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Production of Biodiesel in Pakistan

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ABSTRACT

The article presents the results of a study undertaken on economic viability of production of biodiesel and its acceptability in Pakistan. The secondary data regarding the possibility of production of biodiesel in Pakistan was collected by consultation of literature in different libraries such as D.H.A Library, LUMS Library, and the Libraries and Teaching Resource Centers of Lahore School of Economics. Secondary data was also collected from the material published by concerned establishments and by visiting various websites on Internet. The data gathered from different sources were processed to design alternative projects that were subsequently appraised to determine their Benefit to Cost (B/C) Ratio , Net Present Value (NPV) and Pay Back period (PBP). All the alternatives turned out to be technically sound and economically viable as B/C all evaluations was more than one, NPV was positive and PBP was relatively small.

INTRODUCTION

Biofuels are fuels that are produced from biomass and include ethanol, biodiesel, methanol, etc. These are source of 'fuel' for several industries in solid, liquid or gaseous forms. The main attraction in use of biofuel is that it is 'environment friendly' and 'cost effectiveness. For instance, by using bio fuels we reduce Carbon emissions (smoke, CO, CO_2, etc.) emissions which are harmful for the environment. They do not add carbon to the atmosphere to increase its concentration beyond the permitted level.

Research on biodiesel is being conducted extensively both in the world since Rudolf Diesel designed his prototype diesel engine nearly a century ago. He ran it on peanut oil and envisioned that diesel engines would operate on a variety of vegetable oils. When petroleum-based diesel fuel hit the markets, it was cheap, reasonably efficient, and readily available, and therefore quickly became the diesel fuel of choice. In the mid 1970s, fuel shortages enhanced interest in diversifying the fuel resources, and thus prompted action in development of biodiesel as an alternative to petroleum diesel. At present, the biodiesel use is growing rapidly with additional production capacity available to quickly accommodate further growth. USA is an important example where producers use mostly soy oil and recycled cooking oils. The research for new resources is also simultaneously in progress and in constant review. A few pieces of work are quoted below.

Schumacher and Howell [1] (1994) examined the effect of biodiesel and biodiesel blends on the life of the injection pump and related fuel system components. They concluded that the use of biodiesel should be considered to prevent premature failure of injection pump components. Schumacher, et al [2] (1996) provided an overview of the need for a systematic and sustained approach to conduct biodiesel research. The main variables the writer focused upon were biodiesel, biodiesel blends, diesel, and material compatibility. Schumacher [3] (1997) collected the qualitative and quantitative biodiesel fueling performance and operational data from urban mass transit buses and also collected other than that engine exhaust emission data to provide input into a comprehensive report on alternative fuels. Schumacher and Gerpen [4] (1998) reviewed the real world data collected during the years 1991 – 1995 concerning the fueling of diesel powered vehicles with 100% biodiesel and blends of biodiesel with diesel to identify the recurring issues arising from research that must be resolved before biodiesel could be commercialized on a large scale. Schumacher et al,[5] (1999) evaluated the use of the SVO additive to enhance the cold weather functionality of biodiesel. They concluded that adding the SVO product appeared to increase the centistokes value of the biodiesel blends tested. Fangrui, et al [6](1999) reviewed the status of biodiesel and described how biodiesel had become more attractive than before, and how the cost of production was playing a negative role in the commercialization of bio diesel. Ericsson and Nilsson [7](2004) collected key data related to the Swedish biofuel import and analyzed it from the view of Swedish demand and supply in the Baltic countries as well as supply from Germany or the Netherlands. The authors concluded that the Swedish imports of biofuel illustrated a situation that based on a set of different driving forces working in parallel between Sweden and the exporting countries. Similar studies were conducted by Domac and Richards,Segon [8] (2005) and Kampman, and Croezen [9](2005) on biomass utilization, bio energy technologies, their market share and research interests varying between different countries. Meyer and Thompson [10] (2007) stated that biofuels already held a prominent position in 2007 farm bill debate. The analysis sought contributed to literature in wo ways. It provided perspective on the degree of biofuels dependence on the tax credit and tariffs, and described the impact of discontinuing biofuel subsidies and ethanol import tariff on commodity markets, government costs, and farm income.

Pakistan, due to biodiesal being environment friendly and its likelihood of production from the biomass of the solid waste of different origins, has also joined this hunt for biofuels and as it seems more appropriate to produce biodiesel locally instead of importing it from abroad. As the world oil prices are constantly rising, introducing biodiesel in Pakistan would definitely add value to the Pakistan economy. Thus the aim of the work reported here was to look into whether it is technically and economically possible to produce biodiesel in Pakistan and substitute it as an alternative fuel under the import substitution policy. The objectives of work were as follows:

