased products grow slowly

Key Limitations

- Biodiesel Feedstock Costs Inflate Production Costs
- Cold Flow Properties Limit Fat-Based Biodiesel
- Contamination Issues for Fats and Greases Limit Coproduct Development
- Growth will Swamp Glycerol Markets

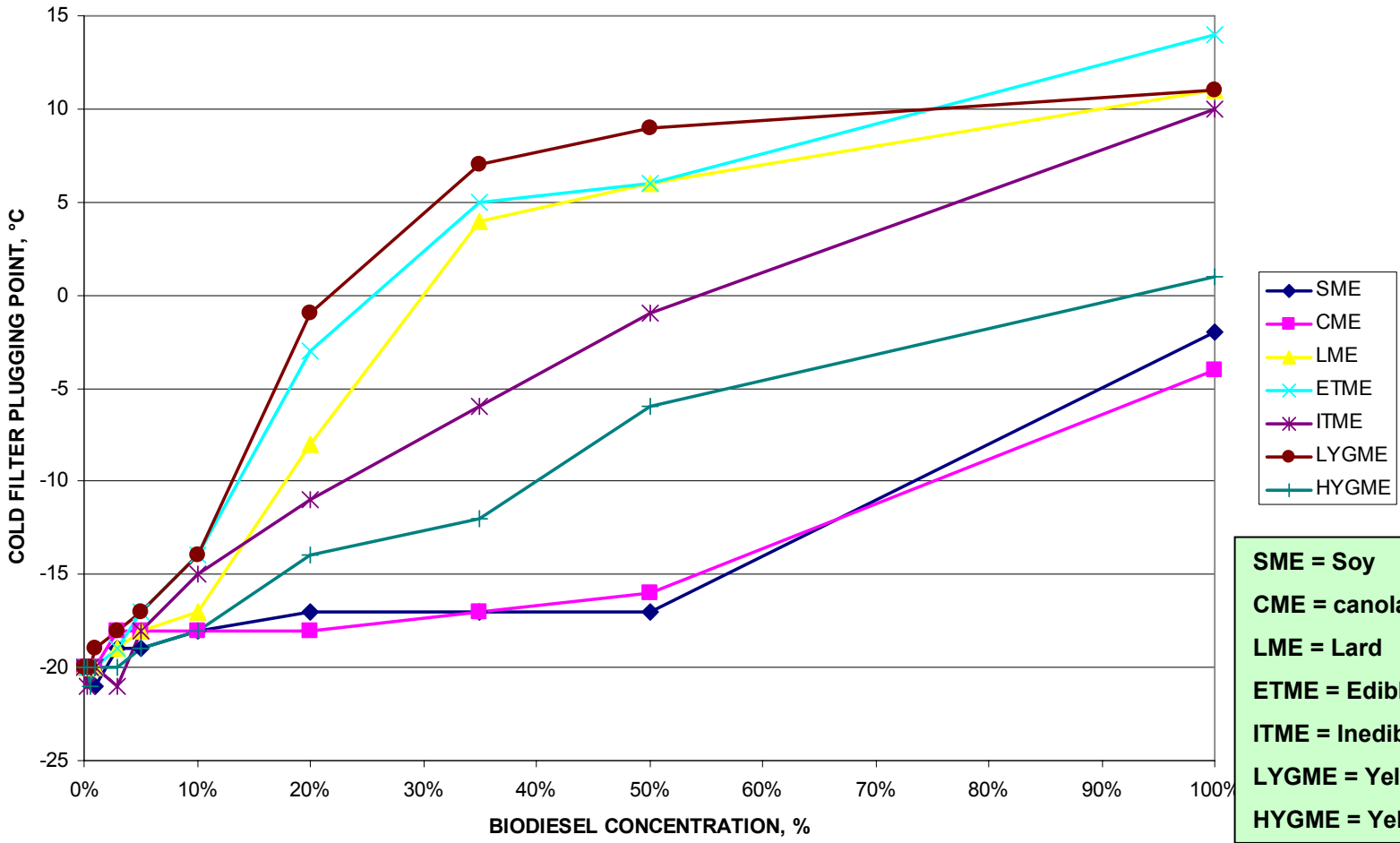

$2.500
$2.000
$1.500
$1.000
$0.500
$0.000
$/gallon biodiesel
High cost soy biodiesel
Low cost soy biodiesel
Soy biodiesel coproduct credit
High cost yel. grease biodiesel
Low cost yel. grease biodiesel
YG biodiesel coproduct credit
Feedstock
Reagents
Labor
Utilities
Maint, ins, tax, pkg, ship, admin
Interest
Depreciation
Coproduct

Limits to Feedstock Potential



Mad Cow Disease (BSE) regulations can add another 1.2 billion gallons of tallow, lard, and other saturated fats (not shown).

