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Production of Thermoelectric Power from the Solid Waste of Gulberg Lahore Pakistan

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Abstract

The work reported in this article was undertaken to study the viability of production of thermoelectric power by incineration of solid waste of Gulberg I, II and III, a posh locality of Lahore, Pakistan. Primary data concerning the production and disposal of solid waste were collected from Lahore Development Authority and the Environmental Protection Department Government of the Punjab. The primary data concerning the production of thermoelectric power from the solid waste such as bagasse were collected by visiting Pattoki Sugar Mills and the prices of machinery and equipment were supplied by the Mill authorities that were verified by visiting the websites of different local manufacturing companies and through telephonic contacts with them. The secondary data was collected from libraries, published materials by concerned establishments, and websites on the Internet. The data were processed to design projects that were subsequently appraised to determine its Benefit to Cost (B/C) Ratio, Net Present Value (NPV) and payback period (PBP). The results indicate that Gulberg I, II and III currently produce about 278,644 Kilograms per annum of solid waste from which 80,756,715 kWh electricity can be produced /annum and The cost analysis and the appraisal of the alternatives, led to the conclusion that the installation of the thermoelectric power plant for generating electricity to meet at least the local demand of Gulberg is feasible.

Keywords: Thermoelectric, Power, Solid, Waste, Gulberg, Lahore

1. Introduction

Electricity is an important commodity, and as the world's population grows, the need for electricity will also grow. World consumption of electricity is expected to grow double over the next 30 years and the increase in demand has dictated search for its new resources and technologies that has translated into the change over from hydraulic to nuclear as a feature of present. Currently about 1 billion consumers around the world depend on nuclear electricity for some of their power needs, yet there are still about 2 billion people living in under-developed countries including Pakistan who are alarmingly deficient in electricity. The energy situation has been recently reviewed by IAEA and ONEA [1] and jointly documented in the form of report; Uranium 2011: Resources, Production and Demand. The report says that although the current situation of demand and supply of uranium in the international market is satisfactory, yet its future is highly uncertain due to two basic reasons: 1) environmental problems brought into limelight by some recent nuclear accidents;2) hesitant investment due to abnormal current and future expected increase in uranium prices. Because of such like uncertainties and other factors the production of electricity from renewable resources including no cost material such as solid waste is expected to be a feature of the future.

An adequate potential of production of electricity from solid waste exists in Pakistan. A figure of 47,920 tons of solid waste per day (urban waste: 19,920 tons rural: 28,730 tons) was recorded from the National Conservation Strategy [2]. Collection efficiency of solid waste is about 54% in the urban centers. A total of 9,856 surveys showed that the industries were generating 21,175 tons of waste. These included wastes from chemicals, fertilizers, tanneries and textile units. Since no city has proper waste collection and disposal system for municipal or hazardous waste, land in urban areas is getting polluted adversely affecting public health. Some studies on thermoelectric power from solid waste have been undertaken in foreign countries. A brief account of these studies is given below.

Barry [3] reviewed a study on waste heat utilization and discussed about waste heat utilization and claimed that as a mean of conserving energy was not a new concept, but the incentive to implement programs was new. Lincoln [4] also reviewed energy conservation and concluded that that the human race could no longer afford ignoring serious potential consequences of their lavish use of energy. If they continued, they would disturb both national security and balance of payments. Frank [5] reviewed thermal pollution consequences in the implementation of the President's energy message on increased coal utilization and warned about its consequences. Waldrop [6] reviewed wood as a fuel of future and suggested that it could be a significant energy source but even this source was not without environment hazards. Marlay [7] conducted a study on trends in industrial use of energy and explained that a part of the reduction resulted from improvements in the efficiency of industrial process technologies. Kajikawa [8] reviewed the status and future prospects of thermoelectric power generation systems to recover electricity from this heat source in Japan. The researcher introduced experimental results on three types of small-scale thermoelectric power generation systems used in the real municipal solid waste processing systems to show the technological feasibility and determine technological problems. A report of Swedish Association of Public Cleansing and Solid Waste Management loaded by Rylander [9] on its website claims that the ongoing treatments of solid waste were not adequate because not required amount of waste was left for incinerators to operate for heat recovery and power production. Whittington [10] stated that in terms of different renewable options available, wind energy could be seen as a short-to-medium-term replacement of thermal plants. Carbo [11] reviewed the market for Municipal Solid Waste Management Equipment in Colombia and reported that Colombia produced over 5.1 million tons of solid waste annually.