1. Computation of import statistics of Biofuels.

2. Identification of scale of production.

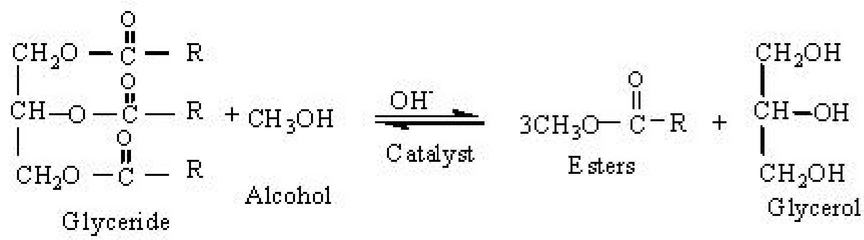
3. Planning and designing of a plant for production of biodiesel in Lahore (Pakistan)

4. Evaluation to judge the project’s technical soundness and economic viabilility

MATERIALS AND METHODS

There are primarily three types of biofuel: biogas, biomass and biodiesel. Here the choice of enquiry was biodiesel that is a clean burning alternative fuel, produced from domestically grown, renewable resources. It has no sulfur like impurities in it. However, fossil diesel can be added to it to make a blend of biodiesel. Biodiesel process applied to produce biodiesel on industrial level is called ‘Transestrification’ because biodiesel is manufactured by reacting vegetable oils with methanol, or ethanol.

Biodiesel is methyl (ethyl) ester derived from esterification of vegetable oils. The process of transesterification is illustrated with the chemical equation as under:



To produce it, it methanol (or ethanol) is added to vegetable oil in ratio 1:9 together with a small amount of basic or acidic catalyst and the mix is processed in a reactor (BIOSTRIM-Fig 1) Manufacturing of biodiesel requires 3 ingredients: feedstock (including) all vegetable oils, new or used, and animal fats, methanol and NaOH (Caustic soda) or KOH (Caustic potash). As used cooking oil or animal fat is the cheapest feedstock source, it is used as raw material. In most cases, a restaurant will be happy to simply provide their used oil, since they would otherwise have to pay to dispose it off. . However, there is a hierarchy of preference for used vegetable oil a under:.

1. Only vegetables (fries, tempura, etc.)
2. Fish
3. Chicken
4. Beef
5. Tallow

The production line is shown with the help of the flow sheet diagram of the process and sub-processes outlined in the form of notes.

