



Biofuels

Lec 3: Biodiesel-Part 3

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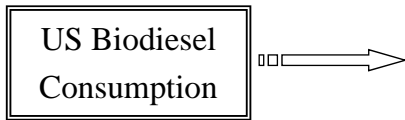


Content



- **US Biodiesel Market**
- **Biodiesel Economics**



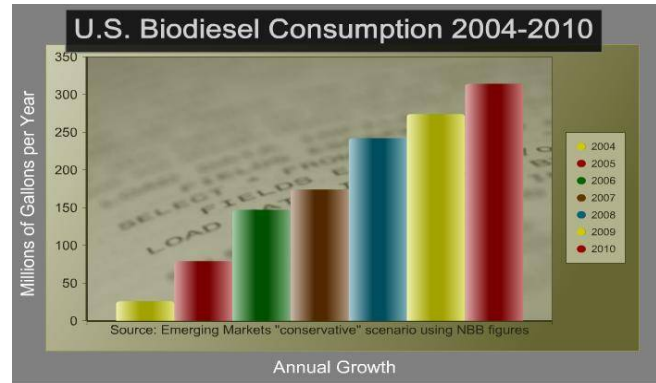


US Biodiesel Plants:

65 operating plants (capacity: **400M gal/yr**)

50 - construction (capacity: **700M gal/yr**)

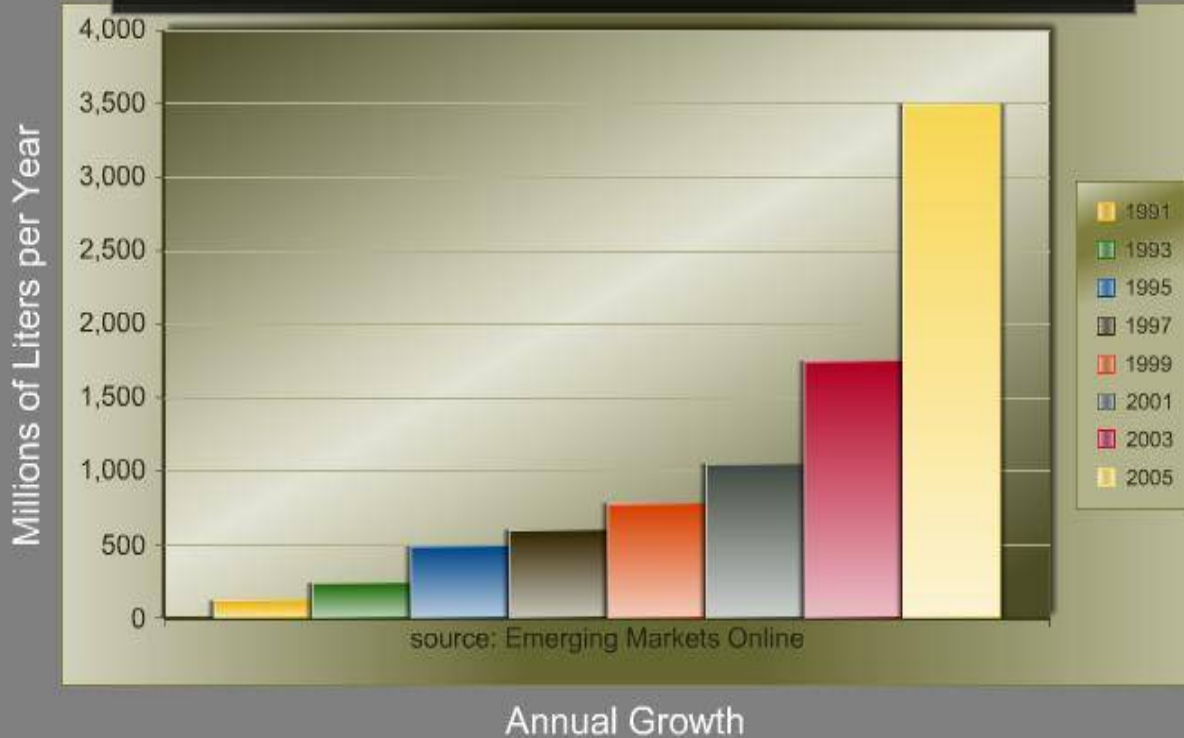
(Source: National Biodiesel Board, Apr. 2006)



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World Biodiesel Production 1991-2005