Cold Flow Limits Use of Fats and Greases



SME = Soy

CME = canola

LME = Lard

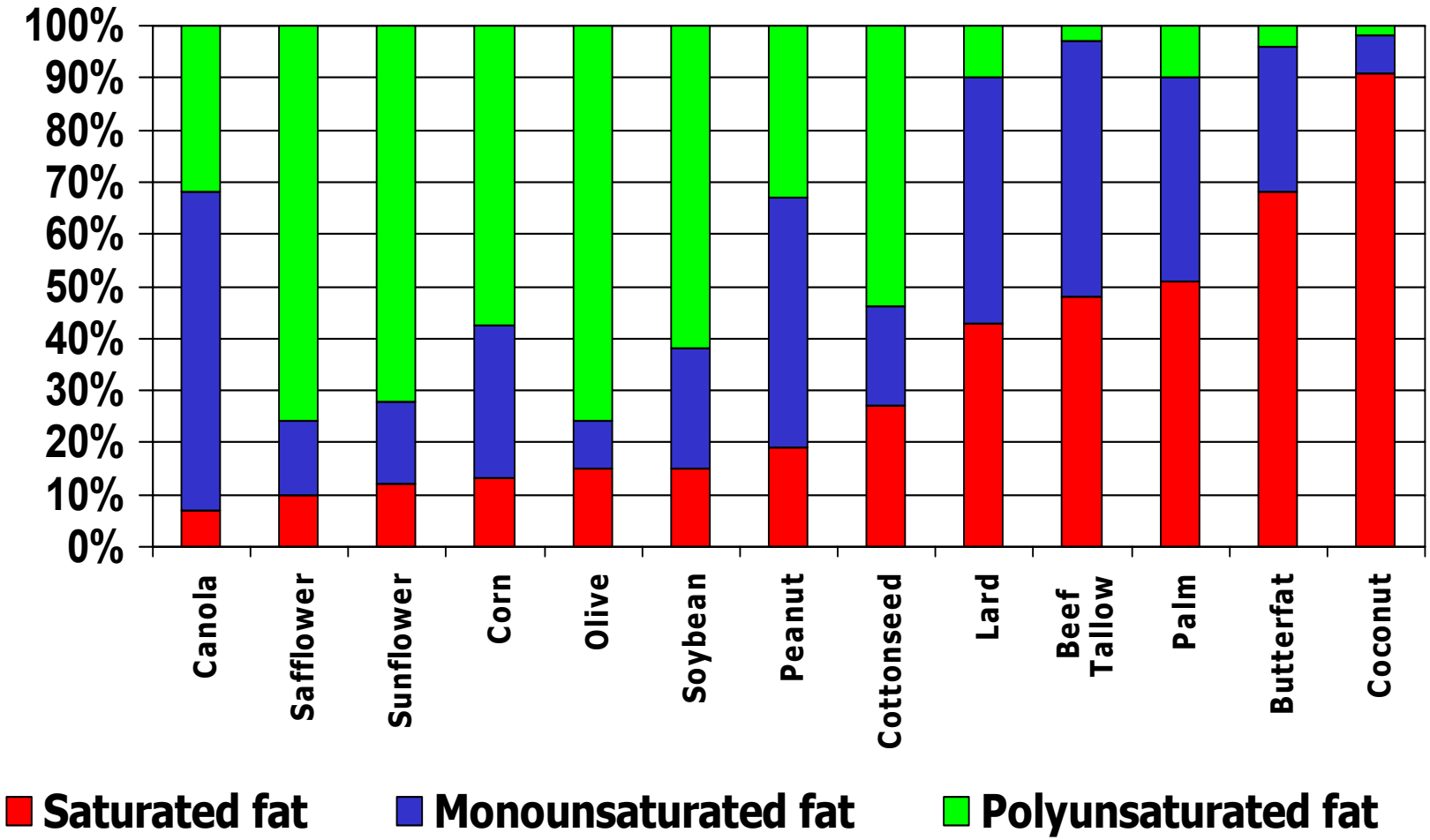
ETME = Edible Tallow

ITME = Inedible Tallow

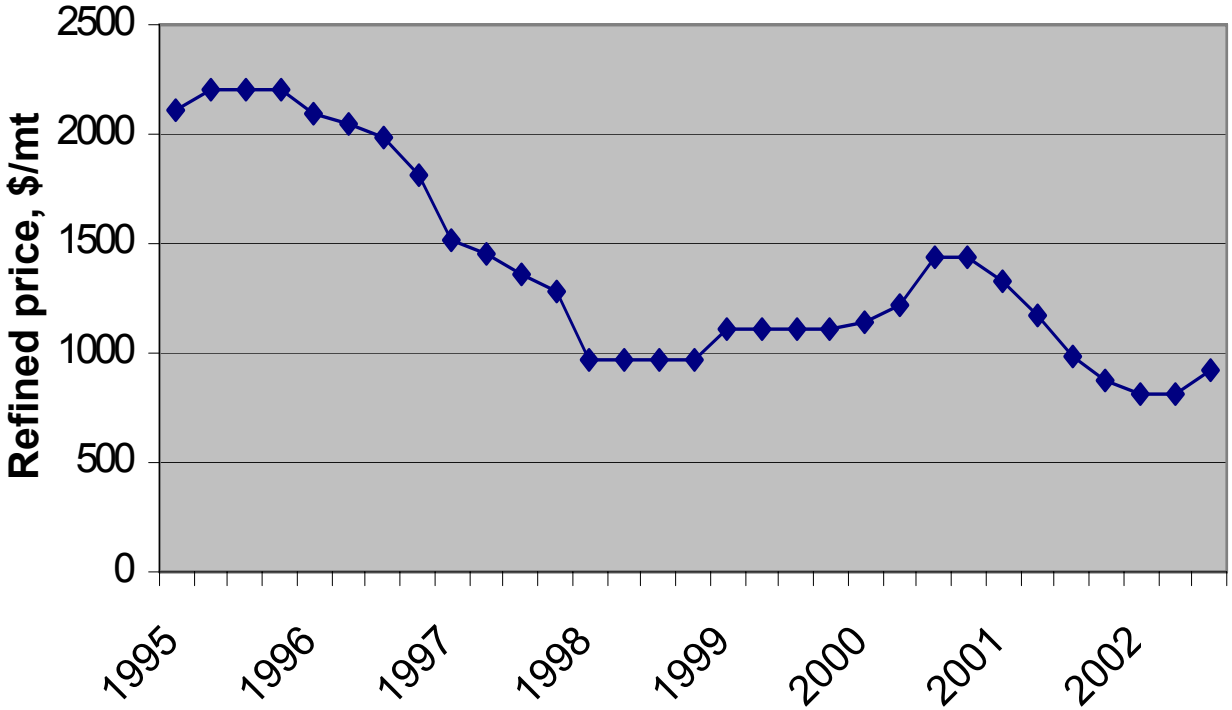
LYGME = Yellow Grease 1

HYGME = Yellow Grease 2

Composition of Fats and Oils



Impact of World Biodiesel Production on Glycerol Markets



$1000 per ton = $0.50/lb

By 2010, glycerol price could be as low as $0.35/lb if world wide biodiesel production continues to grow.