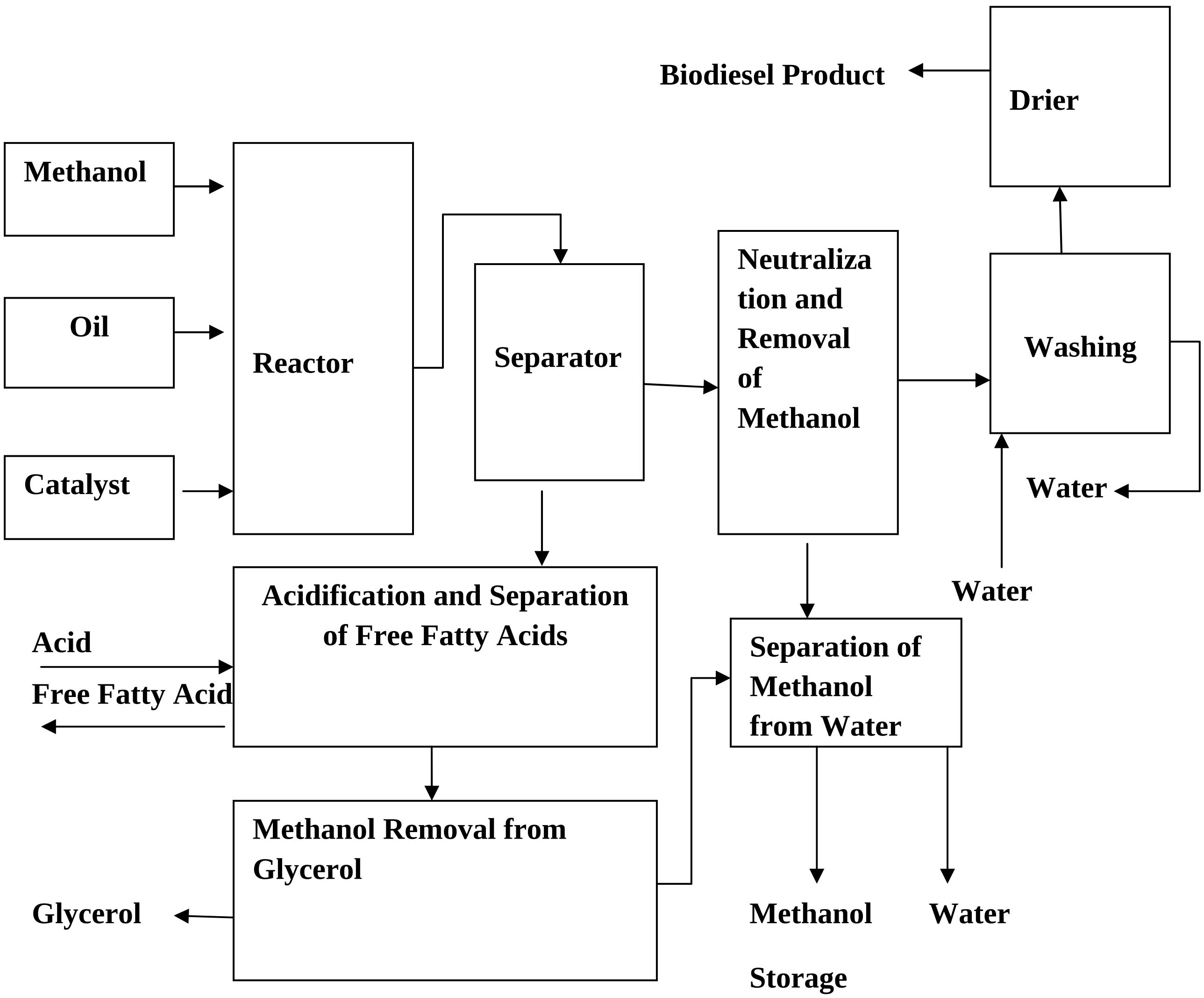


Fig. 1: Flow sheet for manufacturing biodiesel from feedstock oil

1. Basic inputs (vegetable oil, alcohol and catalyst) are transferred from storage tanks by the electric pumps in the reactor.
2. The volume of the input liquids is tracked by the special sensors and a system of electric valves. The operator can quickly change the percentage of the base materials in “online” mode.
3. If a batching system is used the preliminary intensive mixing of all the components takes place with a special device and then the mixture is transferred into the reactor. Processing in the reactor is also called cavitation.

4. After cavitation processing, the mixture is put into a separation column through a special stabilizer preventing mixing of the newly input mixture with the layers which have already been separated.

5. Separated biodiesel fuel goes up the column and is tracked by a sensor.

6. Separated glycerin goes down the column and is also tracked by a sensor.

7. The ready biodiesel fuel and glycerin discharge is carried out through electric valves operated by sensors which track both the quality and volume of the product.

The output products of such reaction are biodiesel and technical glycerol. Both products are highly in demand in today's biofuel market. Furthermore, glycerol can be used for heating boilers due to its excellent high-energy value and also finds an extensive use in medicine.

The characteristics of biodiesel to be produced are computed in Table 1:

Table 1: Characteristics of biodiesel to be produced

Parameter	ASTM D-6751	EN 14214	sample of biodiesel From Biostrim
Methyl ester content	-	>96,5	97
Density (at 15°C)	-	860-900	885
Viscosity (at 40°C)	1,9-6,0	3,5-5,0	4,67
Flashpoint, °C >	>130	>120	130
Sulfur, mg/kg	<0,05 (%)	<10	9
Cetane number	>47	>51	51
Sulfated ash, % (m/m)	<0,02	<0,02	0,0078
Water , %	<0,05	<0,05	absent
Cu-Corros.	<No.3	Class 1	passed
Acid value, mgKOH/g	-	<0,2	0,25
Methanol, % (m/m	-	<0,8	0,7
Monoglyceride, % (m/m	-	<0,2	0,2
Diglyceride, % (m/m)	-	<0,2	0,2
Triglyceride, % (m/m)	<0,02	<0,02	0,05
Free glycerinl, % (m/m)	<0.24	<0,25	0,25
Total glycerol content, % (m/m)	-	<120	61
Iodine number	<0,001%	<10	6,2
Phosphor, mg/kg	-	<5,0	5,0
Group I metals (Na,K)	-	<5,0	0,8
Group II metals (Ca, Mg	-	0,3	0,014

Collection of Data

As there was no establishment producing biodiesel in or near Lahore, the work was totally based on secondary data. There are a number of concerns who are exporting used cooking oils even the one for manufacture of biodiesel which can be contacted through Alibaba.com through Internet.

One of these suppliers claims to be capable of supplying 20,000 tons per day for export anywhere in the world at the cost of $250 to 300 per metric ton. Due to the used cooking oil being illegal for reuse, it is either thrown in the drains by the frying business or reused violating the law of land, it can be directly collected even free of cost from frying businesses. As here projection is at the scale 1000 kg per hour (24 metric tons per day), much more than the required raw material is available in Pakistan to safely install biodiesel industry in Pakistan. Worst come worst it can be supplied at this scale just by one supplier of Pakistan capable of supplying 20,000used cooking oil for biodiesel per day at the cost of $ 250 to 300 per metric ton (http://www.alibaba.com/product-detail/Used-cooking-oil-for-Biodiesel_157484137.html). Here, of course, the project has been based on free pf cost collected oil from the frying businesses.

Processing of the Data

The collected data was processed after designing the project at an industrial scale and subsequent cost analysis was carried out by the application of discounted cash flow techniques followed by Asian Development Bank (2001 and 2003,). The methodology of cost analysis is given below.

