Bioenergy - I:
From Concept to Commercial Processes
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Tomar, Portugal

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Archer Daniels Midland

Oleochemical BIOFUEL

ADM in numbers

- 26,000 employees
- more than 700 processing plants, origination facilities and sales offices
- in 60 countries
- net sales 2004 of $36.2 billion.

http://www.admworld.com

	Metric Tonnes	**Bushels**
Oilseed crushing plants	90,000	3.3 million
Corn milling plants	50,500	2.0 million
Wheat Flour mills	30,000	1.1 million

„green fuel pump“

B 20, (20% Biodiesel)

E 85, (85% Ethanol)

E 10, (10% Ethanol)

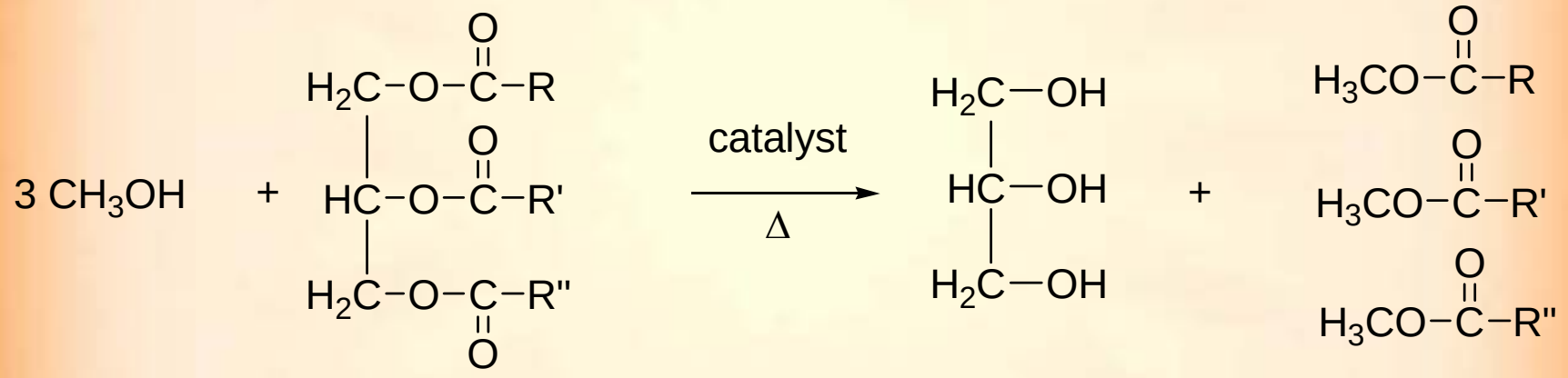
ADM

Oleochemical Biofuel

- Biodiesel in general
- Quality
- Capacities
- Production
- Glycerin

Biodiesel in general

Synthesis of Fatty Acid Methyl Esters (FAME)