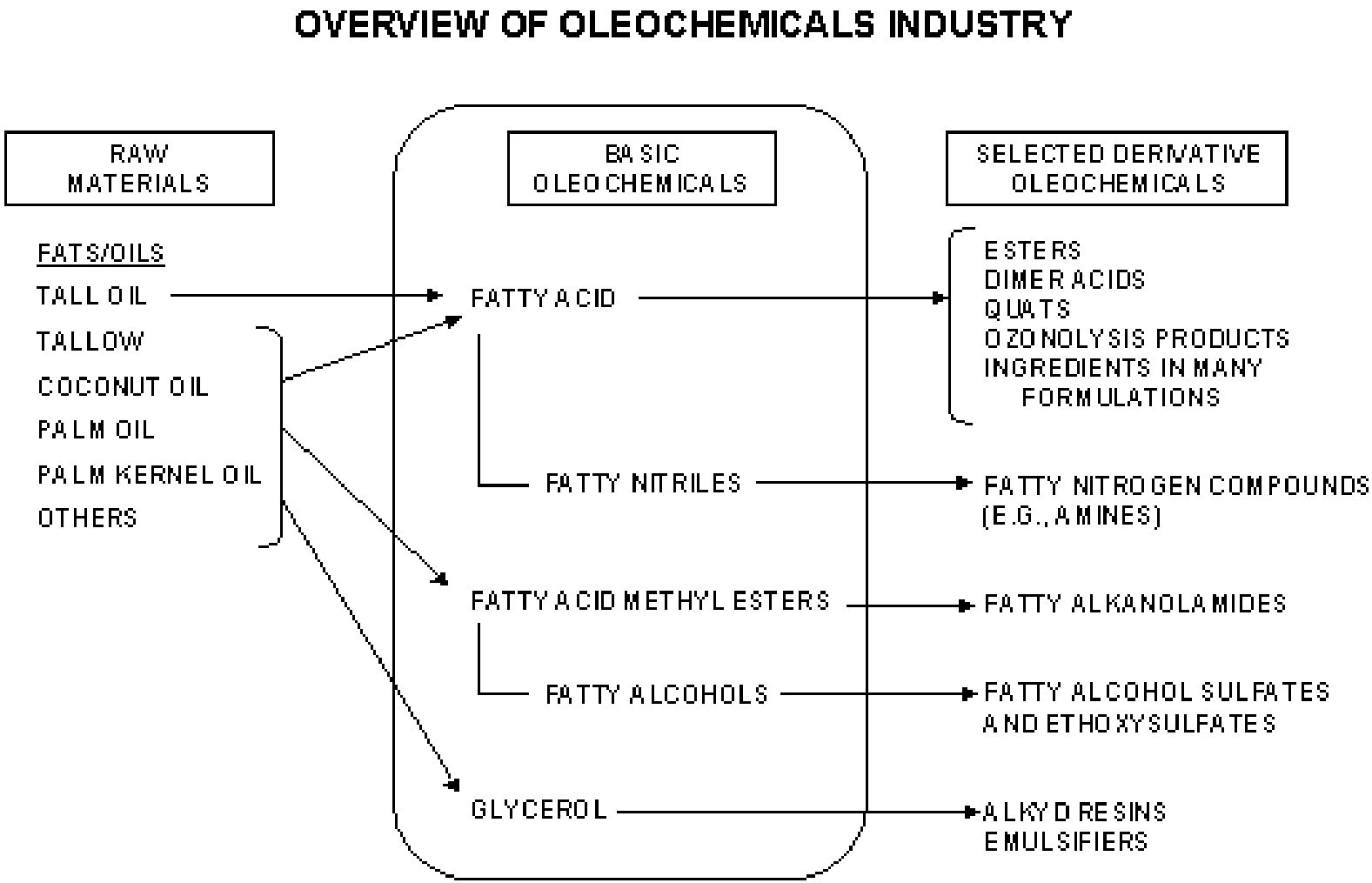
USP 97% + glycerol, Source: Proctor & Gamble, 2003

At prices approaching $0.35/lb or less by 2010, glycerol can become a significant <u>platform chemical.</u>

Two R&D Priorities

- Reduce biodiesel production costs by expanding biobased coproduct R&D
  - Compete in oleochemical markets
  - Develop New glycerol based coproducts
- Expand feedstocks supplies by investing R&D that
  - Modifies feedstock characteristics to
    - Resolve cold flow issues
    - Make feedstock more suitable for coproducts and fuel
    - Improve quality and performance of coproducts