Interpretation of Results

The results obtained in the form of Benefit to Cost Ratio (BSR), Net Present Value (NPV) and Payback Period was interpreted on the basis of the criteria of acceptability of the projects under appraisal. If BCR is more than 1, NPV is positive and PBP is small, the project is accepted. Otherwise, it is rejected provided it is not a priority project falling in the category of a social obligation.

COST ANALYSIS

The project analysis was based on the project assumption given below (ADB, 2001 and 2003)

Project life: 10 years

Base year: 2008

Financial Year: July 1 to June 30

Discount rate: 10%

Different cost components responsible for adding value to both expenditure and return steams are outlined below.

Initial Fixed Investment

It included cost of land, building, machinery, equipment etc.

Land: The current price of land in Kot Lakhpat the installation site was asked from estate agents in the market. It had the components given below.

Total Area: 4,047 m^2

Constructed Area: 2,529 m^2

Open Space: 1,518 m^2

Cost of land/m^2: $ 164.73
Cost of land/acre: $ 666,667

Building: The area of the building was calculated on the basis of dimensions of the machinery to be installed which was collected from machinery manufacturers. The cost of construction per unit such as square foot or square meter was asked from the contractors involved in the construction business. It was approximately 59.31 per square meter in Lahore market.

Cost / m^2 = $ 59.31
Total cost of construction = 2,529 × $ 59.31 = $ 150,000

Installation costs: Free of Charge

Transport: The transport costs are shown in Table 2:

Table 2: Transportation Costs

Transport Type	Destination	Size	Total Number	Price -US$
Ocean Freight	**U.K to Karachi**	**20' / Container**	**2**	**4,000**
Cartage	**Karachi to Lahore**	**20'/ Container**	**2**	**1,500**
Total				**5,500**

Total cost of Transport: US$ 5,500

Table 3: Plant Machinery and Equipment

Plant Machinery & Equipment	Capacity	Quantity	Cost-US$
Fully Automatic Units "Biostrim"	1000 Liter/hr	1	**$ 310,087.5**

Storage Tanks	25 Tons	5	**13,333.33**
Magnetic-Impulse Cavitation Biostrim Reactor	500 Liter/hr	1	**58,628.98**
Total			**382,050**

Total cost of machinery and equipment = US$382,050

Pre Production Expenditure

It will take one full year to install the plant. Thus, the expenditures involved includes salaries of the staff and consultants, etc.

Consultant Fee: US$3333.33

Project Head: US$ 5,000/annum

Maintenance In charge: US$ 4,000/annum

Total pre-production expenditure = US$12,333.33

Total initial fixed investment (with Land) = US$(666,666.66 + 150,000+ 382,049.82 + $ 5500 + 12,333.33) = U$ 1,216,550

Total initial fixed investment (without Land) = US$(150,000+ 382,049.82 + $ 5500 + 12,333.33) = U$ 549,884

Operating Cost

Raw Material Cost: This included the cost of the crude vegetable oil taken from different sources such as hotels, restaurants, frying shops, etc. The cost was zero because they dispose it off as waste.

Cost of Other Inputs: Other cost elements are as under:

Cost of Electricity: The cost of electricity of the project is as follows

Table 4: Cost of electricity

	Per Hour	Number of Hours Operational	Number of Months Operational	Cost per Unit-US$	Total
Power	32 kW	16	12	7	218119.33

Total = US$ 21,827

Labor Cost: The nature and number of employees engaged to run the plant along with their salaries is as follows. This is shown in Table 5:

Table 5: Break Down of Labor and Labor Cost-US$

Labor	Number	Salary per Employee	Salary per Month
Technician	4	116.66	466.66
Tank Helpers	3	83.33	250
Electrician	3	116.66	350
Transport to Biofuel Storage	5	83.33	416.66

Total = Total =US $ 1483.33 /Month =US $ 17800/Annum

Maintenance Cost: The maintenance cost is calculated at the rate of 10% of the purchase price of machinery and equipment. Thus**,**

Maintenance cost = US$ 38,205

Depreciation: Both plant and machinery was depreciated on straight line basis at the rate of 10% of the purchase price.

Depreciation Cost = US$ 38,205

US$ Total operating cost/Annum = US$ (17,800+38,205+ 38,205 + 21,802.66) = US$ 116012.66

Expenditures in the Base Year

Initial Fixed Investment = US$ 1,216,550

Operating cost in base year = Nil

Total Expenditure/ Cash outlay = US$ 1,216,550

Expenditures in Future Years

Apart from the initial investment, no other capital expenditure is assumed over the project life under consideration. The operating cost in the base year (2008-2009) is nil. However, it is subject to alter with changes in labor costs, operating capacity, etc. the optimal plant capacity is said to be 80% of its plant capacity and does not intend to increase in near future. After every three years, it is predicted that the salaries of labor are subject to an increase of 15% every year. Also there is a 10% increase in cost of utilities per annum.