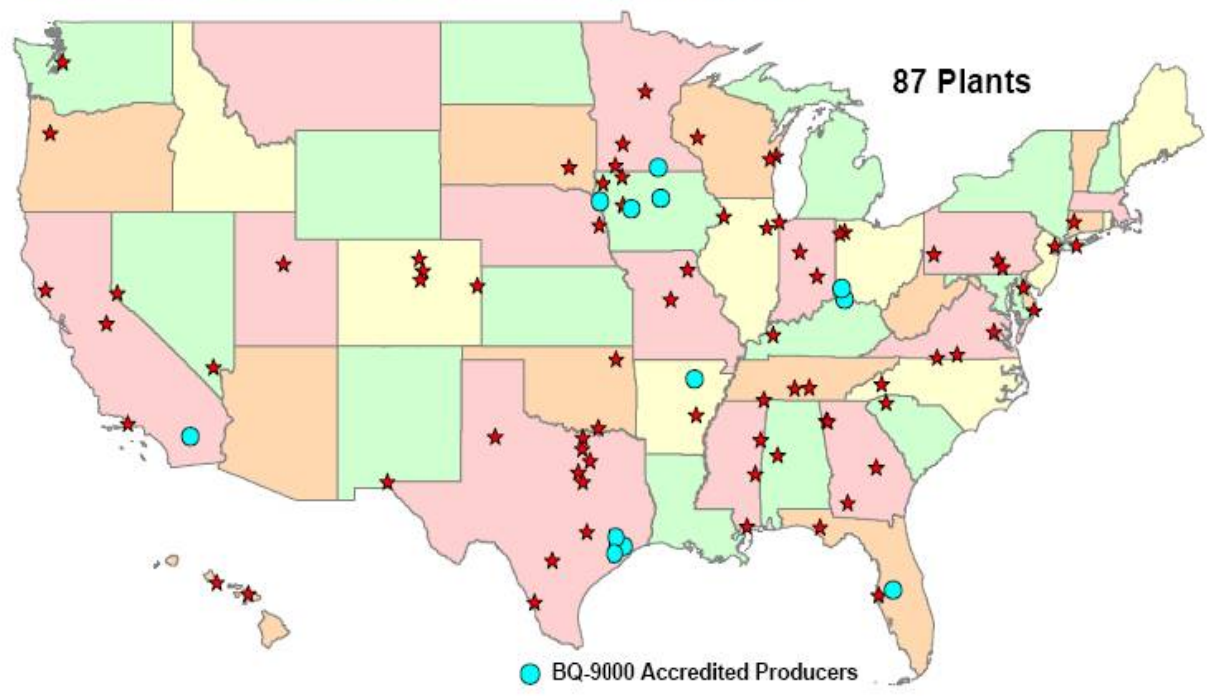


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US – Existing BD Plants

Commercial Biodiesel Production Plants (November 14, 2006)



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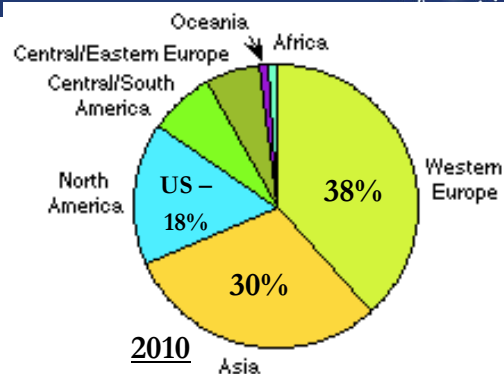
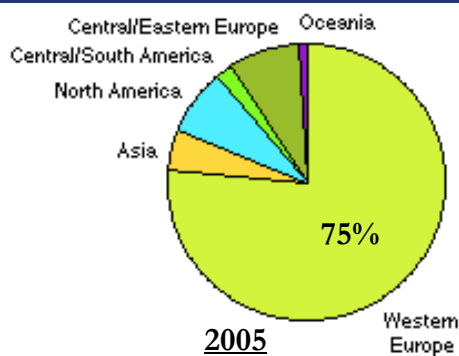


Biodiesel Refineries / Plants (EU)

75% of total biodiesel production belong to 4 corporations:
ADM (Archer Daniels Midland), Cargill, Bunge & Saipol



World Production of Biodiesel



Western Europe (D, FR, IT, UK, etc.) – main producers and consumers – 75% of world