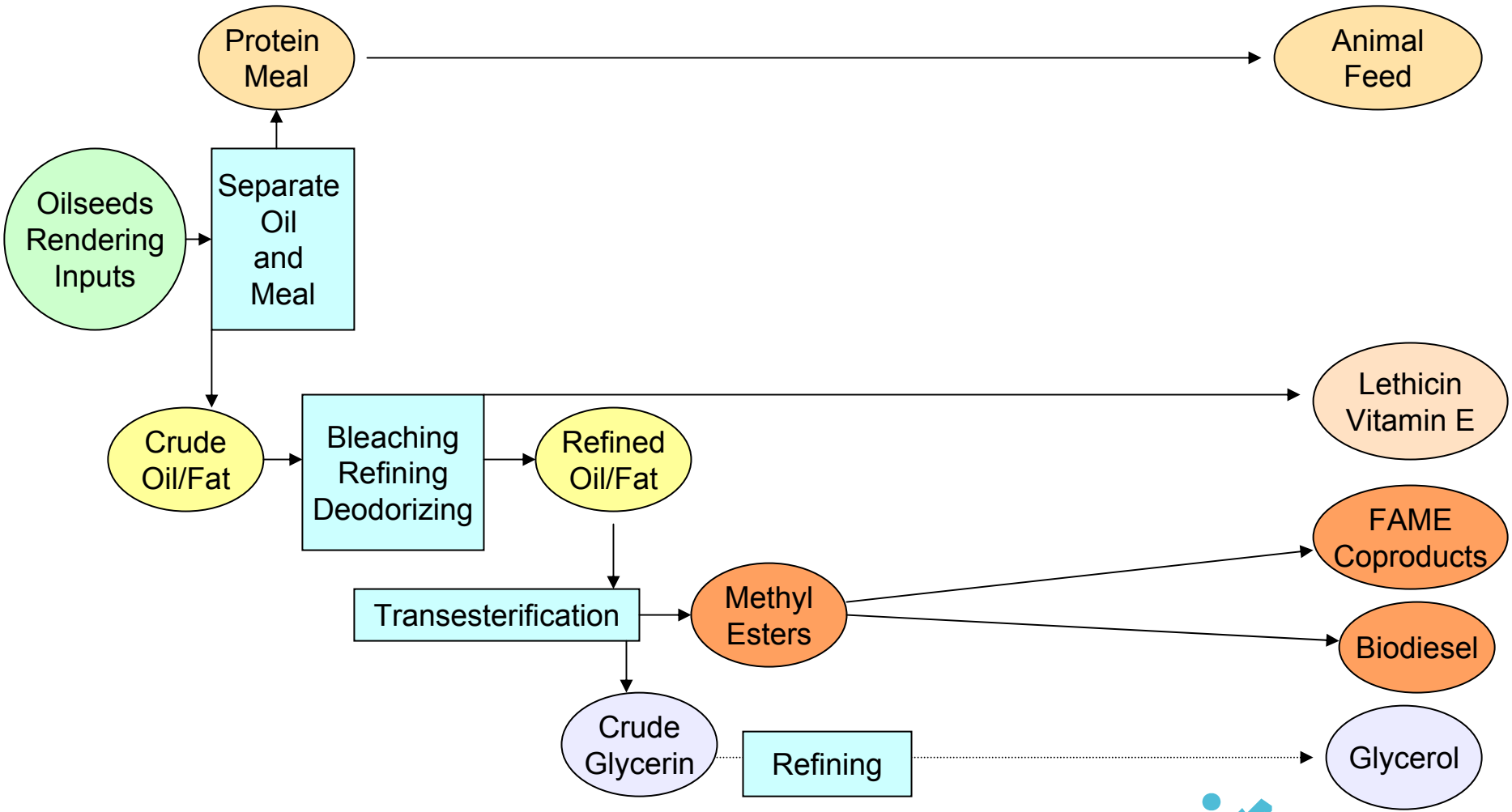
Oleochemical Platform Today



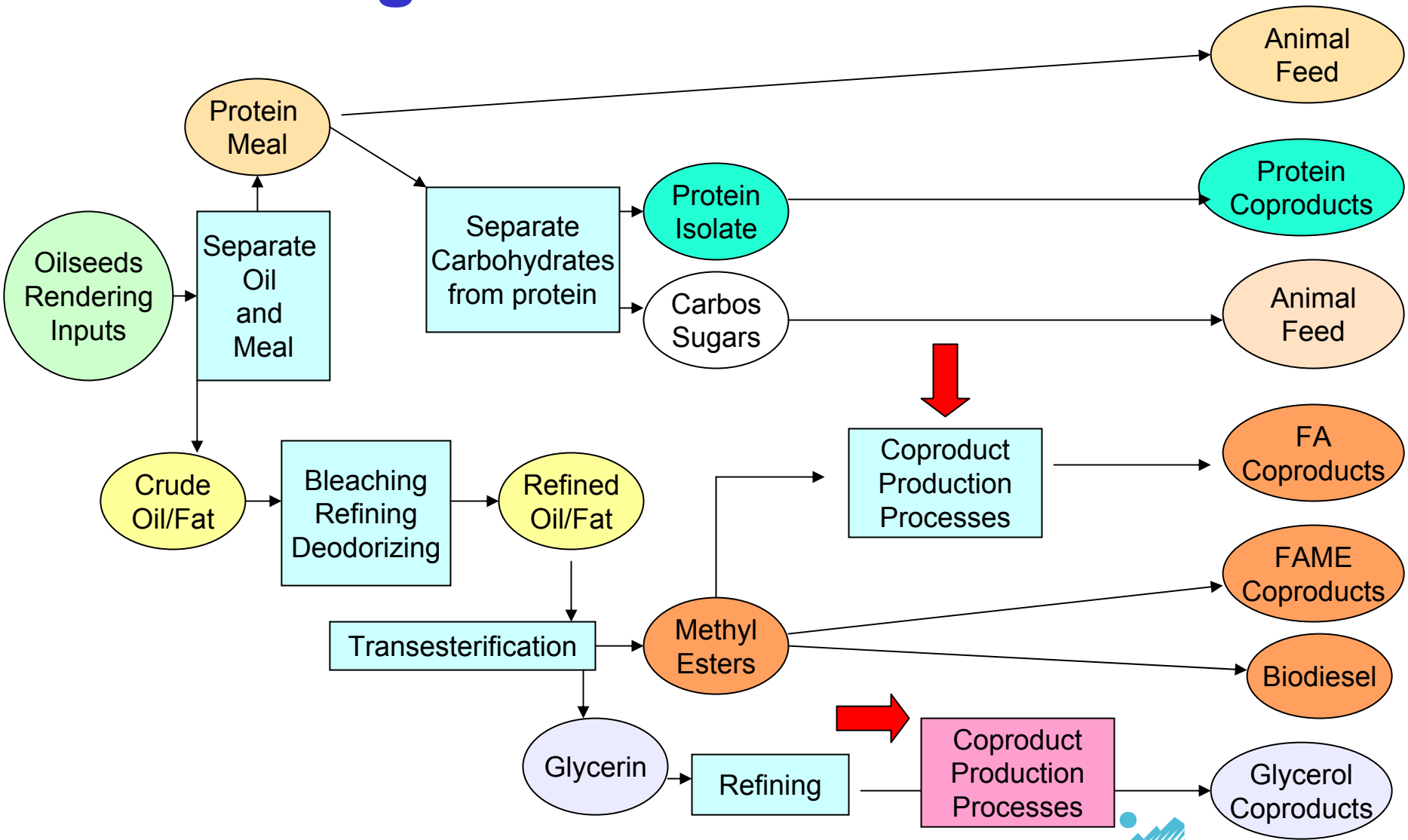
Fatty Acid Products - 2000

Fatty Acid Platforms	10^6 lbs	Fatty Acid Platforms	10^6 lbs
Fatty acids and soaps	1094	Other fatty acid compounds	10
Quaternary Ammonia Salts	101	Alcohol ethoxylates	805
Amines, diamines, ethoxylated amines	103	Alcohol sulfates	60
Esters	353	Polymethacrylate esters	25
Fuel Esters	165	Fatty nitrogen derivatives	20