Some experts such as Khan and associates in Pakistan have undertaken some studies to combine environmental problems with economic problems via techno-economic disposal of solid waste. The major reference here may be the production of thermo-electric power from solid waste of four educational institutions: Lahore School of Economics, Lahore University of Management Sciences, Government College University Lahore, and Kinnaird College Lahore . Most of the work has been published in prestigious journals [12]-[13] or presented in international conferences [14] This work reported here was undertaken, to extend the techno economic exploitation of solid waste for the production of electric power and its economic disposal at higher levels: village, urban colony, city, etc. Other parallel studies conducted at higher level subsequently published are those by Khan [15] and Khan and associates [16]-[19]]. All these studies conclude that there is a significant potential of production of electricity from solid waste in Pakistan.

The major goal of this study was to explore an alternative source of thermoelectric power by studying the feasibility of production of electricity from solid waste of a model urban locality, Gulberg. The objectives of this research were as follows:

- To assess the amount of solid waste produced by a model urban locality with special reference to production of electricity.
- To explore a method for safe and techno-economic disposal of Gulberg's solid waste.
- To check whether this project is cost effective or not.
- To study whether the production of thermo-electric power from the biomass of solid waste of Gulberg is technically sound.
- To make recommendations to the concerned agencies for effective solid waste management.

2. Methodology of Research

Collection of Primary Data: The primary data was collected interviewing the heads of different departments of Lahore Development Authority (LDA) and Environmental Protection Department (EPD) for record of development/environmental issues, and information regarding the collection /dumping points of solid waste and gathering responses of labor, estate agents and dump collectors to the questionnaire. The EPD also guided in selecting the safest place to set up thermo electric plants. The Lahore Electric Supply Company's Revenue Department was contacted for the bills paid by the consumers from which total consumption of electricity per annum by the colony was calculated. The sugar mills of Pakistan being practitioners in production of electricity from bagasse were visited to supply and elaborate on the technology involved. The machinery manufacturers were visited to get exact prices of machinery and equipment such as boilers, turbines, etc. Alternately the websites of machinery manufacturers were visited to have the up to date prices of the machinery and equipment.

Collection of Secondary Data: The secondary data about disposal of solid waste and production of thermoelectric power from its biomass was collected from Lahore Metropolitan Corporation- (LMC), EPD, by consultation of literature in different libraries and from the published material by different people who have recently done work in this field and by visiting various websites on Internet. The data were also collected from Pakistan Energy Yearbook prepared by the Hydrocarbon Development Institute of Pakistan.

Processing of Data: The data collected from different establishments were processed for designing project at the scale of Gulburg solid waste. The responses through questionnaires were analyzed to compute the requisite information. The main points of focus were total solid waste and its burnable component, composition and nature of the solid waste produced at each site. The average heating value of total weight formed the basis of the calculation of its potential to produce electricity.

The solid waste produced at different sites is computed in Table1.

Table 1: The details of the solid wastes produced and disposed at different sites

Sites	**Solid waste produced per day (metric ton)**	**Solid waste produced per month (metric ton)**	**Solid waste produced per annum (metric ton)**
M. M. Alam Road	56	1680	20160
Mini Market	15	450	5400
Main Market	35	1050	12600
Liberty Market	94	2820	33840
Pace	20	600	7200
Al Fatah	14	420	5040
Residential area	240	7200	86400
Firdos Market	50	1500	18000
Gadafi Stadium	30	900	10800
Total			**278640**

Source: Lahore Metropolitan Corporation

Table 2: Physical composition of Solid Waste

Series No.	Description	% Weight	Metric tons per day
1	Vegetables & fruit residuals	29	1508
2	Paper	3	201
3	Plastic & rubber	6	1506
4	leaves, grass, straws. etc	19	1140
5	Rags	7	966
6	Wood	2	200
7	Bones	1.5	150
8	Animal waste	3	432
9	Glass	1	0
10	Metals	0.5	82.5
11	Dust, air, ashes. stones. Bricks, etc	27.99	0
12	Unclassified	0.01	0
	Total	**100**	6185.5

Source: Lahore Metropolitan Corporation

The expenditure on purchase of electric power from Lahore Electric Company (LESCO) by Gulberg is shown in Table 3.