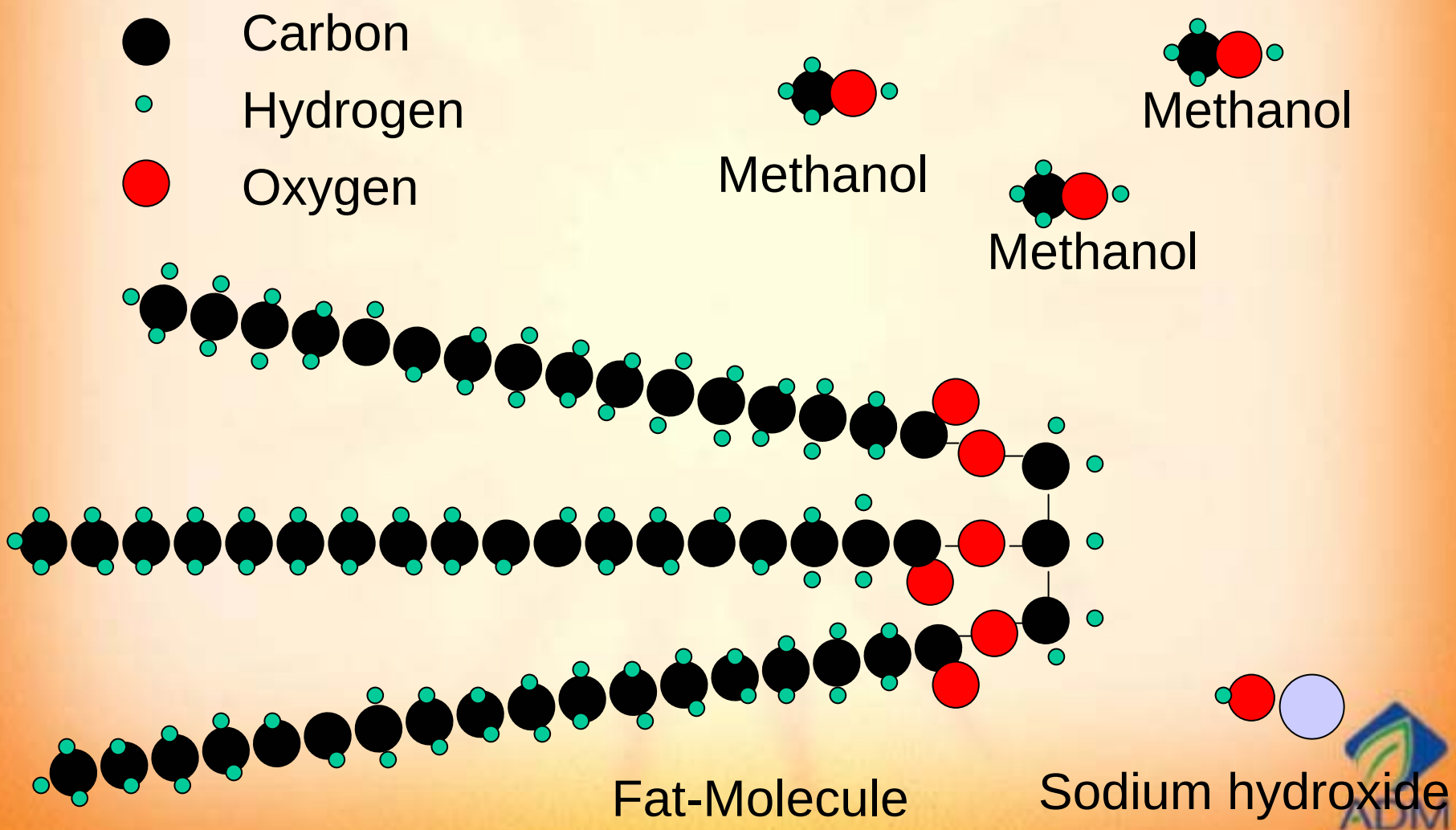
3 Methanol

1 Triglyceride (vegetable Oil)

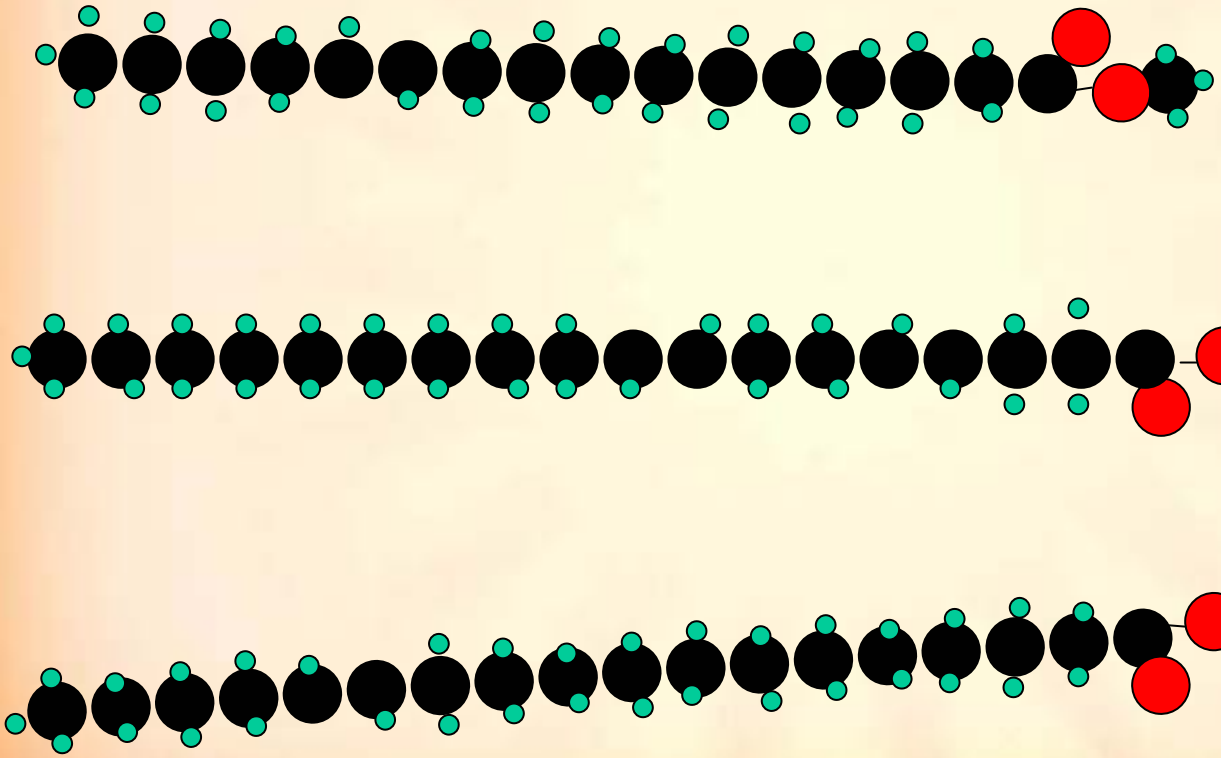
1 Glycerol

3 Fatty Acid Methyl Esters (Biodiesel)

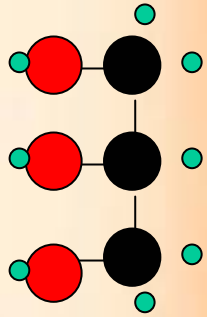
Chemistry – the Raw Materials



Chemistry – the Products



Fatty acid methyl ester (Biodiesel)



Glycerine

Advantages

- lower emissions of HC, CO, PM
- sulphur free
- balanced CO2-emissions
- non toxic, non water hazardous
- excellent lubricity
- high Cetane number

Critical aspects

- Solvent properties; limited resistance of certain materials (metals, plastics)
- Lower energy content, higher fuel consumption
- Hygroscopicity
- Increase of Nox-emissions
- Engine oil dilution
- Lower stability (thermal and storage)
- Higher viscosity at low temperatures

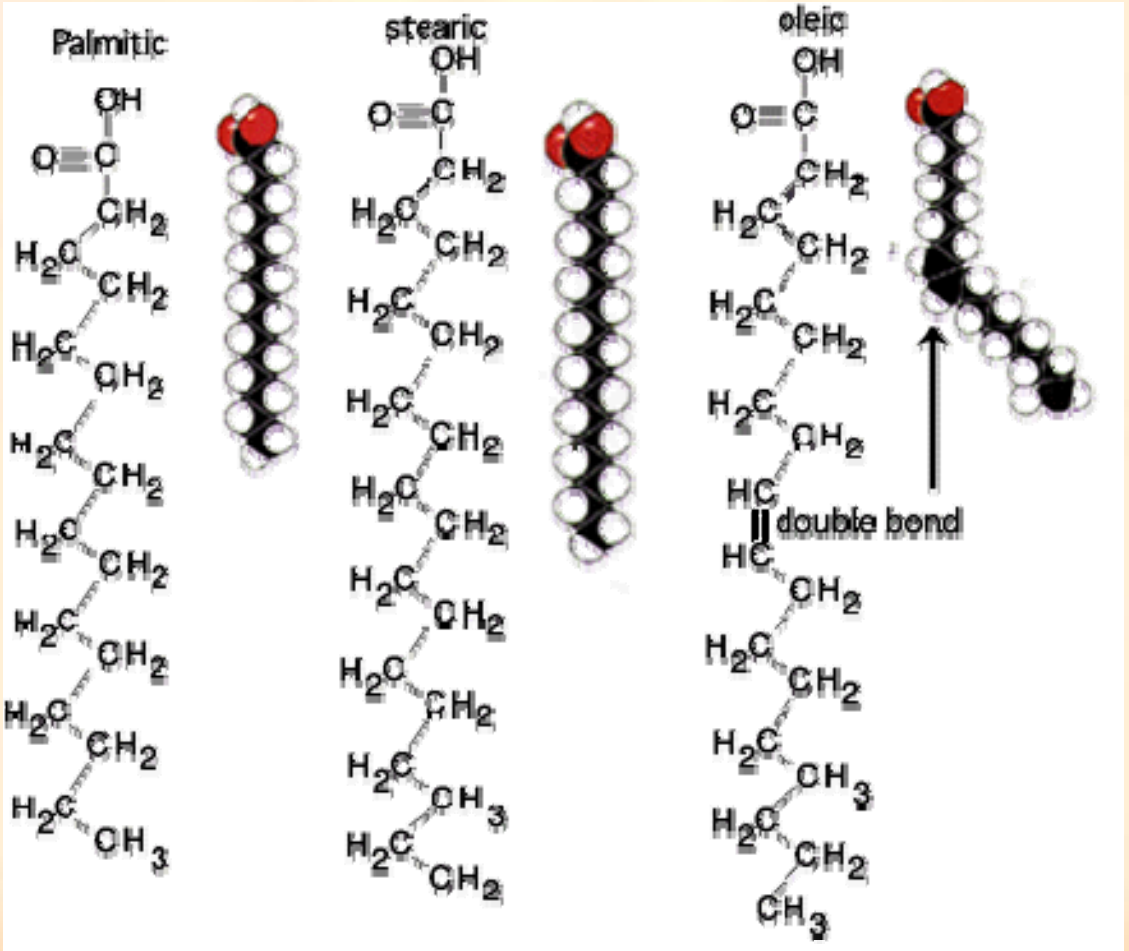
Unsuitable Materials

- Nitrile Rubber, NBR
- Hydrated Nitrile Rubber, HNBR
- PVC
- Copper
- Brass
- Lead
- Zinc
- Chromium / Chromated Surfaces