Eastern Europe & N. America – 2nd largest markets

Asia – although significant market yet, relatively small

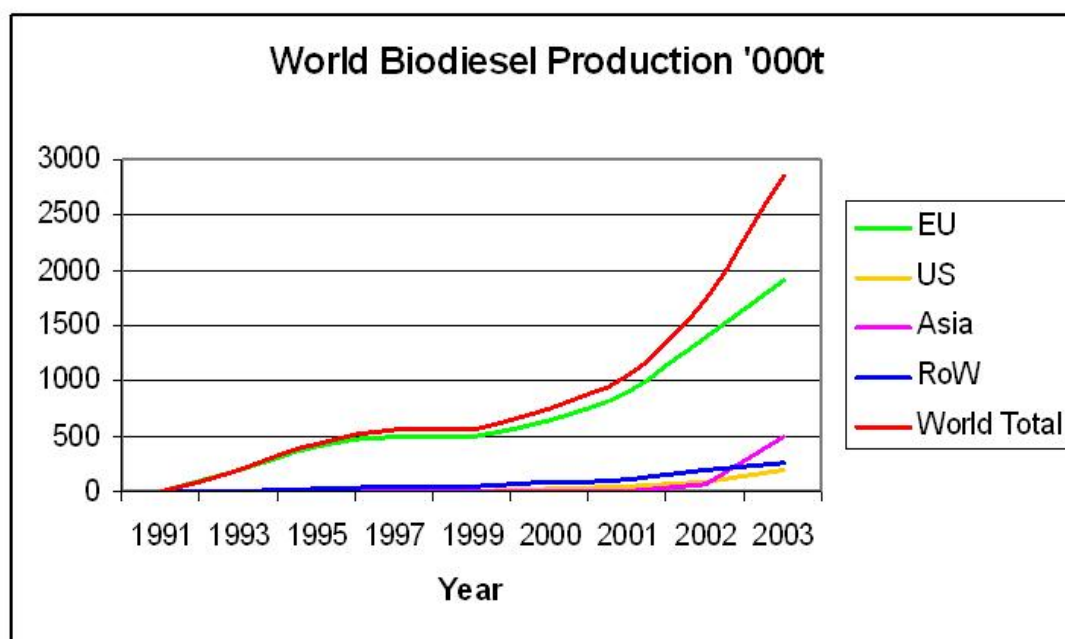
Western Europe (D, FR, IT, UK) – main producers and consumers – 38% of world

Asia – will become the 2nd largest market (China, India – consumption & production)

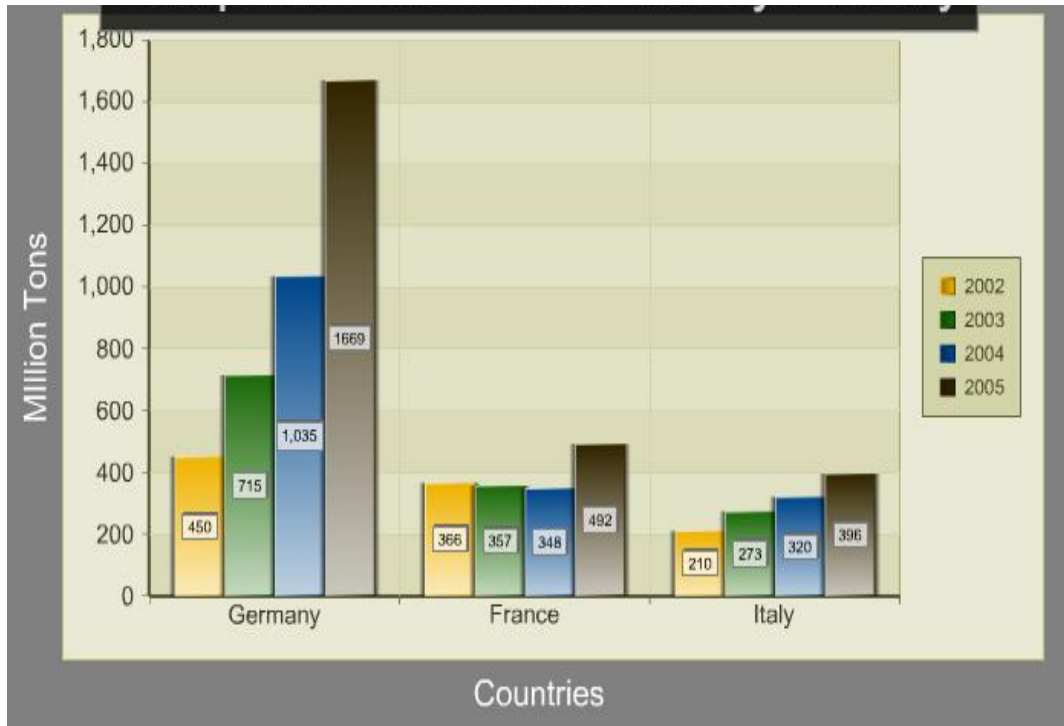
Eastern Europe & N. America – 3rd largest markets, with US as the single largest consumer – 18% of world