Table 3: Fuel and power consumption in Gulberg over the last 4 years

Sr. No.	Year and point of time	Fuel and power consumption (thousand rupees)	Units Consumed (kWh) on the basis of Pak Rupees 6.5 / kWh
1	June 2004	84200	12,953,846
2	June 2005	99350	15,284,615
3	June 2006	105800	16,276,923
4	June 2007	125500	19,307,692

Average = Pak Rupees 103,712,500 Average consumption/annum= 103,712, 500/6.5= 15,955,769 kWh /Ann or 15,956 mwh/Ann or 55mwh /hr

Source: Lahore Electric Supply Company (LESCO)

Interpretation of Data: The collected data (Table 1 to 3) was used to cost design the project at the scale of Gulberg and subsequently the cost analysis was carried out as described in Appendix 1.

3. Results

The results calculated on two main bases have been presented. Firstly, the general information about the amount and nature of solid waste produced in Gulberg I, II and III has been compiled. Secondly, the quantitative aspects of solid waste concerning based on costs and benefits of the project have been reported.

Description of Gulberg: Lahore District is divided into 9 major towns of which one is Gulberg. Gulberg is further divided into Gulberg I, II and III. Gulberg is considered as one of the posh localities in Lahore. It is perhaps the oldest posh area of Lahore. The M. M. Alam Road, Mini Market, Main Market, Liberty Market, Pace, Al Fatah, Firdos Market, Gadafi Stadium and different residential areas all lie in the vast location of Gulberg I, II and III. All the areas mentioned above have different residential and commercial sites all producing waste every day.

Gulberg is an urban area where almost all the workers are skilled. Some of them are employed on permanent basis and others on temporary basis. Most of the workers in Gulberg are involved in profit based activities; meaning they own their own businesses or work in these businesses.

Nature and Composition of Solid Waste in Gulberg I, II and III: Gulberg I, II and III comprise of the main commercial and residential areas of Lahore. The solid waste produced in these areas is of vast sorts as it ranges from household waste to commercial waste. The household waste consists of items such as fruit shells, cardboard, packing boxes, paper waste and a lot more.

The total amount of waste produced has been calculated on daily basis. The main commercial area including the most well known restaurant street in Lahore is the M.M.Alam Road which produces a waste of 56 metric tons per day while the Mini market and the main market together produce 50 metric tons per day a day. A large amount of solid waste has always been expected from the Liberty Market because it has many retail outlets and fast food restaurants plus some fruit chat stalls that throw a large amount of fruit shells as rubbish and thus this site produces a total of 94 metric tons per day of solid waste per day.

The Al-fateh store and the Firdos Market combine to produce 1, 920 metric tons per day of solid waste per month, meaning the per annum waste is of 23,040 metric tons per day. The Gadafi Stadium with its restaurants produces a total waste of 30 metric tons a day, on a normal day. This amount is taken as an average because the amount of waste produced on the day of some cricket match is alone above waste of any other locality.

Despite all these commercial areas, the main portion of Gulberg comprises of the residential areas. Many societies and colonies fall in it. For example, Falcon Society, Askari Villas, and many other residences that fall in none of the societies but their areas belong to Gulberg I or Gulberg II. These areas contribute the largest amount of solid waste which is 240 metric tons per day.

Gulberg is currently consuming 55 mwh electricity out of which as the appraisal of this study indicates is that one sixth can be met from the powerhouse based on the solid waste.

Results of Cost Analysis: 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 untill 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 that the shorter the time period, quicker is 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 desirable.

Alternative 1: The B/C in alternative 1 is 4.95; the NPV is 43,025,824 with a payback period of 0.74 years. The benefit to cost ratio is more than 1, NPV shows a positive value and the Payback Period (PBP) of this alternative is very low. Keeping all these facts in mind this alternative is acceptable.