Suitable Materials

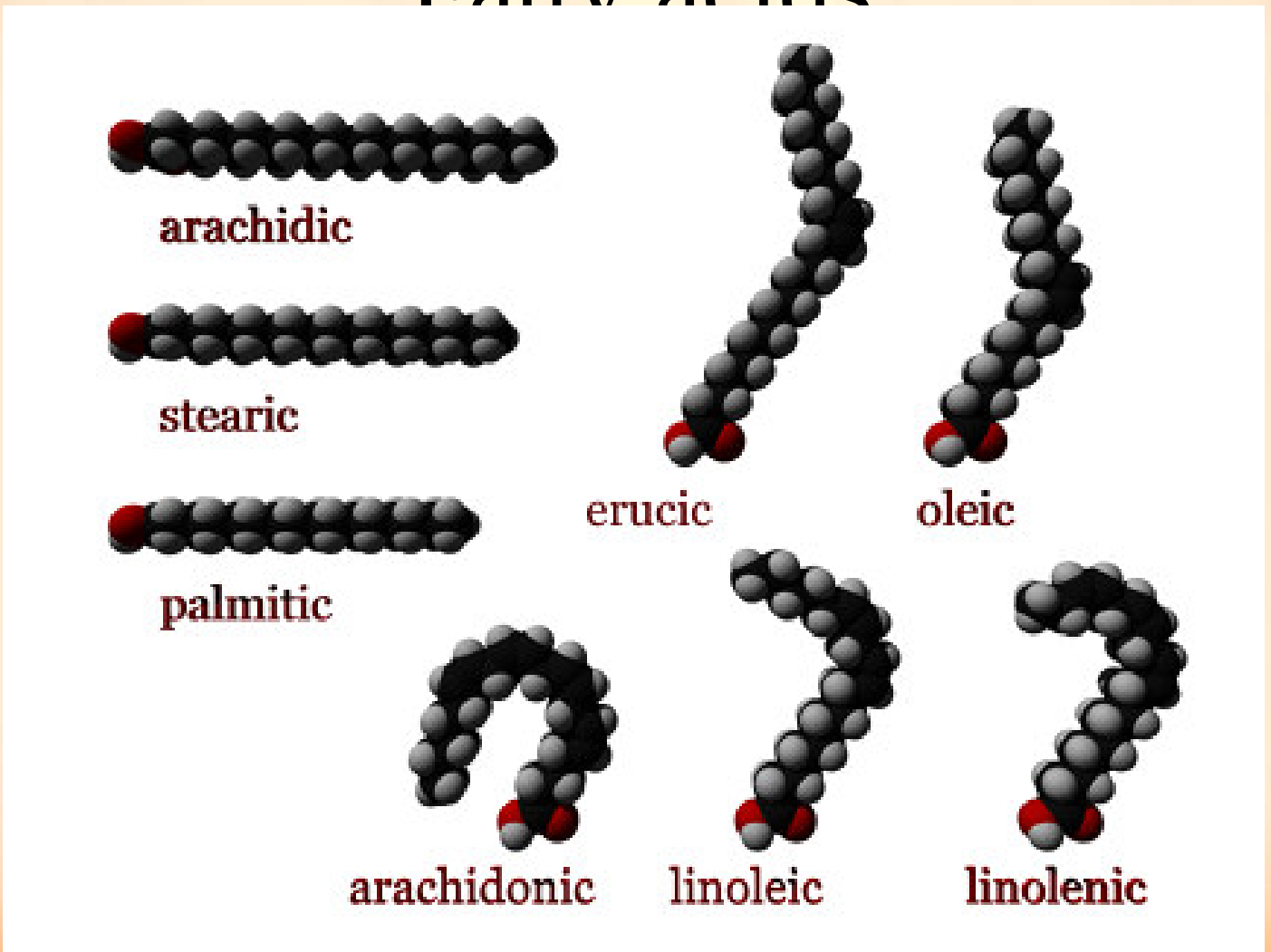
- Flourinated Rubber, FPM
- Polyamide
- Polyoxymethylene
- Aluminium
- Stainless Steel
- Tin

Fatty acids



Source: http://academic.brooklyn.cuny.edu/biology/bio4fv/page/fatty_a.htm

Fatty acids



Source:http://en.wikipedia.org/wiki/Fatty_acid

Crystallisation

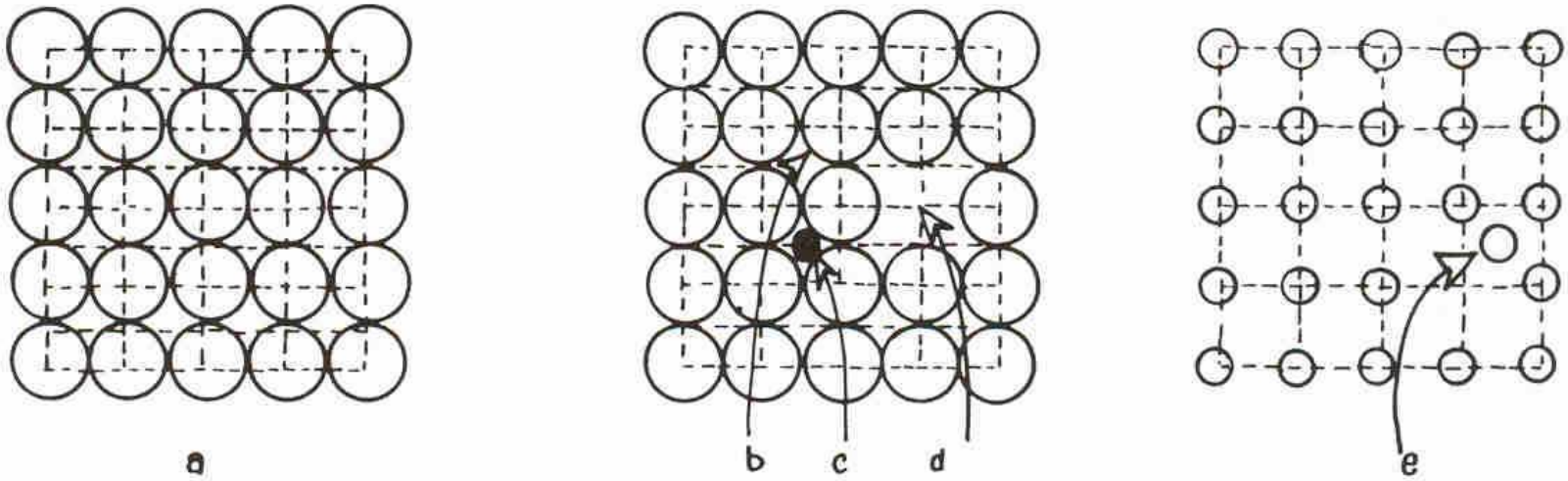


Figure 2.10 Imperfection in crystals: (a) perfect crystal; (b) substitutional impurity; (c) interstitial impurity; (d) Shottky defects; and (e) Frankel defect. (From R.A. Laudise, *The Growth of Single Crystals*, © 1970, pp. 12–13. Reprinted by permission of Prentice-Hall, Englewood Cliffs, NJ.)

