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Production of Thermoelectric Power from Solid Waste of Canal View Cooperative Housing Society Lahore

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Abstract – *The work presented in this article was carried out to study viability of production of thermoelectric power from the solid waste of Canal View Cooperative Housing Society; a colony in Lahore. The primary data collected from concerned sources were used to design the project that was subsequently appraised to determine its benefit to cost ratio, NPV and payback period (PBP). The results indicated that the Canal View, as a whole, consumes 1,144kWh electricity, while, the Society Office consumption including that for tube wells, street lighting, etc, is 62 kWh and it produces approximately 4 metric ton solid waste/day. The electricity that can be produced from this amount of solid waste is 50.47 kWh which is a small proportion of the total consumption. The cost of producing 50.47 kWh will be US$ 0.75 per unit. The benefit to cost ratio at this scale of production was 0.33 which is less than 1; the reference standard, NPV is –$610,795 (below zero) and PBP is infinite; thus, the projection is not feasible in this scenario. However, the project can be pulled towards feasibility if Canal View introduces bag system to collect waste components separately to eliminate zero value stuff to raise heating value of waste and fortify its nage with the waste of its neighboring colony.*

Keywords – *Canal view, Lahore, Pakistan, solid waste, thermoelectric.*

1. INTRODUCTION

Several kinds of pollutants including solid waste are posing big threat to the ecosystems. Different kinds of damages are encountered at different levels. In the villages, the residents throw solid waste indiscriminately in the streets or heap them near residences to form dunghills that constitute a site of littering and dumping of waste and are the cause of infectious diseases and also create a menace of stray dogs that eat even the human excreta lying over there. The status of solid waste from households at town level is the same as it is at the village level. The only difference is that of scale and the amount of waste produced is much larger. The cities display the highest level of solid waste production. The solid waste in both towns and cities is further enhanced by the industrial waste because industry is mostly encountered in urban areas. In the cities too much garbage is lying uncollected in the streets, causing inconvenience and environmental pollution, and is a big risk for public health. Apart from this waste called municipal waste, the industrial waste is a source of many hazardous chemicals.

The solid waste at this point of time is no more considered as waste and may be considered as a resource as it can be processed for resource recovery under the concept of sustainable development. Hence the disposal of solid waste for the production of electricity can be best investigated at this level Thus, experts all over the globe are actively engaged in techno-economic management of solid waste in order to avoid ecological damage and use it as a resource for recovery of energy in form of heat, electricity and biogas such as methane and others. The results are partial successes and failures as reported by different researchers; Tendller [1], Ungar [2], Nicolas [3], Sufian [4], Smith [5], Kagawa [6], Renbi [7], Murphy [8], Dubois [9]. The efforts to exploit solid waste to produce heat and electricity are in progress.

Pakistan is one of the developing nations and thus it is facing dual problem of environmental pollution and energy deficiency. In an attempt to help Pakistan in the current energy crises this task of exploitation of solid waste as an energy resource was undertaken by our predecessors in Lahore School of Economics. Khan and coworkers [10], [11], [12], [13] studied in detail the production of thermo-electric power from the solid waste of some educational institutions of Lahore as a pilot scheme that was to be extended further for enquiry at village, urban locality, and town/ city level. Here it is the extension of work to one of the localities of Lahore.

The goal of the study was to explore an alternative source of thermoelectric power by studying the feasibility its production from solid waste of an urban colony. The objectives of research were as follows:

1. To identify and standardize a method for safe and techno-economic disposal of Canal View Housing Society's solid waste.
2. To study the feasibility of production of thermo-electric power from the biomass of solid waste.
3. If not feasible, to study how to pull the project towards feasibility.
4. To recommend to concerned agencies an effective solid waste management system.

2. METHODOLOGY OF RESEARCH

The research project was conducted in the following stages:

a. *Collection of Secondary Data*

The secondary data about disposal of solid waste and production of thermoelectric power from the biomass was collected by consultation of literature in different libraries

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and from the published material by different concerned establishments and by visiting various websites on Internet.

b. Collection of Primary Data

The primary data was collected from the following establishments:

c. Canal View Cooperative Housing Society, Lahore:

The Canal View Cooperative Society was visited to gather the basic information about the quantity and nature of solid waste produced in the society due to both residential and commercial activity in this urban colony. The Administrative Officer, the Accountant and the Head Office Supervisor were contacted for the supply of relevant information about the solid waste and its disposal. The total consumption of electricity and information about the use of generators, etc, was also provided by these interviewees.