Alternative 2: The B/C in alternative 1 is 4.96; the NPV is US$43,042,263 with a PBP of 0.74 years. The B/C ratio is more than 1, NPV shows a positive value and PBP is very low. With reference to these indices this alternative is also acceptable.

Alternative 3: The B/C in alternative 1 is 5.59; the NPV is US$ 44,275,620 with a PBP of 0.58 years. Thus, the B/C ratio is more than 1, NPV has a positive value and PBP is even better. The project appraisal makes this alternative feasible.

Alternative 4: The B/C in alternative 1 is 5. 59, the NPV is US$ 44,276,720 with a payback period of 0.58 years. The benefit to cost ratio is more than 1, NPV is positive and payback period of this alternative is good. The evaluating technique makes this alternative feasible.

4. Discussion

The purpose of the work reported in this thesis was to find out whether it was feasible to produce thermo-electric power from the biomass of solid waste of Gulberg I, II and III or not. Till now, there is no published study regarding this aspect, particularly in Pakistan except those by our group. The involvement of sugar mills in this activity is being heard since long but there is no published study that could guide the research group to design and evaluate the projects discussed here. So the start was taken from a scratch to work out project framework. On the basis of empirical knowledge, the Pattoki Sugar Mill was approached for evaluation and subsequent comparison. Thus, in discussion, authors are in a position to compare different alternatives with their predecessors in Pakistan. Of all the alternatives evaluated are compared in Table 9

Table 9: Comparison of alternatives-US$

	BCR	NPV	Payback period
Alternative 1	4.95	43,025,824	0.74
Alternative 2	4.96	43,042,263	0.74
Alternative 3	5.59	44,275,620	0.58
Alternative 4	5.59	44,276,720	0.58

The comparison reveals that Alternative 1 and 2 are almost at par with each other on the basis of criteria of acceptability (B/C = 4.95 and 4.96, NPV= US$43,025,824/43,042,263 and PBP= 0.0.74). Alternative 3 and 4(B/ C = 5.59, NPV=44,275,620/44,276,720 and PBP= 0.53) are better than Alternative 1 and the overall grading of alternatives is as,

Alternative 4 > Alternative 3> Alterative 1 and 2 (At par).

As it can be deduced from the above alternatives that this project is feasible and beneficial because one sixth of the electricity consumption of the locality studied can be met from the powerhouse based on the solid waste produced by it. It should also be pointed out that, it can be made more attractive in future if the heating value of the waste is increased by introducing baggage system for separate collection of rubbish components. This way the materials which have no heating value can be separated from the biomass. This can be accomplished by the waste collecting authorities concerned with this assignment at different sites.

Installation of the plant proposed above for generating electric power by incineration of solid waste for Gulberg would bring many economic and social benefits. With the current power shortage situation in Pakistan such a project can help not only the present population but the future generations too by adding value to the national economy. Currently, the electricity consumption is very high as compared to the amount of electricity being produced; therefore almost 6 to 8 hours of load-shedding is being experienced by every citizen of Pakistan. Setting up a power plant would help the citizens living in Gulberg I, II and III to have a continuous supply of electricity from a local thermal power plant. Setting up this project plant will also create job opportunities for people and this can further affect the national income in a positive way. If such like plants are installed in most of the localities of different cities and towns of Pakistan a significant value can be added to GDP that can boost up accordingly.

The social benefits of setting up this power plant can be immense. Foremost is the reduction in environmental pollution. When the waste generated in Gulberg would be utilized to produce electricity, the overall environment would get better. Dumps of garbage would be removed systematically from dumping sites resulting in a cleaner environment. The whole system of waste disposal would get a boost. A neat and clean environment would mean a healthier nation due to prevention of many diseases that impact the public health.

Conclusion

Gulberg is currently consuming 55 mwh electricity out of which as the appraisal of this study indicates one sixth can be met from the powerhouse based on the solid waste. After the cost analysis and the appraisal of the alternatives, it may be concluded that the installation of the thermoelectric plant based on incineration of solid waste in Gulberg Lahore for generating electricity is feasible. Moreover, there are many social benefits attached with this project. By implementing it, Gulberg I, II and III would not only get a way of disposing its waste but it would also reduce solid waste pollution and all the hazards associated with other modes of disposals of solid waste.