The operating cost is calculated as below:

Years	**Calculation (Dollars)** **Operating cost = Cost of [(Labor) + (Maintenance & depreciation)+(Utilities and Chemicals)**	**Operating Cost**

2008-2009	**0**	**0**
2009-2010	**17800+ 64684.16+ 23982.9**	**106467.1**
2010-2011	**17800+ 64684.16+26381.23**	**108865.4**
2011-2012	**17800+ 64684.16+29019.35**	**111503.51**
2012-2013	**20470+ 64684.16+31921.283**	**117075.45**
2013-2014	**20470+ 64684.16+ 35113.416**	**120267.583**
2014-2015	**20470+ 64684.16+ 38624.76**	**123778.93**
2015-2016	**23540.5 + 64684.16+ 42487.25**	**130711.91**
2016-2017	**23540.5 + 64684.16+ 46735.983**	**134960.65**
2017-2018	**23540.5 + 64684.16+ 51409.583**	**139634.25**
2018-2019	**27071.56 + 64684.16+ 56550.55**	**148306.283**

Table 6: Operating cost over 10 years

Table 6: Total Operating Costs Discounted at 10% to the base year

Years	***Calculation***	***Operating Cost –***

		US$
2008-2009	0	0
2009-2010	106467.1*0.01515	94796.733
2010-2011	108865.4*0.01376	86140.916
2011-2012	111503.516*0.012516	78319.416
2012-2013	117075.45*0.011383	73051.516
2013-2014	120267.583*0.01035	66420.2
2014-2015	123778.93*0.0094	60323.65
2015-2016	130711.916*0.00855	56444.0166
2016-2017	134960.65*0.0077833	51382.76
2017-2018	1396342*0.007066	46651.583
2018-2019	148306.283*0.006433	43833.55
	Present Value Of Operating Costs	$ 476426.7

Benefits:

The benefits were calculated on the basis of the following assumptions:

Sales price of Biodiesel = Rs 25 / Litre

(The prices were converted from the USA Biodiesel price that forms 50 percent of diesel price in Pakistan in June 2008.)

Process requisites were as given below

Installed Capacity: 1000 Litre/ Hour

Production Capacity (80 percent) = 800 Litre/Hour

Number of hours Operational = 16 Hour/Day

Return per Annum = (13.34*0.267*6)* 0.4167 = $ 1920000

Benefits Discounted to the Base Year

The revenues return from Biodiesel plants are in the form of constant periodic cash flows of $ 1920000 the total receipts after discounting at 10% can be calculated by applying annuity table. Thus, Present value of $ 0.0167 received constantly per annum for 10 years at 10% discount rate = $ 0.1024095 (From annuity tables).

$ 1920000* 0.1024095= $ 11797574.4

Present value of the Benefits = $ 11797574.4

Scrap Value of the Machinery and Equipment

The residual value of the machinery and equipment at the end of the project life is estimated at 10% of the purchase price.

- **Therefore, the worth asset at which it can be sold or the disposed off will be: Scrap value = $ 38204.983**

Benefits Discounted to the Base Year

The revenues return from Biodiesel plants are in the form of constant periodic cash flows of Rs. 115,200,000 the total receipts after discounting at 10% can be calculated by applying annuity table. Thus, Present value of Rs 1 received constantly per annum for 10 years at 10% discount rate = Rs. 6.14457 (From annuity tables).

Rs 115,200,000 * 6.14457 = **Rs. 707,854,464**

Present value of the Benefits = **Rs. 707,854,464**

Scrap Value of the Machinery and Equipment

The residual value of the machinery and equipment at the end of the project life is estimated at 10% of the purchase price.

Therefore, the worth asset at which it can be sold or the disposed off will be:
Scrap value = Rs. 2,292,299

TOTAL EXPENDITURES AND TOTAL RETURNS DISCOUNTED TO BASE YEAR

Present value of cash outlays = Initial Fixed Investment + Operating Cost

Initial Fixed Investment = $ 1216549.816

Operating Cost-year (2008-2009) = Nil

Present value of operating cost = $ 1216549.816

Present value of Cash outlays = (1216549.81+476426.7) = $ 1692976.516

Returns = Savings + Scrap value

Present Value of Returns = $ 11797574.4

Present Value of Scrap = $ 38205 * 0.006425716 = $ 14729.67

Present Value of Cash Flows (Benefits) = $ (11797574.4+14729.67) = $ 11812304.067

<u>Alternative: 1 (With Biostrim 1000)</u>

$$\textbf{Benefit / Cost (B/C) Ratio} = \frac{\textbf{Present value of benefits}}{\textbf{Present Value Cost}}$$

= 11812304.06 / 1692976.516 = 8.9

Net Present Value = $ 10119327.55

$$\textbf{Payback Period} = \frac{\textbf{Total Investment}}{\textbf{Annual Return}} = \textbf{1216549.816/ 1920000 = 0.63 Years}$$

Alternative: 2 (With Biostrim 500)

Initial Fixed Investment

It included cost of land, building, machinery, equipment etc.