***d. Punjab Urban Unit*:**

The Punjab Urban Unit was visited to get the background information about the production of thermoelectric power from solid waste because the researchers came to know from certain sources that the Unit had done some studies but had not applied its findings to address the problem practically. Ex- Deputy District Officer Planning, Office of the District Officer Planning, Lahore Municipal Corporation who had shifted to the Punjab Urban Unit, and Director, Punjab Urban Unit were very helpful in supplying the required data.

e. Steam Power Station Faisalabad:

This unit is among one of the first few thermal plants installed in Pakistan. The Budget and Accounts officer of the station provided very useful information about production of thermoelectric power from furnace oil.

f. Lahore Development Authority (LDA):

The LDA was approached for the following reasons:

a) It is the institution that knows all about Lahore regarding the development issues.

b) It designs the roads and develops societies; so it can supply information about the main dumping sites for the waste.

The data was collected by interviewing the heads of the departments of LDA and taking the responses of Administration of LDA, laborers and some estate agents attached to LDA against questionnaires.

g. Punjab Environmental Protection Department (EPD):

EPD was approached, because they could guide in selecting the safest place to set up thermoelectric power plants, help in safe and techno-economic disposal of the society's solid waste and to collect information from them about the waste disposal sites in Lahore, The information was collected by interviewing the heads of the departments of EPD, and also by getting the questionnaires filled by other officials.

***h. Sugar Mill*s:**

Some sugar mills are known to produce electricity by incineration of bagasse, the material left after extraction of sugarcane juice from sugarcane. They helped us in the following ways:

- They provided information about all the technologies used in disposing of waste and in production of electricity from it.
- They explained all the sub-processes involved in production of thermoelectric power from a model solid waste bagasse and provided a flow sheet diagram.
- They supplied information about the manufacture of different types of machinery and provided their approximate prices.

***i. Machinery Manufacturers*:**

Some local and international machinery manufacturing establishments such as Brother Engineering (Pvt) Limited, Haseeb Waqas Engineering (Pvt) Limited, Heavy Mechanical Complex, Karachi Shipyard, Descon Engineering (Pvt) Limited and DDFC Engineering (Pvt) Limited were contacted to get exact prices of machinery and equipment such as boilers, turbines, transformers, etc. Alternately, the websites of machinery manufacturers were visited to have up to date prices of the machinery and equipment particularly boilers, turbines, etc., where possible.

A comprehensive questionnaire was designed and that was subsequently served to the officials and workforce concerned to take responses through one to one or group interviews. The 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 heating value of waste that formed the basis for calculation of its potential to produce electricity was averaged. The solid waste produced at different sites is computed in Table 1 and its physical composition in Table 2. The results of general information are computed a0s descriptive research in results section.

Table 1 reveals an estimate of 1,460,000 kg. This was considered to be 1,500,000kg. This is 75 kg/head (Population 20,000) and1.48 kg/m^2). The difference was to account for miscellaneous waste.

Average electricity bill paid by the households /month = $83.333 x 1000 = $83333

Electricity bill paid by the Society Office/month = $ 5833

Total electricity bill/month = $ (83,333+5833) = $ 89,166

Price per kWh =$0.108333

Consumption of electricity by Society Office = $89,166/0.108333/30/24 = 62 kWh.

j. Project Assumptions and Cost Analysis

The project assumptions are narrated and cost analysis is computed in Appendix 1.

3. RESULTS

The results are reported at two levels; qualitative and quantitative. The information gathered from the interviewees about the colony worked upon and methods of disposal in Lahore is reported qualitatively, while the results of cost analysis are reported quantitatively.

a. Description of the Canal View Housing Society Lahore

The Canal View Cooperative Housing Society is located on the Multan Road near Thokar Niaz Baig along right bank of the canal that flows through the city of Lahore and also adds value to its beauty and glory. The Society provides a range of services and thus bears in its layout more than one thousand residences, a business centre, minimarkets and a society office that secures water supply, sanitation services to pump out wastewater from gutters using diesel pumps and maintain overall cleanliness. The Canal View was incorporated in 1974 and is run by an executive committee of 9 members. The construction was started in 1982 and at the point of visit by the researchers 1000 houses had been built out of the total of 1300. The Society is legally approved by LDA.