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Appendix 1
COST ANALYSIS

The project analysis is based on the project assumptions given below:
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 streams are outlined below.
Initial Fixed Investment: It includes the cost of land, building, machinery, equipment, etc:
Land: The proposed site for the installation of thermoelectric power plant was LDA Avenue. The basis of its choice was that it is not in any commercial area and thus its price was reasonable. The market price of land as asked from the estate agents. The cost of land was calculated as under:
Area required = 20,235 m^2
Constructed area = 12,141 m^2
Cost of land/m^2= US$ 250,000
Total cost of land = US$1,250,000

Building: The area of the building was calculated on the basis of the dimensions of the machinery to be installed supplied by the sugar mills and the 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. The cost was approximately US$59.30 per m^2. Thus
Total Cost of Construction = US$ 720,000
Plant Machinery and Equipment: The cost of machinery and equipment was estimated with the help of the machinery manufacturers and producers of electricity in sugar mills by incineration of biomass of solid bagasse.
Table 4: Cost of Plant Machinery and Equipment=US$

Plant machinery & equipment	Capacity	Quantity	Cost
Steam boiler	70 ton/hour	1	1,166,666.66
Water treatment plant	25 ton/hour	1	8,333.33
Feed water storage tank	300 tons	1	83,333.33
Multi stage turbine	10 mWh	1	1,666,666.66
Electric pumps	-	5	12,500
Distribution panel	-	1	500
Transformer	120 MVA	1	833,333.33
Vehicle (truck, bucket loader)	-	5	125,000
Total			**3,896,333.33**

Total cost of Plant Machinery and Equipment = 3,896,333

Pre-Production Expenditure: It was assumes as one full year to install the plant. Thus, the expenditure involved included salaries of the staff and consultants, etc.

Consultant Fee: US$ 10,000
Project Head: US$20,000/annum
Power House In charge: US$9,000
Boiler Foreman: US$ 5,000/annum

Total Pre-Production Expenditure=US$ 44,000

Total Initial Fixed Investment (With Land) = US$(1,250,000 + 720,000 + 3,896,333 + 44,000) = US$5,910,333

Total Initial Fixed Investment (Without Land) = US$ (720,000 + 3,896,333 + 44,000) = US$ 4,660,333
Operating Cost

Raw Material Cost: This included the cost of the solid waste from Gulberg Lahore. This was taken as zero because the waste was to be disposed off.
Cost of Other Inputs: The other inputs are given below. Their costs were worked out on the basis of local market prices.
Cost of Electricity: It involved only the minor cost of initial running of the pumps which were assumed to be self supplied due to in-house production of electricity. Thus, it was neglected.
Labor Cost: The nature and number of employees engaged to run the plant along with their salaries was as follows:
Table 5: Break Down of Labor and Labor Cost- US$

Labor	Number	Salary per Employee	Salary per Month
Boiler/Turbine attendant	3	166.66	350
Boiler/Turbine Helper	3	83.33	250
Turbine Foreman	2	250	500
Water Treatment Plant Labor	3	100	300
Electrician	3	166.66	350
Transport of Waste to Storage	6	83.33	500

Total = 2.250/Month = 27,000/Annum
Maintenance Cost: The maintenance cost is calculated at the rate of 10% of the purchase price of machinery and equipment. Thus,
Maintenance Cost = US$389,633
Depreciation: Both plant and machinery was depreciated on straight line basis at the rate of 10% of the purchase price. Thus,
Depreciation Cost = US$ 389,633
Total Operating Cost/Annum = US$ (27,000 + 389,633 +389,633) = US$806,266

Expenditure in the Base Year

Initial fixed Investment = US$ US$5,910,333
Initial fixed Investment without land = US$5,910,333-
Operating Cost = Nil
Total Expenditure = US$ US$5,910,333

Expenditure 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 (2007 - 2008) is nil. However, it is subject to alter with changes in labor cost, operating capacity, etc. However, Pattoki Sugar Mill Thermoelectric Plant is working at 80% of its plant capacity and its mangers do not intend to increase it in near future. Currently, the optimal plant capacity is taken as 80% which allows for desirable levels of efficiency needed to produce electric power. The salaries of labor are subject to increase 10% after every 3 years. The operating cost is calculated as below:
Table 6: Total Operating Cost-US$