Land: The current price of land in Kot Lakhpat was asked from estate agent in the market. It had the components given below.

Total Area: 1 Acre or 8 Kanal

Constructed Area: 5 Kanal

Open Space: 3 Kanal

Cost of Land: Rs 5,000,000 per Kanal

Cost of Land: Rs 40,000,000

Building: The area of the building was calculated on the basis of dimensions of the machinery to be installed which was collected from machinery manufacturers. The cost of construction per unit such as square foot or square meter was asked from the contractors involved in the construction business. It was approximately Rs 400 per square foot in Lahore market.

Total Cost of Construction= 5×4,500×400= Rs. 9,000,000

Installation costs: Free of Charge

Transport:

Table 8: Transportation Costs

Transport Type	Destination	Size	Total Number	Price
Ocean Freight	**U.K to Karachi**	**20’ / Container**	**2**	**Rs. 240,000**
Cartage	**Karachi to Lahore**	**20’/ Container**	**2**	**Rs. 90,000**
Total				**Rs. 330,000**

Total cost of Transport: Rs. 330,000

Table 9: Plant Machinery and Equipment

Plant Machinery & Equipment	Capacity	Quantity	Cost
Fully Automatic Units “Biostrim”	500 Liter/hr	1	Rs.12,512,127
Storage Tanks	25 Tons	5	Rs. 800,000
Magnetic-Impulse Cavitation Biostrim Reactor	500 Liter/hr	1	Rs. 3,517,739
Total			**Rs.16,829,866**

Total cost of machinery and equipment = Rs. 16,829,866

Pre Production Expenditure:

It will take one full year to install the plant. Thus, the expenditures involved includes salaries of the staff and consultants, etc.

Consultant Fee: Rs.200, 000/annum

Project Head: Rs.300, 000/annum

Maintenance In charge: Rs.240, 000/annum

Total pre-production expenditure = Rs. 740,000

Total initial fixed investment (with Land) = Rs. (40,000,000 + 9,000,000 + Rs. 16,829,866 + 330,000) = Rs. 66,159,866

Operating Cost

Raw Material Cost: This included the cost of the crude vegetable oil taken from different sources such as hotels, restaurants, frying shops, etc. The cost was zero because they dispose it off as waste.

Cost of Other Inputs: Other cost elements are as under:

Cost of Electricity: The cost of electricity of the project is as in Table 10

Table 10: Cost of electricity

	Per Hour	*Number of Hours Operational*	*Number of Months Operational*	*Cost per Unit*	*Total*
Power	16 kW	16	12	7	Rs.654,080

Total = Rs.654,080 /Annum

Labor Cost: The nature and number of employees engaged to run the plant along with their salaries is as follows.

Table 11: Break Down of Labor and Labor Cost

Labor	*Number*	*Salary per Employee*	*Salary per Month*
Technician	4	7000	28000
Tank Helpers	3	5000	15000

Electrician	3	7000	21,000
Transport to Biofuel Storage	5	5000	25,000

Total = 89,000/Month

= 1,068,000/Annum

Maintenance Cost: The maintenance cost is calculated at the rate of 10% of the purchase price of machinery and equipment. Thus**,**

Maintenance cost = RS. 1,331,212

Depreciation: Both plant and machinery was depreciated on straight line basis at the rate of 10% of the purchase price.

Depreciation Cost = RS. 1,331,212

Total operating cost/Annum = Rs (1,068,000+1,331,212+ 1,331,212+ 654,080) =Rs.4,384,504

Expenditures in the Base Year

Initial Fixed Investment = Rs. 66,159,866

Operating cost = Nil

Total Expenditure = Rs. 66,159,866

Expenditures in Future Years:

Table 12: Operating cost over 10 years

Years	***Calculation (Rupees)*** ***Operating cost = Cost of (Labor + Utilities & Chemicals + Maintenance & depreciation***	***Operating Cost***
2008-2009	**0**	**0**
2009-2010	**1,068,000+ 2,662,424+654,080**	**4384504**

2010-2011	**1,068,000+ 2,662,424+719,488**	**4449912**
2011-2012	**1,068,000+ 2,662,424+791,437**	**4521861**
2012-2013	**1,228,200+ 2,662,424+870,581**	**4761205**
2013-2014	**1,228,200+ 2,662,424+957,639**	**4848263**
2014-2015	**1,228,200+ 2,662,424+ 1,053,403**	**4944027**
2015-2016	**1,412,430 + 2,662,424+ 1,158,743**	**5233597**
2016-2017	**1,412,430 + 2,662,424+ 1,274,617**	**5349471**
2017-2018	**1,412,430 + 2,662,424+1,402,079**	**5476933**
2018-2019	**1,624,294 + 2,662,424+1,542,287**	**5829005**