Source:http://en.wikipedia.org/wiki/Fatty_acid

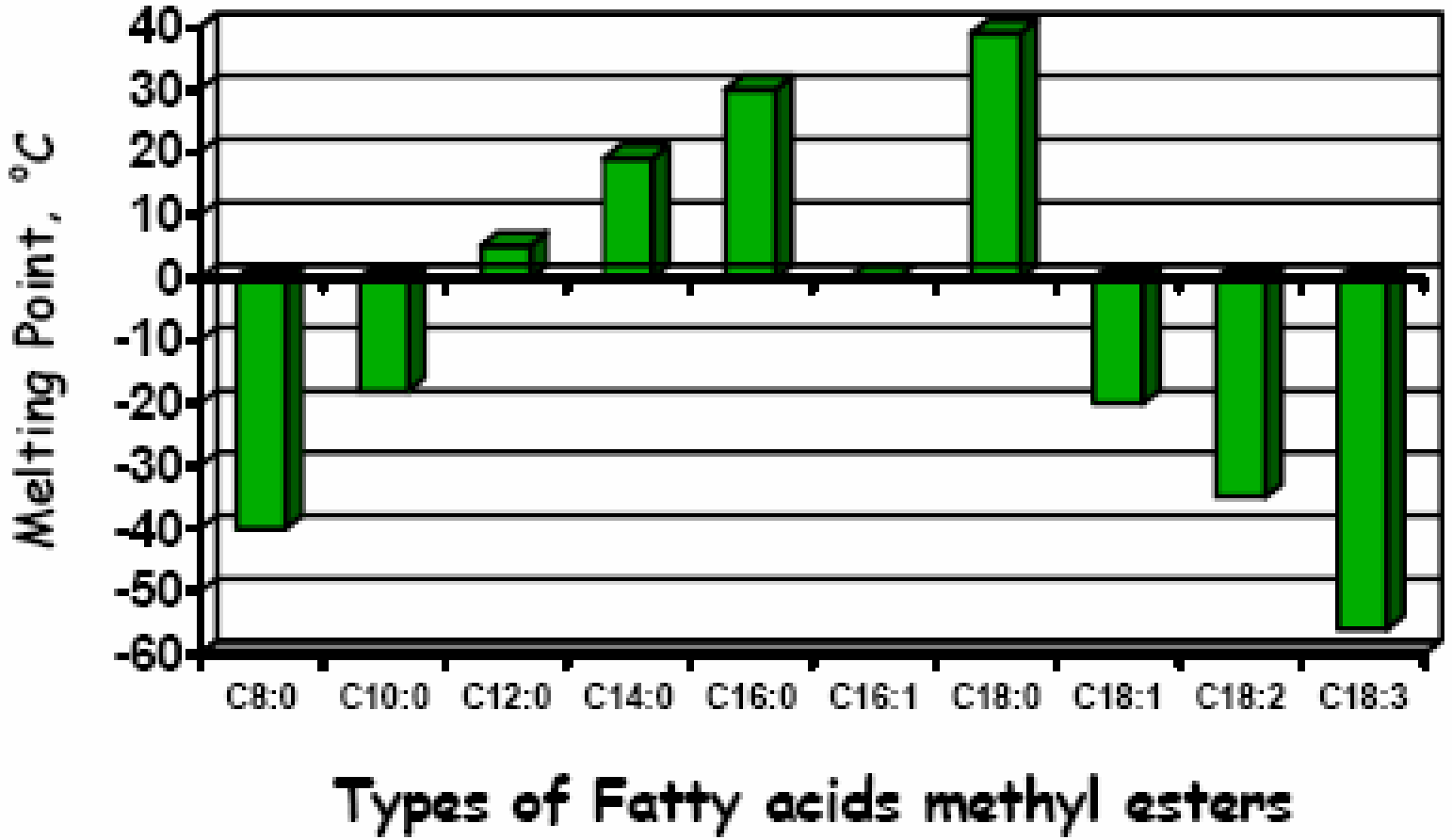


Figure 4. Melting points of biodiesel components.

http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/tp36182.pdf

Oxidation stability

Fatty Acid	Oxidation Rate
Stearic Acid (C18:0)	**1**
Oleic Acid (C18:1)	**10**
Linoleic Acid (C18:2)	**100**
Linolenic Acid (C18:3)	**150**

Feedstocks

Cold flow

ACID		Soy	Canola	Palm	Yellow grease	Tallow
Palmitic	C-16	10	4.5	45	25	24
Stearic	C-18	4	2	4	15	20
Oleic	C-18:1	22	60	40	45	45
Linoleic	C-18:2	54	20	10	10	4
Linolenic	C-18:3	8	9	0.2	0.5	0.5
IV		125 140	110 115	44 58	75 80	50 60
Cetane		53	58	65	60	75
CFFP [°C]		-6	-14		5	10