According to the information gathered from its officials, the Society produces approximately 4,000 kg solid waste daily, which includes light dust, leaves, steel, plastics, vegetable cutoffs, etc. The waste is collected by a company named Clean Buster, managed by its Director Uzma Khan. The contractor was paid $833 per month for the collection of waste using two trucks with three unskilled personnel required for each truck. The cost of electricity consumed by the Society's Office paid to Lahore Electricity Supply Company (LESCO) was around $5833/ month. With this cost it maintains a water tank, and runs two tube wells each equipped with 60 horsepower motor and illuminates around 600 street lights.

b. Nature and Composition of Solid Waste in Canal View

There are nine (9) main local disposal sites in Canal View whose total waste generation is 4 /day, 120 s per month and approximately around 1,500 s per year. With regard to the physical composition, the society's solid waste consists of vegetables and fruit residues, paper, plastic, wood, bones, animal waste, glass, metals, dust, dirt, ashes, ses, bricks, etc. Fruit and residues are the largest component in the trash. The Canal View generates 28% of these components followed by leaves (25%) and dust (22%). Glass, metals, plastic, wood, and food scraps constitute 0 to 8 percent of the solid waste. Rubber, leather, and textiles are in negligibly small amount.

c. Technology of Production of Thermoelectric Power from Solid Waste

The process of production of thermoelectric power from solid waste involves five sub-processes: solid waste storage, incineration and steam raising using boilers, passing of superheated steam through the turbine that produces electricity, accumulation of electricity using a grid system and supply to the consumers. The details are already published and can be seen in articles by Khan and Pervaz (2009) and Khan and Sheikh (2010).

d. Results of the Cost Analysis

Benefit/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 the benefit to cost ratio 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.

Net Present Value (NPV) is the difference between the present value (PV) of the cash flows and of expenditure. A zero NPV means that the project returns original investment without profit and loss. A positive NPV means a better return, and a negative NPV means a bad return. A project may be considered for acceptance if its 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 period tells us the time the project will take to recover initial investment. Shorter the time period, quicker is the recovery of the investment in a project. A longer payback period is not desirable.

In the light of the criteria narrated above, the results of evaluated alternatives are compiled below.

e. Alternatives

i. Alternative 1 (With land):

The B/C ratio in Alternative 1 is 0.32, the NPV is -$610,795, while PBP is infinite, Thus, B/C is less than 1 and the NPV is also negative along with an infinite PBP meaning that the investment can never be recovered. Thus this alternative is not acceptable.

ii. Alternative 2 (With land but without increase in salaries):

The B/C ratio in this alternative is 0.33; NPV is -$ 559,346 and PBP: is infinite. This means that increase in salaries has a minor effect. The B/C is again less than 1 and the NPV is again negative. The payback period remains the same as that in Alternative 1. Thus, Alternative 2 is not feasible as is Alternative 1.

iii. Alternative 3 (Without land):

The B/C ratio in Alternative 3 is 0.46, NPV is- $344,128 and the PBP infinite again. The B/C is still less than 1 and the NPV is also negative. The PBP is the same as in above two alternatives. Thus the project is still not acceptable.

iv. Alternative 4 (Without land and without increase in salaries):

The B/C ratio in Alternative 4 is 0.47, the NPV is -$326,013 where as the PBP is again infinite. The B/ C is still less than 1 and the NPV is also negative. Thus the project is not acceptable.

v. Alternative 5 (Increase in solid waste to 2,000 /annum and with land):

The B/C ratio in Alternative 5 is 0.43; the NPV is -$514,116 and PBP is 21 years. The B/ C with increased nage is still less than 1 and the NPV is also highly negative. So, even increase in the amount of waste does not qualify the project for acceptability.

vi. Alternative 6 (Increase in solid waste to 2, 000 /annum and without land):

The B/C ratio in Alternative 5 is 0.63; the NPV is -$229,334 and PBP is 21 years. The payback period remains the same because the cost of land is excluded from initial investment. The B/ C is still less than 1 and the NPV is also negative. So, even after increasing the amount of waste and excluding the cost of land from the expenditure stream, this project is still not feasible but a high change in parameters does indicate that the increase in nage has highly significant role in pulling the project toward acceptability.