Years	Calculations (Rupees) Operating Cost = Cost of (Labor +Utilities & Chemicals + Maintenance & Depreciation)	Operating Cost

2007-2008	**0**	**0**
2008-2009	**27,000 + 779,266.66**	**806,266.66**
2009-2010	**27,000 + 779,266.66**	**806,266.66**
2010-2011	**27,000 + 779,266.66**	**806,266.66**
2011-2012	**29,700 + 779,266.66**	**808,966.66**
2012-2013	**29,700 + 779,266.66**	**808,966.66**
2013-2014	**29,700 + 779,266.66**	**808,966.66**
2014-2015	**32,670 + 779,266.66**	**811,936.66**
2015-2016	**32,670+ + 779,266.66**	**811,936.66**
2016-2017	**32,670 + 779,266.66**	**811,936.66**
2017-2018	**35,937 + 779,266.66**	**815,203.66**

Table 7: Total Operating Costs Discounted at 10% to the Base Year-US$

Years	Calculations (Rupees)	Operating Cost
2007-2008	**0**	**0**
2008-2009	**806,266.66*0.909091**	**732,969.76**
2009-2010	**806,266.66*0.826446**	**666,335,85**
2010-2011	**806,266.66*0.751315**	**605,760.23**
2011-2012	**808,966.66*0.683013**	**552,534.74**
2012-2013	**808,966.66*0.620921**	**502,304.38**
2013-2014	**808,966.66*0.564474**	**456,640.64**
2014-2015	**811,936.66*0.513158**	**416,651.79**
2015-2016	**811,936.66*0.466507**	**378,774.13**
2016-2017	**811,936.66*0.424098**	**344,340.71**
2017-2018	**815,203.66 *0.385543**	**314,296.06**
Present Value of Total Operating Cost		**4,970,608**

Benefits

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

1. Process requisites were as given below
   - Wt: of solid waste = 278,640 metric tons/annum
   - Calorific value /kg = 6,225 kJ
   - Live steam temp: = 600 C°- 650C°
   - Live steam pressure = 70 – 80 kg/cm²
   - Fuel steam ratio = 1:4
2. Turbine for electricity generation = Multistage condensing turbine with LT generator (400 Volt)
3. Steam consumption per kWh by Turbine = 5 kg/kWh
4. Electricity produced = 80,756,715kWh/annum
5. Calculation based on hourly basis
   - Electricity produced = 9347 kWh or 9 mw/hr

Price of electricity/ kW h= US$0.108

Return per Annum = US$80,756,715×6.5/60 = US$ 8,748,644 /annum

Total Revenue Return per Annum = US$ 8,748,644 /annum

Benefits Discounted to the Base Year

The revenue returns from thermo-electric plant are in the form of constant periodic cash flows, the total receipts after discounting at 10% can be calculated by applying Annuity Table. Thus, Present Value of US$ 1 received constantly per annum for 10 years at 10 % discount rate = US$ 6.14457 (From Annuity Tables)

US$ 8,748,644 * 6.14457 =US$ 53,756,655

Present Value of the Benefits = US$ 53,756,655

Scrap Value of the Machinery and Equipment

The salvage value of the machinery and equipment at the end of the project life was assumed as 10 % of the purchase price.
Therefore, the worth of the assets at which it can be sold or disposed off will be:
Scrap value = US$ 389,333

TOTAL EXPENDITURE AND TOTAL RETURNS DISCOUNTED TO BASE YEAR

Present Value of Cash Outlays = Initial Fixed Investment +Operating Cost

Initial Fixed Investment = US$5,910,333
Operating Cost-Year (2007-2008) = Nil
Present Value of Operating Cost = US$4,970,608
Present Value of Cash Outlays (Cost) = US$ (5,910,333 +4,970,608)= **US$ 10,880,941**
Returns = Savings + Scrap Value
Present Value of Returns = US$ 389,333
Present Value of Scrap = US$ 389,333 *0.385543 =US$150,105
Present Value of Cash Flows (Benefits) =US$ (53,756,655 +150,105) = US$ 53,906,760
Alternative 1: (With Land)

This alternative is in that case when we don't have the land where we want to set up the power plant and it is to be purchased on market price,.