Polymerization

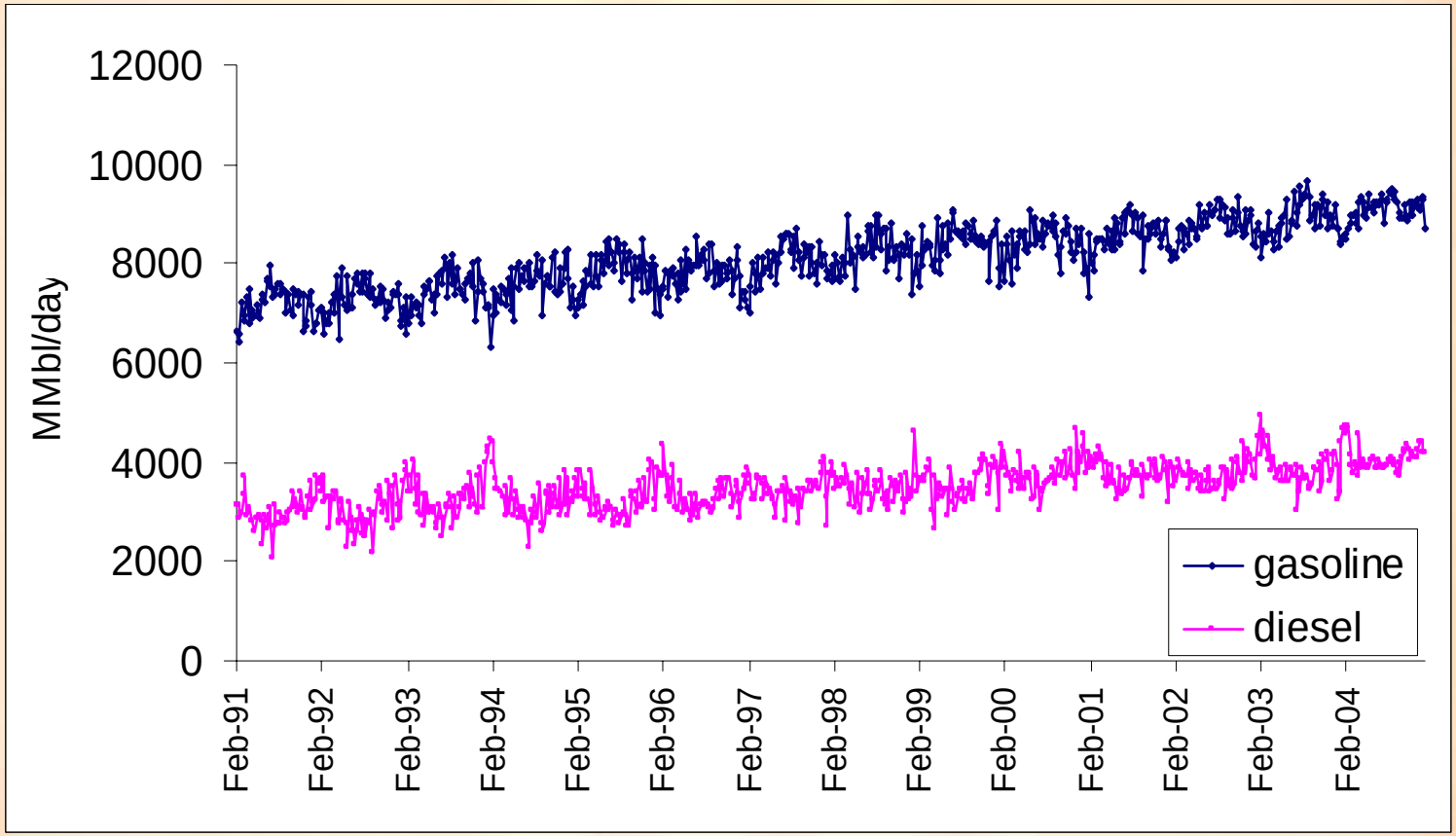
ADM

Energy content

FUEL	Btu/gal (gross)
Diesel Motor Fuel	140,000
Biodiesel (B100)	125,000

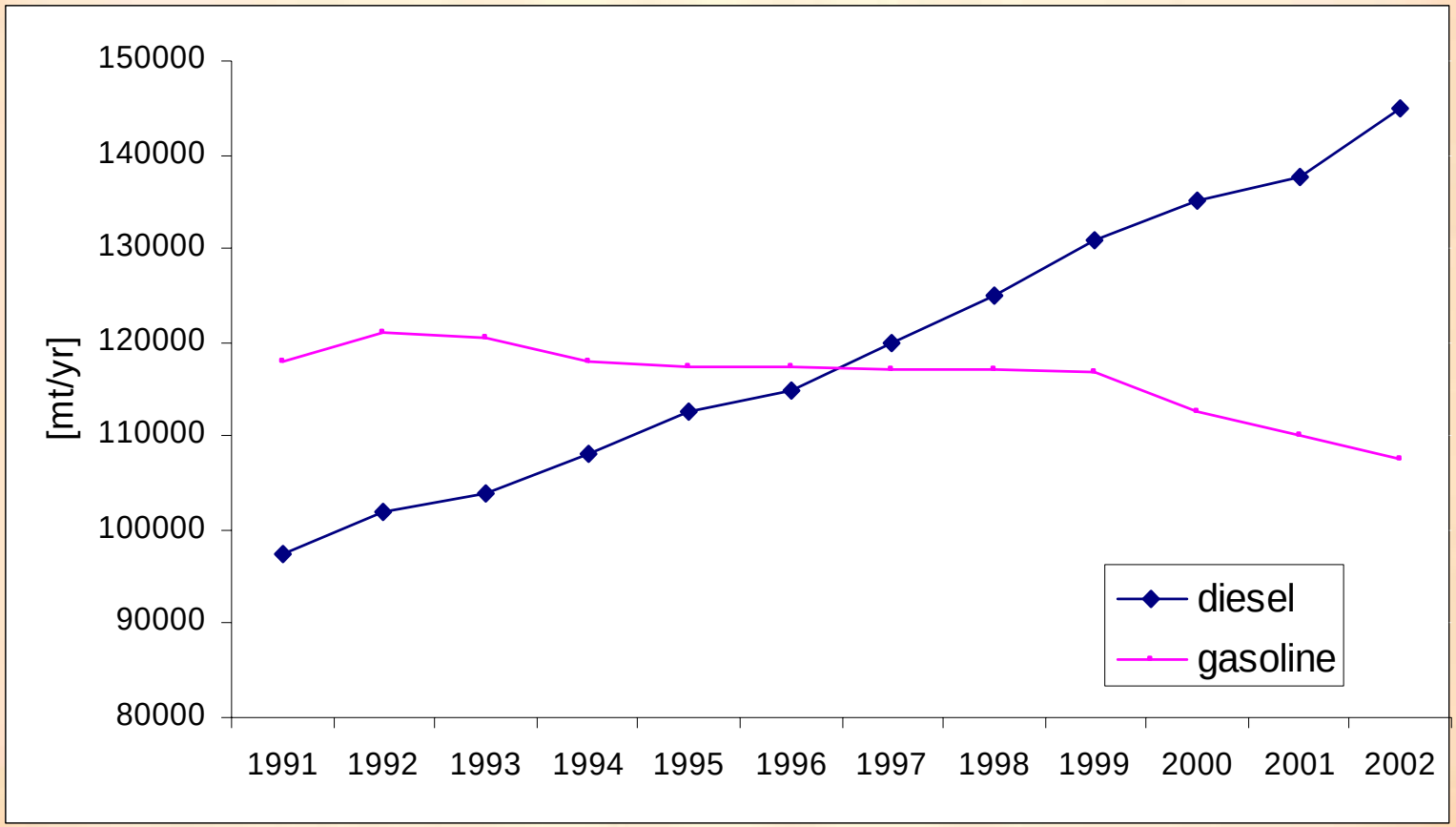
(source: Dep. of Energy)

US Diesel and Gasoline consumption



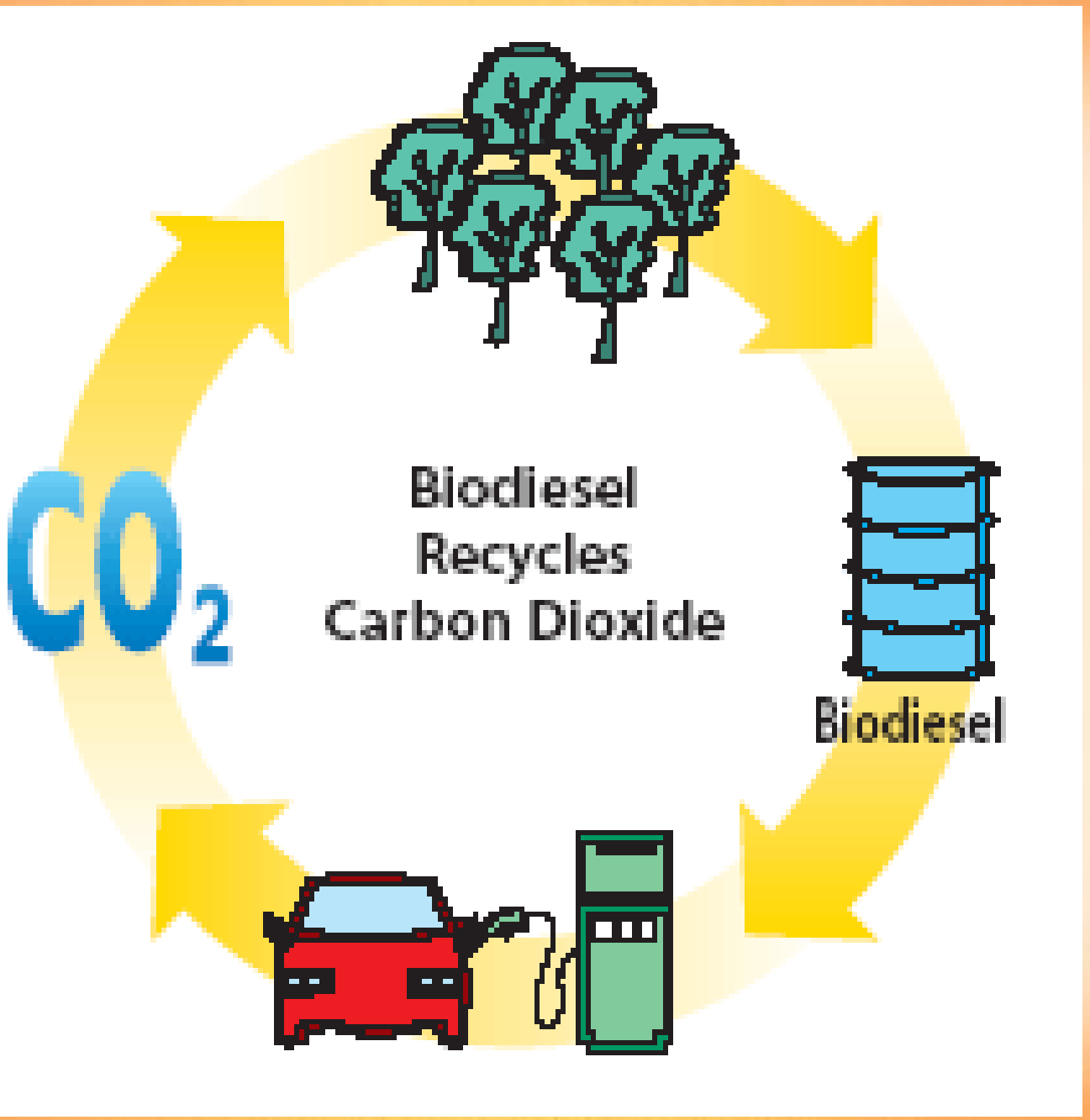
Source: Dept. of Energy

EU Diesel and Gasoline consumption



Source: Total

http://www.bosch-presse.de:
“..51.9 percent of newly registered passenger cars in Western Europe are diesel powered..”