4. DISCUSSION

The main objective of the study was safe and techno-economic disposal of the Society's waste and to study the feasibility of production of thermo-electric power from the biomass of solid waste to meet the domestic demand of the Society as it is being done by the sugar mills of Pakistan. The mills are producing electricity from solid waste, but there is no published material available in contemporary literature which can help researchers in designing and evaluating the projects to produce thermoelectric power from the solid waste by its incineration techno-economically. As a general view of the practical methodology followed by the sugar mills of Pakistan indicated that exploitation of this source for production of thermoelectric power along with the advantage of solid waste disposal in environmental context was quite promising, an attempt was made to develop a simple methodology understandable at the level of the developing countries, Thus one of the major objectives was the development and standardization of this methodology for circulation in the world especially in the developing countries, The activity was started in 2007 with focus mainly on some educational institutions of Lahore (Phase 1). Luckily the work carried in Phase 1 is now well circulated in the form of published research papers. The work being presented here is actually an extension of the work referred above. The same methodology was applied except an additional exercise was done by sorting out the difference in appraisal of the projects by making a change in calculations of the expenditure stream in two ways: Increasing the salaries of the labor overtime in future years and not increasing salaries in future years to compare and see whether there is some difference of results. The difference was minor and negligibly small and thus it may be advisable not to enhance salaries in future years and appraise the projects. This switch over will positively lead to elimination of labor and time involved in construction of future tables and subsequent discounting to the year zero values.

Before discussion on the results, it may be better to talk about demand and supply of electricity in Canal View Cooperative Housing Society. Currently, the total electricity consumed by the people of Canal View calculated from data collected from Lahore Electricity Supply Company (LESCO)/WAPDA and local production from generators was 1,144kWh. The consumption of Society Office including cost of running the tube wells and street lighting, etc, was 62kWh. the electricity that can be produced from the solid waste is 50.47 kWh. The comparison indicates that this is a meager production that forms only 23% of total consumption. Thus the installation of solid waste based plant for Canal View cannot be even thought of. This amount covers more than 80% of the demand of the Society Office. The installation can be considered to meet this demand provided the cost per unit is favorable. If the total investment excluding cost of land is considered because the land if included or excluded appreciates with the passage of time in the current economic conditions, the investment comes out to be $.329,833 and that produces 436,063 kWh per annum. Thus, the cost per unit will be $ 0.75. It is a very high cost. This means that the projection does not qualify in any respect. The results indicate that the primary project based on the solid waste 1500 s per annum is not economically viable because Its B/ C ratio is far less than 1, and NPV is far below zero and the PBP is infinite which means that the projection will go in loss over its life span and thus the investment can never be recovered, Yet there is nothing to be depressed,

The first message to be conveyed to the audience is that the prices of electricity have doubled since 2008 and the raw material being zero cost, there is likelihood of negligibly small increase in the expenditure stream but the revenue will be positively doubled because price per kWh of electricity will soon go beyond $ 0. 216667. Thus using the same ground work and doing a few multiplications and additions will produce revised results which are highly promising. Let the discussion on overall 12 alternatives be directed to these lines and see how the situation crystallizes out. Another parameter that may affect the situation in the positive direction is the enhancement of solid waste nage either due to natural growth of the society as pointed out under society description that there are still about 300 vacant plots on which both construction and population may be expected in near future, That is why alternatives based on 2,000 metric s per annum have been designed and appraised.

Keeping in view the objectives and importance of the work reported before, the results can be discussed on the following lines:

- Impact of change in appraisal methodology (Increasing salaries of labor in future years overtime) on the results.
- Impact of increase in nage of solid waste on economic viability of the project.

- Impact of increase in the price of electricity on economic viability of the alternatives
- Comparison of the results of study of thermoelectric power from the solid waste of Canal View (An urban colony) to the results of the study of thermoelectric power from solid waste of some educational institutions of Lahore.

Let us compare the results of the project appraisal of first four alternatives: Alternative 1 (Increased salaries overtime) with Alternative 2 (Without increase in salaries overtime), no significant difference in different indices is encountered. The change in B/C is around 3% and the change in NPV is around 5% (Table 8) while PBP is infinite in all four. Thus, it may be advantageous to make the change in methodology because that will lead to elimination of lot of labor involved in computation of operating cost overtime in future years and subsequent discounting of all the values to year zero. This method is also followed by majority of experts in this field.

If Alternative 1 to 4 (Solid waste 1,500) are compared to Alternatives 5 and 6, a significant increment is added to indices, B/ C is increased from 0.33 (Alternative 2 without increase in salaries, land cost included) to 0.43 (Alternative 5 without increase in salaries, land cost included) and from 0.47 (Alternative 4 without increase in salaries, land cost excluded) to 0.63 (Alternative 6 without increase in salaries, land cost excluded). Similarly in this comparison NPV is increased from –$559,346 to – $514,116 and from – $326,013 to -$229,334 which in latter is a highly significant increase. There is a big change in PBP; that is from infinite to 21 years respectively. The overall message is that there are significant prospects of pulling the project towards feasibility by increasing the nage of solid waste because basic machinery and equipment and even labor requirements will remain the same.