Metal Salts	239	Alcohol glyceryl ether sulfonates	16
Monomer, dimer, trimer acids	211	Alkylpolyglucosides	16
Ester quats	144	Hindered phenols	8.5
FA polyamine condensates and quats	114	Thiodpropionate esters	6
Anionic surfactants	87	Other	15.5
Fatty acid amides	86	Free alcohols, C12 – C18	41
Amphoteric surfactants	52	C2o+ alcohols	20
Short chain fatty acids	48	Consumer inventory	3
Alkyl ketene dimers	33		

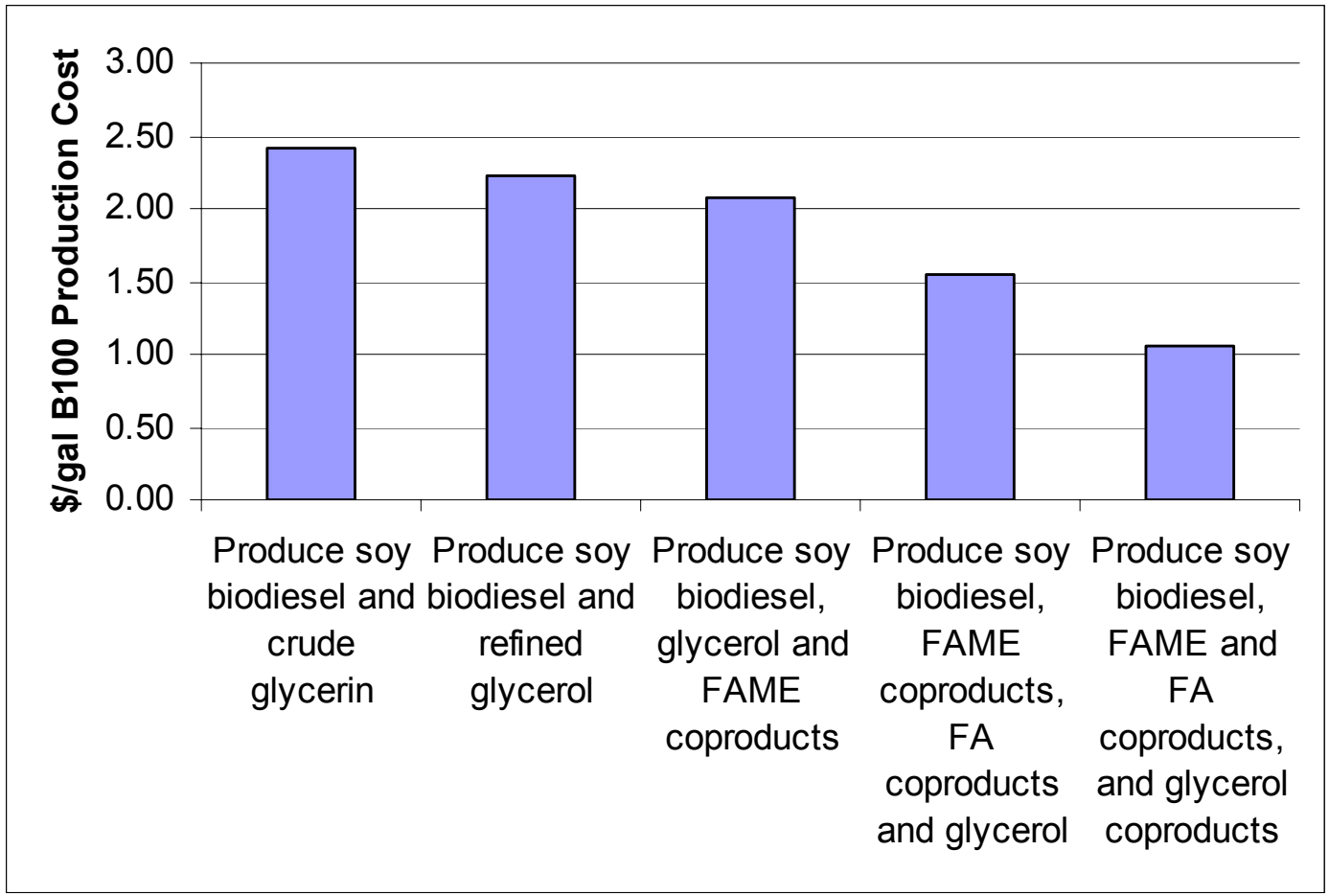
Process Flow Diagram For Existing Biodiesel Plants