$$\textbf{Benefit / Cost (B/C) Ratio} = \frac{\textbf{PV of Benefits}}{\textbf{PV of Cost}} = \frac{53{,}906{,}760}{10{,}880{,}941} = 4.95$$

Net Present Value = US$ (53,906,760 –10,880,941) = US$43,025,824

$$\textbf{Payback Period} = \frac{\textbf{Total Investment}}{\textbf{Annual Return}} = \frac{5{,}910{,}333}{7{,}943{,}377} = 0.74 \text{ years}$$

Alternative 2: (With Land but Without Increase in Salaries)
This alternative was looked into on the basis of the assumption that the salaries may not be increased over time as the factors such as inflation and others that tend to increase the prices of the commodities and products and salaries, etc, also increase revenues or benefits proportionately, thus the effect is nullified. This led to almost no change in cash flows and outlays overtime provided no machinery or equipment is added in future years.
Annuity at 10% for 10 Years of operating cost /annum = US$806,266.66 *6.14457 = 4,954,164
Initial Fixed Investment = US$5,910,333
Operating Cost-Year (2007-2008) = Nil
Present Value of Operating Cost= US$4,970,608
Present Value of Cash Outlays (Cost) = US$ (5,910,333+US$4,954,164)
= US$10,864,497

$$\textbf{Benefit / Cost (B/C) Ratio} = \frac{\textbf{PV of Benefits}}{\textbf{PV of Cost}} = \frac{53{,}906{,}760}{10{,}864{,}497} = 4.96$$

Net Present Value = US$ (53,906,760 –10,864,497) = US$ 43,042,263
Net Annual Return= Annual Return – Operating Cost/Ann - US$(8,748,644-806,267) = 7,943,377

$$\textbf{Payback Period} = \frac{\textbf{Total Investment}}{\textbf{Annual Return}} = \frac{5{,}910{,}333}{7{,}943{,}377} = 0.74 \text{ years}$$

Alternative 3: (Without Land)

This is the case when sponsor. provides the requisite land
Present Value of Cash Outlays = Initial Fixed Investment +Operating Cost
Initial Fixed Investment without land = US$4,660,333

Operating Cost-Year (2007-2008) = Nil
Present Value of Operating Cost = US$4,970,608
Present Value of Cash Outlays (Cost) = US$(4,660,333+4,970,608)
= US$ 9,630,040
Returns = Savings + Scrap Value
Present Value of Cash Flows (Benefits as in Alternative 1) = 53,906,760

$$\textbf{Benefit / Cost (B/C) Ratio} = \frac{\textbf{PV of Benefits}}{\textbf{PV of Cost}} = \frac{\textbf{53,906,760}}{\textbf{9,630,940}} = \textbf{5.59}$$

Net Present Value = US$ (53,906,760 –9,630,940) = US$ 44,275.620

$$\textbf{Payback Period} = \frac{\textbf{Total Investment}}{\textbf{Annual Return}} = \frac{\textbf{4,660,333}}{\textbf{7,943,377}} = \textbf{0.58 years}$$

Alternative 4: (Without Land and Without Increase in Salaries)

This alternative is for the institutions where land is available for the power plant and it has no other use in future and that the salaries may not be increased over time.
Annuity at 10% for 10 Years of operating cost /annum = US$806,266.66 *6.14457 = US$ 4,954,164
Initial Fixed Investment = 4,660,333
Operating Cost-Year (2007-2008) = Nil
Present Value of Operating Cost = US $ 4,954,164
Present Value of Cash Outlays (Cost) = US$(4,660,333+4,954,164)
= US$ 9,630,040

$$\textbf{Benefit / Cost (B/C) Ratio} = \frac{\textbf{PV of Benefits}}{\textbf{PV of Cost}} = \frac{\textbf{53,906,760}}{\textbf{9,630,040}} = \textbf{5.59}$$

Net Present Value = US$(53,906,760 –9,630,040) = US$ 44,276,720

$$\textbf{Payback Period} = \frac{\textbf{Total Investment}}{\textbf{Annual Return}} = \frac{\textbf{4,660,333}}{\textbf{7,943,377}} = \textbf{0.58 years}$$