The question is how to obtain additional 500 or more waste for incineration. The following points may be made in this context:

- The colony is not completed yet because there are still 300 plots lying vacant. When these houses will be constructed, addition of 300 households may add 500 s of waste for processing to produce thermoelectric power. However time factor is crucial. At the current speed of construction of houses in Canal View it may take about five years to make that required quantity of waste available. Thus the time factor would affect the performance over this period of time if the plant is installed now. Moreover the plant which already qualifies marginally will be working at lower than its capacity and thus will run in further losses. The only strategy to adopt will be to start the installation after five years when all the houses are constructed or option given below may be helpful to start mow. Apart from that the alternatives appraised at higher price and discussed later may be looked into to start a plant now.
- There is a relatively small colony named Canalburrg that shares its boundary with Canal View. Both colonies can sign a social contract to raise a joint facility. The tonnage of solid waste will be definitely more than 2000 and thus a thermoelectric power plant can be set as joint exercise for benefit of both sister conies.
- Finally, recommendation may be made to introduce separate bag and container system to sort solid waste at the origin and collect different components separately, sending the recyclable components to the appropriate sites for reprocessing, bulking the incinerable biomass without zero heating value materials and finally incinerating the waste to produce electricity. The fuel efficiency will increase and the prospects of feasibility of the project will be brighter.

The work on the pilot scheme for the production of thermoelectric power from solid waste was conducted in 2007 and 2008. The price of electricity per kWh was $ 0.108333 while the current price in 2010 is $0.216666 and even this is signaled with an increase of 16% which if implemented as such then the price will go up to $0.32. Keeping in view that expected increase has yet to pass through the public debate $0.216666 per kWh seems to be a reasonable figure for reevaluation of the alternatives to check the effect of price of electricity on the feasibility of the project. The results of project appraisal are computed in Table 9. The comparison of acceptability criteria computed in Table 8 (Price0.108333 in 2008) to those in Table 9 (Price $0.216666 in 2010) indicates that all parameters undergo an increase when there is a movement from Alternative 1 to 6. The B/C in Alternative 3 and 4 is raised to 0.91 and 0.94 (Alternative 9 and 10) which is nearly1. In other words, under social obligations the projects can be accepted. The PBP for Alternative 9 and 10 is 7 years which is a reasonable time period for recovery of the investment made in the project. The exercise finally resolves that Alternative 12 appraised at $0.216666 (Alternative 6 reappraised at double price) is the best out of all the alternatives appraised. It gives the highest B/C 1.25 and significantly positive NPV and PBP of four years which is an attractive figure for making an investment. The basis of all these results is that expenditure stream is affected not significantly because the same machinery and equipment will be in use and raw material has zero value while other fuels being used undergo abnormally high increase in prices that also means high increase in expenditure stream. The revenue, on the other hand, undergoes big increase; it has doubled in the present case and thus some of the alternatives are strongly pulled towards feasibility.

Finally let us see how the results of this study compare with the results reported by the predecessors. The predecessors worked on four educational institutions of Lahore. The solid waste produced per annum by each waste was assessed and the projects were designed and appraised as done here. The major difference is that heating value of the solid waste was assumed as the average of the furnace oil and bagasse. It was also based on the assumption that waste produced in educational institutions is very different from ordinary municipal waste that is rich in zero heating value materials such as mud and construction material. Moreover, the educational institution waste is rich in PTN bottles the plastic with high heating value. Anyhow some experts objected that assumed value was very high. Even if it is admitted as high, still the studies carry a highly significant importance. These studies have circulated through published papers and conferences the indigenously developed and standardized methodology of project designing and appraisal understandable at the developing countries level. Secondly the results based on higher heating value still carry a lot of importance because the calculation of results at lower values will be a matter of one or two step multiplication or division. For example if the calculation is to be done for a fuel with heating value half of the value assumed by the predecessors, then the figures reported will have to be divided by 2 to get exact value. Similarly if any policy maker anywhere in the world wants to work out results based on the heating value of his country, he can calculate by one or two step conversion from the results of the predecessors. This way, different scenarios can be developed to help decision takers in different countries.

Here two major changes have been made and additional alternatives have been designed and subsequently appraised. The first change was the computation of the operating cost in the expenditure stream without increasing the salaries of the employees in future years. The evaluations have shown that no significant difference in results following the two approaches. This change was not done by our predecessors. The study recommends with confidence without increase in salaries approach which also leads to elimination of lot of labor involved in computation of future values and discounting them to the year zero.