CO_2
Biodiesel
Recycles
Carbon Dioxide
Biodiesel

Quality

- Cold Flow Properties
- Total contamination
- Oxidation Stability
- Free Glycerol
- Watercontent

Problems of a poor Quality

Feedstock related

Low Oxidation stability

- Formation of Deposits
- Corrosion due to aggressive oxidation products (e.g. Formic Acid)

High Iodine Number

- Nozzle Coking, Oil Sludge

Low Temperature Stability (CFPP)

- Filter Plugging

Problems of a poor Quality

Process related

High Glycerol-/Glyceride Content

- Filter Plugging, Corrosion of Nonferrous Metals (Cu, Zn)

High Metal Content (Na, K, Ca, Mg)

- Filter Plugging (Calcium Soaps)

High Water Content

- Corrosion, Filter Plugging, Microbiological growth

Problems of a poor Quality

Process related

High Acid Number

- Corrosion

High Phosphorus Content

- Catalyst Ageing

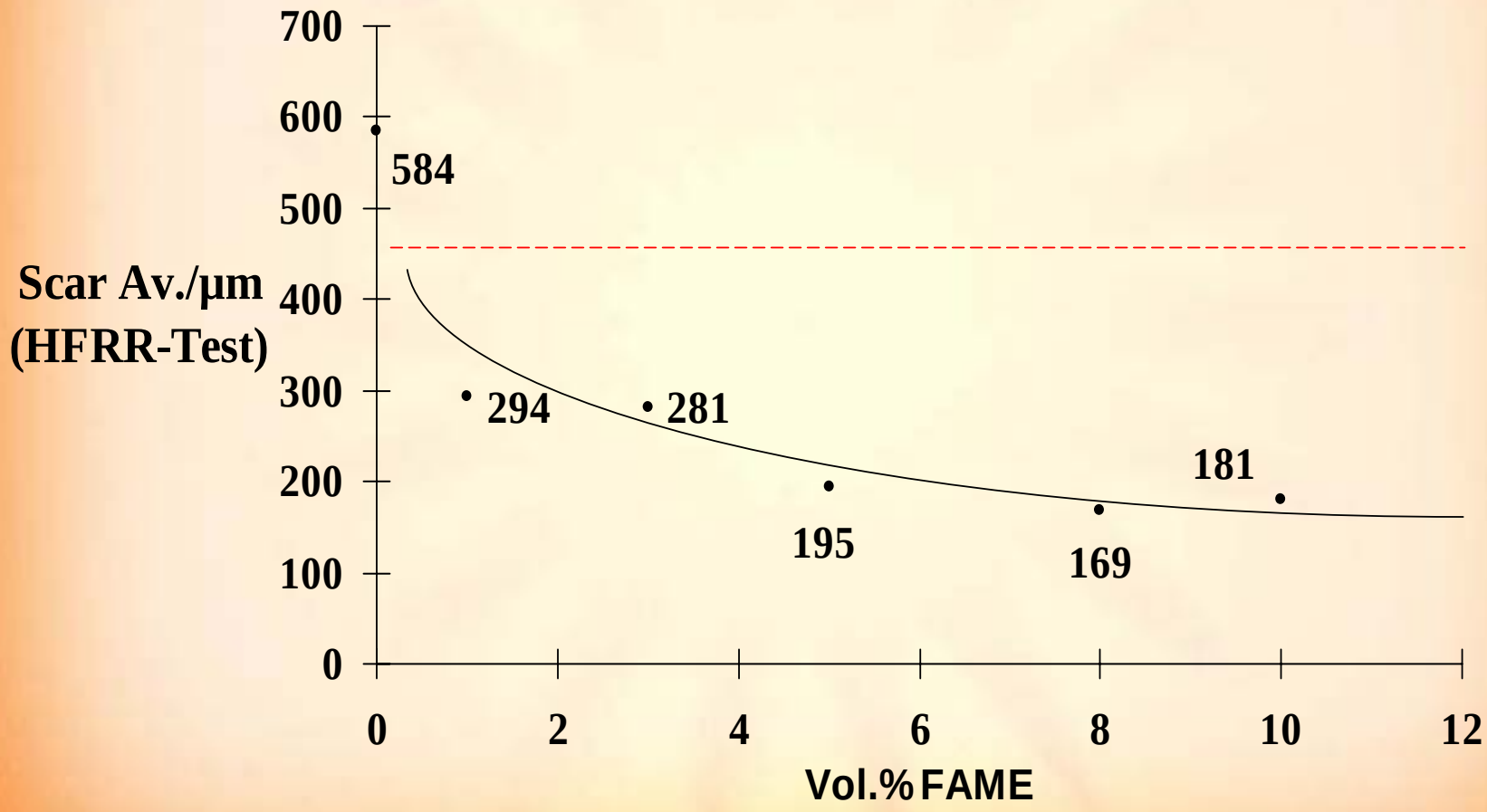
Which blend makes sense?

B 100: biodegradability

B 20: emission reduction

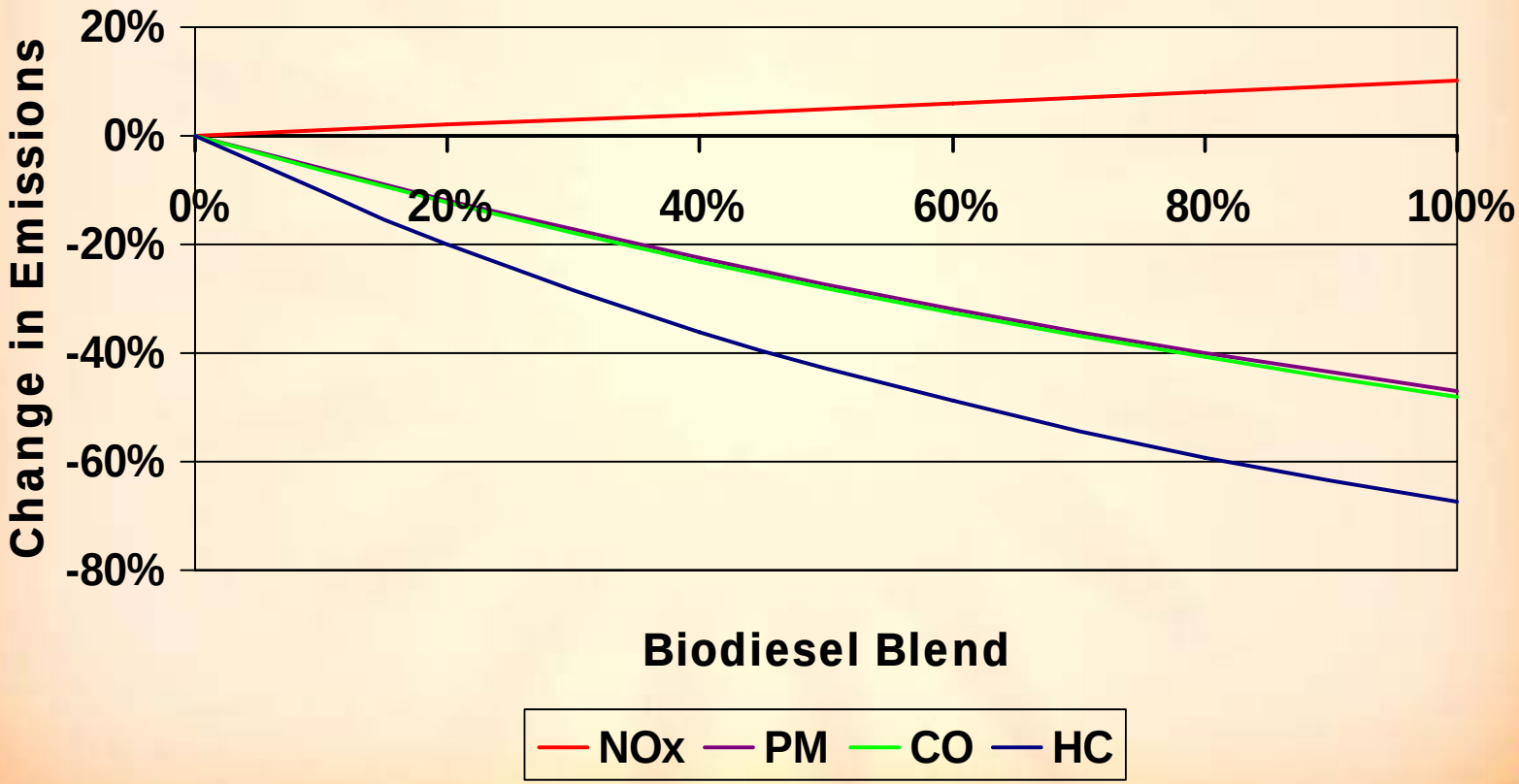
B 2: lubricity

..significant lubricity enhancement at 2%...