Process Flow Diagram For Integrated Oleochemical Plant

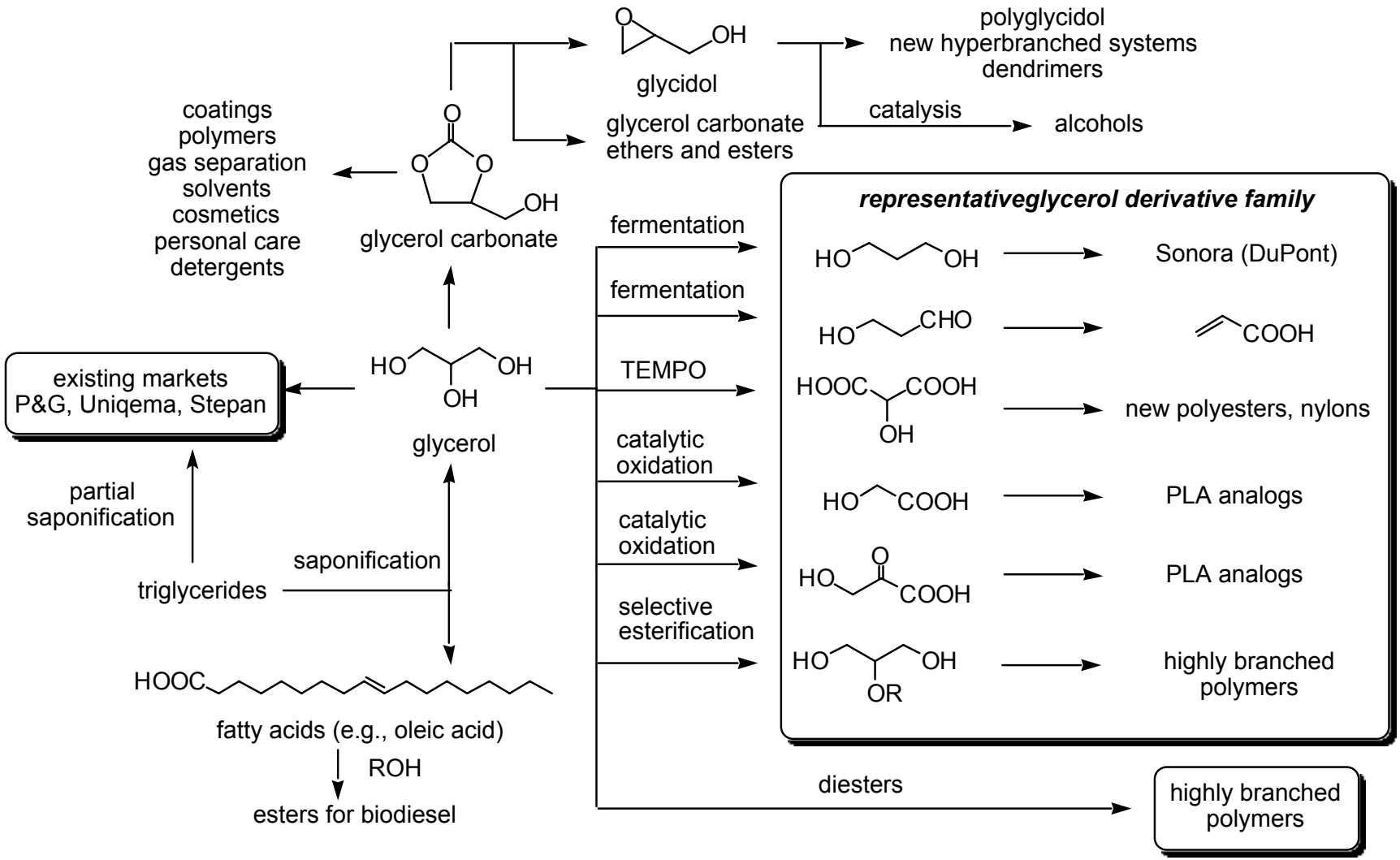


Coproducts Drive Cost Reduction



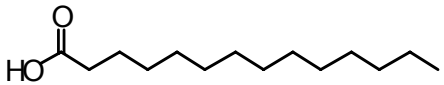
Based on an integrated soy bean crushing mill with biorefinery technology. 10 million gallon per year capacity. HYPOTHETICAL COPRODUCTS.

New Glycerol Platforms



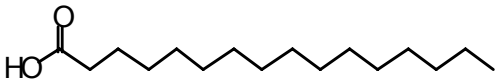
Transform Saturated Fatty Acids into Unsaturated Fatty Acids