The work on educational institutions was conducted when the price of electricity was $ 0.1083333 per kWh. The price has undergone an enormous increase; it has rather doubled after two years. That is why all the alternatives were also appraised on the basis at the current price of 0.216666 per kWh. The results give an important message to the entrepreneur for investment in production of thermoelectric power from solid waste. The results indicate that all the alternatives are strongly pulled towards feasibility. Khan and Sheikh (2010) have already given this message to entrepreneurs but that is with reference to increase in inflation overtime. The message was that some projects which were not feasible turned feasible after adjusting the results for increase in inflation. The argument is again the same that increment due to inflation increases the revenue but not the expenditure stream.

5. CONCLUSION

The results reported and subsequently discussed indicate that none of the alternatives based on 2008 electricity ($0.108333 per kWh) evaluated here has turned out to be techno-economically feasible as a source of thermoelectric power. However it can be pulled towards feasibility by an increase in nage of the solid waste to 2000 or even more. The deficiency is expected to be automatically made up by the solid waste produced by construction of 300 vacant plots in the Canal View and their subsequent occupation by 300 households. Alternatively, Canal View can enter a social contract with its adjoining colony Canalburgh and both can raise a joint facility or latter may authorize former to lift its solid waste for disposal to keep its environment clean. The picture on the basis of the current price of electricity (0.216666/kWh has emerged as totally different. Some projects can be accepted as social obligation and one Alternative 12 can be accepted without any reservation provided the colony can spare a piece of land for plant installation. It sounds to be the best alternative with B/C ratio 1.25, NPV $157,614 and PBP 4 years.

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APPENDIX 1

I. Cost Analysis

The project analysis is based on the assumptions given below:

Project Life: 10 Years
Base Year: 2008
Financial Year: July 1 to June 30
Discount Rate: 10%
Exchange Rate: US Dollar = 60 Pakistan Rupees

This is the exchange rate of 2008 when the study was carried out along with others in the pilot scheme. With the same exchange rate it will be possible to make comparison of results of studies undertaken at that time and also with the results of the alternatives evaluated at increased price of electricity.

The projects were framed and appraised using the guidelines of Asian Development Bank [14]-[15].

a. *Initial Fixed Investment*

It includes the cost of land, building, machinery, equipment, etc:

Land:

The total land required was calculated from the machinery dimensions collected from the sugar mills and the machinery manufacturers to which was added the land required for open storage of solid waste. The price of land was asked from estate agents in vicinity of installation site.

Total area required = One Acre or 4,047m^2
Open storage for waste = 0.375 Acre or 1,518 m^2
Cost of 1 Acre = $266666.67
Total cost of Land = $266666.67

Building:

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 $59.31 per m^2.

Total Constructed Area = 2,529 m^2
Total Cost of Construction = 2,529 ×5931 = $150,000

b. *Plant Machinery and Equipment*:

The cost of machinery and equipment was estimated with the help of the machinery manufacturers and producers of electricity from baggasse. Total Cost of Machinery and Equipment = $ 140,500

c. *Pre-Production Expenditure*:

It takes one full year to install the plant. Thus, the expenditure involved includes salaries of the staff and consultants, etc.

Consultant Fee/Annum =$ 8333
Project Head/Annum=$ 16666
Power House In charge/Annum =$ 9333
Boiler Foreman/Annum=$ 5000
Total Pre-Production Expenditure= $39333

Total Initial Fixed Investment (With Land) = $(266,667 + 150,000 + 140,500 + 39333) = $596.500

Investment =Initial Fixed Investment – Cost of Land = $(506,500-266667) = $329,833

Total Initial Fixed Investment (Without Land) = $(150,000) +140,500 + 39,333) = $329,833

Investment= Initial Fixed Investment (Cost of Land already excluded) = $329,833

d. *Raw Material Cost*:

The raw material being solid waste to be disposed of, its cost was zero.

e. *Cost of Other Inputs*:

The other inputs included labor and electricity. Their costs were worked out on the basis of local market prices.

f. *Cost of Electricity*:

A minor cost of electricity was involved for initial running of the pumps which would be self supplied after the plant became functional. Thus, it was neglected.

g. *Labor Cost*:

The nature and number of employees engaged to run the plant along with their salaries is shown in Table 4

II. Benefits

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

1. The calorific value of waste taken as 6,244 kJ per kg
2. Process requisites were as given below
   Wt: of solid waste = 1500 metric ton/annum

Calorific value = 6,244 /kg
Live steam temperature = 600ºC- 650ºC
Live steam pressure = 70 – 80 kg/cm²
Fuel steam ratio = 1:145