Source: National Biodiesel Board

..significant emission reduction at 20%...



Source: National Biodiesel Board

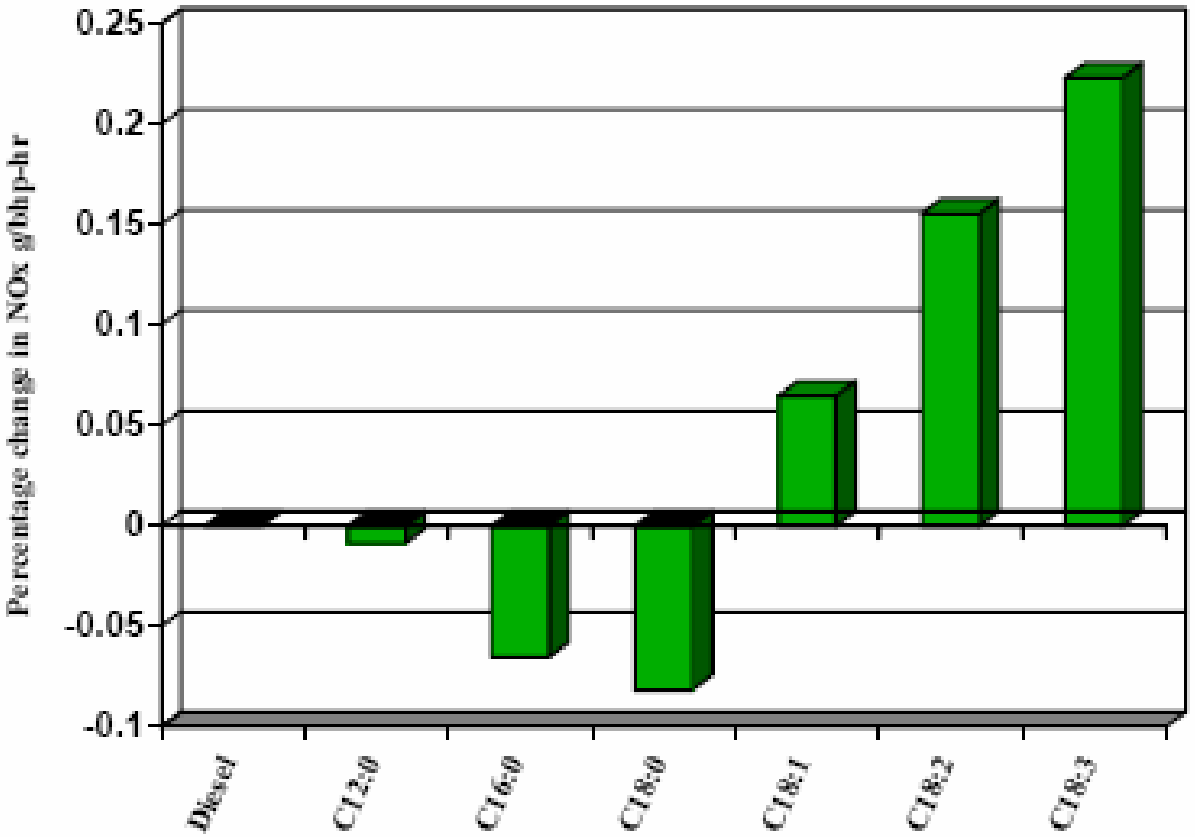


Figure 8. NOx emissions of B100 made from single types of fatty acids[10]

http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/tp36182.pdf

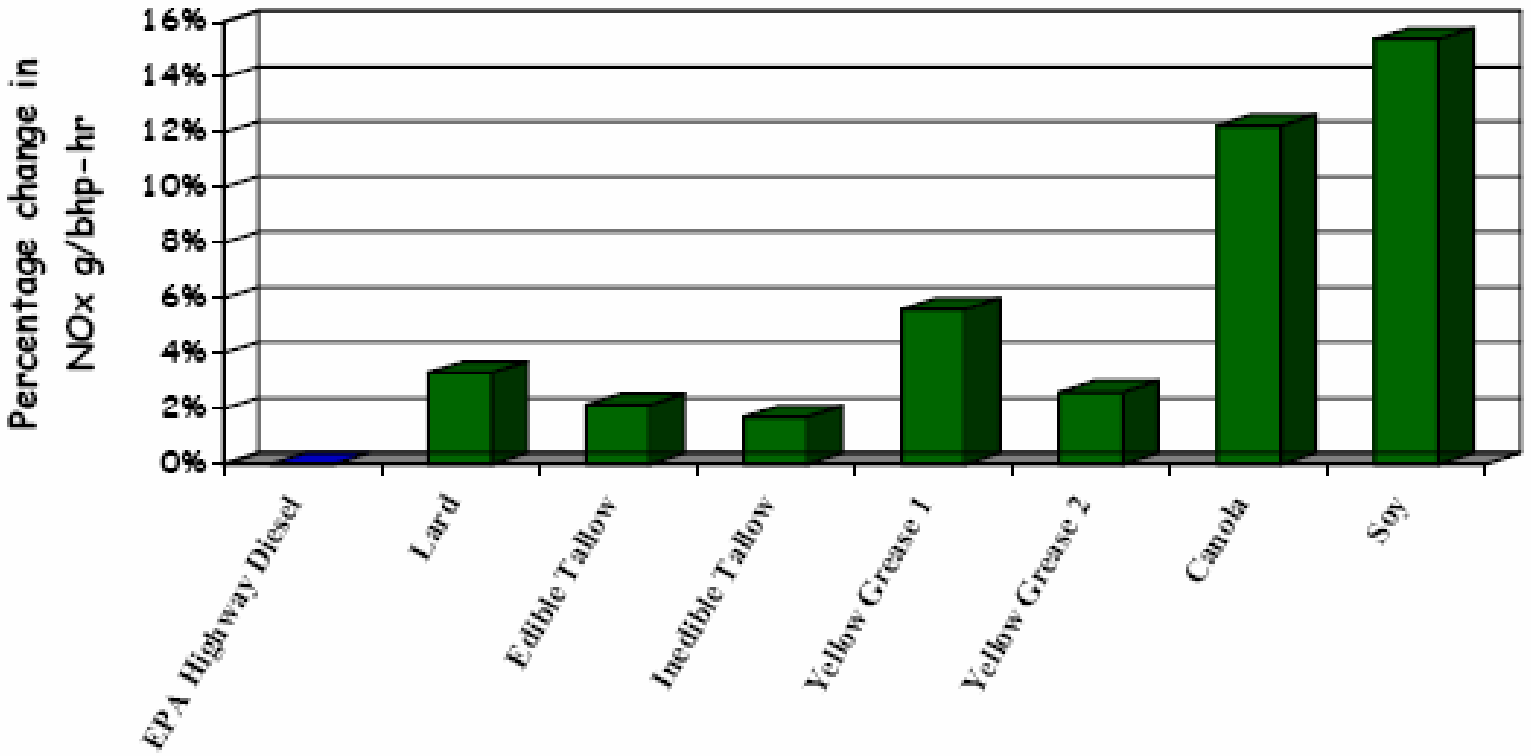
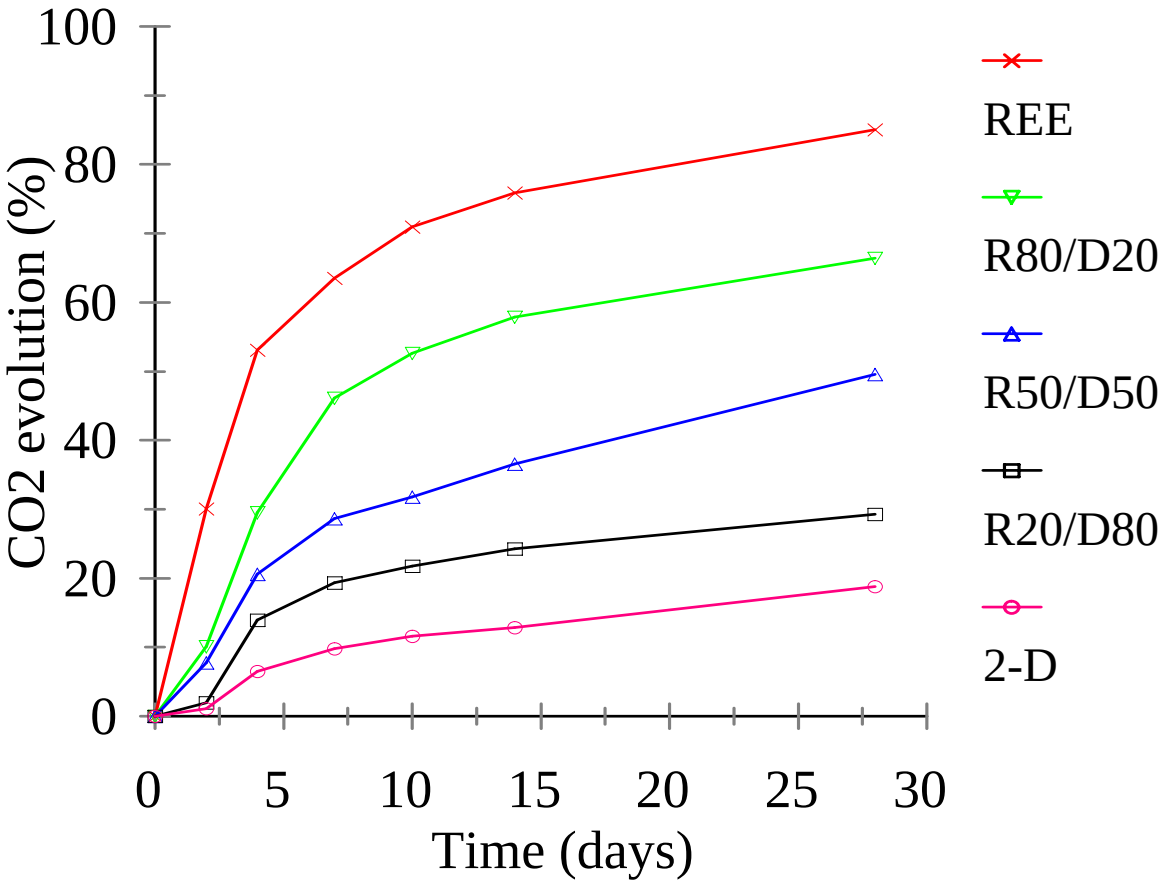