World BD Production



European BD Growth



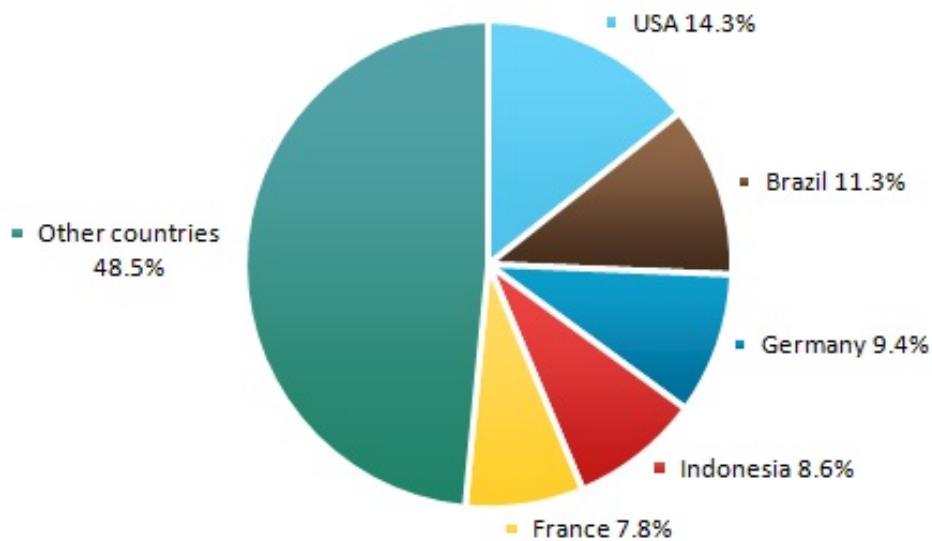
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World BD Production

Global Biodiesel Production in 2013



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Biodiesel Economics

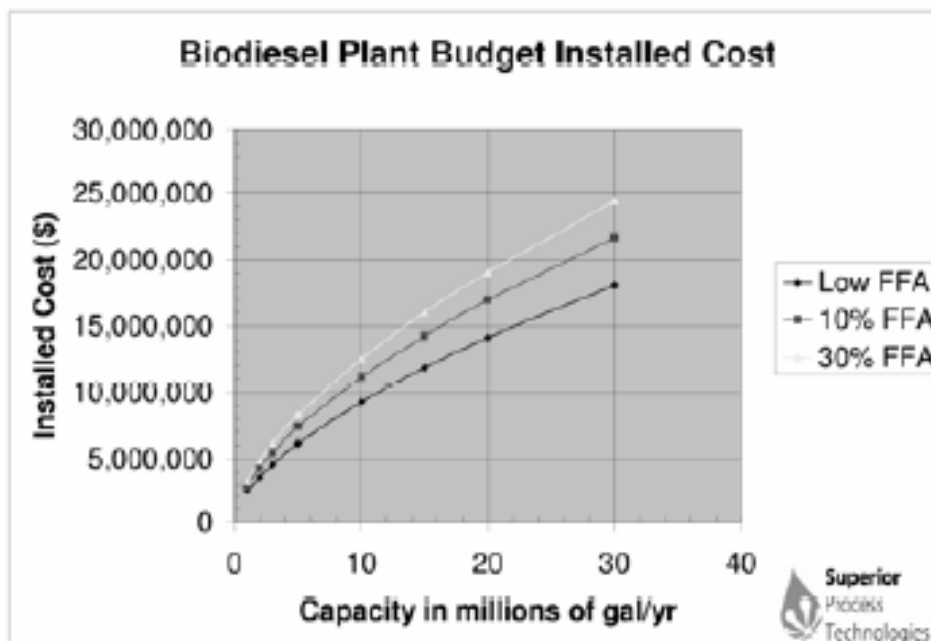
- 60-70% of the cost to process biodiesel is from feed stock costs
- Yellow Grease has a limited supply
- Soybean and other plant oils have long term price issues