3. Steam produced from available fuel = 2,180 s/annum
4. Turbine for electricity generation = Multistage condensing turbine with LT generator (400 Volt)
5. Steam consumption per kWh by Turbine = 5 kg/kWh
6. Electricity produced = 436,063 kWh/annum calculation based on hourly basis
7. Steam produced/hr = 0.30 s/hr
   Electricity produced/hr = 50.47 kWh
   Price of electricity/ kWh = $0.183333
   Return per Annum = $436,063 ×0.1083333 = $47,240
   Total Revenue Return per Annum = $47,240

Benefits Discounted to the Base Year

The revenue returns from thermo-electric plant are in the form of constant periodic cash flows of $47,240. The total receipts after discounting at 10% or present value can be calculated by applying annuity tables. Thus, Present Value of $1 received constantly per annum for 10 years at 10 % discount rate = $ 6.14457 (from annuity tables)
$ 47,240* 6.14457 = $ 290,270
Present Value of the Benefits = $290270
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 of the asset at which it can be sold or disposed off will be: Scrap value = $ 14050

Computation of B/C Ratios, NPV and PBP

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

Initial Fixed Investment = $596,500
Operating Cost-Year (2008-2009) = Nil
Present Value of Operating Cost = $ 309,982
Present Value of Cash Outlays (Cost) =
$ (596500 +$ 309982 = $906,482
Returns = Savings + Scrap Value
Present Value of Returns = $ 290,270
Present Value of Scrap = $ 14050)*0.385543 =$5,416
Present Value of Cash Flows (Benefits) = $(290,270 + 5416) = $ 295687

Alternative 1: (With Land)

PV of Benefits $ 295687)
Benefit / Cost Ratio = ------------- = --------- = 0.32
PV of Cost $ 906482)
Net Present Value = $ 291187 –$ 610495) = $ 610795

Net Annual Return = Annual Return – Operating Cost of Year 1 = $47240 - $ 47500 = -260

$$\text{PBP} = \frac{\text{Total Investment}}{\text{Annual Return}} = \frac{\$\,329{,}833}{-\$259} = \text{Infinite}$$

Alternative Projects

The project evaluated above was not economically feasible. To pull the project towards feasibility overall twelve alternative projects were framed with reference to this fundamental project (Alternative 1) by increasing the amount of solid waste, both including and excluding the cost of land from expenditure stream and with and without enhancement of salaries in future years. Because the four basic alternatives exhibited negligible difference with and without increase in salaries, all additional eight alternatives were appraised without salary enhancement. These were appraised exactly the same way as was done in Alternative 1. The bases of the formation of alternatives were as follows:

1. Major factors that rendered the project non-feasible were less nage of solid waste and cost of land. Here there was the problem of nage deficiency due to the low heating value of the waste. The cost of land was an important factor because the land cost in and around Society was very high. Thus alternative projects were designed with and without cost of land.
2. There are two norms to accommodate the impact of inflation on project appraisal. The first is based on the assumption that if the cost components undergo an increase in price with the passage of time, the revenues also increase proportionately due to the proportionate increase in prices of the products. Thus the impact of inflation is nullified. The other norm is to increase salaries overtime in future years at the rate normally encountered in Pakistan at periodic salary revisions and discount them as a part of project appraisal. Thus the alternatives were also designed by calculating operating cost with and without increase in salaries.
3. The primary calculation of annual revenue return was done in 2008 at the rate of $0.108333 per kWh. After two years the price of electricity has almost doubled. Thus the calculation has been revised at $0.216666 per kWh.

The bases of projects framed are given in Table 7 and 8.

The B/C ratios, NPVs and PBP of all alternatives are compared in Table 9 and 10 (Appendix 2).

APPENDIX 2
Tables

Table 1. The details of the solid waste produced and disposed at different sites.

Sites	Solid waste produced per day (kg)	Solid waste produced per month (kg)	Solid waste produced per annum (kg)
Main Commercial Zone	780	780×30 =23,400	23,400×12=280,800
Butt Market	510	510×30=15,300	15,300×12=183,600
Market near Mosque 2	450	450×30=13,500	1,242×12= 14,904
Market near Water Tank / Society Office	260	260×30= 7,800	2,412×12= 28,944
Block A	370	370×30=11,100	900×12= 10,800
Block B	410	410×30= 12,300	15×12= 180
Block C	440	440×30= 13,200	60×12=720
Block D	380	380×30= 11,400	600×12= 7,200
Block E	400	400×30= 12,000	60,000×12= 360,000
	Total		1,460,000

Table 2. Physical composition of solid waste.