Table 13: Total Operating Costs Discounted at 10% to the base year

Years	*Calculation (Rupees)*	*Operating Cost*
2008-2009	**0**	**0**
2009-2010	**4384504*0.909**	**3985514**
2010-2011	**4449912*0.826**	**3675627**
2011-2012	**4521861*0.751**	**3395918**
2012-2013	**4761205*0.683**	**3251903**
2013-2014	**4848263*0.621**	**3010771**
2014-2015	**4944027*0.564**	**2788431**
2015-2016	**5233597*0.513**	**2684835**
2016-2017	**5349471*0.467**	**2498203**
2017-2018	**5476933*0.424**	**2322220**
2018-2019	**5829005*0.386**	**2249996**
	Present Value Of Operating Costs	**Rs. 29863418**

Benefits:

The benefits were calculated on the basis of the following assumptions:

1. Sales price of Biodiesel = 25 Rs/Litre
2. Process requisites were as given below

Capacity produced = 300 Litre/Hour

Number of hours Operational = 16 Hour/Day

Return per Annum = (300*16*360)* 25 = **Rs 43,200,000**

Benefits Discounted to the Base Year

The revenues return from Biodiesel plants are in the form of constant periodic cash flows of Rs. 201,600,000 the total receipts after discounting at 10% can be calculated by applying annuity table. Thus, Present value of Rs 1 received constantly per annum for 10 years at 10% discount rate = Rs. 6.14457 (From annuity tables).

Rs 43,200,000 * 6.14457 = **Rs. 265,445,424**

Present value of the Benefits = **Rs. 265,445,424**

Scrap Value of the Machinery and Equipment

The residual value of the machinery and equipment at the end of the project life is estimated at 10% of the purchase price.

Therefore, the worth asset at which it can be sold or the disposed off will be:
Scrap value = Rs. 16,829,87

<u>TOTAL EXPENDITURES AND TOTAL RETURNS DISCOUNTED TO BASE YEAR</u>

Present value of cash outlays = Initial Fixed Investment + Operating Cost

Initial Fixed Investment = **Rs. 66,159,866**

Operating Cost-year (2008-2009) = Nil

Present value of operating costs = **Rs. 29,863,418**

Present value of Cash outlays = (66,159,866 + 29,863,418) = **Rs. 96,023,284**

Returns = Savings + Scrap value

Present Value of Returns = **Rs. 265,445,424**

Present Value of Scrap = Rs. 16, 829, 87 * 0.385543 = **Rs. 648,864**

Present Value of Cash Flows (Benefits) = Rs. (265,445,424+648,864) = **Rs. 266,094,288**

$$\textbf{Benefit / Cost (B/C) Ratio} = \frac{\textit{Present Value of Benefits}}{\textbf{Present Value Cost}}$$

=Rs. 266,094,288 / 96,023,284

= 2.77

Net Present Value = Rs. 170,071,004

$$\textbf{Payback Period} = \frac{\textbf{Total Investment}}{\textbf{Annual Return}}$$

=Rs. 66,159,866 / Rs 266,094,288

= 0.24 Years

The above principles were applied to decide the status of different alternatives appraised here to judge their technical soundness and economic viability.

Alternative 1: The BCR in alternative 1 is 6.97; the NPV is $10,119,328 and payback period 0.63 years. Thus, the benefit cost ratio is more than 1, NPV also shows a positive value. Payback period of this alternative qualify the appraisal criteria. Thus, this alternative is feasible.

Chapter 5

RESULTS

As all the work is based upon secondary data collected through internet no descriptive research was involved. Thus, the results are reported only quantitatively. The results obtained on the basis of cost analysis are reported below. These are preceded by the criteria on the basis on which the project's technical soundness and economic viability/ acceptability were decided.

Benefit to Cost Ratio is one of the important criteria for grading a project as non-profitable, profitable or socially acceptable. The decision rule is that if it is more than 1, the project is profitable and thus acceptable. If it is less than one, it is non- profitable and thus not acceptable if it does not fall in the category of social obligations.

For Net Present Value or NPV of the Project the decision rule is that the project is acceptable if NPV is positive. If it is negative, then project is rejected provided it does not fall in the category of social obligations. Usually, the projects meant to produce products for sale for competing in the market are straight away rejected if the NPV is negative. Of course, these may be considered for acceptance if their social cost is high and that is in terms of general social benefits such as cleanliness of environment, response to a community need if no other appropriate source is available, creation of employment opportunities, etc.

Payback method suggests the shorter the time period the quicker the recovery of the investment in a project. It indicates how long does it take for the returns of a project to cover its initial costs. A long payback period is not very desirable.

The above principles were applied to decide the status of different alternatives appraised here to judge their technical soundness and economic viability.

Alternative 1: The BCR in alternative 1 is 6.97; the NPV is $10,119,328

with a payback period 0.63 years. Thus, the benefit cost ratio is more than 1, NPV also shows a positive value. Payback period of this alternative qualify the appraisal criteria. Thus, this alternative is feasible.

Alternative 2: The BCR in alternative 1 is **2.77**, the NPV is $**2834517** with a payback period of **0.24** years. Here again, the benefit cost ratio is more than 1, NPV also shows a positive value and the PBP of this alternative is less than even of the first alternative. Thus, this alternative is feasible as well.