Marketing Year	Soybean Oil	Yellow Grease	Petroleum
2004/05	2.54	1.41	0.67
2005/06	2.49	1.39	0.78
2006/07	2.47	1.38	0.77
2007/08	2.44	1.37	0.78
2008/09	2.52	1.40	0.78
2009/10	2.57	1.42	0.75
2010/11	2.67	1.47	0.76
2011/12	2.73	1.51	0.76
2012/13	2.80	1.55	0.75

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Biodiesel Economics

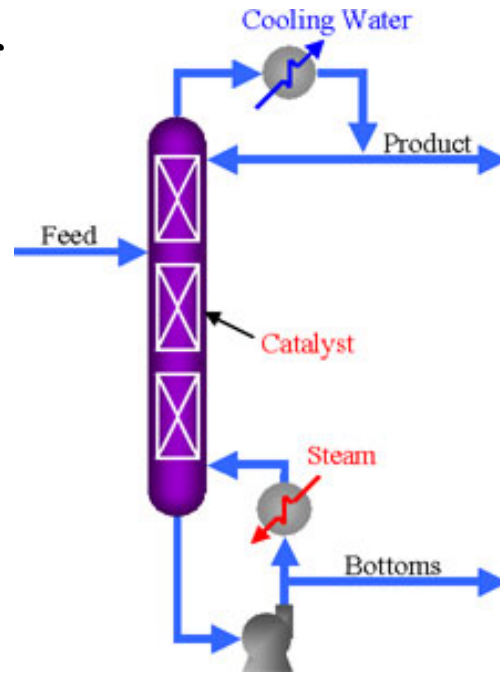


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Biodiesel Economics

- **There is ample room for improvement in the efficiency of processing biodiesel**
 - Development of a continuous transesterification process
 - Recovery of high quality glycerol



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Biodiesel Economics



Production costs of biodiesel depending on raw material and plant capacity

Ferenc K. et al., The economic feature of biodiesel production in serbia, project report.

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Biodiesel Economics

- A biodiesel plant of 10,000 tons capacity per year, using rapeseed grain or virgin rapeseed oil as raw material
- Feedstock costs at 506 €/t for raw rapeseed oil.

Ferenc K. et al., The economic feature of biodiesel production in Serbia, project report.

Capital cost estimates for biodiesel plant (in 000 €)

	Description	Plant capacity (tonne/year)			
		10,000	20,000	40,000	60,000
I	Equipment	3,846	4,899	6,267	7,950
1.	Transesterification unit	3,200	3,800	4,300	5,100
2.	Storage facilities	370	690	1,330	1,971
3.	Infrastructure	100	200	400	600
II	Buildings	225	250	275	290
III	Tariff and transportation	176	209	236	280
IV	Projecting and engineering	379	474	590	736
V	Fixed capital cost	4,450	5,623	7,132	8,977
VI	Working capital	308	820	1,640	2,460
VII	Total investment	4,758	6,443	8,773	11,438

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Biodiesel Economics

Biodiesel Production Cost

(5 million gallon plant)

	Unit Cost	\$/gal
Oil	\$0.27/lb	\$2.03
Methanol	\$1.35/gal	\$0.16
Catalyst (25% NaOCH ₃)	\$0.55/lb	\$0.08
Neutralizer (HCl)	\$0.08/lb	\$0.01
Nat. gas + electricity	\$9./mmbtu, \$0.05/kwh	\$0.02
Labor	1 shift, 5 people	\$0.04
Depreciation/interest	10 yr/6%	\$0.15
Maintenance	3.8% of plant	\$0.04
Admin. + overhead		<u>\$0.02</u>
Total:		\$2.55

Note that the oil is 80% of production cost, infrastructure is only 6% of production cost. Production cost is \$0.52/gal + oil.