Figure 9. Increase in NOx emissions from CI engines using various B100 fuels

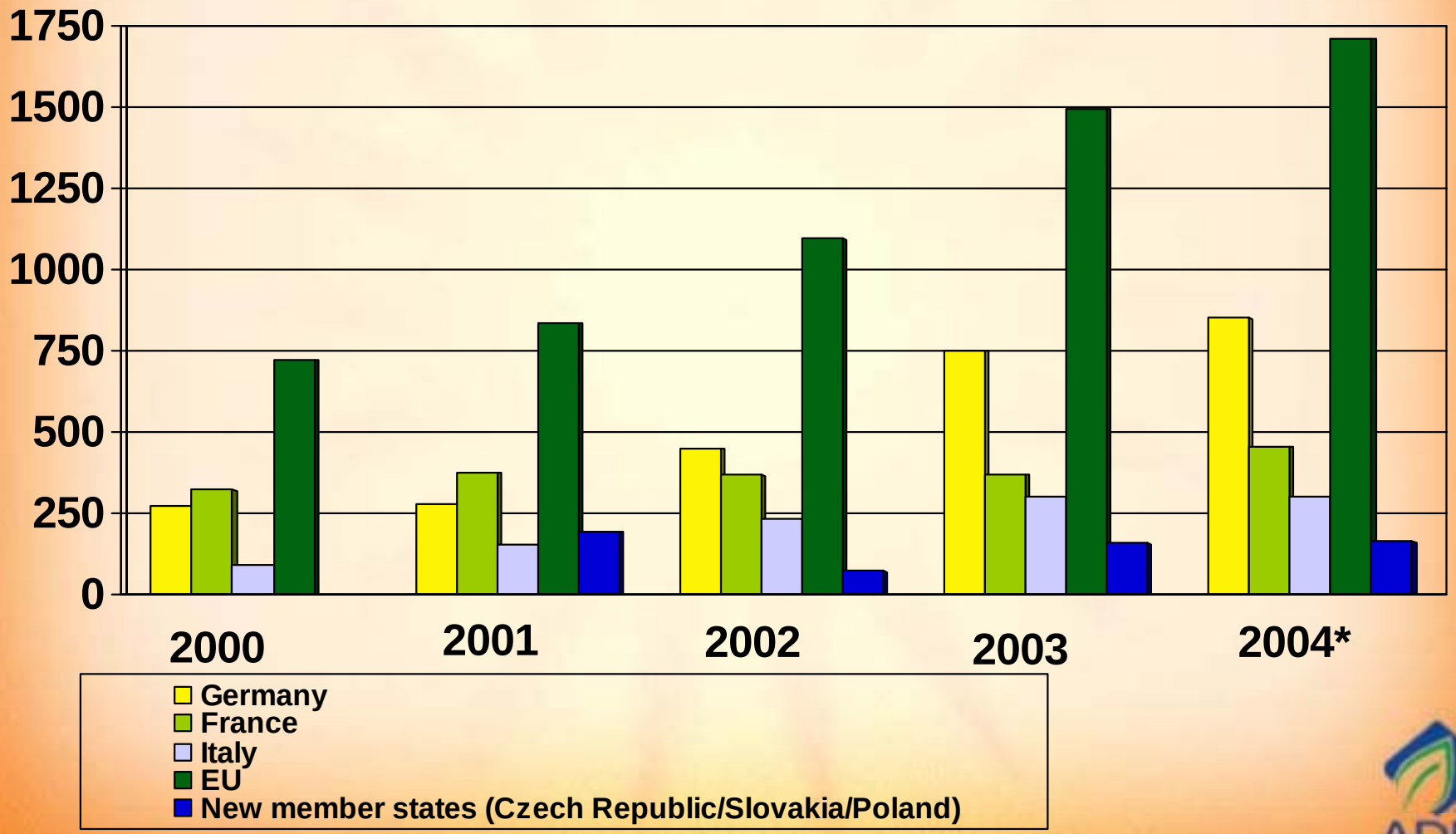
http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/tp36182.pdf

..significant biodegradability at 100%...



Source: Chuck Peterson, U of Idaho

EU and New Member States in mio. Mt/year



What‘s different in the US?

US Production

	[MM gal/a]	[1000 mt/a]
2000	2	6.2
2001	6.5	21.3
2002	8.8	30
2003	18.5	60
2004	70	62
2005[1]	180[1]	600
2006[1]	360[1]	1200

1) estimates

Source: USDA 2004, CCC Data,

Interesting new projects

India: Jatropha

Brazil: Castorseed

Thank you!

Any questions?