Chapter 6

DISCUSSION:

The purpose of the work reported in this thesis was to find out whether it was feasible to produce Biodiesel power from crude and used vegetable oil and other waste oil resources. To this end we did not come across any study on this aspect, particularly in Pakistan. Thus, we had to start from the first principles to work out our project framework. In our discussion, we are in a position to compare different alternatives, but we can't compare any of our results with those of any of our predecessors.

The criteria parameters of all alternatives are compared in Table 9.

Table 14: Comparison of alternatives

	BCR	NPV	Payback period
Alternative 1	**6.97**	**Rs. 607,159,653**	**0.63**
Alternative 2	**2.77**	**170,071,004**	**0.24**

Comparing Alternative 1 and 2

The main difference between the two alternatives is simply the different scale of production of Biodiesel. The only difference it creates is in the initial investment cost, as the price of the units is different. The NPV with Biostrim 1000 turned out to be Rs. 607,159,653 where as the NPV with Biostrim 500 turned out to be Rs. 170,071,004. This shows clearly that, Biostrim 1000 provide the investment with a better opportunity to prosper in future.

The BCR of Biostrim 500 is 2.77 which is greater than one and is feasible enough to be accepted but the BCR with Biostrim 1000 is higher than this, i.e. 6.97. This shows that although producing with Biostrim 500 has a good enough BCR to start production, but with Biostrim 1000 FI has more benefits than costs too and the difference as compared to Biostrim 500 is just of 4.2.

The payback period of Biostrim 1000 turns out to be 0.63 years. And the payback period of Biostrim 500 is 0.24 years. Even though the payback period of Biostrim 500 is less, in both cases the costs are recovered within a year. Thus, the difference between the two is not a major factor in the decision process.

Hence, by every mean of calculation, production by Biostrim 1000 is a way better option than production through Biostrim 500. Of course, it is the market size that seems to be the major determinant of the choice between the two options. The principle of economy of scale works only if the market size is sufficiently receptive for the products.

Pakistan's net oil imports are forecasted to rise substantially in coming years as demand growth outpaces increases in production. The demand for refined petroleum products also exceeds domestic oil refining capacity; so nearly half of Pakistani oil imports are refined products. Pakistan’s largest port is located at Karachi, which serves as the principal entry point for oil imports. PSO leads Pakistan's fuel distribution market, with its main storage facilities located at Port Mohammed Bin Qasim. Thus , biodiesel; produced by the process described in this thesis can play an important role as an import substitution product to save significant foreign exchange being spent on oil import.

Most diesel cars and machines built after 1995 are able to drive on 100% biodiesel. However, it is best to check with the vehicle manufacturer. Thus, the applicability of bio diesel almost immediately is highly probable. The current Price of Diesel is approximately Rs.66. While the selling price of Bio diesel will be Rs.25. which is less than half of the sales price of diesel. Thus, the demand of such a cheap fuel would positively increase. Bio diesel is by far the best alternative to other fuels currently in use. It is cheap, reliable and does not need any change of equipment.

The major benefit associated with the substitution of fossil fuels with biodiesel is that it will liberate far less gaseous pollutants in the air and thus the quality of air in Pakistan will improve as the motor vehicles are major polluting agents all over the globe.

Last but not the least it sounds appropriate tom to give some suggestions to extend the project. After going through the enquiry, we feel that the piece of work reported here can be extended on the following lines;

- Social benefit-cost analysis may be carried out to compare social benefits of use of biodiesel with the use of fuels currently in use. If social benefits are determined, there is the likelihood that Socio-economic Benefit to Cost Ratio may turn out to be many fold of BCR reported here. Carrying out such a work will create attraction in substitution of currently used imported fuels by biodiesel.
- A champagne may be lodged to enhance research in the field of import substitution appraisal. Promising products that can substitute imported stuff in Pakistan may be scheduled for techno-economic enquiry to decide how these can be produced and how much foreign exchange these can save after substitution.

CONCLUSIVE REMARKS AND RECOMMENDATIONS

The results of the study are very favorable to the aspect that the production of Bio diesel should start in Pakistan. It can either be with the less production (Biostrim 500) or with (Biostrim 1000) for large scale production. This project is a good investment for any investor as well as it is a beneficial idea for the Government of Pakistan to carry out.

There is one crucial aspect related to the launch of the product and that is that the product should be marketed in such a way that it gives the image of a "Cheaper Alternatives in Pakistan".

This research covers the financial aspects of producing Biodiesel in Pakistan. However production of Biodiesel has a lot of socio-economic benefits. How many? is the question to be answered. The research work on different facets of the project to answer this question has been left for our successors.

This study has turned out to be a success in terms of achieving positive results for the desired query, due to which this gap in the market can be catered so that financial benefits may be gained by the entrepreneur and economic benefits may be transferred to the nation.

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Biodiesel production: a review

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