Annual costs and expected profit for the annual production of 10.000 t of biodiesel from rapeseed seed and oil (in 000 €)

Phase	Item	Model A		Model B	
		€	%	€	%
Feedstock	Rapeseed grain/ oil	4,444	59.6	5,400	78.5
Processing of raw oil	Expenses to oil plant	554	7.4	-	0.0
	Storage	88	1.2	-	0.0
	Processing	896	12.0	-	0.0
	Total	1,540	20.6	-	0.0
Esterification	Materials	629	8.4	629	9.2
	Depreciation	401	5.4	401	5.8
	Maintenance	118	1.6	118	1.7
	Insurance	59	0.8	59	0.9
	Labour	92	1.2	92	1.4
	Interest	82	1.1	82	1.2
	Management expenses	90	1.2	90	1.3
	Total	1,475	19.8	1,475	21.5
Gross operating costs		7,460	100.0	6,875	100.0
Oilcake		1,388	16.1	-	-
Glycerine		150	1.7	150	2.1
Fertilizer		22	0.3	22	0.3
Biodiesel		7,075	81.9	7,075	97.6
Revenues (€/year)		8,637	100.0	7,248	100.0
Annual profit		1,176		372	
Net annual profit after taxes (10%)		1,059		335	

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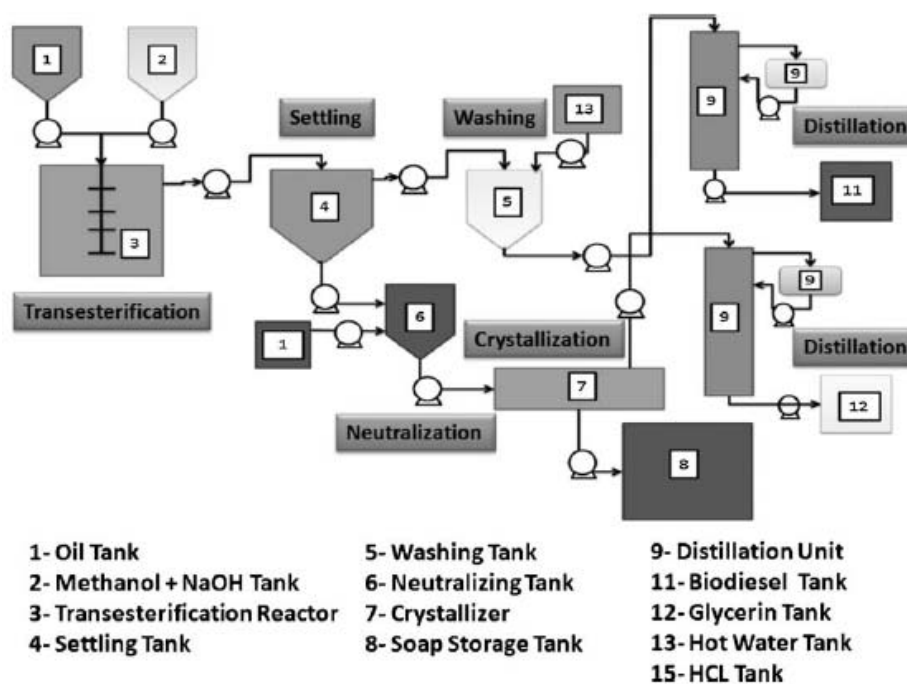


Fig. 1. Sketch of biodiesel production plant using alkali catalyst.

K.R. Jegannathan et al./ Renewable and Sustainable Energy Reviews 15 (2011) 745–751

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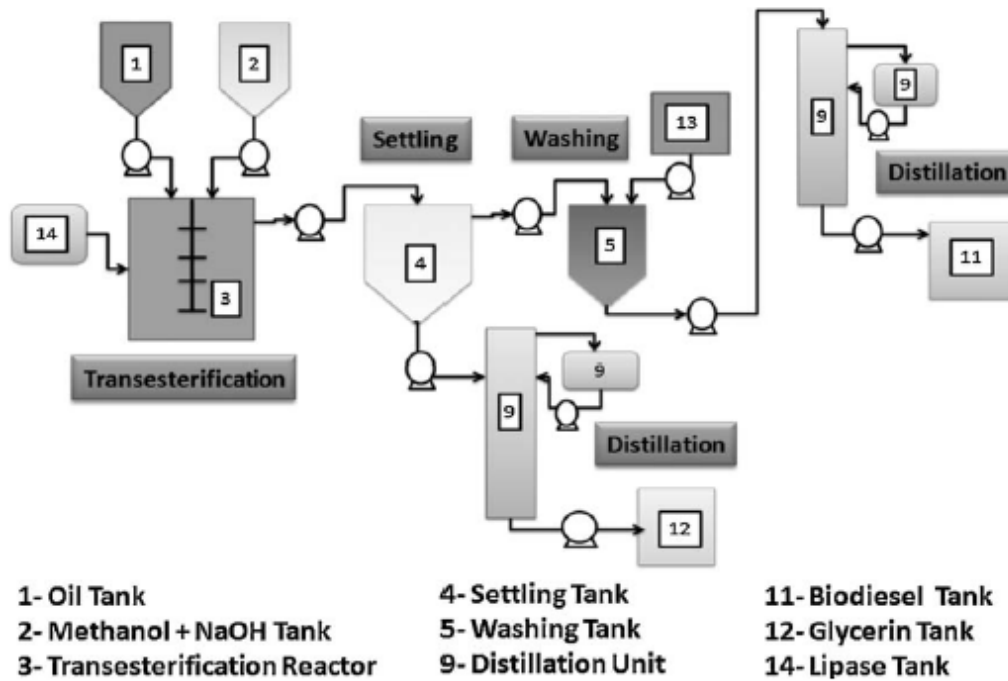