14



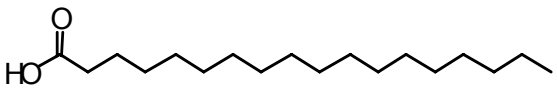
myristic acid

16

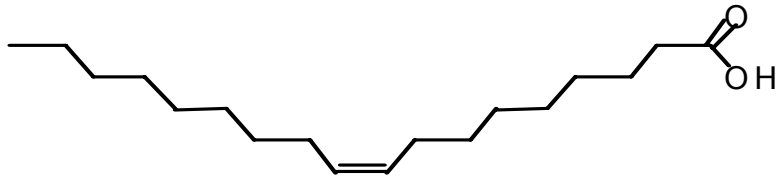


palmitic acid

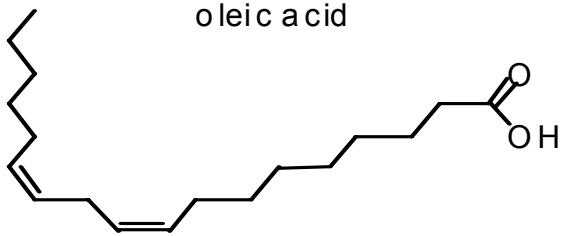
18



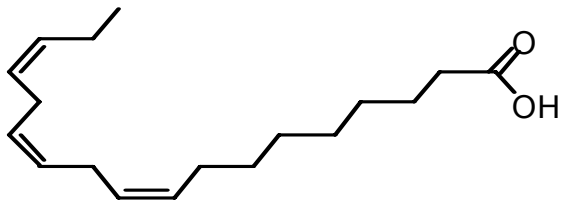
stearic acid



oleic acid



linoleic acid

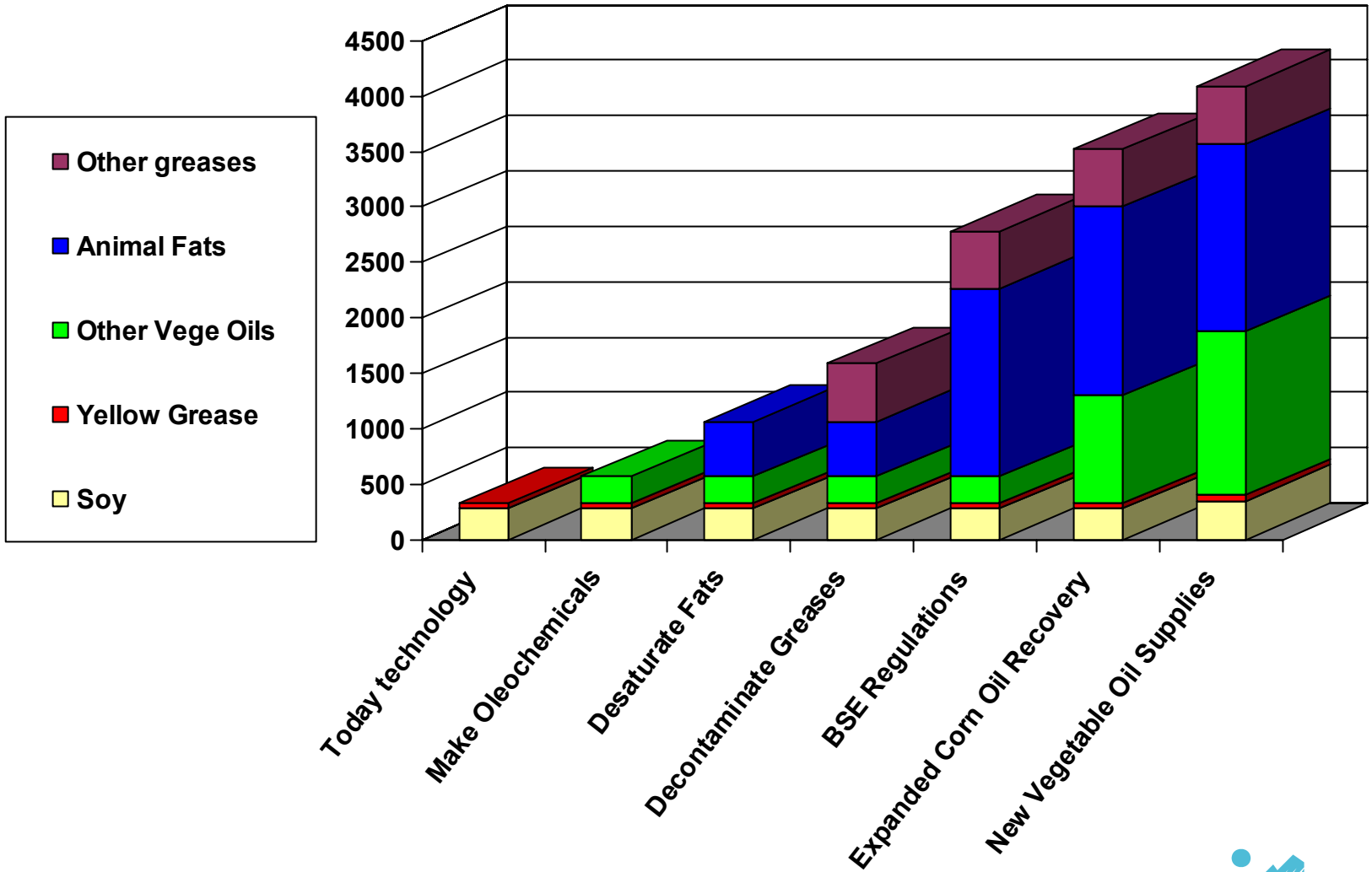


linolenic acid

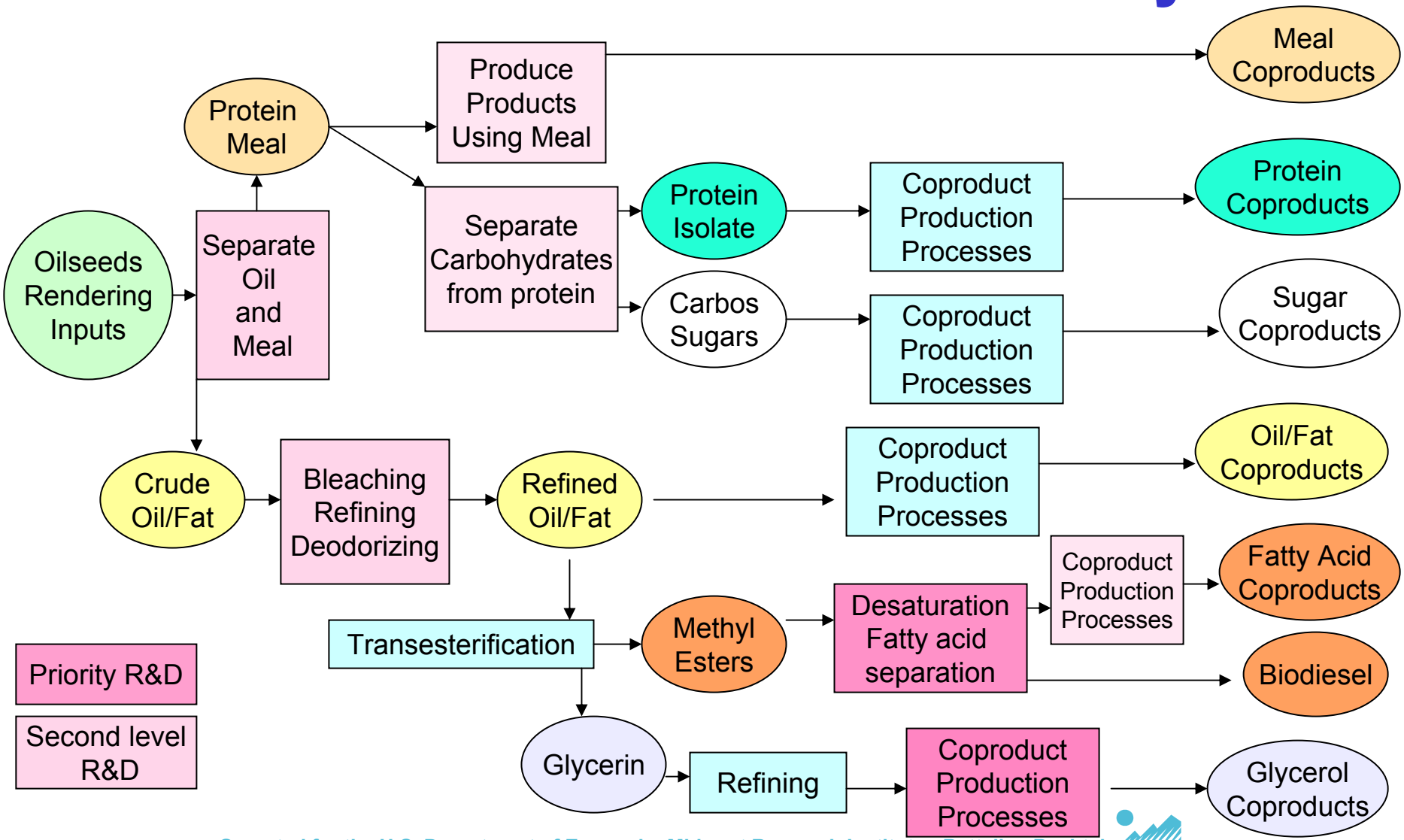
Causes Cold Flow Problems

Good cold flow
Good for coproducts

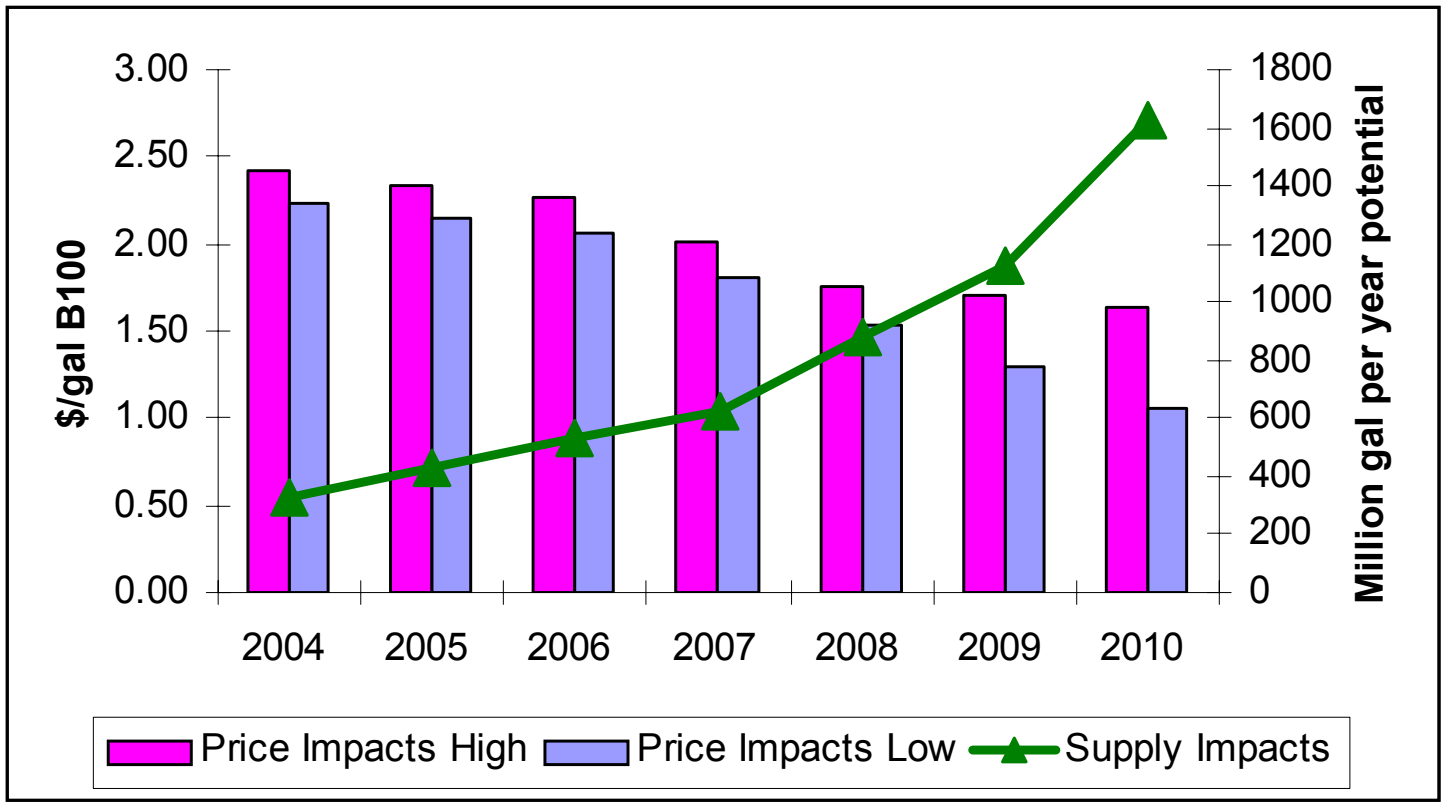
R&D Can Expand Supplies



Process Flow Diagram For Advanced Oil Biorefinery



Production Cost and Supply Impacts of DOE Oil Platform R&D



Outcomes of DOE Investment in Oils Platform R&D

- Reduce biodiesel production costs from more than $2.32/gal B100 to $1.50 or less
- Expand feedstock supplies from 328 million gal/yr to 1.5 billion gal/yr or more
- Displace 34 million bbl/yr of petroleum or more
- Enable and accelerate development of biodiesel biorefineries
- Enable new glycerol platform chemistry and product families
- Modify fatty acids to improve cold flow, expand supplies, and improve coproduct quality and performance