Serial No.	Description	% Weight	kg per day
1	Vegetables and fruit residuals	28	1,120
2	Paper	6	240
3	Plastic and rubber	8	320
4	Leaves, grass, straws etc	25	1,000
5	Glass	4	160
6	Metals	3	120
7	Dust, air, ashes stone, brick, etc	22	880
8	Cloth	4	160
	Total	100	4,000

Table 3. Plant machinery and equipment.

Plant Machinery and Equipment	Capacity	Quantity	Cost ($)
Steam boiler	1 s/hr	2	83,333
Water treatment plant	1 /hr	1	1,666
Feed water storage Tank	25 s	1	13,666
Multi stage turbine	100 kWh	1	6,666
Electric pumps	-	6	8,333
Distribution panel	-	1	625
Transformer	-	1	108,333
Vehicle (Truck)	-	1	250,000
Total			140,500

Table 4. Breakdown of labor and labor cost (US $).

Labor	number	Salary per employee	Salary per month
Boiler/Turbine Attendant	3	133.33	400
Boiler/Turbine Helper	3	83.33	350
Turbine Foreman	1	250	250
Water treatment Plant labor	2	100	200
Electrician	2	133.33	266.66
Transport of waste to storage	3	83.33	250
		Total	= 1,616.66/Month = 19,400/Annum

Table 5: Total operating cost.

Years	Calculations ($) Operating cost = Cost of (labor +utilities and chemicals + maintenance and depreciation)	Operating Cost ($)
2008-2009	0	0
2009-2010	19,400 + 28,100	47,500
2010-2011	19,400 + 28,100	47,500
2011-2012	19,400 + 28,100	47,500
2012-2013	22,310 + 28,100	50,410
2013-2014	22,310 + 28,100	50,410
2014-2015	22,310 + 28,100	50,410
2015-2016	25,657 + 28,100	53,757
2016-2017	25,657 + 28,100	53,757
2017-2018	25,657 + 28,100	53,757
2018-2019	29,505 + 28,100	57,605

Table 6. Total operating costs discounted at 10% to the base year.

Years	Calculations ($)	Operating Cost ($)
2008-2009	0	0
2009-2010	47,500*0.909091	43,181
2012-2013	50,410 *0.683013	34,430
2013-2014	50,410 *0.620921	31,300
2014-2015	50,410 *0.564474	28,455
2015-2016	53,4565*0.513158	27,585
2016-2017	53,757*0.466507	25,077
2017-2018	53,757*0.424098	22,798
2018-2019	57605*0.385543	22,209
Present Value of Total Operating Cost		$ 309,982

Table 7. Bases and requisites of different alternative projects.

Alternatives	1	2	3	4	5	6
Solid waste /yr (metric ton)	1500	1500	1500	1500	2,000	2000
Cost of land	Included	Included	Excluded	Excluded	Included	Excluded
Future salaries	Increased	Not	Increased	Not	Not	Not
Price / kWh (US$)	0.108333	0.108333	0.108333	0.108333	0.108333	0.108333

Table 8. Bases and requisites of different alternative projects.

Alternatives	7	8	9	10	11	12
Solid waste /yr (metric ton)	1500	1500	1500	1500	2,000	2000
Cost of land	Included	Included	Excluded	Excluded	Included	Excluded
Future salaries	Increased	Not	Increased	Not	Not	Not
Price / kWh(US$)	0.216666	0.216666	0.216666	0.216666	0.216666	0.216666

Table 9. Comparison of alternatives at the price of electricity in 2008 (US$).

Alt.	PV Benefits	PV Costs	B/C Ratio	NPV	Investment	Net Return	PBP (Years)
1	295,687	906,482	0.32	- 610,795	329,833	- 259	Infinite
2	295,687	888,367	0.33	- 559,346	329,833	-259	Infinite
3	295,687	639,815	0.46	-344,128	329,833	- 259	Infinite
4	295,687	621,700	0.47	-326,013	329,833	-259	Infinite
5	392,366	906,482	0.43	-514,116	329,833	15474	21
6	392,366	621,700	0.63	- 229334	329833	15474	21

Table 10: Comparison of alternatives at the price of electricity in 2010 (US$).

Alt.	PV Benefits	PV Costs	B/C Ratio	NPV	Investment	Net Return	PBP (Years)
7	585,957	906,482	0.64	--320524	329,833	46980	7.
8	585,957	888,367	0.65	-302409	329,833	46980	7
9	585,957	639,815	0.91	- -53857	329833	46980	7
10	585,957	621,700	0.94	-35742	329833	46980	7
11	779,315	906,482	0.85	-127,167	329,833	78448	4
12	779315	639815	1.25	-157614	329833	78448	4