Fig. 2. Sketch of biodiesel production plant using soluble lipase catalyst.

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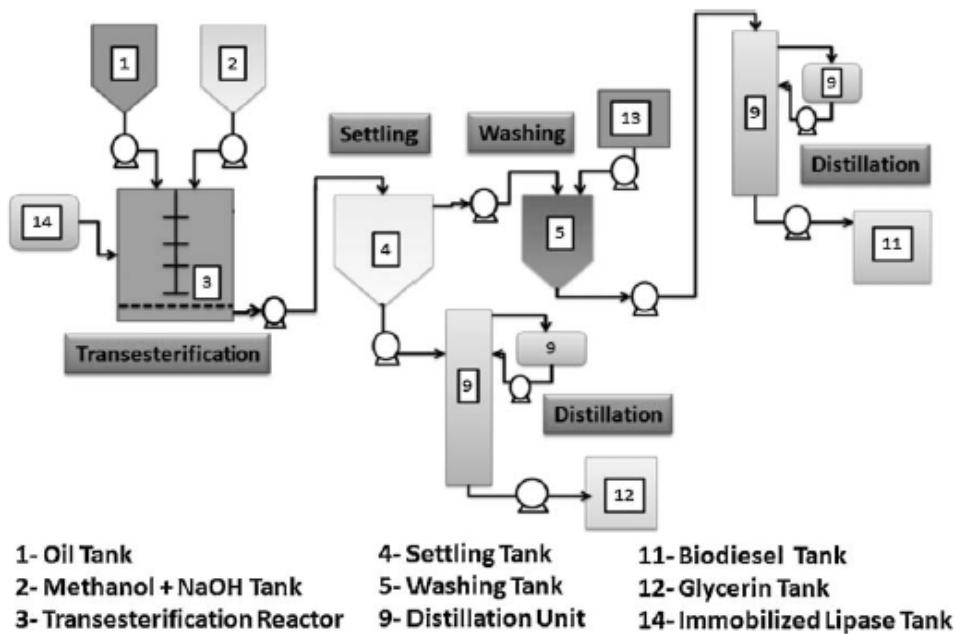


Fig. 3. Sketch of biodiesel production plant using immobilized lipase catalyst.

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Total plant investment costs for biodiesel production with a capacity of 1000tonne using different catalytic processes.

Equipment	100 (%)	633,871	992,327	996,327
Installation	10	63387.1	99232.7	99632.7
Piping	30	190161.3	297698.1	298898.1
Insulation and painting	5	31693.55	49616.35	49816.35
Civil and structure	70	443709.7	694628.9	697428.9
Electric and instrumentation	35	221854.9	347314.5	348714.5
Computer system	25	158467.8	248081.8	249081.8
Engineering and supervising	36	228193.6	357237.7	358677.7
General	22	139451.6	218311.9	219191.9
Plant cost	333%	2,110,790	3,304,449	3,317,769

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Manufacturing costs for biodiesel production.

Expenses	Price (\$)	Alkali catalyst		Soluble enzyme catalyst		Immobilized enzyme catalyst	
		Quantity	Cost	Quantity	Cost	Quantity	Cost
Raw material							
Palm oil	0.56/kg	995	557.2	995	557.2	1050	588
Methanol	0.45/Kg	263	118.35	263	118.35	263	118.35
Tap water	2.27/tonne	147	2.27	130	2.27	130	2.27
Sodium hydroxide	1.82/kg	10	18.2				
HCl	2/kg	38	76				
Lipase	150/kg			40	6000	8	1200
κ-Carrageenan	10/kg					10	60
KCl	1.8/kg					3	5.4
Utilities							
Steam	0.0227/kg	1820	41.314	1000	22.7	1100	24.97
Electricity	0.136/kW h	8.6	1.1696	5	0.68	5	0.68
Manpower		8	300	8	300	8	300
Total			1114.50		7001.2		2299.67
Byproducts							
Glycerol	2/kg	50	100	100	200	100	200
Total	100%		1014.50		6801.2		2099.67
Depreciation	9%		91.30		612.10		188.93
Repair	3%		30.43		204.03		62.99
Interest and tax	3%		30.43		204.03		62.99
Total			1166.67		7821.37		2414.63

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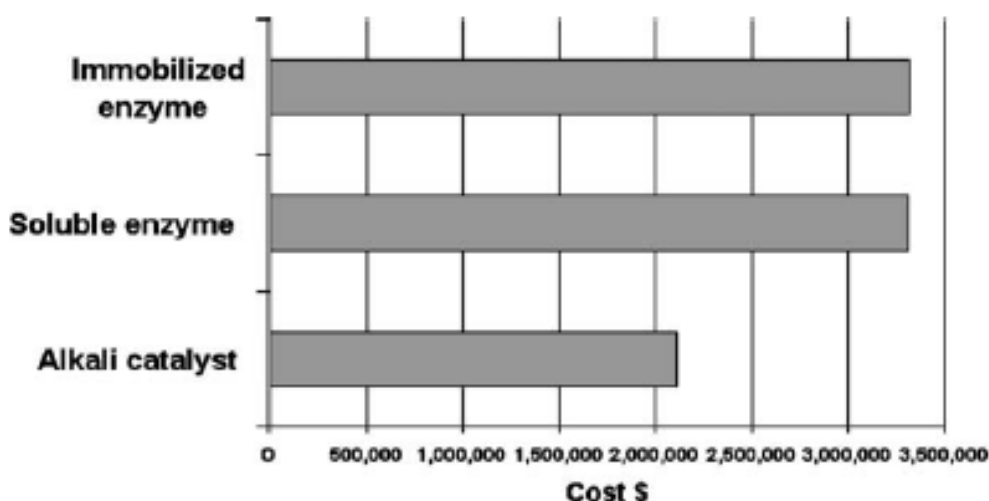


Fig. 7. Plant investment costs for 1000 tonne capacity biodiesel production.

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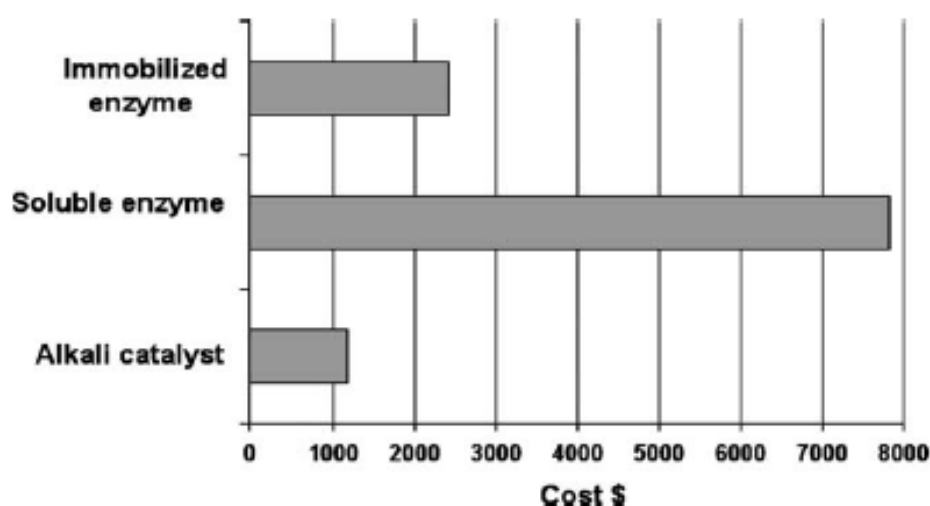


Fig. 8. Manufacturing costs for 1 tonne capacity biodiesel production.

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- **Energy Policy Act (Energy Conservation Reauthorization Act of 1998)**
 - Reduce nations dependency on foreign oil
 - Requires certain fleets to acquire AFVs
 - Credits rewarded for acquisition of AFVs and biodiesel
- **Biodiesel Tax Incentive**
 - Several grant programs
 - Tax credits for blending biodiesel
 - Investment opportunities in certain refueling infrastructure

